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Evaluation of the Vitamin Contents of Palmyra (*Borassus aethiopum M*) New Shoots, Moringa (*Moringa oleifera* L) and Cowpea (*Vigna unguiculata* W) Flours Consumed in Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration between all authors. Author BGHM supervised the whole investigation. Author MMR designed the study, performed the experiment and wrote the manuscript assisted with authors KNY and AYO. Authors DMV, KNY and MMR performed the statistical analysis of the results and checked the revised manuscript. Authors CA and SD participated in interpretation of the results. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aims: To assess the vitamin contents in the flour processed from new shoot tubers of Palmyra (*B. aethiopum*), and the powders of Moringa (*M. oleifera*) leaflets and Cowpea (*V. unguiculata*) beans for improving their valorization.
Study Design: Each vegetable was processed into meal and vitamin parameters analysed.

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Place and Duration of Study: Laboratory of Biochemistry and Food Sciences, Department of Biochemistry, Biosciences Unit, between June 2015 and February 2016.

Methodology: The samples were collected between August and December 2015 from three localities, in Dimbokro, Toumodi and Didiévi, in the center of Côte d'Ivoire. Once acquired, from the samples, 250 Kg, 75 Kg and 75 Kg of Palmyra new shoot tubers, cowpea beans and moringa leaves respectively, were sorted, washed dried and processed into flour. HPLC techniques were used for the separation and quantification of β-carotene and vitamin E and the water-soluble vitamins (vitamins B1, B2, B6 and B9). Vitamin C contained in analyzed samples was determined by titration.

Results: There was wide variation in the vitamin concentration depending on the plant source. Except the vitamins C and B1, the moringa powder has significantly ($p<.001$) more β-carotene (14.7 mg / 100 g), vitamin E (83.94 mg / 100 g), vitamin B2 (2.77 mg / 100 g), vitamin B6 (2.02 mg / 100 g) and vitamin B9 (0.55 mg / 100 g) than the other samples. On the other hand, the meal of Palmyra had the greatest vitamin C content (26.71 mg / 100 g) and B1 (0.34 mg / 100 g). The moringa powder contributed 4.92% of the daily requirement of vitamin E while the powder of Cowpea had a high contribution of 0.09% to 25% of the daily requirement of water-soluble vitamins and 8.54% of β-carotene.

Conclusion: Moringa leaves and Cowpea beans are significant raw sources of vitamin nutrients and could allow fortification of food recipes from Palmyra tubers resulting in alternatives of food valorization and to address poverty and desert hazards in tropical countries.

Keywords: Palmyra new shoots tubers; Moringa; cowpea; flour; vitamins content.

1. INTRODUCTION

The Palmyra palm tree (*Borassus aethiopum*) is a dioecious plant of African origin, which belongs to Palmae or Arecaceae family [1]. In Africa, thousands farmers use various food plants by days for nutritional and medicinal reasons or for additional livelihoods [2]. The trunk has been used in constructing bridges, and telegraphic poles due to its tough and termite resistant nature [3]. The roots, leaves, flowers and fruits are used for multiple purposes such as nutrition agents, treatment for sexually transmitted diseases (e.g., beign herpes), cutaneous fungal infections, and viral infections particularly measles [4]. In Côte d'Ivoire, Palmyra is mainly located in the central region where it represents a sentry against the wilderness projection [5]. In this country, several farmers utilize the Palmyra at the adult stage for production of palm wine, a fermented drink resulting from its sap [6]. Palm wine extracted from Palmyra plays an important role in the diet, securing income and social life but unfortunately extraction methods such as harvesting are destructive so there is a degradation of Palmyra and certain threat the disappearance of this species [7]. Besides, many populations use the new shoots of Palmyra, resulting from the germination of seeds, for food purposes [4]. Facing all the ecological risks incurred, new shoots of Palmyra valorization seems to be a real alternative in the plant's uses, and could ensure its survival and popularization, with significant value-added at nutritional, economical and therapeutical levels. Young shoots of Palmyra well consumed by populations are obtained after 6 to 7 months after the planting of mature fruits by rural populations [8]. Each fruit gives an average of 3 shoots. Part of fallen fruit is naturally in the forest to regenerate the Palmyra and another part is picked up by the rural population for consumption [9]. The young Palmyra shoots are tuberous and edible foods highly valued by the local populations as energeous food resource [10]. They are often processed into flour for the preparation of porridge or local *fufu* [11]. Other studies have revealed that this young shoot has an anabolic effect of androgens; thus, supporting its local use as an aphrodisiac [12]. The studies of Kéita [13] and Oumar et al. [14] revealed also the preventive effect against the gastro duodenal ulcers and the sickly fever provided by the consumption of young shoots of Palmyra. However, this caloric raw food resource is with lower proteins, minerals and vitamins contents like most of the starchy foods. In this case, meals prepared on those tubers basis should be improved with other local edible vegetable sources, particularly with cowpea and moringa which have ability to correct the nutritional deficiency, referring to the recommendations of the Codex Alimentarius [15]. From cowpea beans, previous attempts reported high quality proteins in significant contents of about 25% [5]. Regarding moringa, the food value especially concerns the leaves which have good sources of essential nutrients [16].

Considering their food interest, the development of composite dishes with Palmyra new shoots basis, improved with the moringa leaves and the cowpea beans, could be beneficial for population.

However, it is highly vital to control the vitaminic compound of these three food raw materials before any formulation. The running study is a comparative investigation about the vitamins of the flour deriving from new shoots tubers of *Borassus aethiopum* Mart, and powders of leaves of *Moringa oleifera* Lam and beans of *Vigna unguiculata* Walp, collected from the Ivorian flora, for their fitting development.

2. MATERIALS AND METHODS

2.1 Plant Material

The plant material was the flour processed from Palmyra new shoots tubers, and powders of Moringa leaflets and Cowpea beans.

2.2 Sampling

The raw material samples were collected between August and December 2015 from three localities, especially Toumodi, Dimbokro, and Didiévi, located in the Centre Region, which are the natural habitat accommodating with Palmyra in Côte d'Ivoire and where large quantities of Cowpea and Moringa are also produced. Three retailers of Palmyra shoot tubers and Cowpea beans were considered per town, and then 30 kg tubers and 10 kg beans were bought from each retailer, giving total amount of 270 kg Palmyra tubers and 90 kg Cowpea beans. In addition, 50 kg fresh leaves of Moringa are collected from two sites in each town, 25 kg/site, leading to 150 kg leaflets. Once acquired, the samples are conveyed to the laboratory for analyses. Thus, a pool was constituted by mixing samples by plant species. Finally, 250 kg, 75 kg and 75 kg of respective samples from Palmyra new shoots tubers, Cowpea beans, and Moringa leaves were sorted and washed.

2.3 Processing for Palmyra Flour and Powders from Cowpea and Moringa

Palmyra flour and powders from Cowpea beans and Moringa leaflets were processed according to previous reports of Mahan et al. [5]. The Palmyra new shoots tubers were washed, boiled, peeled, carved, rinsed, and fermented in a tank container for 24 h [17]. The resulted fermented tubers pieces were dried at 65℃ into a ventilated oven (Minergy Atie Process, France) for 6 h, and ground using a hammer mill (Forplex).

The moringa leaflets were disinfected for 5 min with chlorinated water (50 mL of 8% sodium hypochlorite in 30 L of water), rinsed, and fermented in a tank for 24 h. Then, fermented leaflets were dried at 30℃ for 10-14 days with shade ambient temperature and powdered.

Regarding Cowpea, beans were washed, soaked, drained, and sprouted at 30℃ during 48 h. The seeds were dried at 40℃ using the previous oven for 96 h, and the resulted malt was sprout out, heated for 15 min in boiling water and submitted to 24 h fermentation into tank. The fermented Cowpea beans were strained, roasted, dried at 50℃ in the oven for 24 h, and ground.

Finally, flour and powders were filtered using sieves with 250 µm diameter and the resulting products were put in polyethylene hermetic bags and kept in dry place till analyses.

2.4 Determination of Vitamin Content

Vitamin C contained in analyzed samples was determined by titration using the method described by Pongracz et al. [18]. About 10 g of sample were soaked for 10 min in 40 mL metaphosphoric acid-acetic acid (2%, w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 mL of bi-distilled water. Ten (10) mL of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L.A precalibration with ascorbic acid 0.5 g/L was used to determine the value of the vitamin C contained in samples.

On the other hand, the concentrations of water-soluble vitamins of Group B and fat-soluble were determined using a high performance liquid chromatographic system (HPLC, mark Water Alliance). This system included a Waters pump, an automatic injector, a UV / PDA detector and a Servotrace recorder. The operating conditions were adapted to the type of required vitamins.

2.4.1 Preparation of samples for HPLC separation

Two grams of flour samples were extracted vigorously with five excess of n-hexane solvent followed by centrifugation in the cold for 5 min at 3000 rpm. The organic solvent was aspirated and saved. The residue was reextracted with the same solvent and the same steps were repeated until the extract was almost colorless. The total volume of the extract was recorded and an aliquot was injected in the HPLC system.

Fat soluble vitamins were separated on a column Kromasil C18 of 30 X 4 mm (CIL CLUZEAV) in stainless steel. The mobile phase was amixture acetonitrile / methanol (80/20, v / v), of HPLC grade and well furnished by MERCK (Germany). The column temperature was 30℃, the elution length was 35 min and the flow rate was 1.2 mL / min.

Water soluble vitamins were separated on a Zorbax column to silica support post grafted in C18 (150 mm X 4.6 mm) with particles of 3 mm. The mobile phase was a mixture of ammonium acetate and methanol, of grade HPLC and furnished by MERCK (Germany). The flow rate was programmed to 2 mL / min on a length of 20 min.

Standard β-carotene and vitamin E were purchased from Fluka Chemie (Switzerland), while water soluble vitamins were purchased from Sigma-Aldrich (UK). Table 1 present the concentrations of the standard vitamins used for injection in the HPLC system.

Table 1. Concentration for injection and wavelengths

Vitamins	Concentration range (µg/ml)	Wavelengths (nm)
vitamin B_1	0,1 à 3,5	270
vitamin B_2	0,1 à 7	265
vitamin B_6	0,5 à 12	257
vitamin B_9	0,5 à 5	280
β-carotene	0,2 à 4,5	445
vitamin E	0,2 à 5,5	295

2.4.2 Validation of vitamin analysis

The validation of vitamins dosage by HPLC was been achieved by the application the NFV03-110 norm [19]. This process consists in the study of the linearity of the standardization range, the determination of the limits of detection and quantification, the calculation of the variation coefficient on tests of repeatability and reproducibility, as well as the calculation of the percentage of addition recovery measured.

2.4.2.1 Test of linearity

The linearity was tested between 0 and 125 µg / mL using 5 points of calibration: 0, 25, 50, 75 and 125 µg / mL, five distinct tests were carried out.

2.4.2.2 Limits of detection and quantification

The limits of detection (LD) and quantification (LQ) were calculated with the standards of the various required vitamins. Ten (10) distinct tests were carried out and the values were obtained with the following formulas:

LD = Average (MX) + 3 standard deviation

LQ = Average(MX) + 10 standard deviation

2.4.2.3 Test of repeatability and reproducibility

To test the repeatability, 10 trials of extract from a reference sample were analyzed by HPLC. For reproducibility, 5 separate tests sample from a reference sample were analyzed by HPLC at intervals of several days. The standard concentrations are 1 mg / mL.

2.4.2.4 Test of accuracy

Ten separate trials from reference samples were analyzed to assess the recovery rate by the method used for determination of vitamins. The standard concentrations are 5 mg / mL.

2.5 Estimate of Nutritive Supply at the Consumer

Vitamin supply have been estimated according to the method of the Codex Alimentarius that takes into account the concentrations in vitamins recovered in the food and the daily consumption of an adult individual of 70 kg (Table 2) of this food. These quantities of food are given by World Health Organization studies [20]. The contribution of this food in daily requirement has been calculated also from the values of daily recommended intakes [21].

Estimated Daily Intake (EDI) = C × Q

Contribution (%) = (EDI × 100) / DRI

With: **C**, Vitamin concentration measured; **Q**, food daily consumption; **DRI**, daily recommended intake.

Table 2. Main daily consumption of the studied food resources

Meal sources	Main consumption (g/day)
Tubers of *B. aethiopum*	< 6,02
Beans of *V. unguiculata*	15,07
Leaves of *M. oleifera*	0,7
Total consumption	21,79

2.6 Statistical Analysis

The data were recorded with Excel file and statistically treated with Statistical Program for Social Sciences (SPSS 22.0 for Windows). The statistical test consisted in a one-way analysis of variance (ANOVA) with the type of meal assessed basis. From each parameter, means were compared using Student Newman Keuls post-hoc test at 5% significance level. The software STATISTICA (STATISTICA version 7.1) used for an analysis in principal components (PCA) to determine the most discriminating variables. This analysis was carried out by considering the components whose eigenvalue is greater than or equal to 1, according to the Kaïser statistical rule.

3. RESULTS

3.1 Results of the Validation

The results of the validation are presented in Table 3. The coefficients of determination obtained for the study of linearity are between 0.996 and 0.999 for the various required vitamins. The limits of detection lie between 25 µg / L and 135 µg / L, whereas the limits of quantification vary from 83 µg/L with 449 µg/L. The coefficients of variation determined for the repeatability oscillate between 1.0±0.05% and 1.7±0.04% and those of the tests of reproducibility lie between 2.5±0.47% and 4.4±0.60%. As for the outputs of extraction of the proportioned additions, the rates are consisted between 96.8±0.14% and 100.5±0.07%.

3.2 Samples Vitamins Contents

The different samples contain statistically different levels of vitamins (P<0.001) (Table 4). Thus, ascorbic acid was the most abundant vitamin in the studied samples. The Palmyra flour provided the greatest vitamin C content to 26.71 mg / 100 g. The lowest vitamin C content is provided by moringa (17.61 mg / 100 g). B. aethiopum also had the highest vitamin B1 content, whereas *M. Oleifera* and *V. unguiculata* contain only few traces unquantifiable by the used method. However, the Moringa powder provided the highest levels of β-carotene (2450 ER/100 g), vitamin E (83.94 mg / 100 g), vitamin B2 (2.77 mg / 100 g), vitamin B6 (2.02 mg / 100 g) and vitamin B9 (0.55 mg / 100 g).On the other hand, 100 g of samples derived from Palmyra or Cowpea provide less than 650 ER of β-carotene and 0.4 mg of vitamins B2 and B9. Besides, the quantities of vitamins B6 and E of these two samples were unquantifiable (Table 4).

3.3 Estimated Daily Intake of Vitamins

The intakes of vitamin elements estimated of the foods analyzed are presented in Table 5. The vitamin C intake was estimated at 4.82 mg/day, with a higher value from the Cowpea beans powder (3.10 mg/day). The Palmyra flour provided a vitamin C intake lower at 1.61 mg/day and that of moringa was estimated at 0.12 mg/day. The daily intakes in vitamins B1 and B6 were significantly appreciated only in Palmyra new shoots and moringa leaves, with estimates of 0.02 mg/day and 0.01 mg/day respectively (Table 5). As for vitamin B2, the daily intake provided by the three dietary resources is 0.06 mg/day, with 0.03 mg/day for cowpea, 0.02 mg/day for moringa and less than 0.01 mg/day for Palmyra. Vitamin B9 provided a total daily intake of approximately 0.14 mg/day divided into 0.05, 0.004 and 0.1 mg/day provided by cowpea, moringa and Palmyra respectively.

Regarding fat-soluble vitamins, the vitamin E intake was only significantly expressed in moringa, with an estimate of 0.59 mg/day. The total intake in β-carotene was estimated at 123.73 ER mg/day, including 68.33 ER/day for cowpea, 16.67 ER/day for moringa and less than 38.33 ER/day for Palmyra.

3.4 Contribution of Estimated Daily Intake

In order to assess the share of the food studied, their contribution was evaluated and presented in Table 6. Thus, moringa and cowpea accounted for 63.75%, 27%, 5.37%, 4.92%, 3.57% and 0.8% of β-carotene, vitamins B9, C, E, B2 and B6 respectively of total dietary intake. The results show that the contribution of cowpea in β carotene (51.25%), vitamins B9 (25%), C (5.17%) and B2 (2.14%) is higher than that of moringa. On the other hand, moringa brings more vitamins E (4.92%) and B9 (0.71%) than cowpea (Table 6).

Table 3. Tests results of analytic validation of the HPLC vitamins dosage

Validation parameters		β-carotene	Vitamin E	Vitamin B_1	Vitamin B_2	Vitamin B_6	Vitamin B_9
Linearity	ESL	Y=326,6x+152,9	Y=836,2x-5800	Y=723,4x+1346	Y=4787x+7107	Y=550,9x+627,1	Y=942,4x-1615
	CD (R^2)	0.999	0.997	0.998	0.998	0.996	0.999
CV repeat (%)		1.5 ± 0,12	1,7 ± 0,04	1,3 ± 0,10	1,6 ± 0,94	1,0 ± 0,05	1,2 ± 0,21
CV reprod (%)		4,4 ± 0,60	3,1 ± 0,51	3,2 ± 0,98	3,6 ±0,22	2,8 ± 0,41	2,5 ± 0,47
EYAV (%)		98,7 ± 0,88	100,5 ± 0,07	97,3 ± 0,55	96,8 ± 0,14	97,7 ± 0,59	98,6 ± 0,44
LOD (ng/ml)		125 ± 0,69	98 ± 0,23	62 ± 0,17	54 ± 0,2 9	25 ± 0,38	33 ± 0,75
LOQ (ng/ml)		416 ± 0,25	326 ± 0,41	206 ± 1,09	179 ± 0,76	83 ± 0,47	109 ± 0,15

ESL, equation of standard lines; CD, coefficient of determination; CV repeat, coefficient of variation from repeatability test; CV reprod, coefficient of variation from reproducibility test; EYAV, extraction yield from added vitamins; LOD, limit of detection; LOQ, limit of quantification;

Table 4. Vitamins composition in samples of meals deriving from new shoots tubers of *Borassus aethiopum* Mart., leaflets of *Moringa oleifera* Lam., and beans of *Vigna unguiculata* Walp. (mg / 100 g)

Meal sources	Water-soluble vitamins					Fat-soluble vitamins	
	Vit C	Vit B_1	Vit B_2	Vit B_6	Vit B_9	β-Car (ER/100g)	Vit E
BAMF	26,71±0,72[a]	0,34±0,01[a]	0,13±0[b]	< 2,5.10[-3b]	0,16±0,00[c]	648,33±1,24[b]	< 9,8.10[-3b]
VUW	20,59±0,79[b]	< 6,2.10[-3b]	0,22±0,03[b]	< 2,5.10[-3b]	0,36±0,01[b]	450±0,14[c]	< 9,8.10[-3b]
MOL	17,61±0,79[c]	< 6,2.10[-3b]	2,77±1,72[a]	2,02±0,93[a]	0,55±0,03[a]	2450±0,41[a]	83,94±0,18[a]
F	109,18	1554,02	6,82	14,05	424,65	226,98	663383,04
p	**<0,001**	**<0,001**	**<0,001**	**<0,001**	**<0,001**	**<0,001**	**<0,001**

*From the same column, values differ statistically at P=5% according to the lowercase letter. **BAMF**, B. aethiopum fermented; **VUW**, V. unguiculata Walp; **MOL**, M. oleifera Lam; F, value of the Ficher statistical test of ANOVA; P-value, value of the ANOVA probability test. **Vit**, vitamin; **β-Car**, β-carotene;*

Table 5. Estimated daily intakes of vitamins provided by consumption of meals deriving with *Borassus aethiopum* Mart., leaflets of *Moringa oleifera* Lam., and beans of *Vigna unguiculata* Walp

Meal sources	Estimated intakes (mg/day) from an adult individual of 70 kg weight						
	water-soluble vitamins					fat-soluble vitamins	
	Vit C	Vit B_1	Vit B_2	Vit B_6	Vit B_9	β-Car (ER/j)	Vit E
BAMF	< 1,61	< 0,02	< 0,01	< 5.10^{-4}	< 0,1	< 38,33	< $1,96.10^{-3}$
VUW	3,10	< $3,1.10^{-3}$	0,03	< $1,25.10^{-3}$	0,05	68,33	< $4,91.10^{-3}$
MOL	0,12	< $1,44.10^{-4}$	0,02	0,01	0,004	16,67	0,59
Total	**4,82**	**0,02**	**0,06**	**0,01**	**0,14**	**123,73**	**0,6**

BAMF, fermented tuber of B. aethiopum Mart; VUW, V. unguiculata Walp; MOL, M. oleifera Lam; Vit, vitamin; β-Car, β-carotene

3.5 Multivariate Parameters

The Principal Components Analysis (PCA) was achieved with the F1 and F2 factors which support 93.82% of the total variability. F1 component expresses 78. 36% variance and F2 only 15.46% of variance. Thus, Fig. 1 shows that the grouping of moringa powder samples was superimposed to the fat-soluble vitamins (β-carotene and vitamin E) and vitamins B2, B6 and B9.The flour of Palmyra tubers is distinguished by the highest vitamins C and B1contents. The powder deriving from Cowpea presents values often intermediate to data from Palmyra and Moringa.

4. DISCUSSION

4.1 Validation Parameters

The R^2 determination coefficients got from the calibrations tests were close to 1, forecasting a quasi-linear estimation of the vitamin nutrients according to their concentration in the meals. Also, the lower coefficients of variation (<5%) resulting from reproducibility and repeatability translate quite stability of the HPLC chromatography technique used, which is as fitted as the full amount of each vitamin nutrient is revealed, as shown by the weak extraction defaults below 2.7% from the added vitamins. Thus, these characteristics highlight the reliability and precision of the outcomes in the vitamins contents determination using the HPLC chromatography technique.

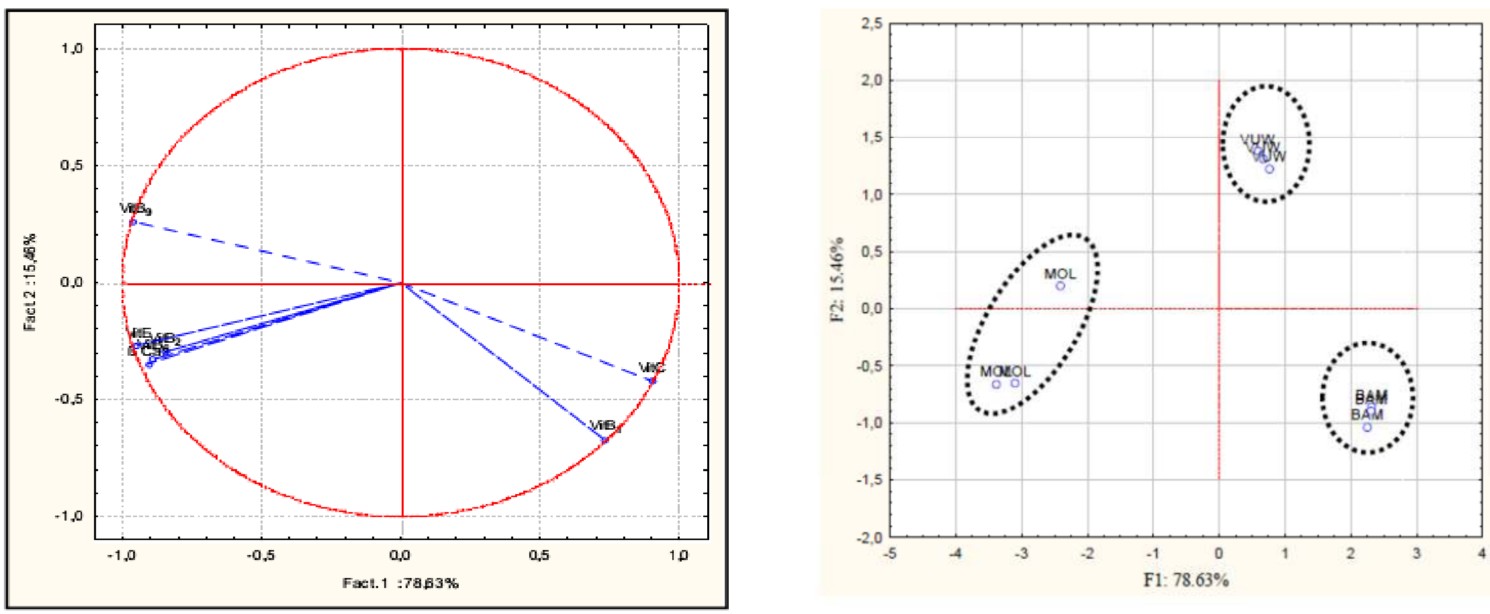
4.2 Vitamin Nutrients

The Moringa leaves have expressed the most important vitamins contents, including β-carotene, vitamins E, B2, B6 and B9. El-Massry et al. [16] found comparable amounts (2931.67 ER) of β-carotene within 100 g of Moringa. β-carotene is an inhibitor of free radicals, protective agent of the cellular membranes, skin, internal mucous membranes and eyes [22,23]. The deficiency in β-carotene remains a problem of public health which touches 19 million pregnant women in Africa [24]. The need in β-carotene is estimated at 800 µg / day in the pregnant women's [25]. Its prolonged deficiency can cause the paediatric blindness and of the severe infections often mortals in the children [26]. Moreover, to the difference of the Cowpea and Palmyra, 100 g of the powder deriving from Moringa contains 83.94 mg of vitamin E; in agreement with the estimates (77 mg) of Moyo et al. [27]. Vitamin E is an antioxidant implied in the protection of fabrics and the skin against oxidation and the infections [28]. It also protects the cells against the carcinogenesis [29]. Thus, a diet supplemented with moringa leaves powder could support the food safety with significant contribution to the β-carotene and vitamin E required for the populations. The vitamin C contents in the present study (17.61 to 26.71 mg / 100 g) seemed low and could be increased by the consumption of fruits and vegetables-leaves uncooked. Vitamin C is an essential cofactor in various biological reactions and an antioxidant in the aqueous phase [30]. This vitamin is implied in the iron absorption and the collagen formation, main protein of the connective tissue that protects various organs [22]. Of this fact, the vitamin C contained in the produced samples would contribute to reinforce the immune system and the children health. This study revealed the presence of vitamin B1 only in the Palmyra shoots flour, whereas the presence of this vitamin was reported by El Sohaimy et al. [31] in powder deriving from Moringa in Egypt. Various cultural conditions as climate, soil quality, and agronomical practices often consisting in application of natural or artificial manure could result in heterogeneous vitamin traits of the plants edible crops. Vitamin B1 has an essential role in many cellular functions, especially in the carbohydrates metabolism. The study shows most important source of vitamins B2, B6 and B9 with the powder of Moringa leaves probably due to the soft drying safe from the sun. Indeed, these vitamins are degradable, even to average temperature, as shown by their lower residual contents in samples of the Palmyra and Cowpea dried at 65℃. Vitamin B2 is important in the energy metabolism and vitamin B9 synthesis, itself implied in the vitamins C and B12 metabolism. Vitamin B9 is a basic component of the coenzymes of the synthesis of certain amino acids. It is essential in the formation of the globules red and necessary at the correct operation of the central nervous system [32]. This vitamin makes it possible to correct maternal anaemia [33]. As for vitamin B6, it is a coenzyme implied in the metabolism of proteins, the amino acids, glycogen, and the synthesis of the neurotransmitters and also contributes to the formation of antibody and the red globules [34]. Its deficiency, although rare, can however berelated to certain medicament us catches for inhibiting purpose on its biological activity [35].

Table 6. Daily vitamins recommended intakes and contribution of the food resources in their fitting

Meal sources	Vitamines hydrosolubles										Vitamines liposolubles			
	Vit C		Vit B_1		Vit B_2		Vit B_6		Vit B_9		β-Car		Vit E	
	DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr	DRI	Contr
BAMF	60	< 2,68	1,1	< 1,82	1,4	< 0,71	1,4	< 0,04	0,2	< 50	800*	< 4,79	12	< 0,02
VUW		5,17		< 0,28		2,14		0,09		25		8,54		< 0,04
MOL		0,2		< 0,01		1,43		0,71		2		2,08		4,92

*DRI, daily recommended intake (mg/day), * (ER/day) ; contr, contribution (%)*



(A) **(B)**

Fig. 1. Correlations drawn between the F1-F2 factorial design of the PCA and the vitaminic parameters (A) and samples (B) deriving from mealsof*B. aethiopum* M. (BAM), *V. unguiculata* W. (VUW) and *M. oleifera* L. (MOL)

Vit, vitamin; β-Car, β-carotene ; BAMF, fermented tuber of B. aethiopum Mart; VUW, V. unguiculata Walp; MOL, M. oleifera Lam

The daily food consumption from adult individuals in Africa is about 1018.1 g [20]. With such a consumption basis, the main daily intakes of Cowpea beans (15.07 g), Moringa leaves (0.7 g) and Palmyra tubers (< 6.02 g) remain lower, being in respective contribution of 1.48%, 0.07% and below 0.6% of the daily food consumption. Moringa and Cowpea which are considerable sources of vitamins cumulate 1.55% daily consumption. The high proportion of Moringa and Cowpea relative to the ration weight percentage (1.55%) could be explained by their richness in these vitamins. The Moringa nutritional interest is related to the leaves which have good minerals and vitamins properties [16]. Thus, the high contribution of cowpea to that of the Moringa may be due to the high consumption of Cowpeas compared to the Moringa. The increase in the consumption of these foods could provide more nutrients for populations.

5. CONCLUSION

The study showed more vitamins from powder of Moringa leaflets. The Cowpea beans powder has also considerable vitamin quality for fitting the minerals daily recommended intakes. Besides, the flour processed from Palmyra new shoots tubers is less provided in vitamins. The Moringa leaflets and Cowpea beans could be significantly used to address the recurring food safety concerns for the harshen populations. Such uses are able to promote the cultivation of these vegetable species, to protect the biodiversity, and to provide significant incomes. Results from this work would sustain formulation of composite floor containing Palmyra new shoot tubers and vegetables for their better valorization.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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