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PROXIMATE AND MINERAL COMPOSITION AND SOME ANTI-NUTRITIONAL FACTORS OF FLOUR FROM FIVE IMPROVED SWEET POTATO (*IPOMOEA BATATAS* (L.) LAM) VARIETIES ROOTS

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ABSTRACT

Proximate and mineral compostion and some anti-nutritional factors of flour from roots of five (5) improved sweet potato (*Ipomoea batatas* L.Lam) varieties were determined. The parameters such as moisture, ash, crude protein, fat, fiber, total carbohydrate, total sugars and reducting sugars had contents in flours varying from 4.00 ± 0.20% dw to 5.19 ± 0.19% dw (dry weight), 3.25 ± 0.01% dw to 4.60 ± 0.40% dw, 1.61 ± 0.03% dw to 2.16 ± 0.01% dw, 0.60 ± 0.05% dw to 0.76 ± 0.10% dw, 1.25 ± 0.25% dw to 1.41± 0.14% dw, 87.70 ± 1.5% dw to 88.00 ± 0.60% dw, 1.43 ± 0.01% dw to 2.08 ± 0.01% dw, 0.11± 0.01% dw to 0.65 ± 0.01% dw respectively. Indeed, the rates ash, crude protein, Fat, Fiber, total carbohydrate, reducting sugar, Ca, Na, Mg, P and K in *Kabode* variety flour were found to be higher than those recorded in other varireties flours. Besides, the Analysis of Variance (ANOVA) showed that variety factor had significant effect ($P \leq 0.05$) on these parameters. It so appeared significant differences ($p \leq 0.05$) between their contents. Concerning caloric enregy, the values ranging from 374.8 ± 0.5Kcal/100g to 379.5 ± 0.1Kcal/100 g, didn't differ significantly ($p>0.05$) from one variety to another. Furthermore, mineral elements (K, P, Mg, Ca and Na) studies were influenced by variety main effect and they varied significantly ($p \leq 0.05$). These minerals content found to be high in *Kabode* variety flour. *Kabode*, *Irène*, *Fatoni* and *Bela Bela* were the best sources of mineral elements and could be used in the diets of infants and young children. Otherwise, the results revealed that both *kabode* and *Irène* varieties flours contained high rate of oxalate (66.00 ± 0.01%) where as the phytate (9.46 ± 0.30%) and tannin (20.66 ± 0.20%) contents were found to be high in Tib variety flour. Besides, the Analysis of Variance (ANOVA) showed that the variety main effect had significant effects ($P \leq 0.05$) on these parameters. Thus, there were significant differences ($P \leq 0.05$) between their rates.

KEYWORDS: Sweet potato, improved variety, proximate, mineral, anti-nutritional factors.

1-INTRODUCTION

Sweet potato (*Ipomoea batatas* L.Lam) is a dicotyledonous plant belonging to Convolvulaceae family. It is a major staple food in Africa, Asia, the Caribbean, and South America. Sweet potato ranks seventh in the world from the viewpoint of total production. Indeed, it is among the important food crops in the world, after wheat, rice, maize, Irish potato, barley and cassava (Hironori *et al*., 2007). Sweet potato ranks second following Irish potato in the world's root and tuber crops production and third after Irish potato and cassava in consumption in several parts of tropical Africa (Teshome *et al*. 2012). The sweet potato crop is highly adaptable and tolerates high temperatures, low soil fertility, and drought. It is a short season crop, provides food on marginal and degraded soils. It is widely cultivated worldwide mainly for itsedible roots (Ukom *et al*., 2009). The Sweet potato roots are important sources of carbohydrates, vitamins A and C, fiber, iron, potassium, and protein (Woolfe, 1992). Despite its high carbohydrate content, sweet potato has a low glycemic index due to low digestibility of the starch making it suitable for diabetic or overweighed people (Ellong *et al*., 2014; Fetuga *et al*., 2014; Ooi and Loke, 2013). Moreover, some varieties of sweet potato contain colored pigments, such as β-carotene and phenolic compounds as anthocyanin. These substances have beneficial influence on human organism, as it protect against cardiovascular disease, and cancer, as well as reduce blood cholesterol level (Kaur and Kapoor 2001, Astley 2003). Sweet potato is a higher source of energy and provides more than 450KJ/100g of energy, compared to other root and tuber staples such as yam and taro (Tortoe *et al*., 2017). Otherwise, it is one of the crops that can be used to combat malnutrition in developing countries. A report by the FAO (2013) indicated that 24.8% of the population in

Sub-Saharan Africa remained undernourished and agricultural projects (crops) that can deliver quick results were needed to meet the millennium goal number 1 (MGD1). Sweet potato can be used as a quick turnover crop due to its wide ecological adaptation, drought tolerance and a short maturity period of three to five months (Bovell-Benjamin 2007; Agili *et al*., 2012). It can also be harvested sequentially, thus ensuring continuous food availability and access, an important dimension of food security. Sweet potato roots are used as vegetables, eaten boiled, baked, fried, or dried and ground into flour to make biscuits, bread, and other pastries, dehydrated chips, canned, cooked and frozen, creamed and used as pie fillings much like pumpkin. The root is reported to usually have higher protein content than other roots and tubers, such as cassava and yams (Oloo *et al*., 2014).

In Côte d'Ivoire, sweet potato is cultivated in all regions for consumption and also as a source of income. The Domestic food production is low and it is estimated at 47 914 tons. In Côte d'Ivoire, to fight against food insecurity and vitamin A deficiencies, the National Agronomic Research Centre (CNRA and Helen Keller International (HKI) have developed improved varieties of sweet potatoes. Agronomic studies of these improved varieties were carried out (Dibi *et al*., 2017). To the best of our knowledge, no study has so far beencarried out to determine the biochemical parameters of these improved varieties. Therefore, there is the need to know the parameter of improved sweet potato varieties for product development and industrial applications of flour from these varieties. The objective of the study was to assess the proximate and mineral compostion and some anti-nutritional factors of five improved varieties of sweet potato *(Ipomoea batatas)* cutivated in Côte d'ivoire.

2-MATERIALS AND METHODS

2-1-Raw material

The tubers of improved sweet potato varieties came from the collection of the National Agronomic Research Centre (CNRA) of Bouaké (City of Côte d'Ivoire center). These sweet patato varieties were *Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*. Their roots were harvested at physiological maturity in December 2017. They were transported to the Laboratory of Biochemistry and Food Technology of university of Abobo-Adjamé (Côte d'Ivoire) where study was conducted. Table 1 presents five improved varieties description including their vernacular name and their flesh and peel.

Table 1: Characteristics of sweet potato roots.

Variety	Status	Color of the flesh
Kabode	Improved	Pale orange
Irène	Improved	Dark orange
Fatoni	Improved	Cream
Tib	Improved	Pale Orange
BelaBela	Improved	Yellow

2-2-Methodes

2-2-1-Preparation of sweet potato flour

Matured and freshly harvested sweet potato roots were hand-peeled, washed in potable water and manually cut into slices (2-4mm thick) (Figure 1). Subsequently, the slices were immersed in hot water for 1 min to prevent browning. These were then dried at 65 °C in ventilated oven (MEMMERT) for 48 hours. The dried samples were ground into fine powder. Sweet potato powder was obtained after sieving (250 µm diameter). Dried powdered samples were packed into airtight sealed HDPE plastic bags and stored in the refrigerator f at 4°C for later use.

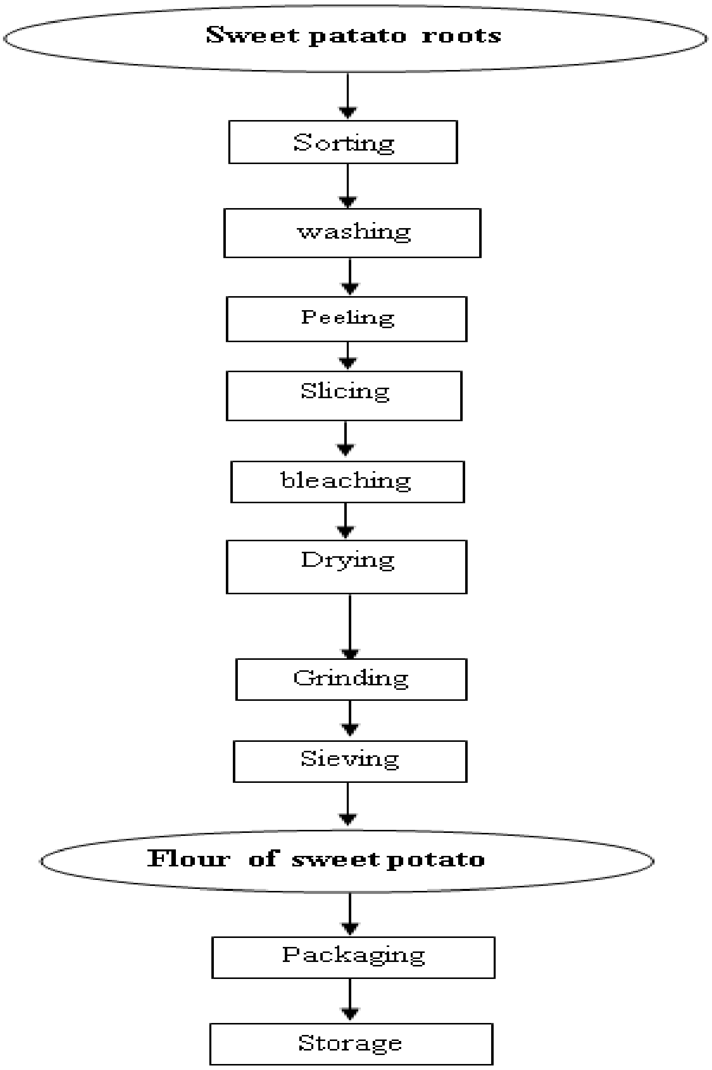

Figure 1: Preparation of sweet potato flour.

2-2-2-Proximate analysis

Moisture content was determined by drying in an oven at 105ºC during 24 h to constant weight (AOAC, 1990). Crude protein content was calculated from nitrogen (Nx6.25) obtained using the Kjeldahl method by AOAC (1990). Fat content was determined by continuous extraction in a Soxhlet apparatus for 8 h using hexane as solvent (AOAC, 1990). Ash was determined by incinerating in a muffle 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 carbohydrate content was calculated as 100% minus the sum of moisture, protein, fat and ash contents (Rand *et al*., 1991). Crude fiber was estimated by the gravimetric method (AOAC, 1990). The caloric energy value was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors; 4 kcal/g for protein, 9 kcal/g for fat and 4 kcal/g for carbohydrates and expressed in calories as described by Ihekeronye and Ngoddy (1985).

2-2-3-Mineral analysis

All minerals were determined by scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS).

2-2-4-Determination of anti-nutritional factors

Oxalate content

Oxalate content was determined by the method of Ukpabi and Ejidoh (1989). Two (2) g of flour were dissolved in 2 mL of 6M hydrochloric acid. The obtained suspension was homogenized at an ambient temperature (28°C) for 2 min and then diluted in 30 mL of distilled water contained in a 50 mL conical centrifuge tube. Two (2) drops of caprylic alcohol (5%) were added to the reaction medium and the mixture was heated for 15 min in a boiling water bath. It let cool at an ambient temperature (28°C) for 2 min and was centrifuged at 5000 rpm for 10 min using a centrifuge ORTO ALRESA. Twenty (20) mL of the supernatant was diluted in 5 mL of tungstate phosphoric reagent contained in a conical centrifuge tube. The obtained mixture was allowed to stand on the bench at an ambient temperature (28°C) for 6 h and then was centrifuged at 5000 rpm for 10 min. The solution obtained was recentrifuged under the same conditions as previously. The pellet, taken up in 10 mL of sulfuric acid (10%, v/v), was homogenized by manual stirring for 2 min at an ambient temperature (28 °C). This solution was heated in a boiling water bath for 2 minutes and then the oxalic acid contained in this reaction medium was titrated with a solution of potassium permanganate (0.02 mM) until pale pink colour persisted for 30 seconds. The oxalate content was calculated by using the volume of potassium permanganate. A blank was carried out in the same conditions. Calibration was performed using an oxalic acid solution (0.2M).

Phytate content

The phytate content was carried out according to the method of Mohammed *et al*. (1986). Five (5) of flour was dissolved in 25 mL of trichloroacetic acid (3%, w/v). Eight (8) mL of this mixture were homogenized for 45 min at an ambiant temperature (28°C) and was then centrifuged at 3000 rpm for 15 min in a centrifuge ORTO ALRESA mark. Five (5) mL aliquot of the obtained supernatant, mixed with 3 mL of iron chloride hexahydrate (1%, v/v) prepared in hydrochloric acid (1N), was heated in a boiling water bath for 45 min. The mixture was cooled at ambiant temperature (28 °C) for 5 min and was then centrifuged at 3000 rpm for 10 min. The pellet was dissolved in 1 mL of hydrochloric acid (0.5N) and it let cool at ambiant temperature (28°C) for 2 h. Seven (7) mL of water and 3 mL of sodium hydroxide (1.5N) were added. The obtained mixture was heated in a boiling water bath for 15 min, was let cool and was then centrifuged at 3000 rpm for 10 min. 0.2 mL aliquot of the supernatant was diluted in a solution consisting of 4.6 mL of distilled water and 2 mL of a chromogenic solution. The reaction medium, heated at 95°C. for 30 minutes, was let cool on the bench at ambiant temperature (28°C.). The coloration intensity of the reaction medium was determined at 830 nm against a blank not containing phytate. Calibration was performed by using 0.58 g of phytic acid as the assay. The phytate content of the assay was expressed as mg of phytate per 100 g of dry matter.

Tannin content

The tannin content was preformed according to the method of Makkar *et al*. (1993). 0.2 g of flour was dissolved in 20 mL of a solution of diethyl ether containing glacial acetic acid (1%, v /v). The mixture was let cool on the bench at room temperature (28°C) for 10 minutes and was then centrifuged at 3000 rpm at 15°C for 10 min in a centrifuge ORTO ALRESA mark. After centrifugation, The pellet was dried in an oven at 50°C for 2 h and was then dissolved in 15 ml of acetone (70%, v/v). The mixture in a 50 mL beaker was homogenized at ambient temperature (28°C) for 2 min. It closed with cotton wool. This acetone extract was placed in an ice bath and then stirred for 12 minutes. The obtained cloudy solution was centrifuged at 3000 rpm at 4°C for 10 min. the obtained supernatant was transfered into a 50 mL beaker and held at 4°C. 1.1g of polyvinyl polypyrrolidone was added to 10 mL of the acetone supernatant. The mixture was homogenized and was stirred at ambient temperature (28 °C.) for 2 minutes. It was allowed to stand at 4°C for 10 min to precipitate the tannins. The mixture was then centrifuged at 3000 rpm at 4°C for 10 min. The result was expressed as mg of tannin per 100 g of dry matter.

2-2-5-Statistical analysis

All analyses were carried out in triplicates. Results were expressed by means of ± SD. Statistical significance was established using one-way analysis of Variance (ANOVA) models to estimate the variety effect on some anti-nutritional factors, proximate and minerals composition of flour from roots of Sweet potato (*Ipomoea batatas* L.Lam) at 5% level. Means were separated according to Duncan's multiple range analysis ($p \leq 0.05$), with the help of the software STATISTICA 7 (StatsoftInc, Tulsa-USA Headquarters).

3-RESULTS

3-1-Proximate Composition

The proximate composition of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties is shown in Table 1.

Moisture content

The moisture content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties is shown in Table 1. The moisture content ranged from 4.00 ± 0.20% dw to 5.19 ±0.19% dw (dry weight). The highest moisture content was found to be 5.19 ± 0.19% dw for the flour from *Bela Bela* variety root, while the lowest moisture content was obtained with flour from the root of *Kabode* variety. The Analysis of Variance (ANOVA) revealed that variety main effect appeared significant ($p \leq 0.05$). There were significant variations ($p \leq 0.05$) between the moisture contents of flour from sweet potato varieties roots. However, slight differences were observed between the flour from *Fatoni* and *Tib* varieties and didn't differ significantly ($p \leq 0.05$) between them.

Crude protein content

The crude protein content is given in table 1. The values of crude protein content varied from 3.25 ± 0.01% dw to 4.60 ± 0.40% dw for the flour from *Irène*and *Tib*varieties roots respectively. The flour from *Tib* variety roothad the highest crude protein content whereas the flour from *Irène* variety root had the lowest crude protein content. The analysis of variance showed that variety variable had significant effect ($p \leq 0.05$) on crude protein content. Therefore, there apparead significant differences ($p \leq 0.05$) between the crude proteins content of flour from different varieties, except from crude protein contents of flour from *Kabode* and *Tib* varieties tubers and those of flour from *Fatoni* and *Bela Bela* varieties roots.

Ash content

The ash content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties is shown in Table 1. It ranged from 1.61 ± 0.03% dw to 2.16 ± 0.01% dw. The lowest Ash content was obtained with flour from *Tib* variety root, while the flour from *Fatoni* variety root had the highest Ash content. The variety main effect appeared to be stronger. Thus, there were significant variations ($p \leq 0.05$) between the ash contents of flour from different varieties. However, slight differences were observed between the flour from *Fatoni*and *Bela Bela* varieties and weren't significant ($p \leq 0.05$) between them**.**

Fat content

The fat content is presented in table 1. The values of fat content varied from 0.60 ± 0.05% dw to 0.76 ± 0.10% dw for the flour from *Irène* and *Tib* varieties roots respectively. The flour from *Tib* variety root had the highest crude protein content whereas the flour from *Irène* variety root had the lowest crude protein content. The analysis of variance showed that variety factor had significant effect ($p \leq 0.05$) on crude fat content. Therefore, there apparead significant differences ($p \leq 0.05$) between the fat content of flour from different varieties, except from crude protein contents of flour from *Kabode* and *Fatoni* varieties roots and those of flour from *Tib* and *Bela Bela* varieties roots.

Fiber content

The fiber content of flour from five sweet potato varieties roots ranged from 1.25±0.25% dw to 1.41±0.14% dw for flour from *Irène* and *Fatoni* varities roots respectively (Table1). The flour from *Irène* variety root had the lowest fiber content (1.25±0.25%), while the highest fiber content (1.41±0.14%) was found in flour from *Fatoni* variety root. Besides, the Analysis of Variance (ANOVA) indicated that variety main effect had significant effect ($P \leq 0.05$) on fiber content. Thus, there were meaningful differences ($P \leq 0.05$) between the fiber content in flour from roots of different sweet potato varieties. However, there didn't appear significant differences ($P > 0.05$) between fiber content of flour from roots of *Irène*, *Fatoni* and *Bela Bela* varieties of sweet potato.

Total carbohydrate

The total carbohydrate content ranged from 87.70± 1.5% dw to 88.00± 0.60% dw for flour from the roots of *Bela Bela* and *Fatoni* varitieties respectively (Table1). The flour from *Bela Bela* variety root had the lowest total carbohydrate content while the highest value was obtained with the flour *Fatoni* variety root. Otherwise, the analysis of variance showed that the variety factor hadn't significant effect ($p > 0.05$) on total carbohydrate content of flour from sweet potato roots. Thus, there weren't meaningfully ($p > 0.05$) differences between Total carbohydrate content of flour from different sweet potato varieties roots.

Total sugars

The Total sugars content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties is shown in Table 1. It varied from 1.43 ± 0.01% dw to 2.08 ± 0.01% dw. The lowest total sugar content was obtained with flour from *Fatoni* variety root, while the flour from *Irène* variety root had the highest total sugars content. The variety main effect appeared to be stronger. Therefore, there were significant variations ($p \leq 0.05$) between the total sugars contents of flour from different varieties. However, slight differences were obtained between the flour from *Kabod*e and *Tib* varieties roots and didn't differ significantly ($p \leq 0.05$) between them**.**

Reducting sugars content

The reducting sugar content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties ranged from 0.11±0.01% dw to 0.65±0.01% dw for flour from the root of *Fatoni*and *Kabode* varitieties respectively (Table1). The lowest reducting sugar content was found in flour from root of *Fatoni* variety, whereas the highest reducting sugar content was obtained with the flour from *Kabode* variety. Besides, the Analysis of Variance (ANOVA) revealed that variety main effect appeared significant ($P \leq 0.05$). Thus, the reducting sugar content of flour from root of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties varied meaningfully ($P \leq 0.05$). Nevertheless, slight differences were observed between the flour from *Tib* and *Bela bela* varieties roots and weren't significant ($p \leq 0.05$) between them**.**

Caloric energy

The caloric energy value is presented in table 1. The values of caloric energy ranged from 374.8 ± 0.5% dw to 379.5 ± 0.1% dw for flour from the roots of *Bela Bela* and *Kabode* varitieties respectively. Besides, the Analysis of Variance (ANOVA) revealed that the variety main effect didn't appear to be stronger. It appeared slight differences between the caloric energy values of flour from roots of five (5) different sweet potato (*Ipomoea batatas* L.Lam) varieties. However, the caloric energy values of flour from sweet potato varieties roots didn't differ meaningfully ($p > 0.05$).

Table 1: Proximate composition of flours from five (5) sweet potato varieties.

Parameters (%)	flours				
	Kabode	Irène	Fatoni	Tib	BelaBela
Moisture	4.00 ± 0.20^a	4.20 ± 0.01^b	4.90 ±0.30^c	4.83 ±0.76^c	5.19 ±0.19^d
Ash	2.40 ± 0.01^d	2.35 ± 0.05^c	2.16 ± 0.01^b	1.61 ± 0.03^a	2.17 ± 0.01^b
Crude protein	4.50 ± 0.01^c	3.25 ± 0.01^a	3.93 ± 0.43^b	4.6 ± 0.40^c	4.12 ± 0.87^b
Fat	1.03 ± 0.01^c	0.60 ± 0.05^a	1.00 ± 0.02^c	0.76 ± 0.10^b	0.86 ± 0.02^b
Fiber	3.16 ± 0.28^b	1.25±0.25^a	1.41±0.14^a	3.25±0.25^b	1.50±0.01^a
Total carbohydrate	88.07 ± 1.30^a	89.6 ± 0.70^a	88.00± 0.60^a	88.20± 0.50^a	87.70± 1.50^a
Total sugars	2.63 ± 0.02^d	2.08 ± 0.01^b	1.43 ± 0.01^a	2.64 ± 0.01^d	2.33 ± 0.02^c
Reductingsugars	0.65 ± 0.01^d	0.16±0.02^b	0.11±0.01^a	0.53±0.01^c	0.51±0.03^c
Caloricenergy (Kcal/100 g)	379.50± 0.10^a	376.80± 0.20^a	376.80± 0.30^a	378.00± 1.30^a	374.80± 0.50^a

*The obtained values are averages ± standard deviation of triplicate determination.
*Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of Duncan.

3-2-Some mineral composition of flours

Table 2 summarizes some mineral composition of flour from five (5) sweet potato varieties roots. Ca, Mg, K and P contents were highest in flours and were ranged from 30.80 ± 0.04 to 47.80± 0.17 mg/100 g dw, 44.50 ± 0.20 mg/100 mg to 111.30 ± 0.70 mg/100 mg dw, 835.80± 0.90 mg/100 mg to 1241.50 ± 1.00 mg/100 mg and 106.40 ± 0.60mg/100 mg dw to 158.60 ± 0.20 mg/100 mg dw respectively. On the other hand, iron content varying from 0.47 ± 0.04 to 3.26 ± 0.13 mg/100 was found to below. Besides, the ANOVA indicated that the factor variety had significant effect (P≤ 0.05) on all studied minerals. The values K/Na ratio ranged from 96.758 to 376.21 for *Kabode* and *Irène* varieties respectively.

Table 2: Mineral composition of flours from five (5) sweet potato varieties.

Minerals (mg/100 g)	flours				
	Kabode	*Irène*	*Fatoni*	*Tib*	*BelaBela*
Na	12.0 ± 0.11^e	3.3 ± 0.05^b	5.4 ± 0.03^d	2.58 ± 0.26^a	4.77 ± 0.05^c
Mg	81.4 ± 0.47^c	66.98 ± 0.2^b	46.44 ± 0.2^a	44.5 ± 0.2^a	111.3 ± 0.7^d
P	158.6 ± 0.2^c	152.5 ± 0.1^c	157.7 ± 0.1^c	106.4 ± 0.6^a	131.9 ± 0.6^b
S	24.0 ± 0.12^d	11.98 ± 0.1^a	20.52 ± 0.1^c	14.97 ± 0.2^b	13.67 ± 0.1^b
K	1161.1 ± 2^c	1241.5 ± 1^d	1210.7 ± 2^d	835.8 ± 0.9^a	1059.8 ± 1^b
Ca	47.8 ± 0.17^d	38.5 ± 0.12^b	45.36 ± 0.1^d	30.8 ± 0.04^a	41.9 ± 0.18^c
Sc	1.44 ± 0.1^a	7.75 ± 0.04^d	3.89 ± 0.07^c	2.74 ± 0,1^b	2.39 ± 0.08^b
Mn	2.64 ± 0.08^b	4.94 ± 0.25^d	4.1 ± 0.04^c	4.03 ± 0.2^c	1.52 ± 0.07^a
Fe	0.48 ± 0.03^a	0.47 ± 0.04^a	2.8 ± 0.17^b	0.48 ± 0.06^a	3.26 ± 0.13^c
Co	1.68 ± 0.1^a	3.76 ± 0.16^d	3.45 ± 0.25^c	1.93 ± 0.2^b	1.95 ± 0.16^b
Ni	1.2 ± 0.05^a	7.75 ± 0.45^d	5.4 ± 0.44^c	2.25 ± 0.24^b	1.3 ± 0.11^a
Cu	0.72 ± 0.04^a	7.52 ± 0.28^d	3.67 ± 0.27^c	2.09 ± 0.14^b	0.87 ± 0.07^a
Zn	2.64 ± 0.14^b	7.52 ± 0.28^d	8.42 ± 0,42^e	2.09 ± 0.19^a	4.34 ± 0.12^c
I	1.68 ± 0.12^a	9.4 ± 0.61^c	9.72 ± 0.2^c	5.15 ± 0.09^b	1.74 ± 0.11^a
K/Na ratio	96.758	376.21	224.20	323.95	222.18

*The obtained values are averages ± standard deviation of triplicate determination.
*Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of Duncan.

3-3-Anti-nutritionnal factors

Oxalate content

The oxalate content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties is presented in Table 4. It ranged from 40.33 ± 6.3% dw to 66.0 ± 0.01% dw. The lowest oxalate content was obtained with flour from *Fatoni* variety root, whereas the flour from *Irène* and *Kabode* varieties roots had the highest total oxalate content. The variety main effect appeared to be stronger. Therefore, there were meaningful variations (p≤0.05) between the total oxalate contents of flour from different varieties roots. However, slight differences were obtained between the flour from *Kabode*, *Irène* and *Tib* varieties roots and didn't appear significant (p≤0.05) between them.It is the same for *Fatoni* and *Bela Bela* varieties.

Phytate content

The phytate content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties varied from 7.72 ± 0.24% dw to 9.46 ± 0.30% dw for flour from the roots of *Irène* and *Tib*varieteties respectively (Table 4). The lowest phytate sugar content was found in flour from root of *Irène* variety, while the highest phytate content was obtained with the flour from *Tib* variety. Besides, the Analysis of Variance (ANOVA) revealed that variety main effect appeared significant (P≤ 0.05). Thus, the phytate content of flour from roots of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieties varied significantly ($P \leq 0.05$). Nevertheless, slight differences were found between the flour from *Tib* and *Kabode* varieties roots and weren't significant ($p \leq 0.05$) between them.It was the same for *Fatoni* and *Bela Bela* varieties.

Tannin content

The tannin content is presented in table 4. The values of tannin content ranged from 14.84 ± 0.4% dw to 20.66 ± 0.2% dw for the flour from *Kabode* and *Tib* varieties roots respectively. The flour from *Tib* variety root had the highest tannin content whereas the flour from *Irène* variety root had the lowest tannin content. The analysis of variance showed that variety factor had significant effect ($p \leq 0.05$) on tannin content. Therefore, there apparead significant differences ($p \leq 0.05$) between the tannin content of flour from different varieties roots, except to tannin contents of flour from *Irène* and *Fatoni* varieties roots and whose of flour from *Tib* and *Bela Bela* varieties roots.

Tableau 4: Some antinutritional factors of flours from five (5) sweet potato varieties.

Parameters (%)	flours				
	Kabode	***Irène***	***Fatoni***	***Tib***	***BelaBela***
Oxalate	66.0 ± 0.01[b]	66.0 ± 0.01[b]	40.33 ± 6.3[a]	62.33 ± 6.3[b]	44.0 ± 0.01[a]
Phytate	9.45 ± 0.29[c]	7.72 ± 0.24[a]	8.54 ± 0.38[b]	9.46 ± 0.3[c]	8.73 ± 0.09[b]
Tanins	14.84 ± 0.4[a]	17.67 ± 0.3[b]	17.7 ± 1.0[b]	20.66 ± 0.2[c]	20.54 ± 0.1[c]

*The obtained values are averages ± standard deviation of triplicate determination.
*Means not sharing a similar letter in a line are significantly different $p \leq 0.05$ as assessed by the test of Duncan.

4-DISCUSSION

The results of one-way Analysis of Variance (ANOVA) showed that the variety main effect had significant effect on moisture content. The obtained values were close to those reported by Kamal *et al.* (2013), who found the moisture content ranging from 5.25 to 5.62% dw in flour from two Bangladesh sweet potato varieties. On the other hand, our values were lower than those recorded in two sweet potatoes flour from Congo-Brazzaville, with moisture content varying from 7.3 to 8% (NDangui, 2015). These values of moiture content were also lower than those found in sweet potatoes flour from Nigeria by Olatunde et *al.* (2015), who published the rate ranging from 8 to 12%. Hoverwise, this biochemical parameter is important in the storage of flour, levels greater than 12% allow for microbial growth. Chew *et al.* (2011) reported that reduced moisture content ensured the inhibition of microbial growth, hence is an important factor in food preservation. The moisture levels were however within the acceptable limit of not more than 10% for long term storage of flour (Polycarp *et al*., 2012). It should be pointed out that when these products are allowed to equilibrate for periods of more than one week at 60% relative humidity and at room temperature (25 to 27°C), moisture content might increase (Adegunwa *et al*., 2011).

Crude protein content of five (5) sweet potato(*Ipomoea batatas* L.Lam) varieties flours ranged from 3.25 ± 0.01% to 4.6 ± 0.4%. These results were in accordance with those found in sweet potato flours from Bangladesh (Alam *et al*., 2016) and Thailand (Fessehaye and Rungarun, 2017), with respective values ranging from 1.91% to 5.83% and 3.47% to 4.33%. However, our results were higher than those reported in sweet potato flours grown in Sri Lanka by Senanayake *et al.* (2013), who obtained protein content varying from 1.2% to 3.3%. Although protein content of sweet potatoes was generally low (1.0% and 8.5%)(Van Hal, 2000), It was higher than that observed in cassava flour (1.0% to 2.5%) (Montreka and Bovell-Benjamin, 2003, Woolfe, 2008), and similar to that recorded in rice flour (Avula and Singh, 2009). Our results showed that *Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela* sweet potato varieties grown at CNRA-station contained good amount of protein.

The found fat content in sweet potato varieties flours ranged from 0.6 ± 0.05% to 1.03 ± 0.01%. Similar studies were carried out on sweet patato flours by Mu *et al.* (2009) and Kamal *et al.* (2013), who noted the respective fat content of 0.6% and 0.75-0.81%. On the other hand, Ishida *et al*. (2000) and Tumuhimbise *et al*. (2013) obtained in sweet potato flours the low lipid content of 0.17% and 0.2% -0.33% respectively. Like other roots and tubers, sweet potatoes are well recognized for their low lipid content (Alam *et al*., 2016).

Total carbohydrates were the highest biochemical parameters in the flours of the five sweet potato varieties, with rate ranging from 87.66 ± 1.01% to 89.6 ± 0.71%. Our results were significantly higher than those reported on sweet potato flours by Kamal *et al.* (2013) and NDangui (2015), with respective values varying from 78.98% to 80.49% and 82.4% to 86.6%. Moreover, total carbohydrates mainly composed of starch, are the most important chemical components in flours, whereas proteins and lipids are very little present (NDangui, 2015). The slight differences in the total carbohydrate content of sweet potato flours grown in Côte d'Ivoire and Congo Brazzaville may be attributed to factors such as the varieties difference or the maturity stage of tubers. The high total carbohydrate content of sweet potato varieties (*Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*) flours could suggest that these tubers are good sources of energy for the populations.

Dietary fiber regulates intestinal mobility and helps to prevent the development of worms and chronic diseases including heart disease, colon cancer and other gastrointestinal disorders (Topping and Clifton, 2001). The fiber content of five (5) sweet potato (*Ipomoea batatas* L.Lam) varieries (*Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*) flours ranged from 1.25 ± 0.25% to 3.25 ± 0.25%. These results were higher than those obtained with sweet potato flour from Nigeria by Oladebeye *et al*. (2008) (0.75%) and Ukom *et al*. (2009) (2.30% to 2.80%). However, Senanayake *et al*. (2013) and Fessehaye and Rungarun. (2017) found high fiber contents in sweet potato flours grown in Sri Lanka and Thailand, ranging from 2.1% to 13.6% and 3.36% to 3.42%, respectively. Due to their high crude fiber content, sweet potato varieties (*Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*) flours could play a role in the prevention of colon cancer, obesity, constipation and diabetes facilitating digestive transit (Chen *et al*., 2003, Ingabire and Vasanthakaalam, 2011).

The total sugars and reducing sugars contents varied significantly from one variety to another. Concerning total sugars, the obtained contents were closed to those reported on sweet potatoes by Abubakar *et al*. (2010) and Olatunde *et al*. (2015). As for reducing sugars, our results were in agreement with to those recorded in sweet potato flours by NDangui (2015), who found values ranging from 1.2% to 2.8%.

Minerals are important elements of the diet because of their physiological and metabolic function in the body. The observed ash content in the different sweet potato flours varied from 1.61 to 2.4%. Our results were in accordance with those noted in sweet potato flours from Nigeria and Congo Brazzaville by Ukom *et al*. (2009) and NDangui (2015) repectively. These authors reported respective values ranging from 1.3 to 1.7% and from 1.2 to 1.9%. On the other hand, Avula *et al*. (2006) and Kamal *et al*. (2013) found hight ash content in sweet potato flours from in the United States (3.0%) and Bangladesh (4.12-4.17%) respectively.

Mineral Composition

The results of this study revealed the presence of several minerals in the flours of five sweet potato varieties. These variations could be attributed to intrinsic differences between varieties (Serges, 1996). Potassium is the predominant mineral in sweet potato varieties flours with rate ranging from 835 to 1241 mg /100 g. Our results were higher than those found in sweet potato varieties from Nigeria (115 to 203 mg / 100 g) (Ukom *et al*., 2009) and Congo Brazzaville (145.3 to 148.4 mg / 100 g) (NDangui, 2015). Potassium regulates heart rate and blood pressure, body water content and neuromuscular excitability. The daily intake of potassium is 2000 mg for an adult and 1600 mg for a child (NRC, 1989). Otherwise, the consumption of 100 g of varieties sweet potato flour (*Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*) could cover the daily needs of the adult and the child, with rate ranging from 41.75 to 62.05% and from 52.19 to 77.56% respectively.

The phosphorus content in sweet potato flours was ranged from 106 to 158 mg / 100 g. These results were closed to those obtained by Purcell *et al*. (1989), who reported the value of 115 mg / 100 g in sweet potatoes grown in Canada. On the other hand, our results were lower than those published on sweet potato from the United States by Avula *et al*. (2009), who noted the values of 500 mg / 100 g. Furthermore, Phosphorus, the most abundant mineral in the body, after calcium, plays a vital role in the formation and maintenance of healthy bones and teeth. It participates in the growth and regeneration of tissues and helps maintain the pH of normal blood. Phosphorus is also one of the constituents of cell membranes. The daily intake of phosphorus is estimated at 120 mg. Thus, sweet potato flours may be considered as undeniable sources of phosphorus because they could cover 100% of daily phosphorus requirements.

The magnesium content in sweet potato flours ranged from 44.5 to 111.3 mg / 100 g. The gotten values were higher than those obtained in sweet potato flours by Elkins *et al*. (1979) and Lopez *et al*. (1980), who found the amount varying 18.3 to 22.2 mg / 100 g. Besides, they were also higher if compared to 12.2 and 30.4 mg / 100 g recorded by Ukom *et al*.(2009) for sweet potato varieties from Nigeria. In view of the obtained results, sweet potato varieties grown at CNRA (*Kabode*, *Irene*, *Fatoni*, *Tib* and *Bela Bela*) could be considered as good sources of magnesium for populations. Otherwise, Magnesium is necessary for the biochemical reactions of body, to maintain the muscle, improving the functioning of nerve, the maintenance of regular heart rate and regulation of blood sugar (Saris *et al*., 2000).

The calcium content in sweet potato flours ranged from 30 to 47 mg / 100 g. These amounts were in agreement with those reported by Olapade and Ogunade (2014) on sweet potato varieties from Nigeria (45 to 55 mg / 100 g). On the other hand, our results were higher than the report of 23.8 mg/100 g on sweet potato fries by Abubakar *et al*. (2010) Calcium promotes the growth of children and intervenes in the fortification of the bones and the development of the teeth. It is also useful in training muscles, heart and digestive system (Paiko *et al*., 2012). Besides, the calcium content change in sweet potato may be attributed to differences in varieties, climate, soil type, geographical location, and several other factors (Serge, 1996).

The found iron content in sweet potato flours was lower than that observed on sweet potato varieties from Sri Lanka (4.2 to 6.3 mg / 100 g) and Ethiopia (8.7 to 11.45 mg / 100 g) by Senanayake *et al*. (2013) and Endrias *et al*. (2016) respectively. Iron is indispensable for a large number of metabolic reactions. It is involved in the constitution of hemoglobin, myoglobin and many enzymes (Lokombé *et al*., 2004). Iron can also act as an antioxidant and may help prevent cardiomyopathy and stunting (Buss *et al*., 2003). The observed little amounts of iron in sweet potato flours were also noted by Purcell *et al*. (1989), Odebunmi et *al.* (2007) and NDangui. (2015). Otherwise, the iron content variation in sweet potato may be attributed to differences in varieties, climate, soil type, geographical location, and several other factors (Serge, 1996).

Sodium is involved in the control of the osmotic pressure that develops between blood and cells due to unequal ionic concentrations (Paiko *et al*., 2012). It also allows the body to regulate the inflow and outflow of potassium to greatly reduce the risk of deficiency. Our results were lower than the reports ranging from 23 to 33 mg / 100 g in sweetpotato varieties from Nigeria by Ukom *et al*. (2009). They were also lower than the findings varying from 85.1 to 88.5 mg / 100 g on sweetpotato varieties from Congo Brazzaville by NDangui. (2015). Moreover, the sodium content variation in sweet potato may be attributed to differences in varieties, climate, soil type, geographical location, and several other factors (Serge, 1996).

The zinc content in sweet potato flour was significantly affected by variety. The gotten values are higher than those recorded on peeled and unpeeled sweet potato varieties by ENV / JM / MONO (2010) (0.6 and 1.3 mg / 100 g) and Endrias *et al*. (2016) (0.68 to 0.93 mg / 100g). Zinc is one of the most concentrated minerals in the brain. Also, it is essential to cover zinc requirements in infants where brain growth is particularly important. Zinc is involved in immunity because it reduces the incidence and severity of diarrhea in children (Lokombé *et al*., 2004). Its deficiency can lead to a lack of appetite and a weakening of the immune system (Paiko *et al*., 2012). Moreover, the observed variation might be for the same reasons of calcium content that was mentioned above (Endrias *et al*. (2016).

The K/Na ratio (96.758 to 376.21) was close to the recommended 5.0 (Szentmihalyi *et al*., 1998). Dietary changes leading to reduce consumption of potassium than sodium have health implications. Diets with higher ratio K/Na are recommended and these are found usually in whole foods (Arbeit *et al*., 1992). Foods, naturally higher in potassium than sodium, may have a K/Na ratio of 4.0 or more (CIHFI, 2008). The high K/Na suggests that the flours from sweet potato varieties could be suitable in helping to ameliorate sodium-related health risk (Appiah *et al*., 2011).

The obtained oxalates contents in sweet potato varities flour (*Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*) were very low compared to those reported on some sweet potato dishes consumed in the state of Kwara from Nigeria by Abubakar *et al*. (2010), who noted value ranging from 126.93 to 178.27 mg/100 g. However, they were high compared to findings varying from5.71 to 8.30 mg / 100 g by Endrias *et al*. (2016) on sweet potato flours grown in Ethiopia. A high content of total oxalates in sweet potato presents a great risk to health. Indeed, Agwunobi *et al*. (2002) showed that consumption of a high dose of oxalates leads to a decrease in serum calcium and causes renal damage. An oxalate content reduction in a food increases the bioavailability of essential minerals and reduces the risk of irritation of the digestive system, particularly the stomach and kidneys (Chai and Liebman, 2005). The survey of Oke (1966) and Munro and Bassir (1969), mentioned that the lethal dose of oxalate in a food is between 2000 and 5000 mg/100 g of food. However, the obtained oxalate contents were much lower than the lethal dose published by these authors. As a result, consumption of five sweet potato varieties would be safe for the populations.

It is important to remember that tannins are widespread in plants and especially in fruits and grains (Shils *et al*., 2006). Tannins have been reported to form complexes with proteins reducing their digestibility (Shils et al., 2006; Abou *et al*., 2010). They also bind to iron, rendering it unavailable (Aletor and Adeogun, 1995) and other evidence suggests that condensed tannins can cut DNA in the presence of copper ions (Shirahata *et al*., 1998). Tannins also decrease palatability, cause bowel damage and improve carcinogenesis (Makkar and Becker, 1996). Our results were lower than those obtained by Endrias *et al*. (2016) on sweet potato flour from Ethiopia (34.38 mg / 100 g). However, Abubakar *et al*. (2010) and Ojo and Akande. (2013) found insignificant tannins content in boiled sweet potatoes (0.68 mg / 100 g) and dishes made from mixtures of sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta Crantz*) (0, 08 to 0.1 mg / 100 g). The low tannin content noted by these authors could be due to certain methods used in their processes of food processing (soaking, bleaching and drying). The toxic effects of tannins are generally observed from daily consumption exceeding 560 mg (Anonymous, 1973). The tannin content obtained in flours from the five of sweet potato varieties showed that these flours could be safely used in food formulations.

As for the phytate content of sweet potato flour, it varied from 7.72 to 9.46 mg / 100 g. These amountswere lower than those found by Olapade and Ogunade (2014) (12 to 16 mg / 100 g) and Endrias *et al*. (2016) (49.35 to 111.43 mg / 100 g) on mixtures of sweet potato and corn flour and on sweet potato flour from Ethiopia respectively. On the other hand, our results were higher than the report of 0.88 mg/100 g by Abubakar *et al*. (2010) on boiled sweet potatoes. Knowledge of the phytate content of a food is necessary because a high content can have detrimental effects on digestibility (Nwokolo and Bragg, 1977). Indeed, Lind *et al*. (2003) showed that high phytate consumption is correlated with low iron and zinc levels in small children. According to Onomi *et al*. (2004), the permissible phytate content in a food to maintain good health ranges from 25 to 35 mg / 100 g of food. Abdoulaye *et al*. (2011) suggested that an excess of 800 mg of phytate is not recommended for the acceptable daily intake (ADI). However, Pamplona-Roger (2006) showed that phytates have beneficial effects because they contain antioxidants that eliminate free radicals from the body. With these low phytate contents, the consumption of sweet potato varieties (*Kabode*, *Irène*, *Fatoni*, *Tib* and *Bela Bela*) grown at the CNRA may be safe for the populations.

5-CONCLUSION

The results of this study showed that the variety factor had significant effect ($p \leq 0.05$) on some proximate, mineral and anti-nutritional parameters of sweet potato varieties flours. Indeed, the rates of parameters such asashes, crude protein, Fat, Fiber, total carbohydrate, reducting sugar, Ca, Na, Mg, P and K in *Kabode* sweet potato variety flour were found higher than those recorded in other varireties flours. One the other hand, the obtained values of these parameters in*Irène*, *Fatoni*and *Bela Bela* varieties flours were relatively high compared to those observed in *Tib* variety flours. Concerning anti-nutritional factors, the work revealed that *Tib* variety flour contained high values of phytate and tannin. On the other hand, oxalate content was found to be high in *Kabode* and *Irène* varieties flour. Otherwise, the result of this work indicated that sweet potato flour was the best sources of mineral elements and could be used in the diets of infants and young children.

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