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Nutritional and Anti-nutritional Evaluation of Cakes and Almond Flours of *Momordica cabrae* Consumed in the Center-West Côte d'Ivoire

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Abstract *Momordica cabrae* is a wild plant whose kernels are of nutritional and therapeutic interests for consumers. In this study, biochemical properties of the flours (raw and roasted) and almond cake of *Momordica cabrae* were determined. Results showed that almonds are rich in carbohydrates, fats and proteins. Indeed, the raw flour of *Momordica cabrae* contains more carbohydrates (37.03%). Cake presented the high protein content (41.45%) in the while the toasted flour is richer in lipids with a content of 24.35%. The most abundant minerals are magnesium (0.218 g/100 g), calcium (0.250 g/100 g), phosphorus (0.590 g/100g) and potassium (1.150 g/100 g) and were obtained in flours (raw and roasted). Statistical analysis of levels of phenolic compounds in the flours (roasted and raw) and the cake showed significant difference ($p \leq 0.05$) in terms of phenolic acid, tannin and phytate content. Indeed, levels of phenolic acids, tannins and phytates observed in raw flour (respectively 1050.47 mg/100 g; 423.56 mg/100 g; 540.05 mg/100 g) are higher when compared toasted flour (respectively 920.17 mg / 100 g; 319.07 mg / 100 g; 404.54 mg / 100 g). The lowest values of these compounds are obtained in the meal. Presents results indicate nutritional properties and phytochemical constituents which are beneficial for health.

Keywords: *Momordica cabrae, almonds, biochemical properties, cake, raw flour*

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1. Introduction

Momordica are vegetable crops, belonging to the *Cucurbitaceae* family [1]. Most of these plants are native to tropical Africa and Asia [2]. The name *Momordica* comes from the Latin word *Momordica;* which means to bite in reference to the shape of the rough and indented seeds which give the impression of having been nibbled [3]. There are 45 species of *Momordica* that grow in tropical forests. Majority of these species are perennial [4]. Well known varieties, identified for their nutritional and medicinal properties are *Momordica chanratia*, *Momordica dioca*, *Momordica cochinchinensis* and *Momordica balsamina* [5,6]. Nevertheless, the work [7] in the Center-West of Côte d'Ivoire identified a species of *Momordica*: It is *Momordica cabrae*, a plant ill- known by the Ivorian population. The roasted almonds of this plant are either crushed or pounded to serve respectively as condiment or food supplement by the indigenous population of «Gôh region» (south-west of Côte d'Ivoire). Braised and crushed almonds are mixed with palm oil and used as treatment of sores that often appear on the breasts of nurses.

However, at level of knowledge, safeguarding, protection and enhancement of this wealth, the interdisciplinary approaches that would allow a more global strategy are almost non-existent [7]. This has therefore led to a decrease in the area occupied by these plants under the weight of demographic pressure, agriculture, and livestock [8]. The fact is that this plant is endangered. Nutritional and chemical knowledge about almonds by scientific community could certainly be an indicator for its integration into agro-forestry systems insofar as these almonds are consumed without prior knowledge of their nutritional value. This work therefore aims to exploit the composition and chemical profile of *Momordica cabrae* kernels.

2. Material and Methods

2.1. Plant Material

Plant material consists of almonds obtained after shake-out of the seeds from the ripe fruits of *Momordica cabrae* (Figure 1). This spontaneous plant belongs to botanical family of *Cucurbitaceae* and the genus *Momordica.*

The plant is found in the Center-West of Côte d'Ivoire and is called 'Gblimion' by the local population.The ripe fruits of *Momordica cabrae* were picked in the localities of Ouragahio, Logobia, Gnagbodougnoa and Zoha from August 22 to September 09, 2017. A sufficient quantity of 5 kg per locality was harvested and packaged in a jute bag. Then, it was transported to the Nangui Abrogoua University Biochemistry Laboratory. The denting took place and followed by drying of the seeds in a MEMMERT brand ventilated oven at 45°C for 4 days. Following the drying of the seeds, shakeout was done in stainless steel equipment. The kernels obtained were stored away from light and humidity at 4°C to avoid oxidation and degradation phenomenon.

2.2. Sample Preparation Methods

Five hundred (500) grams of almonds were removed and then ground using a Mill IKA type grinder (Germany/Deutschland). Then, a second sample batch of 500 g of almonds was taken and roasted at 55°C for 15 min before being ground. The shredded material obtained was sieved using a 250 µm mesh sieve. The flours obtained were packaged in labeled glass bottles, previously dried in an oven at 45°C and hermetically sealed. These vials of flour were kept for later analyses.

2.3. Biochemical Composition of *Momordica cabrae*

2.3.1. Proximate Analysis of Samples

Moisture, ash, crude protein, crude fat, crude fiber and total sugars were determined respectively by following the standard method [9,10], while carbohydrate contents were calculated by equation [100- (protein + crude fat + ash + crude fiber)] [11]. In addition, the energy value (EV) was calculated by applying the heat coefficients of [12] according to the following equation: **[EV (Kcal/100g) = (4 x Protein %) + (4 x Carbohydrate %) + (9 x Fat %)]**. Values were means of three determinations.

2.3.2. Amino acid Analysis

Amino acid contents of samples were determined using Automatic Amino Acid Analyzer (BIOCHROM 30, serial 103274), according to the method outlined in A.O.A.C. [13].

Chemical score (CS) of essential amino acids (EAA) was calculated using the following equation according to FAO/WHO scoring pattern [14] following Equation:

$$chemical\ score = \frac{EAA\ in\ test\ potein\left(\frac{g}{100g}\right)}{EAA\ requierement\ patern\left(\frac{g}{100g}\right)}$$

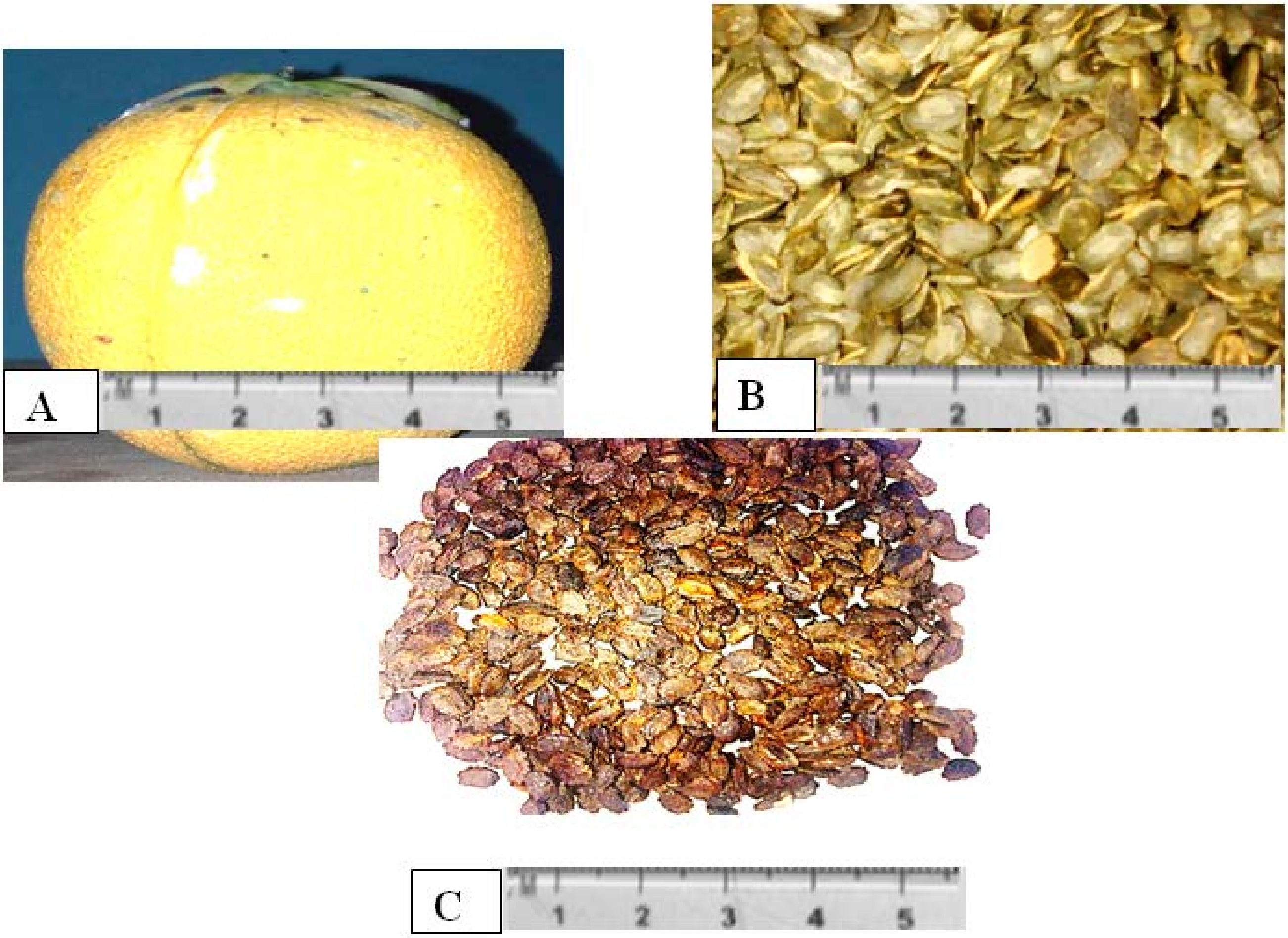

Figure 1. Ripe fruit (A) , Seeds (B) and Almonds (C) of *Momordica cabrae*

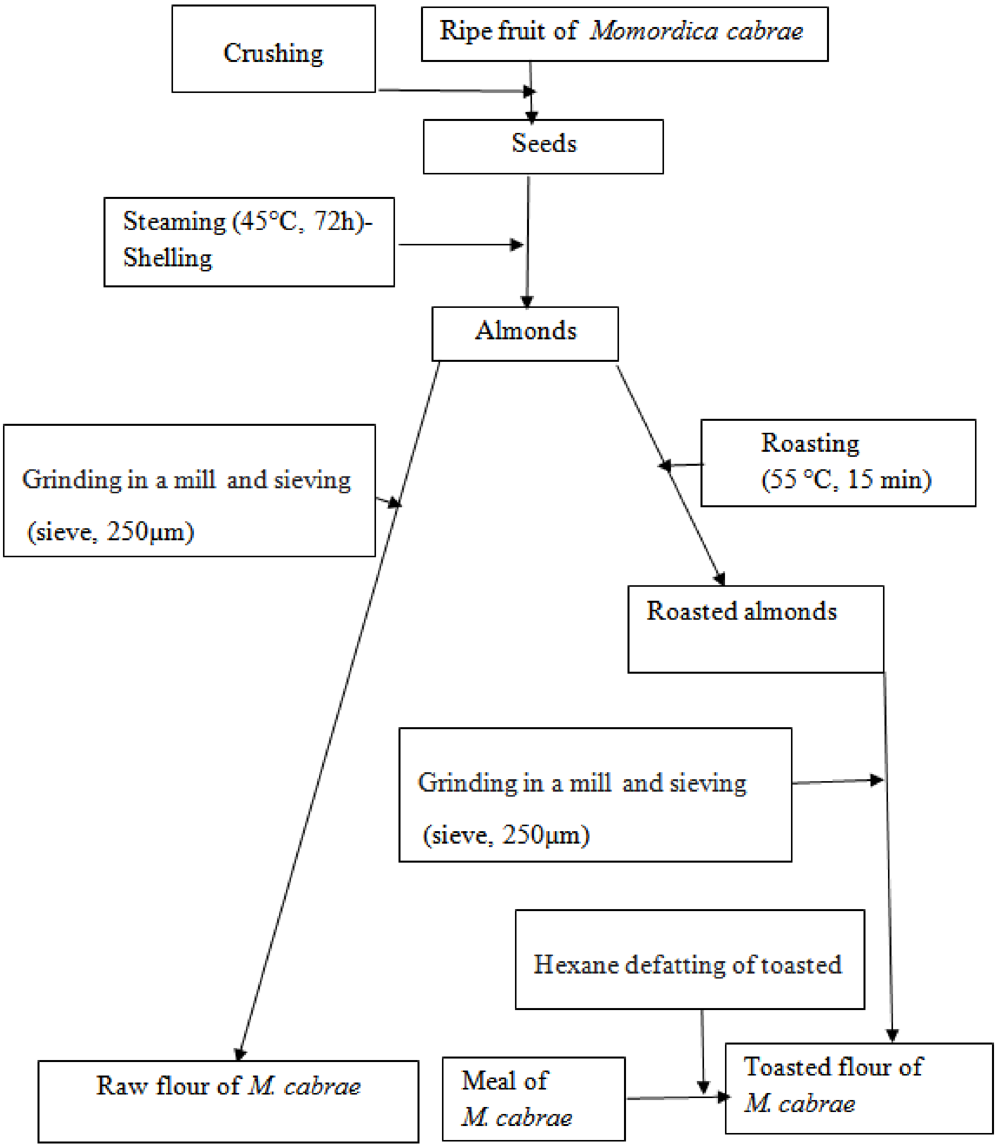

Figure 2. Process for production of *Momordica cabrae* meal and cake

2.3.3. Mineral Analysis

Minerals were analyzed by the method reported by [15]. The ash obtained from 1g of sample was dissolved in 10 % HCl, filtered with filter paper and made up to standard volume with dionised water. Flame photometry method reported by [16] was used to determine sodium and potassium contents of the sample. Ca, Fe, Mg, Zn and Cu were determined using Atomic Absorption Spectrophotometer (AAS). Phosphorus was estimated colorimetrically (UV-visible spectrophotometer, Model DR 2800/United States).

2.3.4. Total Phenolic, Tannin and Phytic Acid Factors Estimation

The total polyphenols were extracted with methanol and then determined according to the method of [17]. The total phenol content was expressed in milligrams of gallic acid equivalent (GAE) per 100 g dry weight (mg GAE/100g DM). Phytic acid content was determined according to the method described by Wheeler and Ferrel [18]. Tannins were determined by using the Vanillin-HCL method modified by [19]. Catechin was used to prepare the standard curve.

2.4. Statistical Analyzes

The results were expressed as the mean ± SEM (Standard Error of the Mean). The Chi-square significance test was used to track the evidence of relationships among categorical variables. For the comparison between two groups, a Student Test was used. For multiple differences, an analysis of variance (ANOVA) test was performed. Differences are considered significant when p is less than 0.005 ($p \leq 0.05$). Statistical data processing was performed using Statistica software version 7 and Excel 2013.

3. Résultats

3.1. Biochemical Composition and Energy Value of *Momordica cabrae* Almond Flour and Cake

The biochemical composition and energy value of almond flour and cake of *Momordica cabrae* are shown in Table 1. Highest lipid levels (24.35%) and energy value

(471.67 Cal/100g) are obtained with the toasted flour while the brown crab showed the lowest levels. However, highest humidity (11.56%) and carbohydrates levels (59.9%) are observed in the meal. Also, the highest protein level (34.97%) is obtained in raw flour. Statistical analysis revealed that rate of ash and fiber do not differ significantly (p >0.05) to flours (toasted and raw) and brown crab.

Table 1. Biochemical composition (g/100g DM) of *Momordica Cabrae* almond flour and cake

Settings	Meal	Raw flour	Toasted flour
Moisture (%)	21,56 ± 2,82[c]	10,55 ± 1,28[b]	08,96 ± 1,04[a]
Ash (%)	3,67 ± 1,05[a]	3,26 ± 1,15[a]	3,56 ± 1,02[a]
Fiber (%)	12,36 ± 2,13[a]	13,02 ± 2,03[b]	12,75 ± 1,53[a]
Lipid (%)	3,42 ± 1,03[a]	14,55 ± 3,16[b]	24,35 ± 4,01[c]
Protein (%)	41,45 ± 3,23[c]	34,61 ± 4,06[b]	28,16 ± 3,17[a]
Carbohydrate (%)	29,90 ± 2,84[a]	37,03 ± 2,61[c]	34,97 ± 2,23[b]
Energy (Cal / 100g)	316,18 ± 10,24[a]	417,51 ± 12,41[b]	471,67 ± 12,22[c]

For each parameter, on the lines, the means ± standard deviations assigned different letters are significantly different from each other at the p <0.05 level according to Duncan's test.

3.2. Mineral Composition

The mineral composition of the meals and cake are recorded in Table 2. The study showed that, there is no significant difference (p > 0.05) in the average rate sodium, zinc, magnesium, iron, phosphorus, and calcium. Also, study showed that the flour potassium levels did not differ (p > 0.05). However, this rate varies significantly (p ≤ 0.05) from that obtained in meal.

Table 2. Mineral composition (%) of *Momordica cabrae* almond flour and cake

Composition (%)	Meal	Raw flour	Toasted flour
Zinc	0.02 ± 0.01[a]	0.02 ± 0.01[a]	0.02 ± 0.01[a]
Sodium	0.10 ± 0.00[a]	0.11 ± 0.00[a]	0.11 ± 0.00[a]
Potassium	1.09 ± 0.01[a]	1.15 ± 0.01[b]	1.12 ± 0.01[b]
Magnesium	0.20 ± 0.01[a]	0.21 ± 0.01[a]	0.21 ± 0.00[a]
Iron	0.04 ± 0.01[a]	0.04 ± 0.01[a]	0.04 ± 0.00[a]
Phosphorus	0.58 ± 0.01[a]	0.59 ± 0.01[a]	0.57 ± 0.01[a]
Calcium	0.24 ± 0.01[a]	0.25 ± 0.01[a]	0.25 ± 0.01[a]

For each parameter on the lines, the means ± standard deviations assigned different letters are significantly different from each other at the threshold of p ≤ 0.05 according to Duncan's test.

3.3. Amino Acid Level

Table 3 shows the amino acid content and the essential amino acid ratio on non-essential amino acids. The study of the chromatographic profile of amino acids in the toasted flour and the cake of the grilled almonds of *Momordica Cabrae* made it possible to note the presence of essential amino acids such as isoleucine, leucine, L-histidine, L-threonine, phenylalanine and non-essential amino acids such as L-asparagine, L-serine, asparagine, glycine, alanine, sarcosine, and arginine. The levels of the different amino acids the most important elicited are observed in toasted flour. Leucine is the amino acid essential which predominates with a value of 51.55 mg/100 g in the meal against 30.35 mg/100 g in toasted flour. The least represented amino acid is L threonine with a rate of 6.15 mg/100 g in brown crab and 2.04 mg/100 g in toasted flour.

Table 3. Amino acid content of the flour and the cake of the roasted almonds of *Momordica cabrae*

Composition (%)	Meal	Roasted almond flour
Protein	41,45±3,23[b]	28,16±3,17[a]
Isoleucine*	11,63±2,21[b]	10,14±2,01[a]
Leucine*	51,55±4,01[b]	30,35±3,01[a]
L-Aspartique	31,25±4,09[b]	22,54±3,11[a]
L-Serine	21,06±3,12[b]	15,86±2,51[a]
L-Asparagine	16,94±3,22[b]	12,55±2,71[a]
Glycine	10,01±2,01[b]	9,72±1,51[a]
Alanine	34,36±3,07[b]	32,33±2,64[a]
Sarcosine	28,17±2,47[b]	22,35±2,07[a]
L-Histidine*	11,40±1,11[b]	7,12±0,91[a]
L-Thréonine*	6,15±1,67[b]	2,04±1,01[a]
Arginine	20,02±3,07[b]	15,13±2,11[a]
Phénylalanine*	22,18±3,20[b]	16,68±2,64[a]
Rapport AAE / AANE	0,63	0,5

For each parameter, on the lines, the means ± standard deviation assigned different letters are significantly different from each other at the threshold of p ≤ 0.05 according to the Student test*: Essential amino acids AAE: Essential amino acid AANE: Non-essential amino acids.

3.4. Level of Secondary Metabolites

Table 4 presents the level of secondary metabolites. Statistical analysis of its compounds in flours (toasted and raw) and cake showed significant difference (p ≤ 0.05) in terms of phenolic acid, tannin and phytate content. The levels of phenolic acids, tannin and phytates observed in raw flour (respectively 1050.47 mg/100 g; 423.56 mg/100 g; 540.05 mg/100 g) are greater than those of toasted flour (respectively 920.17 mg / 100 g; 319.07 mg / 100 g; 404.54 mg / 100g). The lowest values (respectively 806.33 mg/100 g; 264.28 mg/100 g and 315.28 mg / 100 g) are obtained in the meal.

Table 4. Level of secondary metabolites (mg/100g of DM) of the flours and cake of the almonds of *Momordica cabrae*

Settings (mg /100g)	Meal	Raw flour	Toasted flour
Phenolic acids	806.33 ± 45.15[a]	1050.47 ± 62.2[c]	920.17 ± 50.11[b]
Tannin	264.28 ± 17.16[a]	423.56 ± 21.12[c]	319.07 ± 27.25[b]
Phytic acid	315.28 ± 34.4[a]	540.05 ± 25.03[c]	404.54 ± 41.21[b]

For each parameter, on the lines, the means ± standard deviations assigned different letters are significantly different from each other at the threshold of p ≤ 0.05 according to Duncan's test.

3.5. Phytate/mineral and Mineral/mineral Ratios

The phytate/mineral and mineral/mineral ratios of meals and cake are recorded in Table 5. The highest phytate/mineral ratios are achieved in raw meal while cake has the lowest ratios. Analysis statistics revealed that the mineral/mineral ratios of flours (toasted and raw) did not differ (p > 0.05) when compared to brown crab.

Table 5. Estimated phytate/mineral and mineral/mineral ratios of *Momordica cabrae* almond flours and cake

Rapport	Meal	Raw flour	Toasted flour
Phytates/Zn	15.01 ± 1.08ª	25.71 ± 2.28ᶜ	17.58 ± 1.58ᵇ
Phytates/Fer	7.16 ± 1.51ª	12.00 ± 1.06ᶜ	8.79 ± 1.68ᵇ
Phytates/Ca	1.27 ± 0.78ª	2.16 ± 0.27ᶜ	1.61 ± 0.16ᵇ
Phytates/Mg	1.45 ± 0.72ª	2.47 ± 0.73ᶜ	1.85 ± 0.21ᵇ
Ca/P	0.41 ± 0.02ª	0.42 ± 0.02ª	0.42 ± 0.02ª
Na/K	0.09 ± 0.00ª	0.08 ± 0.00ª	0.09 ± 0.00ª

For each parameter, on the lines, the means ± standard deviations assigned different letters are significantly different from each other at the threshold of p ≤ 0.05 according to Duncan's test.

4. Discussion

The moisture content of the flours (raw and toasted) and cake obtained from the kernels of *Momordica cabrae* are less than 12%. Indeed, these rates are 11.56%, 10.55% and 8.96% respectively for cake, raw flour and toasted flour. *Momordica cabrae* cake and flours contain little water and therefore may be immune to the growth of certain microorganisms. Furthermore, it is known that a high water content in food promotes microbial growth and enzymatic activities that accelerate their deterioration [20]. Low humidity would limit the proliferation of microorganisms and reduce enzymatic activity [21]. *Momordica cabrae* flours could therefore be immune to the activity of certain microorganisms responsible for food spoilage. According to [22], humidity above 12% is a key parameter for the growth of microorganisms. The humidity levels recorded in the flours (raw and toasted) of *Momordica cabrae* almonds are higher than those observed by [23] in loofah aegyptiaca and loofah cylindrica kernel flours from Niger. According to these authors, humidity in these flours is 5%. Also, these humidity rates are similar to those reported by [24] on almond flour from *Sterculia Striata* and *Terminalia catappa*. However, the values determined are lower than those of [25] observed in the almond flours of *Momordica dioica*, *Momordica balsamina* and *Momordica cymbalaria*. According to these authors, the moisture content of these flours varies between 16% and 20%. Similarly, the moisture content (11.56%) observed in the cake from *Momordica cabrae* is lower than that recorded in the cake from *Parinari macrophylla* (12.10%) [26].The ash contents observed in cake and flours (raw and roasted) of kernels of *Momordica cabrae* did not differ significantly ($p \leq 0.05$). This similarity would be justified by the fact that the roasting techniques and delipidation do not influence the quantity of minerals contained in the almonds of *Momordica Cabrae*. The results obtained are lower than those mentioned in works of [27]. These authors have shown that, the ash content of certain species of *Momordica*, in particular *Momordica chanratia*, *Momordica dioica*, *Momordica balsamina*, *Momordica cymbalaria* and *Momordica cochinchinesis*, varies between 6.7% and 18%. Similarly, these values are lower than those of oilseeds commonly used in the Sahel such as sesame whose content varies from 4.5 to 6% [28]. However, the ash rates recorded in this study are much higher than 2.4% mentioned by [29] in the seeds of Allium tubero. It appears from this study, that the almonds of *Momordica cabrae* consist of several minerals. In orders of magnitude, the most important are potassium (1150 mg / 100 g), phosphorus (590 mg / 100 g), calcium (250 mg / 100 g) and magnesium (208 mg / 100 g). Next come sodium (100 mg/100 g), iron (47 mg/100 g) and zinc (23 mg/100 g). *Momordica cabrae* almonds with their high potassium and magnesium content could be used to supplement the deficiencies of these minerals in the human diet. According to [30] a food is rich in potassium and magnesium when its contents are between 700 mg/100g and 3850 mg/100 for potassium and between 108 mg/100g and 467 mg/100g for magnesium. The values of calcium (250 mg), sodium (113 mg) and iron (45 mg) found in kernels of *Momordica cabrae* are similar to those found by [6] in five species of *Momordica* (*charantia*, *dioica*, *balsamina*, *cymbalaria*, *cochinchinesi*). According to these authors, the calcium content varies from 20 to 941 mg /100 g while those of sodium and iron respectively varied from 1.2 at 122.49 mg/100 g and from 0.34 to 60 mg/100 g. However, the potassium (1150 mg) and phosphorus (590 mg) levels obtained in the kernels of *Momordica cabrae* are higher than those found by [6] in the five species of *momordica* mentioned above. These authors found potassium and phosphorus contents which vary respectively from 8 to 500 mg/100 g and from 0.46 to 13 mg/100 g compared to the almonds of certain species of *Cucurbitaceae*, in particular *Luffa aegyptiaca* and *Luffa cylindrica*. The almonds of *Momordica cabrae* have a high content of zinc, sodium, potassium, iron and phosphorus unlike the contents of calcium and magnesium. The almonds of the above-mentioned plants have an average content of 89 mg of phosphorus; 14.14 mg of iron; 1020mg potassium; 10.16 mg of sodium and 10.57 mg of zinc. The calcium and magnesium are respectively 711.81 mg and 350 mg [23]. According [31] levels of mineral elements in plants generally vary according soil, plant species and whether or not fertilizer is added. The fiber contents observed in the raw flours (13.02%) varied significantly at the 5% from those observed in the toasted flour (12.75%). These results would be due to the effect of heat on the flour. Roasting contributes to decrease water content, which results in a reduction in fiber content [32]. The fiber contents observed in meals and oil cake fall within the ranges of high fiber foods. According to [33], a food is rich in fiber when the fiber content is between 6.1% and 27% per 100 g of dry matter. *Momordica cabrae* almonds therefore represent an important source of dietary fiber. In fact, fibers participate in the regulation of carbohydrate metabolism by reducing hyperglycemia [34,35]; therefore to the prevention and control of diabetes [36]. In addition, fiber softens the stool thereby preventing constipation [37]. According to the work of [38], fibers help reduce cardiovascular disease, induce better satiety and participate directly in weight regulation [39]. The results obtained are similar to those of [27] on the *Momordica charantia* species but lower according to the same authors than those observed on kernels of *Momordica dioica* (21.3%) and *Momordica balsam* (29%). Moreover, the fiber contents obtained in this study are much higher than 4.4% and 4.8% determined by [40] respectively in kernels of *Cucurbita sp* and *Citrulus sp*. The same is true for the fiber content (2%) reported by [41] in seeds of *Cucumeropsis mannii*.

Lipid levels are significantly different at the 5% level. Flour from roasted almonds show highest rate (24.35%). Lowest lipid levels (14.55% and 3.42%) are observed respectively in the flour of raw almonds and in the cake. These results could be justified by the treatment (roasting) undergone by the kernels of *Momordica cabrae*. According to [42], some technical processes including heating and roasting would reduce water content of almonds thus increasing their oil content. These results confirm the work of [43] who showed an increase in oil content of shea nuts by increasing the extraction temperature. Also, the oil content in the cake could be justified by the delipidation technique used.

In fact, the oil content of the meal depends on extraction method [44]. Oil contents observed in kernels of *Momordica cabrae* do not fall within the ranges of oil-rich foods, i.e. between 40 and 99.9% per 100 g of dried material [30]. Oil contents of raw flour (14.55%) and toasted flour (24.35%) of *Momordica cabrae* almonds are nevertheless higher than that determined in *Beilschmiédia mannii* almonds (13.09%) [7].The same is true of those obtained by [45] in kernels of some *Momordica* species including *Momordica charantia*, *Momordica dioica*, *Momordica balsamina* and *Momordica cochenchinesis*. According to these authors, the oil content of these seeds varies between 0.1 and 6.11%. On other hand, the almond cake from *Momordica cabrae* contains less fat (3.42%) compared to the cake from *Arachis hygogaea* (7.28%), baobab (9.8%) and copra cake (5 .87%) [46]. Protein contents observed in flours (roasted almonds and raw almonds) and cake show a significant difference at the 5% threshold. Protein content of raw flour (34.61%) is higher than that of toasted flour (28.16%) and cake (21.45%).

A decrease in the protein content of the flour of the roasted almonds is observed. This decrease would be due to the roasting which led to the carbonization of a large part of the proteins. This is because proteins are denatured by heat and break down into amino acids. These are either degraded or participate in Maillard reactions with sugars to give certain aromatic compounds that do not respond to the specific protein assay [47]. The same is true for protein content of meal. Protein rate determined in kernels of *Momordica cabrae* (34.61%) is higher than protein content in kernels of *Irvingia gabonensis* (7.39%) and *Sesamum indicum* [7]. Also, the protein contents of almonds of *Momordica cabrae* obtained in this study are higher than protein contents, respectively observed in almonds of *Momordica charantia* (27.88%) and *Momordica dioica* (19.38%) by [45]. Furthermore, compared to almonds and cakes from the seeds of *Ricindendron heudelotii*, *Tetracarpidicim conophorum*, seeds of *Arachis hygogaea* and seeds of *Anacardium occidental*, the seeds of *Momordica cabrae* are less rich in protein. According to [48] and [49], protein content of almonds and cakes from these different plants vary respectively between 25% to 40% for almonds and 30 to 50% for cakes. In view of these various observations, almonds of *Momordica cabrae* represent good protein sources. According to [33], a food is rich in protein, if this rate is between 28% and 84.4%. In a country marked by a protein deficit in diets, the consumption of *Momordica cabrae* almonds could help to prevent disorders linked to protein deficiency which often prevails in developing countries such as Côte d'Ivoire. Indeed, in developing countries such as those of sub-Saharan Africa, because of their high price, animal proteins are inaccessible to poorest and most needy social strata. The diet is thus characterized by protein deficit, the consequences of which are particularly evident in young children. At the time of weaning, the latter pass without transition from breast milk to unbalanced family diets based on cereals (maize, rice, millet) and tubers (cassava, yam, potato) low in protein [50]. These growing children therefore require protein supplementation. The study also showed that the level of amino acids in the meal and the toasted meal presents a significant difference at the 5% threshold. This observation would be due to the difference in protein concentration mentioned above between the meal (41.45%) and toasted flour (28.16%) from *Momordica cabrae* almonds.

The essential amino acids seen in *Momordica cabrae* seeds are isoleucine, leucine, L- histidine, L-threonine, and phenylalanine. [51,52] and [27] also showed presence of these amino acids in the seeds of *Momordica charantia*, and *Momordica balsamina*. Since *Momordica cabrae* almonds are consumed after roasting, the amino acid profile of the raw flour has not been determined. Carbohydrates are the most predominant components in plant matter in general. This finding is observed in the almonds of *Momordica cabrae* studied. Results obtained in this study show a significant difference at the 5% threshold between the different samples. The highest carbohydrate rate (59.9%) is observed to the cake, while the flour from the roasted almonds contains the lowest carbohydrate rate (34.97%). The reduction in rate of carbohydrates in toasted flour would be linked to the heat treatment which would promote a partial gelatinization of the starch content, hence the reduction in the rate of carbohydrates. Carbohydrate levels (37.03%) observed in the unroasted almonds of *Momordica cabrae* approach those determined (34.31% and 39.05%) respectively in the almonds of *Momordica charantia* and *Momordica balsamina* [51]. Moreover, these carbohydrate contents (37.03%) are higher than those determined by [7] for some seeds of spontaneous plants. These are *Ricinodendron heudelotii*, *Strombosia pustulata*, *Irvingia gabonensis*, *Sesamum indicum* and *Beilschmiedia mannii* with contents varying between 0.8 to 8.7% per 100 g of dry matter in the Center West of Côte d'Ivoire. The carbohydrate content (29.90%) of cake from roasted almonds of *Momordica cabrae* is higher than that determined (25%) by [46] in the seed cake of *Arachis hygogaea*. Energy values observed in toasted flour (471.67 Cal/100 g), raw flour (417.51 Cal/100 g) and cake (316.18 Cal/100 g) show a significant difference ($p \leq 0.05$) between them. This finding could probably be justified by lipid rate (24.35%) of flour from toasted almonds being higher than the lipid rate of the untoasted flour (14.55%) and cake (3.42%). Indeed, energy value is the sum of energy values of each simple organic food and especially because one gram (1 g) of lipid provides an energy value of 9 kilocalories [53]. Compared to the energy values obtained by [27] in seeds of *Momordica charantia* (241.66 Cal /100 g) and *Momordica dioica* (311.5 Ccal / 100 g), seeds of *Momordica cabrae* have a high energy value. In view of these results, *Momordica cabrae* seeds could be classified in the same energy group as oilseeds [30]. According to these authors, energy value of these seeds is between 350 to 617 Cal. Energy value (316.18 Cal/100 g) obtained in almond meal of *Momordica cabrae* is lower than those found by [54] in soybean meal (427.28 Cal/100 g) and in *Arachis hygogaea* meal (428.62 Cal/100 g). Analysis of phytochemical compounds of *Momordica cabrae* kernels revealed presence of phenolic compounds (phenolic acids and total tannins) and phytates. Unroasted almonds contain more total phenolic acids (1050.47 mg/100g), tannins (423.56 mg/100g) and phytates (540.05 mg/100g) than roasted almonds (respectively 920.17 mg/100g; 319.07mg/100g; 404.54mg/100g). The lowest values are observed in toasted flour and cake. The decrease in level of phenolic compounds in the toasted flour and in brown cake could be justified respectively by the roasting and the delipidation suffered by the kernels of *Momordica cabrae*. Indeed, after roasting for 20 min at 100°C, total phenolic acids are reduced by 12.40%, phytates by 25.09% and tannins by 24.66%. These results confirm the heat-labile characteristics of tannins and phytates, unlike phenolic acids which have a heat-resistant character [55]. Nevertheless, this treatment influenced the level of secondary metabolites in seeds of *Momordica cabrae.* This made it possible to determine a level of total phenolic compounds lower than the limit indicated by [56]. Those limit varied from 130 mg/100 g to 970 mg/100 g in several wild vegetables consumed in Cameroon including *Talinum triangulare*, *Momordica charantia*, *Moringa oleifera* and *Vigna unguiculata [56]*. *Momordica cabrae* kernels contain a higher content of phenolic compounds than those found by [57] in dry seeds of *Momordica charantia* and *Momordica dioca*. According to these authors, the contents of total phenolic acids and total tannins are respectively 33.90 mg/100 g and 8.51 mg/100 g in dry seeds of *Momordica charantia.* For *Momordica dioica* seeds, these values are 49.31 mg /100 g for phenolic acids and 19.25 mg/100g for tannins. However, phytate levels observed in kernels of *Momordica cabrae* (540.05 mg/100 g) are much lower than 943 mg/100 g and 1014 mg/100 g found by [58] in oats and whole wheat flour respectively. These observed differences are certainly due to the composition of the solvent. Indeed, a solvent with a high ethanol content facilitates the extraction of polyphenolic compounds [59]. Regarding the meal of *Momordica* species, no data on the composition of secondary metabolites are available. On the other hand, the rate of tannins (264.28 mg/100 g) obtained in this study is higher than those obtained by [48] in seed cakes of *Ricinodendron heudelotii* and *Tetracarpidium conophorum* cooked in water between 0 to 120 min with tannin values respectively between 190 and 250 mg / 100 g and between 170 and 220 mg / 100 g. *Momordica cabrae* almond cake could therefore be used in animal feed like rapeseed and sunflower cake after recovery of phenolic compounds [60]. According to [6], phenolic acids are the chemicals considered to be the main secondary metabolites of plant origin. Thus, this study made it possible to determine several specific phenolic acids both in the almonds (raw and roasted) and in the cake of the almonds of *Momordica cabrae*. These are the most important procyanidin, catechin, epigallocatechin, chlorogenic acid, caffeic acid and gallic acid in raw flour. Procyanidin, chlorogenic acid and caffeic acid remain undetermined in the meal. These findings could be explained by the roasting and delipidation of *Momordica cabrae* kernels. Very little data is available on the phytochemical composition of *Momordica*. Nevertheless, it appears that rate of chlorogenic acids (11.37mg/100g) of kernels of *Momordica cabrae* is higher than that obtained in the seeds of *Momordica cochinchinensis* (2.98 mg/100g). On the other hand, level of caffeic acids (3.39 mg/100) in kernels of *Momordica cabrae* is similar to that obtained by [61] in seeds of *Momordica cochinchinensis* (3.41 mg/100g). Moreover, gallic acid content (4.92 mg/100g) is lower than that determined by the same authors in the seeds of *Momordica charantia* (20.2 mg/100g). With these results, *Momordica cabrae* kernels could be used as an important source of phenolic compounds [62]. One food ingredient can slow down or enhance the action of another. Thus, divalent cations such as iron, magnesium, zinc and calcium are chelated by phytates, thus reducing their biological availability [63]. The respective phytate/Zn (25.71; 17.58; 15.01) and phytate/Fe (12.00; 8.79; 7.16) ratios obtained in raw almond flour, toasted almond flour and meal are greater than 3 and 0.5, which are the limit thresholds for the bio-accessibility of iron and zinc respectively in a food [64]. Since these ratios are too high, iron and zinc contained in *Momordica Cabrae* almonds are not bio-available. Furthermore, phytates/Ca and phytates/Mg ratios below 2.50 indicate that the amount of phytates has no effect on the bio-availability of both minerals. The main function of calcium (Ca) and phosphorus (P) is to produce and maintain bones in the body. Too much of one of these minerals can therefore prevent the body from benefiting from the other. The too low Ca/P ratio (0.42) recorded leads to the need to provide a calcium supplement in any diet based on *Momordica cabrae* almonds sodium and potassium are also of interest for good blood circulation. Indeed, excessive sodium consumption is linked to high blood pressure [65]. The very low sodium to potassium ratio (0.09) illustrates a high potassium content in *Momordica cabrae* almonds. The consumption of these almonds would therefore be recommended for individuals suffering from arterial hypertension in order to balance this ratio (0.57), i.e. 2 g of sodium for 3.5 g of potassium per day [65] to prevent high blood pressure leading to stroke [66].

5. Conclusion

Analysis of biochemical composition of *Momordica cabrae* almonds revealed that almonds contain a very wide variety of nutrients including carbohydrates, lipids and proteins. Their profile revealed a range of essential amino acids, including isoleucine, leucine, histidine, threonine and phenylalanine, all essential for the wellbeing of the consumer. The main minerals are potassium, phosphorus, calcium and magnesium. To these compounds, are added fibers and several antinutritional compounds including phytates and phenolic compounds. All of these compounds mentioned above, are present in unroasted almonds, roasted and cake almonds. Untreated almonds presented high concentrations of antinutritional compounds.

Roasted *momordica cabrae* almonds can be recommended in diet of Ivorian populations to combat cardiovascular diseases and cancers, etc. *Momordica cabrae* cake can be used as animal feed.

References

[1] Armougom R. Study of the lipid fraction of the seeds of lipid cucurbits of the *genera lagenaria*, luffa and *momordica*, 69 p, 2010.

[2] Hanno S., Susanne S. "A three-genome phylogeny of *Momordica* (Cucurbitaceae) suggests seven returns from dioecy to monoecy and recent long-distance dispersal to Asia", Molecular Phylogenetics and Evolution, 54: 553-555, 2010.

[3] François C. Plants and their names, unusual story, quae edition, p 85, 2012.

[4] Palamthodi S., Lele S. Nutraceutical application of gourd familly vegetables: *Benincasa hipida*, *lagenaria siceraria* and *momordica chanrantia*, p 1. 2013.

[5] Danos E., Bouza J., Chauvet M., Grosclaude C. The names of different cucurbits, p 5, 2008.

[6] Abirami A, Nagarani G., Siddhuraju P. Food prospects and nutraceutical attributes of *Momordica* species: Apotential tropical bioresources. *Food Science and Human Wellness,* 3: 117-126, 2014.

[7] Kouamé M., Gnahoua M. Spontaneous alimentary trees and lianas of the department of Gagnoa (center west of the Côte d'Ivoire), p 69, 2008.

[8] Assogbadjo AE, Glèlè Kakaï R, Houtoutou Adjallala F, Azihou AF. Ethnic differences in use value and use patterns of the threatened multipurpose scrambling shrub (Caesalpinia bonduc L.) in Benin; J. of Med. Plants Research Vol. 4: 1540-1549, 2010.

[9] AOAC. Official methods of analysis of the Association of Official Analytical Chemists, 15th ed, Washington DC, 1230p, 1990.

[10] Bernfeld. Amylase β and α, In: method in enzymology 1, Colowick S.P. and Kaplan N.O., Academic Press, pp149-154, 1955.

[11] FAO/INFOODS. FAO/INFOODS, Guidelines for verifying food composition data before publication of a user table/database-Version 1.0. FAO, Rome, 2015.

[12] Atwater and Rosa. A new respiratory colorimeter and the conservation of energy in human body. Physiol. Rev., 9: 214-251, 1899.

[13] Analysis Association of Official Analytical Chemists. Official Method of Analysis Association of Official Analytical Chemists. 19th Edition, Analysis Association of Official Analytical Chemists, Washington DC, 2012.

[14] Food and Agriculture Organization of the United Nations, Dietary Protein Quality Evaluation in Human Nutrition. Report of FAO Expert Consultation, Auckland, 31 March-2 April 2011, 27, 2011.

[15] Oshodi A.A. Proximate composition, nutritionally valuable minerals and functional properties of Adenopus breviflorus benth seed flour and protein concentrate. Food Chem, 45: 79-83, 1992.

[16] AOAC. Official Methods of Analysis. Washington, DC: Association of Official Analytical Chemists15th edn, 1990.

[17] Singleton V. L. Orthofer R, & Lamuela-raventos R.M., "Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent", Methods Enzymol, 299: 152-178, 1999.

[18] Wheeler, E.L. and Ferrel, R.E. A Method for Phytic Acid Determination in Wheat and Wheat Fractions. Cereal Chemistry, 48: 312-320, 1971.

[19] Price, M.L., Van Scoyoc, S. and Butler, L.G. A. Critical Evaluation of Vanillin Reaction as an Assay for Tannin in Sorghum Grain. Journal of Agricultural and Food Chemistry, 26: 1214-1218, 1978.

[20] Aremu M. O., Basu S. K., Gyar S. D., Goyal A., Bhowmik P. K., Datta B. S. Proximate Composition and Functional Properties of Mushroom Flours from *Ganoderma spp., Omphalotus olearius* (DC.) Sing and *Hebeloma mesophaeum* (Pers.) Quél. Used in Nasarawa State, Nigeria. *Malnutrition Journal Nutrition*, 15, (2): 233-241, 2009.

[21] Fergani Khadidja. Cellulolytic activities of *Trichoderma longibrachiatum* grown on wheat bran, p 23, 2015.

[22] Aryee F. N.A., Oduro I., Ellis W.O& Afuakwa J. The physicochemical properties of flour samples from the roots of 31 varieties of cassava. Food control, 17: 916-922, 2006.

[23] Sabo H., Sadou H., Saadou M. Leger C. L. Overall chemical composition of the seeds and physico-chemical characteristics of the oils of *luffa aegyptiaca* and *luffa cylindrica* from Niger. *J. Soc. Ouest-Afr. Chim*, 20: 119-133, 2005.

[24] Oliveria J. T. A., Vasconcelos L. M., Bezerra L. C. N. M., Silveira S. B., Monteiro A. C. O., Moreira R. A. Composition and nutritional properties of seeds from Pachira aquatic Aubl, *Sterculia striata* St Hil et Naud and *Terminalia catappa* Linn. *Food Chemistry*, 70: 185-191, 2000.

[25] Singh E., Cumming G., Manoharan H. Medicinal chemistry of the anti-diabetic effects of *Momordica Charantia*: active constituents and modes of actions, Med. Chem. J. p 70, 2011.

[26] N'Diaye Fatou. Contribution à etude chimique et biochimique des graines de *Balanites* a*egyptiaca* et *Parinari macrophylla*, p 167, 1997.

[27] Nagarani G., Abirami A. Siddhuraju P. Food prospects and nutraceutical attributes of *Momordica* species: Apotential tropical bioresources. *Food Science and Human Wellness,* 3: 117-126, 2014.

[28] Sadou H., Amoukou I. A. Determination of the chemical composition of various varieties of sesame classified according to the color of the seed coat *J. Soc. Ouest-Afr. Chim,* 14: 115-125, 2002.

[29] Hu G., Lu Y., vvei D. Chemical characterization of Chinese chive seed (*Allium tuberosum Rottl*.). *Food Chemistry*, 99: 693-697, (2006.

[30] Favier J., Max F., Ireland.R. Food composition table, p 1436, 1991.

[31] Lal B., Dattan N. A study of kernel oils of some cultivated cucurbits, qual plant foods hum nutr. P 32, 1983.

[32] Mokhiles B. Effect of heat treatment of fibers on the properties of wood-polymer composites, p 22, 2016.

[33] Cornu A., Delpeuch F. Favier J.-C. Use in human food of cotton seed without gossypol and its derivatives. *Ann. Nutr. Alim*, 31: 349-364, 1997.

[34] Jenkins D. J. Dietary fibre, lente carbohydrates and the insulin-resistant diseases. *British Journal of Nutrition*, 83: 157-163, 2000.

[35] Bourre J., Bégat A., Leroux M., Mousques V., Pérardel N., Souply F. Nutritional value (macro and micro-nutrients) of French flours and breads. Medicine and Nutrition, p 44, 2008.

[36] Venn B. J., Mann J. I., Cereal grains, legumes and diabetes. A review: *European Journal of Clinical Nutrition*, 58: 1443-1461, 2004.

[37] Verma A. K & Banerjee R. Dietary fibre as functional ingredient in meat products: a novel approach for healthy living-a review. Journal Food Sciences Technology, p 47, 2010.

[38] Streppel M. T., Ocke M. C., Boshuizen H. C., Kok F. J., Kromhout D. Dietary fiber intake in relation to coronary heart disease and all-cause mortality over 40 y: The Zutphen Study. *American Journal of Clinical Nutrition*, 88: 1119-1125, 2008.

[39] Tucker L. A., Thomas K. S. Increasing total fiber intake reduces risk of weight and fat gains in women. *Journal of Nutrition*, 139: 576-581, 2009.

[40] El-Adavvi T.A & Taha K. M. Characteristics and composition of different seeds oil and flour. *Food Chemistry*, 74: 47-54, 2001.

[41] Telliez Angelique, Baert D., Augem V. Promotion of a product of Congolese origin (*cucumeropsi mannii*), p 7, 2014.

[42] Ahouannou Clément, Tchobo Fidèle, Toukourou A. Influence of thermal operations involved in traditional shea butter extraction processes in Benin, p 9, 2014.

[43] Coulibaly Y., Ouédraogo S., Niculescu N. Extraction of shea butter by centrifugation, p 4, 2004.

[44] Masseyeff R. Peanut flour, interest, acceptability, possibility of production in Cameroon, p 3.1995.

[45] Behera T. K., John J. K., Bharathi L. K. Chapter 10 *Momordica*, in:C. Kole (Ed.), Wild Crop Relatives: Genomic and Breeding Resources, Vegetables, Springer-Verlag, Berlin, Heidelberg: 217-220-246, 2011.

[46] Gaulier R., Serres H. Amino acid composition of some cakes from Madagascar, p 3, 1971.

[47] Razafindahy Benjamin and Mickaël Joelina., Effects of physico-chemical treatments on the nutritional quality and on the L-Dopa content of *Mucuna pruriens,* var utilis noire, P 43, 2016.

[48] Laurette B. M. Nutritional and functional properties of proteins from cakes, concentrates and isolates of *Ricindendron heudolotii* (Bail.) Pierre ex Pax AND OF *Tetracarpidium conophorum* (Müll. Arg), p 22, 29, 36, 50, 51, 2010.

[49] Diomande M., Kouame Kan B., Koko Anauma C. Comparison of the chemical properties of peanut and cashew nut oil and meal sold in the markets of Daloa, Côte d'Ivoire, p 30, 2017.

[50] Félix. Biochemical and nutritional study of wild food plants in the south of V baoulé (Côte d'Ivoire), p 5, 1992.

[51] Hassan L. G., Umar K. J. Nutritional value of balsam apple (*Momordica balsamina* L.) leaves, Pak. *J. Nutr*, 5: 522-529, (2006).

[52] Horax R., Hettiarachchy N., Chen P. Extraction, quantification, and antiox-idant activities of phenolics from pericarp and seeds of bitter melons (*Momordica charanti*) harvested at three maturity stages (immature, mature, and ripe). *J. Agric. Food Chem*, p 58-112. 2010.

[53] Crisan E.W. Sands, A Nutritional value. In: Chang ST and Hayes WA (eds.). The biology and cultivation of edible mushrooms. Academic press, New York, 172-189, 1978.

[54] Ponka R., Goudoum A., Chami A., Fokou E. Nutritional evaluation of some ingredients used in the feed formulation of laying hens and pigs on a breeding farm in North-West Cameroon, p 2076, 2016.

[55] Matos L., Nzikou JM, Kimbonguila A, Ndangui C. Composition and Nutritional Properties of Seeds and Oil from Terminalia catappa L., ad. *J. of food Sci and Tech*., 6 p, 2009.

[56] Aissatou K. Tchiégang C. Ethnonutritional data and physico-chemical characteristics of leafy vegetables consumed in the Adamaoua savannah (Cameroon), P 2, 2004.

[57] Jae S., Hyun-Soo R., Seul L., Kiwon J., Kwan B., Ki H. Antiproliferative effect of *Momordica cochinchinnensis* seeds on human lung cancer cells and isolation of the major constituants, p 330, 2017.

[58] Alice L., Danielle R. Guide to drug, nutrient and natural product interactions, Presses Université Laval., p 465, 2003.

[59] Norzia M., Hani A., Torkamani S., Wan A., Pablo J. The effects of ultra sound assisted extraction on antioxidative avtivity of polyphenolics obtained from *Momordica charantia* fruits using response surface approch, p 11, 2017.

[60] Oscar L. Valorization of phenolic compounds from rapeseed and sunflower meal: fractionation of raw materials towards the synthesis of multifunctional molecules, p 1, 2019.

[61] Kubola J, Siriamornpun S. Phenolic contents and antioxidant activities of bitter gourd *(Momordica charantia L.) leaf*, stem and fruit fraction extracts in vitro, Food, 2008.

[62] Komal R., Dileep K., Rajesh A. Promise of bitter melon (*Momordica charantia*) bioactive sin cancer prevention and therapy, p 1.110881-890, 2016.

[63] Jean G. Ideal meal, Editions Edilivre, p 43, 2018.

[64] Icard-Vernière C., Greffeuille V. C., Bertrand T., Serge B. P. Influence of soaking, germination, fermentation and addition of phytases on the bioavailability of iron and zinc in millet flours, p 9, 2003.

[65] WHO. Potassium intake for adults and children, 2 p, 2012.

[66] Sofia Z., Antoinette P., Michel B. Potassium and blood pressure an old story revisited, p 3, 2016.