Asian Research Journal of Agriculture

7(1): 1-15, 2017; Article no.ARJA.36697
ISSN: 2456-561X

Nutritive Contents of Cakes Enriched with Almonds Powder of *Terminalia catappa* of Côte d'Ivoire

Douati Togba Etienne[1*], Mahan Makado Romuald[1], Konan N'Guessan Ysidor[1], Sidibe Daouda[1], Coulibaly Adama[2] and Biego Godi Henri Marius[1,3]

[1]Laboratory of Biochemistry and Food Science, Training and Research Unit of Biosciences, Felix Houphouet-Boigny University, 22 P.O.Box 582, Abidjan, Côte d'Ivoire.
[2]Training and Research Unit of Biological Sciences, Peleforo Gon Coulibaly University, P.O.Box 1328, Korhogo, Côte d'Ivoire.
[3]Training and Research Unit of Pharmacological and Biological Sciences, Department of Public Health, Hydrology and Toxicology, Felix Houphouet-Boigny University, P.O.Box 34, Abidjan, Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration between all authors. Author DTE designed the study, wrote the protocol, fitted the data and wrote the first draft of the manuscript. Author KNY performed the statistical analysis, checked the first draft of the manuscript for submission and revised the manuscript. Authors MMR, SD and CA managed the literature and assisted the experiments implementation. Author BGHM expertized the results interpretations. All authors read and approved the submitted manuscript.

Article Information

DOI: 10.9734/ARJA/2017/36697
Editor(s):
(1) Rusu Teodor, Department of Technical and Soil Sciences, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania.
(2) Fábio da Costa Henry, Laboratory of Food Technology, State University of Northern of Rio de Janeiro, Brazil.
Reviewers:
(1) National Technical University of Athens, School of Chemical Engineering, Greece.
(2) Celenk Molva, Izmir Institute of Technology, Turkey.
(3) Alice Vilela, Escola de Ciências da Vida e Ambiente, Portugal.
Complete Peer review History: http://www.sciencedomain.org/review-history/21768

Original Research Article

Received 9th September 2017
Accepted 25th October 2017
Published 6th November 2017

ABSTRACT

Aims: To assess the nutrients of cakes enriched with the almonds powders of *Terminalia catappa* cultivated in Côte d'Ivoire and their daily contributions in adult people's diet.
Study Design: Six groups of cakes, 5 enriched with almonds powders from *Terminalia catappa* (cake1, cake2, cake3, cake4 and cake5) and 1 non-enriched (control) were obtained using the composite central plane and prepared. Then, their nutrient composition was determined.
Place and Duration of Study: Laboratory of Biochemistry and Food Sciences, Biochemistry

**Corresponding author: E-mail: douati5@gmail.com;*

department of Biosciences Unit, Félix Houphouet-Boigny University, between January and June 2017.

Methodology: The analysis of the 6 cakes consisted of the determination of their nutritive content (moisture content, protein, lipids, total sugars, reducing sugars, carbohydrates, fiber and ash) and phenolic compounds (polyphenols and flavonoids). Also their energy value and daily intake were estimated.

Results: The analysis of the results indicates that the protein contents are between 9.13 ± 0.02 and 10.37 ± 0.02 g / 100 g, those of the lipids vary between 24.03 ± 0.01 - 26.23 ± 0.01 g / 100 g. when the ash fluctuates between 6.08 ± 0.02 and 8.03 ± 0.03 g / 100 g. The moisture levels revealed ranged between 6.20 ± 0.01 and 7.91 ± 0.02 g / 100 g. The total sugars show contents between 0.01 ± 0.01 and 0.051 ± 0.01 g / 100 g. However, the reducing sugars have a constant content (0.01 g / 100 g). As for the fibres, they have contents which vary between 4.88 ± 0.02 and 5.08 ± 0.01 g / 100 g. Total carbohydrates have levels ranging from 55.16 ± 0.07 to 55.32 ± 0.21 g / 100 g. The energy values indicate contents of 473.43 ± 0.02 and 498.83 ± 0.01 Kcal. The total polyphenols have levels ranging from 280 ± 0.01 to 352.8 ± 0.01 mg EAG / 100 g, whereas the total flavonoids have levels between 10 ± 0.01 and 15 ± 0.01 mg EQ / 100 g. The oxalate levels revealed ranged between 4.5±0.01 and 5.40 ±0.01 mg / 100 g Ms, whereas the phytate have levels ranging between 3.8±0.01 and 4±0.01 mg / 100 g Ms.

Conclusion: The valorisation of cakes enriched with almond powders from *T. catappa*, particularly cake 4, could help to combat malnutrition and increase the economic resources of populations.

Keywords: Enriched cakes; Terminalia catappa; nutrition; Côte d'Ivoire.

1. INTRODUCTION

Terminalia catappa L., a plant belonging to the *Combretaceae* family, is native to southern Asia and develops throughout the tropics in coastal environments [1,2]. This plant is known as “Cocoma” in Côte d'Ivoire, Badamier in Europe and M'handaya in the Comoros [3]. *T. catappa* is generally planted for its shade, for ornamental purposes and its edible nuts [4]. The leaves representing the most used part of the plant have anti-carcinogenic, antioxidant, anti-inflammatory and antidiabetic properties [5,6]. Fruits of *T. catappa* also have several pharmacological properties and are used in traditional medicine in the treatment of leprosy, headaches, intestinal parasites, and wounds [7]. These fruits contain hard seeds with an edible almond [8]. Almonds can be consumed as aperitifs [9], roasted or steamed at breakfast [10]. In addition, some studies by Monnet et al. [1], Udotong and Bassey [11], Ladele et al. [12], Douati et al. [2] and many other researchers, have highlighted the richness of almonds of *T. catappa* in nutritive compounds (proteins, lipids, essential fibres, vitamins and minerals). The proteins of its almonds have a good profile in essential amino acids and are highly digestible [13]. Moreover, they are very rich in unsaturated fatty acids, particularly oleic acids (31.48%) and linoleic acids (28.93%) [14,12].

These interesting nutritional properties of the almonds of *T. catappa* could be exploited to diversify and improve the profitability of *T. catappa*, and above all to contribute to the fight against malnutrition in Côte d'Ivoire. Given that in Africa, and particularly in Côte d'Ivoire, food is based on cereals and tubers lacking essential nutrients. This lack of nutrients in food is the cause of malnutrition, the prevalence of which in Côte d'Ivoire, in children under 5 years of age, is 30% with 12% of severe form with insufficient weight affecting 15% of children [15]. Faced with this situation, which is particularly damaging to the future of many children, the enrichment of staple foods remains an important way to combat malnutrition [16]. Thus, the incorporation of almond powders from *T. catappa* into other essentially energetic foods, especially cakes made from wheat, could enhance their nutrient content and generate substantial income for the populations.

The objective of this study was to produce composite cakes made from wheat enriched with almonds powder from *T. catappa* which can cover the need for essential nutrients of the populations, and also fight poverty by these economic resources brought.

2. MATERIALS AND METHODS

2.1 Vegetable Material

The vegetable material consisted of dried ripe fruits from *T. catappa* collected from suppliers in different regions of Côte d'Ivoire.

2.2 Sampling

The ripe dried fruits of *T. catappa* were collected between October and December 2016 from farmers in two regions of Côte d'Ivoire, namely Tonkpi region (Man and Danané cities) and Guemon region (Duékoué city), where this crop is cultivated. Per location, 3 suppliers were considered, from each of them 60 kg of dried fruits of *T. catappa* were collected. Thus, a total volume of 540 kg of dried fruits were collected, brought to the in the laboratory for analyses.

2.3 Preparation of Powdered Almonds of Dried Fruits of *Terminalia catappa*

Dried fruits of *T. catappa* were crushed using nutcracker. Once extracted, the almonds were dried at 50°C for 48 h in an oven (MEMMERT, Germany). After cooling to room temperature, they were crushed (Magimix Crusher) and sieved using a column of sieves of different meshes (0.1, 0.14, 0.25, 0.36 and 0.4 mm) thus giving 5 batches of flour (Fig. 1). These batches of flour were stored in sealed polyethylene bags and stored in the desiccator until the cakes were made.

2.4 Preparation of Composite Powders

The Composite Central Plane (PCC) was used to obtain a well-structured range of almond powders that will provide various nutrient characteristics. Two controllable factors have been taken into account: the quantity of *T. catappa* almond powder varying from 5% to 10% and the particle size of the almond powder of *T. catappa* which oscillates between 0.1 mm and 0.4 mm (Table 1). For this plane, each factor presented 5 levels (-α, -1, 0, +1 and + α). Referring to Plackett and Burman [17], the combination of the levels of the two factors studied led to the implementation of 11 trials corresponding in reality to 9 formulas, since tests 9, 10 and 11 have the same proportions and sizes of almond powder to be used (Table 1).

The grouping of these 9 tests according to the 2 factors made it possible to prepare 5 cakes

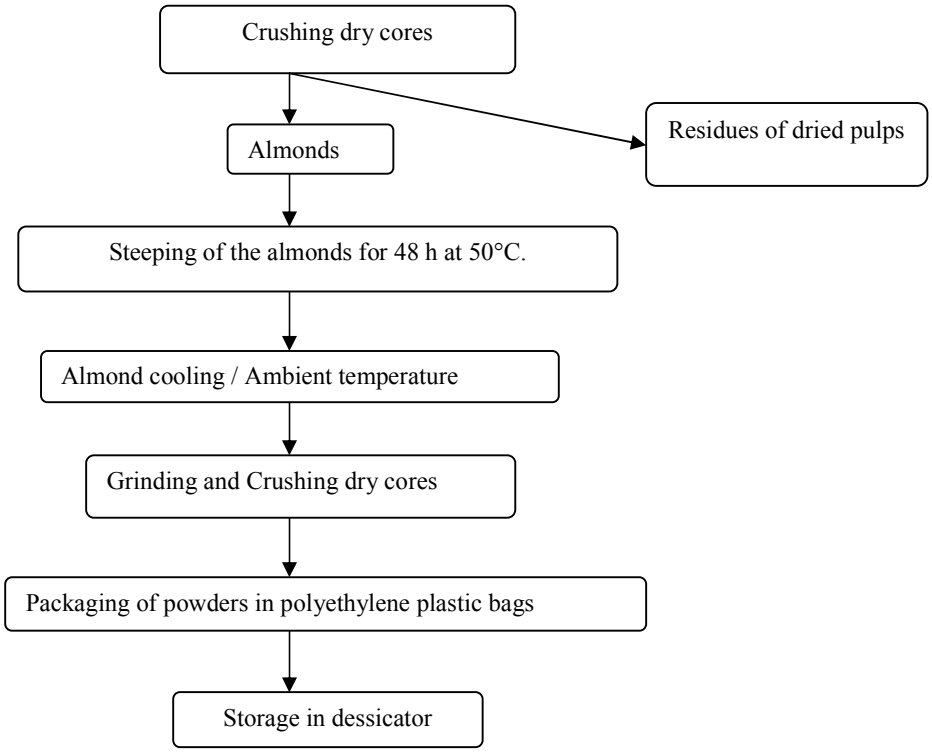

Fig. 1. Diagram for obtaining almond powder from *T. catappa*

Table 1. Experimental plan for the composite plan used for the formulation of different cakes

Test	Factors	
	X1 **Amount of *T. catappa* almond powder (%)**	**X2** **Particle size of the almond powder of *T. catappa* (mm)**
1	5	0.10
2	9.25	0.14
3	5.75	0.36
4	9.25	0.36
5	5	0.25
6	10	0.25
7	7.50	0.10
8	7.50	0.40
9	7.50	0.25
10	7.50	0.25
11	7.50	0.25

X1, the amount of almond powder of T. catappa which varies from 5% to 10%, X2, the particle size of the almond powder of T. catappa

distributed as follows: cake 1 (F1 and F5), cake 2 (F2 and F4), cake 3 (F3), cake 4 (F6) and cake 5 (F7, F8 and F9).

2.5 Preparation of Cakes

The bakery flour, the nine types of almond powders of *T. catappa*, fresh eggs, butter, sugar and baking powder were used for the preparation of cakes. Thus, from these ingredients, five cakes were prepared according to the method described by Bennion and Bamford [18] (Table 2). Indeed, using a Kenwood drummer (Kenwood Chef - Model A910D), the sugar was whitened in white and egg yolk at 240 rpm for 1 min. Then baking flour and yeast were added to the mixture and the mixture was blended at 300 rpm for 5 min. To this mixture, the almond powder of *T. catappa* was added and mixed at 240 rpm for 1 min. Finally, the butter was added and mixed again at 300 rpm for 4 min. The paste obtained was carefully reversed in a pre-induced oil mold, introduced into a preheated oven and baked at 150°C for 45 min. After cooking, the cakes were cooled to room temperature, demolded, packed in aluminum foil and then stored in a dry place. After 24 h, the nutrient components were evaluated.

2.6 Determination of the Cake Moisture

The moisture content was determined by drying 5 g of raw cake at 105°C in an oven till constant weight upon a two-digit scale. The weight loss after ovening allowed deduction of the water content [19]. The tests were performed in triplicate.

2.7 Determination of the Nutrients of Prepared Cakes

The nutritional evaluation of prepared cakes involved the quantification of chemical parameters (proteins, fat, total sugars, reducing sugars, carbohydrates, fibre and ash) and phenolic compounds (total polyphenols and flavonoids). It also concerned the calculation of the energy value and the estimated intakes of cakes.

Table 2. Composition of cakes prepared

	Control	Cake 1	Cake 2	Cake 3	Cake 4	Cake 5
Wheat (g)	100	100	100	100	100	100
Sugar (g)	64.4	64.4	64.4	64.4	64.4	64.4
Fresh eggs (g)	75	75	75	75	75	75
Butter (g)	60	60	60	60	60	60
Baking powder (g)	1.25	1.25	1.25	1.25	1.25	1.25
Almonds powder (%)	00	5	9.25	5.75	10	7.50

Control, non-enriched cake, cake 1, cakes enriched with 5% almond powder, cake 2, cakes enriched with 9.25% almond powder, cake 3, cake enriched with 5.75% almond powder, cake 4, cakes enriched with 10% almond powder; cake 5, cakes enriched with 7.5% almond powder

2.7.1 Protein content

The determination of the proteins content regarded the total nitrogen in each cake sample according to Kjeldhal method. Thus, 1 g of cake dried powder was mineralized at 400°C for 2 h using concentrated sulfuric acid and potassium sulfate catalyst. The resulting solution was diluted with distilled water, mixed with sodium hydroxide, and then distilled for 10 min.

The distillate was collected into a flask containing boric acid and methylene bromocresol reagents, and the total nitrogen was titrated against a 0.01N sulfuric acid solution.

The total nitrogen content was converted into proteins contents [19] according to the equation (1) given below. The tests were performed in triplicate.

$$PRC\ (g/100\ g) = TNC*6.25 \quad (1)$$

Where PRC, proteins content; TNC, total nitrogen content (g/100 g)

2.7.2 Fat content

The lipids were measured after solvent extraction using hexane and Soxhlet device for 7 h [18]. The hexan-oil mixture resulted from the extraction was separated with a rotavapor apparatus and the sample's weight difference before and after the process revealed the lipids content. Analyses were performed in triplicate.

2.7.3 Carbohydrates contents

The total carbohydrates content was calculated according to the following formula (2) provided by the FAO [20].

$$TCC\ (\%) = 100 - [PC + LC + MC + AC + FC] \quad (2)$$

Where TCC, total carbohydrates content; PC, LC, MC FC, respective contents in proteins, lipid, moisture, and fibers

Afterwards, the total ethano-soluble carbohydrates were extracted according to the method of Agbo et al. [21]. Thus, 1 g of cake powder was treated with ethanol, zinc acetate, and oxalic acid solutions at respective concentrations of 80% (v/v), 10% (w/v), and 10% (w/v). The extract was centrifuged at 3.000 rpm for 10 min, and the ethanol residue was evaporated from the extract upon a hot sand bath. Then, the extracted total soluble sugars were measured out using phenol and sulfuric acid reagents [22] and spectrophotometer (PG instruments). The total reducing sugars content (TSR) was also determined from the extract with 3, 5- dinitro-salycilic acid reagent [23] and spectrophotometer.

Prior to both total soluble and reducing carbohydrates contents determinations, calibrations were performed with standard solutions of glucose and sucrose.

2.7.4 Crude fibres content

The determination of the crude fibres (%) percentage consisted in treatment of 2 g of cakes with 50mL of 0.25 N sulfuric acid and 50 mL of 0.31 N sodium hydroxide, and filtration of the mixture upon a Whatman paper. The residue was dried for 8 h at 105°C then incinerated at 550°C for 3 h into oven [19]. The tests were performed in triplicate.

The crude fibres content was calculated according to the following formula (3):

$$\text{Crude fibres contents } (\%) = (m_1 - m_2) * 100 / m_e \quad (3)$$

Where m1, mass of oven dried residue (g); m2, mass of the ash after incineration (g); me, mass of the test sample (g).

2.7.5 Ash content

The ash content was measured by incineration of 5 g of cake powder in an electric muffle oven. The sample was beforehand carbonized on a Bunsen burner, and then placed into the oven at 550°C for 12 h. The ash consisting of the resulted white residue was weighed and expressed in percentage [19]. Analyses were performed in triplicate.

2.7.6 Caloric energy value

The caloric energy value of the almond samples was calculated using relating coefficients of the main macronutrients (4), namely proteins, carbohydrates, and fat [24] as stated below:

$$CEV\ (kcal/\ 100\ g) = 4*ProC + 4*TCC + 9*Fat\ C \quad (4)$$

Where CEV, caloric energy value; Pro C, TCC, Fat C, the respective contents in proteins, total carbohydrates and oil.

2.7.7 Phenolic compounds

2.7.7.1 Extraction of phenolic compounds

The extracts of cakes powder were prepared using acidified water. 10 g of sample was mixed with 50 mL of solvent with stirring (100 trs/min) at laboratory room temperature (22±2°C) for 30 min. The mixture was then centrifuged for 2 min at 2000 trs/min. Extracts obtained were filtered through a filter paper (Whatman N°1) and stored at 4°C in a refrigerator for subsequent determination.

2.7.7.2 Total polyphenols content

Total polyphenols were determined by colorimetry, using the Singleton and Rossi method [25] modified by Wood et al. [26]. Diluted Folin-Ciocalteu reagent (1/10, v/v, 2.5 mL) was added to 30 µL of sample. After 2 min of incubation in the dark at room temperature, 2 mL of aqueous sodium carbonate (75 $g.L^{-1}$) was added. After gentle stirring, the mixture was incubated in a water bath at 50°C for 15 min and rapidly cooled down to stop the reaction. The absorbance was measured at 760 nm with distilled water as blank. A calibration curve was performed with gallic acid at different concentrations (0-1 $g.L^{-1}$). Analyses were performed in triplicate and polyphenols level was expressed in grams of gallic acid equivalent per liter of extract (g EAG /L).

2.7.7.3 Total flavonoids content

Total flavonoids were determined by the method of Marinova et al. [27]. A volume of 0.75 mL of sodium nitrite ($NaNO_2$) to 5% (w/v) was added to 2.5 mL of extract in a 25 mL flask. The mixture was added 0.75 mL of aluminum chloride ($AlCl_3$) to 10% (w/v) and incubated for 6 minutes in the dark. After incubation, 5 mL of sodium hydroxide (NaOH 1N) were added and the volume was made up to 25 mL. The mixture was stirred vigorously before being dosed with UV-Visible spectrophotometer. The reading was taken at 510 nm with distilled water as a blank. A calibration curve was performed with quercetin at different concentrations (0-1.5 $g.L^{-1}$). The tests were performed in triplicate and the flavonoids content was expressed in g quercetin equivalents of extract (g QE/ L).

2.8 Determination of the Antinutrients of Prepared Cakes

2.8.1 Phytate content

The phytate content was determined using the colorimetric method of the Wade reagent [28]. A test portion of one gram of almond powder was stirred in 20 ml of 0.65 N HCl with stirring for 12 h at room temperature. After homogenization, the mixture was centrifuged at 12000 rpm for 40 minutes and 0.5 mL of supernatant was taken and then treated with 3 mL of Wade reagent. The absorbance of the solution was read at 490 nm on the spectrophotometer (PG instruments) against a control not containing an extract. A calibration using sodium phytate at 10 µg/mL made it possible to determine the phytate content according to the following equation (5). Analyses were performed in triplicate.

Phytate content (mg/100 g) = DO 490*4/ 0.33*me (5)

2.8.2 Oxalate content

The total oxalates were extracted in HCl (6N) for 1 h in a boiling water bath. The oxalates extracted were assayed by potassium permanganate (KMnO4) (0.05N) in a hot sulfuric acid (3N) medium (AOAC, 1990) [19]. 2 g of the almond powder sample were weighed (m) and then homogenized in 200 mL of distilled water in a 250 mL flask. 20 mL of HCl (6N) was added to the solution. The mixture was incubated for 1 h in a boiling water bath. The mixture was then filtered (filtrate 1). 20 mL of HCl (6N) was added to 50 mL of the filtrate 1 and then the mixture was homogenized and filtered again (filtrate 2). The residue 2 was washed with boiling distilled water, dried in an oven and stored. Three (03) drops of methyl red (0.1% in ethanol) were added to the filtrate 2 and then concentrated ammonia to the yellow turn. The mixture was heated in a boiling water bath for 10 minutes, cooled and then filtered (filtrate 3). The residue 3 was recovered, washed with boiling distilled water, dried in an oven and stored. The filtrate 3 was boiled and 10 ml of calcium chloride (5%, w / v) was added with stirring. The mixture was then allowed to stand for 24 h to form the oxalate crystals and then filtered (filtrate 4). The residue 4 was recovered, washed with distilled water, dried in an oven and then stored. Residues 2, 3 and 4 were recovered in a beaker and then dissolved in 10 mL of sulfuric acid (H2SO4) diluted to ¼. The mixture obtained was titrated by

hot potassium permanganate solution (0.05 N) to a persistence of pink coloring for at least 30 s. The tests were performed in triplicate and the total oxalate content as a percentage of dry mass of sample is determined by the following formula (6):

$$\text{Oxalate (\%)} = (5*N*V*10^{-3})*(5*126*100)/2*me \quad (6)$$

Where N, normality of the $KMnO_4$ solution; V, volume (ml) of $KMnO_4$ fed to equivalence; me, mass of the test portion (g)

2.9 Estimation of Nutrient Intakes in an Ivorian Adult Individual

The intakes were estimated using the Codex Alimentarius method (7), which takes into account the levels found in the food and the daily intake of an adult individual of 70 kg [29].

$$\text{Estimated intake} = C \times Q \quad (7)$$

Where C, measured concentration; Q, daily intake of food

2.10 Statistical Analysis

The data were statistically processed using the Statistical Program for Social Sciences software (SPSS 22.0 for Windows). The statistical evaluation consisted of a one-way analysis of variance (ANOVA) assessing the type of formulated cake. Means of the measured parameters were compared using the Student Newman Keuls test at 5% significance level. Multivariate analyses, namely Principal component analysis (PCA, accounting the higher eigenvalue components) and Hierarchical Ascending Clustering (HAC, built from the Unweighted Pair Group Method with Arithmetic means) were as also performed using Statistica software (STATISTICA 7.5) to determine the discriminative variables among the overall parameters studied.

3. RESULTS

3.1 Nutrient Parameters of Cakes

The results indicate that the total carbohydrate contents (55.16 ± 0.07 "cake control" at 55.54 ± 0.21 g / 100 g "cake 4") of the cakes studied are statistically identical (P> 0.05). However, protein, lipids, total sugars, reducing sugars, fibres, ash, moisture, and the energetic values of the cakes studied are statistically different (P <0.001) (Table 3). Indeed, the protein content of the cakes studied varied between 9.13 ± 0.02 g / 100 g (control cake) and 12.25 ± 0.02 g / 100 g (cake 4). The lipid contents are between 24.03 ± 0.01 g / 100 g (control cake) and 29.50 ± 0.01 g / 100 g (cake 4). The total sugar content of the cakes varied between 0.01 ± 0.00 g / 100 g (control cake) and 0.42 ± 0.01 g / 100 g (cakes 4). As for the reducing sugars, they oscillate between 0.01 ± 0.01 "control cake" and 0.02 ± 0.01 g / 100 g "cake 4". The fiber contents are between 4.88 ± 0.02 g / 100 g (control cake) and 5.40 ± 0.01 g / 100 g (cake 4). As regards ash, the contents oscillate between 6.08 ± 0.02 g / 100 g (control cake) and 6.62 ± 0.03 g / 100 g (cake 2). The moisture content varies between 6.20 ± 0.00 g / 100 g (control cake) and 6.55 ± 0.02 g / 100 g (cake 2). The energy values of the cakes studied ranged from 473.43 ± 0.02 Kcal / 100 g (cake control) to 536.66 ± 0.00 Kcal / 100 g (cake 4).

The results showed that the composite cakes studied had protein, lipid, and total sugars, reducing sugars, fibre, ash, moisture content and higher energy valuesthan those of the control cake (Table 3).

Concerning the phenolic compounds of the cakes studied, the results revealed that the total polyphenol and total flavonoid contents are statistically different (P <0.001). The total polyphenol contents ranged between 280 ± 0.01 mg EAG / 100 g (control cake) and 352.8 ± 0.01 mg EAG / 100 g (cake 4). For total flavonoid contents, they fluctuate between 10 ± 0.01 and 15 ± 0.01 mg EQ / 100 g (Table 3).

3.2 Antinutrient Parameters of Cakes

The results indicate that the oxalate contents (4.5±0.01 “cake1” at 5.40 ±0.01 mg / 100 g Ms “cake 4”) and phytate contents (3.8±0.01 ”cake 1” at 4±0.01 ”cake 4”) of the cakes studied are statistically different (P <0.001) (Table 4).

3.3 Processed Cakes Variability for Nutrient Compounds

Principal component analysis (PCA) was performed by considering F1 and F2 components (Table 5) displaying greatest eigenvalues, according to the Kaïser statistical rule. Emphasized groupings of the PCA were then clarified by the UPHR method (UPH) using the

Unweighted Pair Group Method with Arithmetic Means (UPGMA).

3.3.1 Description of principal component analysis

Fig. 2A presents the circle of correlations of the factorial axes F1 and F2, which express 96.53% total variability of the studied parameters. The component F1 with an eigenvalue of 10.03 expresses 91.14% of the variance. It is totally established by a negative correlation with nutrient content. Component F2, of eigenvalue 0.59, expresses 5.39% of the variance and does not express any significant correlation with the parameters (Table 4). Hence, the projection of both nutritive traits and studied samples in the F1-F2 factorial design emphasizes 4 groups of cakes. The group 1 consists of cakes 4 and 2 (F6, F2, and F4) is characterized by high protein, lipid, total soluble carbohydrates, fibres, ashes, moisture, and energy values. The group 2 contains cakes 5 (F7, F8 and F9) whose nutrient contents follow those of group 1. The cake1 (F1 and F5) and cake 3 (F3), with lower nutrient content compared to the other composite cakes, are gathered in group 3. The 4th group is the cake taken as control (T) and displaying lower nutrient levels than composite cakes (Fig. 2B).

3.3.2 Ascending hierarchical clusters

Hierarchical classification corroborates the variability resulting from the principal component analysis (Fig. 3). Indeed, at the Euclidean distance of aggregation of 49, the UPGMA dendrogramme shows four classes of cakes samples. The first class characterized by high levels of proteins, lipids, total soluble carbohydrates, fibres, ashes, moisture, and energy consists of cakes 4 and 2 (F6, F2 and F4). The cakes 5 (F7, F8 and F9) having low nutrient contents than those of the first class constitute the second class. The third class consists of cake1 (F1and F5) and cake 3 (F3) having low nutrient contents than those of other composite cakes. The control cake forms the fourth class with the low nutrient content as those of composite cakes (Fig. 3).

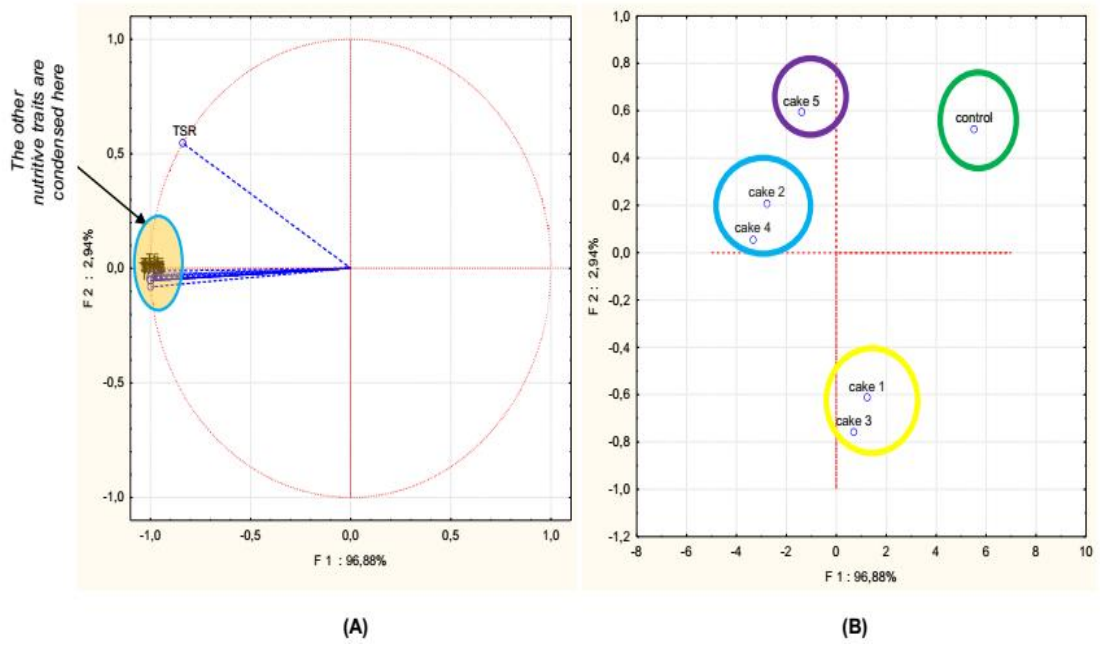

Fig. 2. Projection of nutrient characteristics and cake samples studied in factor plane 1-2 of principal component analysis

with control, non-enriched cake , cake 1, cakes enriched with 5% almond powder, cake 2, cakes enriched with 9.25% almond powder, cake 3, cake enriched with 5.75% almond powder, cake 4, cakes enriched with 10% almond powder; cake 5, cakes enriched with 7.5% almond powder, TSR, total reducing sugars

Table 3. Nutrient content of studied cakes. Means ± standard deviations with the same lowercase letters are statistically identical at 5% significance. F, value of the statistical Ficher test, P, probability value of the statistical test

Parameters		Control	Cake 1	Cake 2	Cake 3	Cake 4	Cake 5	F-value	P-value
Biochemical compounds	Total carbohydrates (g/100g)	55.16±0.07^{a}	55.36±0.07^{a}	55.51±0.23^{a}	55.38±0.27^{a}	55.54±0.21^{a}	55.44±0.32^{a}	0.217	0.948
	Total sugars (g / 100g)	0.1±0.01^{d}	0.26±0.01^{c}	0.40±0.01^{a}	0.28±0.01^{c}	0.42±0.01^{a}	0.34±0.01^{b}	167.195	<0.001
	Reducing sugars (g / 100g)	0.01±0.01a	0.01±0.01a	0.02±0.01^{a}	0.01±0.01a	0.02±0.01^{a}	0.02±0.01^{a}	1.318	0.320
	Protein (g / 100g)	9.13±0.02^{d}	10.70±0.09^{d}	12.02±0.02^{a}	10.92±0.03^{c}	12.25±0.02^{a}	11.47±0.02^{b}	343.930	<0.001
	Lipids (g / 100g)	24.03±0.01^{d}	26.77±0.01^{c}	29.10±0.01^{a}	27.17±0.01^{c}	29.50±0.01^{a}	28.14±0.02^{b}	15518.036	<0.001
	Fibers (g / 100g)	4.88±0.02^{c}	5.14±0.01^{b}	5.35±0.02^{a}	5.17±0.01^{b}	5.40±0.01^{a}	5.30±0.01^{a}	120.300	<0.001
	Ash (g / 100g)	6.08±0.02^{c}	6.35±0.07^{b}	6.62±0.01^{a}	6.40±0.02^{b}	6.62±0.03^{a}	6.50±0.02^{a}	140.510	<0.001
	Moisture (g / 100g)	6.20±0.01^{b}	6.40±0.01^{a}	6.53±0.02^{a}	6.40±0.01^{a}	6.55±0.02^{a}	6.50±0.01^{a}	201.121	<0.001
	Energy value (Kcal)	473.43±0.02^{d}	505.17±0.01^{c}	532.02±0.03^{a}	509.73±0.01^{c}	536.66±0.01^{a}	520.90±0.01^{b}	4328.14	<0.001
Phenolic compounds	Polyphenols (mgEAG / 100 g)	280±0.01^{d}	316.4±0.01^{c}	347.34±0.01^{a}	321.86±0.02^{c}	352.8±0.01^{a}	334,6±0.01^{b}	9.939	<0.001
	Flavonoids (mgEQ / 100 g	10±0.01^{d}	12.5±0.01^{c}	14.62±0.01^{a}	12.87±0.01^{c}	15±0.01^{a}	13.75±0.01^{b}	5.866	<0.001

Control, non-enriched cake, cake1, cakes enriched with 5% almond powder, cake 2, cakes enriched with 9.25% almond powder, cake 3, cake enriched with 5.75% almond powder, cake 4, cakes enriched with 10% almond powder; cake 5, cakes enriched with 7.5% almond powder

Table 4. Antinutrient content of studied cakes. Means ± standard deviations with the same lowercase letters are statistically identical at 5% significance. F, value of the statistical Ficher test, P, probability value of the statistical test

Parameters	Control	Cake 1	Cake 2	Cake 3	Cake 4	Cake 5	F-value	P-value
Oxalate (mg / 100 g Ms)	4.5±0.01^{d}	4.95 ±0.01^{c}	5.34±0.01^{a}	5.02 ±0.02^{c}	5.40 ±0.01^{a}	5.18 ±0.01^{b}	12.528	<0.001
Phytate (mg / 00 g Ms)	3.8±0.01^{d}	3.90±0.01^{c}	3.98 ±0.01^{a}	3.90 ±0.01^{c}	4±0.01^{a}	3.95±0.01^{b}	7.612	<0.001

Control, non-enriched cake, cake 1, cakes enriched with 5% almond powder, cake 2, cakes enriched with 9.25% almond powder, cake 3, cake enriched with 5.75% almond powder, cake 4, cakes enriched with 10% almond powder; cake 5, cakes enriched with 7.5% almond powder

Table 5. Matrix of the eigenvalues and correlations between the studied cakes nutrients and the main components (F1 and F2) of the PCA

Principal components	Eigenvalue	Variance (%)	Cumulative variance (%)	TCC	TSCC	RCC	ProC	FatC	AshC	MoiC	FibC	EV	TPC	FlaC
F 1	10.03	91.14	91.14	-0.99	-0.90	-0.77	-0.99	-0.99	-0.95	-0.90	-0.99	-0.99	-0.99	-0.97
F 2	0.59	5.39	96.53	0.01	-0.40	0.63	0.01	0.02	-0.11	-0.11	-0.02	0.02	0.06	-0.01

TCC, total carbohydrates content ; TSCC, total soluble carbohydrates content ; RCC, reducing carbohydrates content ; ProC, protein content ; FatC, fat content; AshC, ash content; MoiC, moisture content; FibC, fibers content; EV, caloric energy value; TPC, total polyphenols content; FlaC, flavonoid content

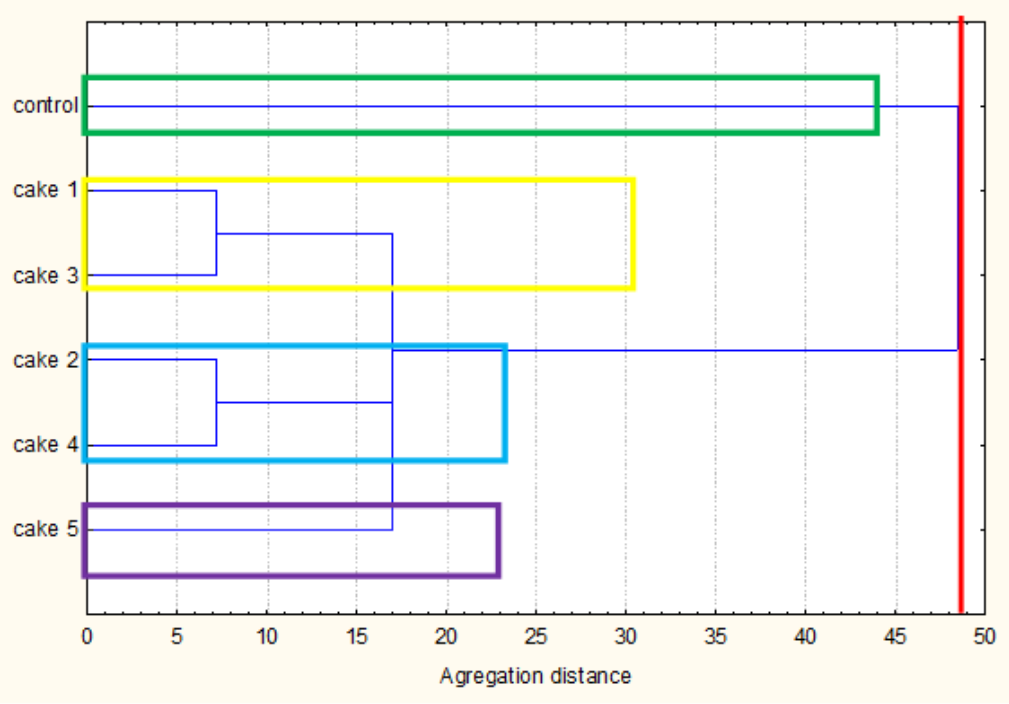

Fig. 3. Hierarchical clusters of the studied cakes relating to the nutritive traits

3.3 Estimated Intakes and Contribution of Essential Nutrients in Ivorian Adults

The daily intake for the average consumption of 23 g of cakes, protein, lipids, total sugars, reducing sugars, total carbohydrates, fibre, ash, total polyphenols, total flavonoids and energy values of composite cakes are higher than those of the control cake. The estimated intakes of composite cakes into proteins, lipids, total sugars, reducing sugars, total carbohydrates, fibres, ash, total polyphenols and energy values are between 2.46 ± 0.02 g / d (cake 1) and 2.81 (Cake 4), 6.15 ± 0.05 g / d (cake 1) and 6.80 ± 0.02 g / d (cake 4), 0.06 ± 0.01 g / Cake 1) and 0.09 ± 0.01 g / d (cake 4), 0.0023 ± 0.01 g / d (cake 1) and 0.0046 ± 0.01 g / d (cake 4), 12.73 ± 0.01 (Cake 1) and 12.77 ± 0.05 g / d (cake 4), 1.18 ± 0.01 g / d (cake1) and 1.24 ± 0.01 (cake 4) (Cake 1) and 0.08 ± 0.4 g / d (cake 4), 0.07 ± 0.3 g / d (cake 1), And 112 ± 0.01 kcal / d (cake 1) and 115 ± 0.01 kcal / d (cake 4). The estimated intakes of composite cakes in total flavonoids are identical (0.003 g / d) but higher than that of the control cake (0.0023 g / d). The control cake recorded the respective daily intakes 2.09 ± 0.01 g / d in proteins, 5.52 ± 0.04 g / d in lipids, 0.023 ± 0.01 g / d in total sugars, 0.0023 ± 0.01 g / d of reducing sugars, 12.68 ± 0.01 g / d total carbohydrate, 1.12 ± 0.01 g / d of fibre, 1.40 ± 0.01 g / 0.06 ± 0.2 g / d in total polyphenols and 109 ± 0.01 kcal / d in energy (Table 6).

Concerning the contribution, the cakes studied provide less than 10% of the nutrient requirements. Nevertheless, the contribution of composite cakes to nutrient constituents is higher than that of the control cake (Table 7).

4. DISCUSSION

The moisture content of the cakes studied is less than 12%, the maximum limit for good food preservation [30]. The results presented in Table 3 showed that the enrichment modifies considerably the nutritive characteristics of the cakes. This results in an increase in the protein, lipid, ash, fiber, total sugar, reducing sugars, total polyphenol, total flavonoids and energy content of the cakes as the rate of addition increases. Thus, cake 4 with the highest incorporation rate of almond powder (10%) is distinguished by its richness in nutrients compared to other cakes (cake 1, 2, 3, 5 and control). Moreover, all the composite cakes obtained have a higher nutritional content compared to the control cake usually consumed. These observations are in

Table 6. Estimated intakes of essential nutrients from the consumption of 23 g of cake in African adults

	RDI	Estimated intakes					
		Control	Cake 1	Cake 2	Cake 3	Cake 4	Cake 5
Total carbohydrates (g /d)	150	12.68±0.01	12.73±0.01	12.76±0.05	12.73±0.06	12,77±0.05	12.71±0.07
Total sugars (g / d)	-	0.023±0.01	0.06±0.01	0.09±0.01	0.06±0.01	0.09±0.01	0.0078±0.01
Reducing sugars (g / d)	-	0.0023±0.01	0.0023±0.01	0.0046±0.01	0.0023±0.01	0.0046±0.01	0.0046±0.01
Protein (g / d)	66	2.09±0,01	2.46±0.02	2.76±0.01	2.51±0.01	2.81±0.01	2.63±0.01
Lipids (g / d)	66	5.52±0.04	6.15±0.05	6.70±0.03	6.24±0.01	6.8±0,02	6.47±0.07
Fibres (g / d)	25	1.12±0.01	1.18±0.01	1.23±0.01	1.18±0.01	1.24±0.01	1.21±0.01
Ash (g / d)	-	1.40±0,01	1.46±0.02	1.52±0.01	1.47±0.01	1.52±0.01	1.50±0.01
Energy value (Kcal/d)	2500	109±0,01	116.20±0.01	122.36±0.01	117.23±0.01	123.43±0.01	119,80±0,01
Total polyphenols (g/d)	1	0.06±0,2	0.07±0.3	0.08±0.7	0.07±0.1	0,08±0,4	0.08±0.1
Flavonoids (g/d)	0.181	0.0023±0,5	0.003±0.8	0.003±0.2	0.003±0.4	0.003±0.1	0.003±0.3

Table 7. Recommendations and contribution of cake nutrients to the satisfaction of recommended intakes

	RDI (g/d)	Contribution (%)					
		Control	Cake 1	Cake 2	Cake 3	Cake 4	Cake 5
Total carbohydrates	150	8.45±0.07	8.48±0.04	8.50±0.03	8.48±0.04	8.51±0.02	8.50±0.05
Total sugars	-	nd	Nd	nd	nd	nd	nd
Reducing sugars	-	nd	Nd	nd	nd	nd	nd
Protein	66	3.16±0.02	3.72±0.01	4.18±0.01	3.80±0.08	4.25±0.08	4±0.02
Lipids	66	8.36±0.1	9.31±0.16	10.15±0.1	9.45±0.03	10.30±0.06	9.80±0.07
Fibres	25	4.48±0.01	4.72±0.01	4.92±0.01	4.72±0.01	4.96±0.01	4.84±0.01
Ash	-	nd	Nd	nd	nd	nd	nd
Energy value	2500	4.36±0.01	4.64±0.01	4.89±0.01	4.68±0.01	4.93±0.01	4.79±0.01
Total Polyphenols	1	6±0.2	7±0.3	8±0.7	7±0.1	8±0.4	8±0.1
Flavonoids	0,181	1.27±2.76	1.65±4.41	1.65±1.10	1.65±2.20	1.65±0.55	1.65±0.65

RDI: Recommended daily intake

harmony with those made by Alozie and Chinma [31], who emphasized the improvement in the nutritional content of cakes enriched with beet powders. Indeed, cake made from wheat flour is poor in essential nutrients. The increase in essential nutrient content of composite cakes could be attributed to the richness of the almonds of *Terminalia catappa* in these essential nutrients [11,12,2]. However, the total carbohydrate content is comparable to that of the control cake.The advantage of incorporating *Terminalia catappa* into wheat cake is that it contains proteins with a good profile of essential amino acids, essential fatty acids, essential vitamins and minerals [13,14,12]. In addition, the consumption of food sources of vegetable proteins should be encouraged because they are available and inexpensive compared to animal proteins [30]. Nutrients provide important roles in the body. Thus, the proteins participate, among other things, in maintaining the cellular structure and the growth of the organism [32]. As for lipids, which are essential to the organism by their implication in brain functions, their role in the absorption of fat-soluble vitamins and the improvement of the taste of food [33,34], the high fat content represents an advantage for the upgrading of almonds in the oilseed chain, such as groundnut and oil palm. It should be pointed out that the ash obtained after incineration of the organic matter consists essentially of minerals. As a result, samples of ash-rich cakes could have considerable amounts of minerals. The present work shows that the ash contents of the composite cakes studied are higher compared to those obtained (1.8 to 1.9 g / 100 g) in wheat flour cakes enriched with soybeans by Sanful et al. [35]. Composite cakes record high fibre contents. These fibres reduce the risk of constipation, colon cancer and especially glycemia by lowering intestinal absorption of glucose [36,37]. They also prevent absorption of excess cholesterol [38]. The good total polyphenol contents of the cakes studied represent an important advantage in the valorisation of *Terminalia catappa* almonds. Indeed, phenolic compounds (total polyphenols, total flavonoids) contribute to antioxidant activities and protect the body against degenerative diseases [39]. Thus, total polyphenols struggle effectively against aging and the occurrence of cancer cells [40,41]. These composite cakes can be recommended for human consumption to fight diseases caused by oxidative stress [42].

To evaluate the nutritional quality of Cake prepared, their antioxidant (oxalate and phytate) content was also determined. Antinutritional factors can fix bivalent cations such as calcium, magnesium, iron and zinc, thus decreasing their bioavailability [43]. The oxalate content found in the cake enriched varied between 4.95±0.01mg / 100 g Ms “cake 1” and 5.40 ±0.01 mg / 100 g Ms “cake 4”. These levels are well below the toxic dose of oxalate (2 to 5g / day) recommended [44]. This indicates that the doses of oxalates in fortified cakes are not toxic.

On the other hand, the phytate content found in the cake enriched fluctuates between 3.90±0.01 mg / 100 g Ms “cake1” to 4±0.01 mg / 100 g Ms “cake 4. These levels are well below the recommended phytate levels of 250-800 mg/d [45]. This confirms that cakes enriched with almond powders are not toxic.

The low levels of oxalate and phytates observed would increase the bioavailability of divalent cations and could also be beneficial to the health of consumers of cake.

The contribution to meeting nutrient requirements in composite cakes and control was evaluated by taking into account the average daily amount of cake consumed by an adult in Africa, which is 23 g [46]. This amount of cake consumed daily represents 2.26% of the 1018.1 g of food consumed on average by one African adult per day [47]. The results show that with the consumption of 23 g of cake, the estimated daily intakes of essential nutrients in an African adult were greater in the composite cakes, particularly the cake 4 in contrast to the control cake. This distribution shows the importance of wheat-based cake fortification with *Terminalia catappa* almonds. Indeed, the incorporation of almond powder from *Terminalia catappa* into the wheat-based cake helped increase the nutrient content. The consumption of the cakes studied contributes less than 10% of the nutrient requirements. Nevertheless, the contribution of composite cakes to nutrient constituents have higher than the control cake and also higher than 2.26% representing the proportion of the 23 g of cake on the 1018.1 g of food consumed by an adult per day. Thus, the consumption of composite cakes especially that of cake 4, could contribute to improving the health of the populations. Cake 4 could be recommended in the human diet.

5. CONCLUSION

The cakes studied have a varied nutritional composition. The composite cakes studied were found to have the highest protein, lipid, ash, fibre, total polyphenol and energy content of the usual cake control. They constitute a considerable improvement of the control cake. The enrichment of the cake with almonds of *T. catappa* is a considerable improvement of the nutritional characteristics of the cake. Among the composite cakes, cake enriched with 10% almond powder was distinguished by the highest nutrient content and a good contribution to the recommended daily intake. The popularization of cake enriched with 10% almond powder could help increase the consumption of almonds of *T. catappa*, combat malnutrition of populations and generate important sources of income for the populations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Monnet YT, Gbogouri A, Koffi PKB, Kouamé LP. Chemical characterization of seeds and seed oils from mature *Terminalia catappa* fruits harvested in Côte d'Ivoire. International Journal of Biosciences. 2012;10(1):110-124.
2. Douati TE, Konan NY, Coulibaly A, Sidibé D and Biego GHM. Nutritive components in the *Terminalia catappa* L. (Combretaceae) Almonds Cultivated in Côte d'Ivoire. Journal of Applied Life Sciences International. 2017;12(1):1-10.
3. Ackah JAAB, Kra AKM, Zirihi GN and Guédé-Guina F. Evaluation and optimization tests for the anticandidic activity of *Terminalia catappa* Linn (TEKAM3), an extract of Combretaceae from the Ivorian pharmacopoeia. Bulletin of the Royal Society of Sciences of Liège. 2008;77:120-136. French
4. Dos Santos ICF, De Carvalho SHV, Solleti JI, Ferreira de La Salles W, Teixeira da Silva de La Salles K and Meneghetti SMP. Studies of *Terminalia catappa* L. oil: Characterization and biodiesel production. Bioresource Technology. 2008;99:6545–6549.
5. Masuda T, Yonemori S, Oyama Y, Takeda Y, Tanaka T, Andoh T, Shinohara A and Nakata M. Evaluation of antioxidant activity of environmental plants: Activity of leaf extracts from seashore plants. Journal of Agricultural and Food Chemistry.1999;47: 1749-1754.
6. Nagappa AN, Thakurdesai PA, Venkt RN and Singh J. Effective protection of *Terminalia catappa* L. leaves from damage induced by carbon tetrachloride in liver mitochondria. Journal of Ethnopharmacology. 2003;88:45-50.
7. Kirtikar M, Basu BD. India medicinal plants. Periodical Exparts Books Agency, New Delhy, India. 1999;10-16.
8. Thomson LAJ, Evans B. *Terminalia catappa* (tropical almond), ver. 2.2. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai'i; 2006.
   Available:http://www.traditionaltree.org
9. Biego GHM, Konan AG, Douati TE and Kouadio LP. Physicochemical Quality of kernels from *Terminalia catappa* L. and sensory evaluation of the Concocted kernels. Journal of Sustainable Agriculture Research. 2012;1(2):1-6.
10. Ola Lasekan and Kassim Abbas. Analysis of volatile flavour compounds and acrylamide in roasted Malaysian tropical almond (*Terminalia catappa*) nuts using supercritical fluid extraction. Food and Chemical Toxicology. 2010;48:2212–2216.
11. Udotong JIR, Bassey MI. Evaluation of the Chemical Composition, Nutritive Value and Antinutrients of *Terminalia catappa* L. fruit (Tropical Almond). International Journal of Engineering and Technical Research (IJETR). 2015;96-99.
12. Ladele B, Kpoviessi S, Ahissou H, Gbenou J, Kpadonou KB, Herent MF, Bero J, Larondelle Y, Quetin L and Moudachirou M. Chemical composition and nutritional properties of *Terminalia catappa* L. oil and kernels from Benin. Chemistry Reports. 2016;19(7): 876-883.
13. Ezeokonkwo CA, Dodson WL. The potential of *Terminalia catappa* (tropical almond) seed as a source of dietary protein. Journal of Food Quality. 2004;27: 207-219.
14. Matos L, Nzikou JM, Kimbonguila A, Ndangui CB, Pambou-Tobi NPG, Abenan AA, Silou TH, Scher J, Desobry S. Composition and nutritional properties of seeds and oil from *Terminalia catappa* L.

Advance Journal of Food Science and Technology. 2009;1(1):72-77.

15. MSLS/INS/ICF International. Côte d'Ivoire Demographic and Health and Multi-Indicator Survey 2011-2012: Synthesis report. Calverton, Maryland, USA: Ministry of Health and Welfare, National Institute of Statistics and ICF International. 24. French
16. FAO/WHO. Codex Alimentarius: Joint FAO / WHO Food Standards Program. Report of the thirtieth session of the Codex Committee on Nutrition and Foods for Special Dietary Uses. Cape Town, South Africa, 3-7 November. 2008;1-223. French.
17. Plackett RL, Burman JP. The design of optimum multifactorial experiments. Biometrika. 1946;33:305-325.
18. Bennion EB, Bamford GST. The technology of cake making 6th ed. Londres: Blackie Academic & Professional; 1997.
19. AOAC. Official methods of analysis. Association of Official Analytical Chemists Ed., Washington DC, USA. 1990;684.
20. FAO. Food energy methods of analysis and conversion factors. FAO Ed, Rome, Italy. 2002;97.
21. Agbo NG, Uebersax MA and Hosfield GL. An efficient extraction technique of sugars from dry edible beans (*Phaseolus vulgaris* L.) and estimation in HPLC. Anna University National Conference. 1985;20: 167-187.
22. Dubois M, Gilles K, Hamilton JD, Rebers A and Smith M. Colorimetric, methods for determination of sugars and related substances. Analytical Chemistry. 1956; 28:350-356.
23. Bernfeld P. Alpha and beta-amylases. In, Methods in Enzymology, Colowick S. P. et Kaplan N., eds. Academic Press, New York. 1955;1:149-158.
24. FAO. Investing in agriculture for food security. World Food Day / Telefood, Rome, Italy; 2006. French.
25. Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. American Journal of Enology and Viticulture. 1965; 16:144-158.
26. Wood JE, Senthilmohan ST and Peskin AV. Antioxidant activity of procyanidin-containing plant extracts at different pHs. Food Chemistry. 2002;77(2):155-161.
27. Marinova D, Ribarova F, Atanassova M. Total phenolics and total flavonoids in bulgarian fruits and vegetables. Journal of the University of Chemical Technology and Metallurgy. 2005;40(3):255-260.
28. Latta M, Eskin M. A simple method for phytate determination. J. Agric. Food Chemistry. 1980;28:1313–1315.
29. WHO. Diet, Nutrition and Chronic Disease Prevention, Report of a WHO / FAO Expert Consultation, Geneva, WHO, Technical Report Series. 2003;916:189.
30. Mahan MR, Konan NY, Deigna-Mockey V, Sidibé D, Coulibaly A, Assi YO, Biego GHM. Nutritive compounds from flours of *Borassus aethiopum* new shoots enriched with *Moringa oleifera* leaves and *Vigna unguiculata* beans powders. Asian Journal of Biotechnology and Bioresource Technology. 2017;1(1):1-14.
31. Alozie YE, Chinma CE. Proximate composition, physical and sensory properties of cake prepared from wheat and cocoyam flour blends. Journal of Food Research. 2015;4(5):181-188.
32. Dimeglio DP, Mattes RD. Liquid versus solid carbohydrate: Effects on food intake and body weight. International Journal of Obesity and Related Metabolic Disorders. 2000;24:794-800.
33. Bogert JL, Briggs GM, Galloway DH. Nutrition and physical fitness. International Journal of Food Sciences and Nutrition. 1994;45:223-230.
34. Saidu AN, Jideobi NG. The proximate and elemental analysis of some leafy vegetables grown in Minna and environs. Journal of Applied Science and Environmental Management. 2009;13:21-22.
35. Sanful RE, Sadik A, Darko S. Nutritional and sensory analysis of soya bean and wheat flour composite cake. Pakistan Journal of Nutrition. 2010;9(8):794-796.
36. Ishida H, Suzuno H, Sugiyama N, Innami S, Todokoro T, Maekawa A. Nutritional evaluation of chemical component of leaves stalks and stems of sweet potatoes (*Ipomea batatas* Poir). Food Chemistry. 2000;68:359-367.
37. Lairon D, Cherbut C, Barry JL. Dietary fiber. In: Recommended nutritional intakes. Paris: Tec and Doc. Lavoisier. 2001;99-108. French
38. Mensah JK, Okoli RI, Ohaju-Obodo JO and Eifediyi K. Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology. 2008;7:2304-2309.

39. Osman H, Rahim AA, Isa NM, Bakhir NM. Antioxidant activity and phenolic content of *Paederia foetida* and *Syzygium aqueum*. Molecules. 2009;14:970-978.
40. Scalbert A, Manach C, Morand C, Rémésy C, Jiménez L. Dietary polyphenols and the prevention of diseases. Critical Reviews in Food Science and Nutrition. 2005;45:287-306.
41. Xia Q, Li R, Zhao S, Chen W, Chen H, Xin B, Huang Y, Tang M. Chemical composition changes of postharvest coconut inflorescence sap during natural fermentation. African Journal of Biotechnology. 2011;10(66):14999-15005.
42. Sugiura M, Nakamura M, Ogawa K, Ikoma Y, Ando F, Yano M. Bone mineral density in post-menopausal female subjects is associated with serum antioxidant carotenoids. Osteoporosis International Journal. 2008;19:211-219.
43. Sandberg AS. Bioavailability of minerals in legumes. Br. J. Nutr. 2002;88:281–285.
44. Hassan LG, Umar KJ, Umar Z. Antinutritive factors in *Tribulus terrestris* (Linn) leaves and predicted calcium and zinc bioavailability. J. Trop. Biosci. 2007;7: 33–36.
45. Wenche Frølich, Heddie Mejborn, Inge Tetens. Phytate – a natural component in plant food. DTU National Food Institute. 2011;1-3.
46. Anonyme 1. Manufacturers of cakes and biscuits from France. Treatment CREDOC in CCAF 2014; 2017. French
(Accessed on 11/03/2017)
47. WHO. GEMS/Food regional diets: Regional per capita consumption of raw and semi-processed agricultural commodities / prepared by the Global Environment Monitoring System/Food Contamination Monitoring and Assessment Program (GEMS/Food); 2003.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/21768