

Full Length Research Paper

Assessment of proximal, mineral composition and content of vitamin A and C of leaves and flowers from *Lippia multiflora* vegetable in Benin

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Lippia multiflora is a plant whose leaves and flowers are used as a food in Benin, so it is important to determine the nutritional properties of leaves and flowers of *L. multiflora*. Biochemical analyses for the determination of macronutrients, mineral salts and vitamins A and C on leaves and flowers of this leaf vegetable were done. The result indicates that the contents in leaves and flowers are, respectively: 5.44± 1.27 and 6.37± 1.61% for proteins, 13.17± 2.79 and 2.1 ± 0.54% for lipids, 0.46±0.09 and 12.53± 2.38% for carbohydrates, 19.65± 1.05 and 23.65± 0.46%, for fiber, 570±110.99 and 283.868± 26.64 mg/100 g for phosphorus, 2872± 371.13 and 2755.83± 427.7 mg/100g for calcium, 683.5±113.35 and 2755.83± 427.7 mg/100 g for magnesium, 2009.83± 167.12 and 1722± 94.55 mg/100 g for potassium, 57.25± 14.97 and 46.75± 6.36 mg/100 g for iron, 64.47±10.73 and 40.52 ± 8.47 mg/100 g for vitamin A, 3511.5±200.03 and 2778.83±444.66 mg/100 g for vitamin C. In conclusion, leaves and flowers of *L. multiflora* are rich in nutrients and could constitute for this population an important food supplement.

Key words: *Lippia multiflora*, nutritional properties, food supplement, Benin.

INTRODUCTION

Leaf vegetables constitute excellent contribution for diversification of human food (Agbankpé et al., 2014).

Indeed, they play an important role in food regimes of all world population, especially in Africa, Asia and Oceania,

where they assure essential part of nutritional and medicinal needs (Batawila et al., 2005; Vodouhè and Dansi, 2012; Akakpo and Achigan-Dako, 2019). These leaf vegetables contain micronutrients (vitamins, minerals) that contribute to human well-being (Food and Agriculture Organization, 1988; Rubaihayo, 1992; Achikanu et al., 2021). They are foods with high nutritional value because they contain carotenes (provitamin A), various B vitamins (thiamin, riboflavin, niacin), folic and folates acid, vitamin C, minerals and proteins (Stevens, 1990; Maundu, 2005; Soro et al., 2012; Melse-Boonstra, 2020). Recent nutritional studies carried out in Benin on some leafy vegetables showed that *Crassocephalum rubens* and *Crassocephalum crepidioides* are rich in nutrients and minerals and are very good sources of vitamin C (Adjatin et al., 2013). *Vernonia amygdalina*, *Crateva adansonii* and *Sesamum radiatum* are also rich in nutrients and mineral salts (Agbankpé et al., 2015). An ethnobotanical survey in Benin on LFTs revealed 187 plant species including *Lippia multiflora* which proved to be of major interest (Dansi et al., 2012; Djengue et al., 2017). *L. multiflora* is used in Benin like a nutritious food in addition to its medicinal value and possessing antibiotic, antidiabetic, anti-malarial, anti-diarrheal, antidiuretic properties and treats indigestion problems indigestion, headache and toothache, chicken pox, ulcer, fever, stress, hemorrhoids, anemia, dysentery, and epilepsy. It is also used as an aphrodisiac and laxative and is without risk of toxicity for consumers (Djengue et al., 2017).

In spite of its medicinal importance, its nutritional value is not known in Benin. Therefore, the aim of this study was to determine the nutritional properties of *L. multiflora* in order to stimulate interest in its use by raising awareness among the populations on its nutritional importance as a food. Specifically, it was about:

- (1) Assessing macronutrients content (water, lipids, carbohydrates, proteins, ash and fiber) of leaves and flowers;
- (2) Determinate mineral salts content and vitamins A and C of leaves and flowers.

MATERIALS AND METHODS

Samples collect and preparation

The samples (leaves and flowers) of *L. multiflora* were collected from six districts (Bantè, Dassa Zoumè, Djidja, Glazoué, Savalou and Savè) of central Benin. To prepare the samples, leaves and flowers of *L. multiflora* were washed thoroughly under running tap water followed by sterile distilled water, cut into smaller pieces and dried under shade for 9 days. The dried plant parts were ground

using electric blending machine and the powdery samples obtained were sieved using two sieves of 0.2 mm (mesh size) and stored in air tight sterile containers until needed. Chemical analyses were done on the powders of leaves and flowers for assessment of the following constituents: water, proteins, lipids, carbohydrates, fiber, ashes, mineral components (calcium, copper, iron, magnesium, manganese, phosphor, potassium, and sodium) and of vitamin A and C (Senga et al., 2013).

Determination of macronutrients content

Chemical analysis was carried out on powdered materials of leaves and flowers of *L. multiflora*. Analyses were made for: water, crude proteins, crude lipids, ashes, fibers and carbohydrates (Adjatin et al., 2013; Nair et al., 2012; Senga et al., 2013; Salma 2020). Crude protein was determined by using the Kjeldahl method (Nair et al., 2012; Salma, 2020). Water and crude lipids were determined according to the procedure of Association of Official Analytical Chemist (AOAC, 1990). The total crude fiber content of powders was determined using method described by Diallo et al. (2015). The percentage was calculated based on the dry weight. Ashes were determined after incineration in a muffle furnace following Bangash et al. (2011). Fehling's method was adopted to detect the presence of carbohydrates in leaves and flowers of leaf vegetable (EPSIC, 1999).

Determination of mineral composition

Mineral composition of samples was determined according to methods recommended by Association of Official Analytical Chemists (AOAC, 1990), Badau et al. (2013), and Kamal et al. (2021). The samples were incinerated in the oven at a temperature of 550°C for 3 h. The samples of *Lippia multiflora* were each digested using a mixture of concentrated Nitric (HNO₃), perchloric (HClO₄) and sulphuric (H₂SO₄) acids in the ratio 9:2:1 (v/v), respectively (Nair et al., 2012). Copper (Cu), iron (Fe), zinc (Zn), sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg) and manganese (Mn) were determined by Atomic Absorption Spectrophotometer (AAS) (PerkinElmer A Analyst 700, England). Phosphorus contents of the samples were determined using Flame photometer as specified in Alinnor and Oze (2011).

Dosage of vitamins

Dosage of provitamin A and Vitamin C

Provitamin A was assayed according to AOAC method (AOAC, 2005). The assay was performed with 1 mL of trifluoroacetic acid, using a Biomate 3 spectrophotometer at 620 nm. Vitamin C was assayed by the Camag TLC Scanner III densitometer according to the method of Nair et al. (2012).

Statistical analysis

ANOVA was performed to compare the 2 factors (zone and parts) and the interaction. Level of significance was set at 5% (p < 0.05). Quantitative data were processed using XSLTAT version 2015 and CATS 1.2softwares.

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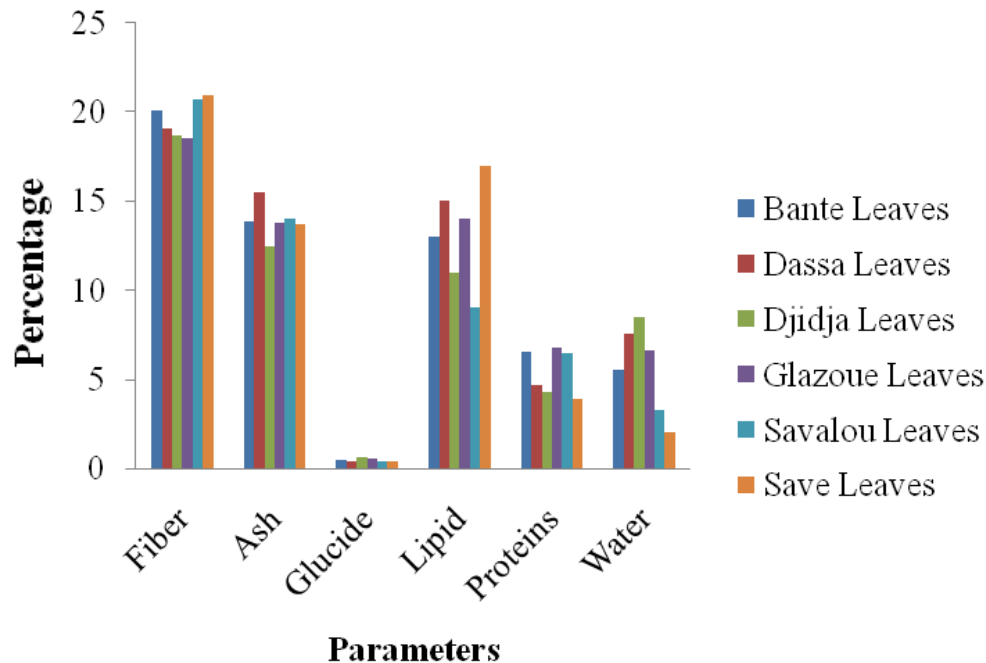


Figure 1. Proximal compositions of *L. multiflora* leaves from six areas.

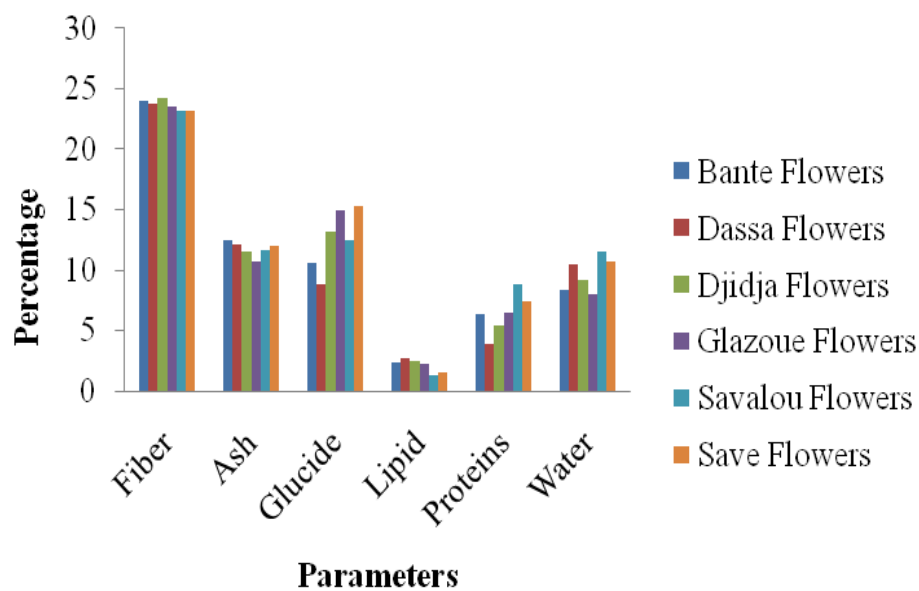


Figure 2. Proximal compositions of *L. multiflora* flowers from six areas.

RESULTS AND DISCUSSION

Proximal composition

Figures 1 and 2 show variations of proximal compositions of leaves and flowers of six areas (Bante, Dassa-Zoume, Djidja, Glazoue, Savalou and Save). Fiber content is

between 18.525 and 20.93% for leaves and 23.15 and 24.22% for flowers. Ash content is between 12.46 and 15.49% for leaves and 10.65 and 12.51% for flowers. That of carbohydrates is between 0.4 and 0.62% for leaves and 8.8 and 15.25% for flowers. Lipids content is between 0.9 and 1.7% for leaves and 1.3 and 2.7% for flowers. That of proteins is between 3.92 and 6.75% for

Table 1. Analysis of variance proximal composition of leaves and flowers from *L. multiflora* according to area collection.

Source	DF	Model	Zones	Parts	Zone*Part
		11	1	5	5
Fiber	MS	14.213	0.696	95.760	1.888
	F	18.886	0.925	127.238	7.282
	Pr > F	< 0.0001	0.490	< 0.0001	0.004
Ash	MS	5.250	1.723	27.255	0.976
	F	4.599	1.509	23.874	0.744
	Pr > F	0.005	0.242	0.000	0.608
Glucide	MS	129.412	6.403	873.868	6.139
	F	57.178	2.829	386.103	11.128
	Pr > F	< 0.0001	0.051	< 0.0001	0.001
Lipid	MS	111.412	9.011	734.827	7.971
	F	34.181	2.764	225.443	6.482
	Pr > F	< 0.0001	0.055	< 0.0001	0.006
Proteins	MS	5.181	6.184	5.245	2.925
	F	4.217	5.033	4.270	7.299
	Pr > F	0.008	0.006	0.055	0.004
Water	MS	17.712	4.569	101.106	12.118
	F	4.242	1.094	24.215	23.165
	Pr > F	0.008	0.401	0.000	< 0.0001

leaves and 3.84 and 8.8% for flowers. Finally, the water content is between 2 and 8.5% for leaves and 7.96 and 11.54% for flowers. We note that there is a variation of these parameters in leaves and flowers of one area to another. This variation could be explained by phenology or plant development stage. These results are similar to those reported in Ivory Coast by Kane et al. (2010) which have demonstrated there is a variation of these parameters on different types of soil.

Table 1 describes the significance of these different values. From these results, no significant difference ($p > 0.05$) was observed about water, lipid, carbohydrates, fiber, ash and sodium content by area. However significant difference ($p < 0.05$) was shown with protein content. In leaves and flowers of the same area, a significant difference ($p < 0.05$) was observed with fiber, ash, carbohydrates, protein, lipid and water. But the difference in protein content was not significant ($p < 0.05$). This significant difference could be due to used organs. Furthermore, Dougnon et al. (2012) showed that there is a significant difference in terms of proximal composition between *Solanum macrocarpon* leaves and fruits. With regard to interaction zone-part, the difference is significant ($p < 0.05$) for fibers, carbohydrates, proteins, lipids and water content but is not significant ($p > 0.05$) for

ash content.

Results on proximal composition revealed that leaves and fibers were most abundant followed by ash, lipids, water, proteins and carbohydrates (Table 2). In flowers, fibers are also most abundant followed by carbohydrates, ash, water, proteins and the least abundant elements are lipids. Thus, flower was richer in fiber, carbohydrates, protein and water than leaf while leaf was richer in ash and lipids.

The water contents of leaves and flowers of *L. multiflora* were 5.58 and 9.68%, respectively. These values were respectively less than 12 and 17% reported by Kane et al. (2010) and 20.36 and 36.82% according to Ekissi et al. (2011) in Ivory Coast. In addition, Ekissi et al. (2011) reported a water content of less than 19.86% in the flowers of this plant. This difference may be related to phenology. Moreover, these values were also lower than those reported by Adjatin et al. (2013) on *C. crepidioides* and *C. rubens*, Yameogo et al. (2011) on *Moringa oleifera* (73.90%). The differences observed between the results of this study and those of these authors could be due to the plant species used. The low content in water of leaves and flowers of *L. multiflora* indicates that this species would not be susceptible to microbial attack during storage and would not also be highly perishable

Table 2. Means of proximal composition of leaves and flowers from *Lippia multiflora*.

Parameter	<i>L. multiflora</i>	
	Leaves	Flowers
Water content	5.58 ± 2.35 ^b	9.68 ± 1.39 ^a
Total proteins (%)	5.44 ± 1.27 ^b	6.37 ± 1.61 ^a
Total lipids (%)	13.17 ± 2.79 ^a	2.1 ± 0.54 ^b
Carbohydrates (%)	0.46 ± 0.09 ^b	12.53 ± 2.38 ^a
Fibers (%)	19.65 ± 1.05 ^b	23.65 ± 0.46 ^a
Total ashes (%)	13.89 ± 1.25 ^a	11.76 ± 0.87 ^b

Number of repetitions n=3; significant difference $p \leq 0.01$.

(Pillai and Nair, 2013).

The average protein contents of leaves and flowers of *L. multiflora* are 5.44 and 6.37% g^{-1} , respectively of dry matter. According to the results reported by Kane et al. (2010) and Ekissi et al. (2011), the protein content of fresh leaves were lower than that of dry leaves with values of (8.05%; 8.75%) and (9.63%; 11.21%). In the same plant, the protein content in flowers was also lower (12.95%) according to Ekissi et al. (2011). These results are similar to those reported by Itoua et al. (2015) on *Phytolacca dodecandra* and different from those reported by Kouame et al. (2015) on *Myrianthus arboreus* with a protein content of 57.02%. Food plants whose protein content is more than 12% of caloric value are considered to be good sources of protein.

The total lipid contents in leaves and in dried flowers of *L. multiflora* were 1.32 and 2.1%, respectively. These values are lower than those reported by Adjatin et al. (2013) on *C. crepidioides* (3.45%) and *C. rubens* (2.75%), and Kouame et al. (2015) on leaves of *M. arboreus* (5.8%). A diet providing 1 to 2% of caloric energy as fat may be sufficient for humans because excess in fat consumption leads to cardiovascular disorders such as arteriosclerosis, cancer, and aging (Antia et al., 2006).

Fiber content in leaves and flowers were 19.65 and 23.65%, respectively. These values are higher than those reported by Adjatin et al. (2013) on *C. crepidioides* (8.18%) and *C. rubens* (7.95%), and Sodamade (2013) on *V. amygdalina* (10.46 mg/100 g). However, these values are lower than those reported by Ejoh et al. (2007) on *Gymnantheum amygdalinum* (25.47%) known as one of leafy vegetables particularly rich in fiber. *L. multiflora* is a very good source of dietary fiber and deserves more attention. Fiber is involved in digestion and reduces the risk of cardiovascular disease (Badau et al., 2013).

Studies have shown that increasing fiber intake may help reducing the incidence of some diseases such as diabetes, coronary heart disease, colon cancer, and various digestive disorders (Badau et al., 2013). Consuming fiber also softens the stool and lowers blood cholesterol levels in the body (Pillai and Nair, 2013).

Maintaining internal distension for normal peristaltic movement of the gastrointestinal tract is a physiological function provided by crude fibers. However, very high fibers content can cause intestinal irritation and decreased nutrient bioavailability (Pillai and Nair, 2012).

The average ash content was 13.89% for the leaves and 11.76% for the flowers of *L. multiflora*. These results are similar to those reported by Ekissi et al. (2011). However, Adjatin et al. (2013) and Kouamé et al. (2015) reported higher values on *C. crepidioides* (19.02%), *C. rubens* (19.76%) and *M. arboreus* (36%) while that Yaméogo et al. (2011) and Andzouana and Mombouli (2012) reported lower values on *M. oleifera* (11.10%) and *Ochthocharis dicellandroides* (4.19%). The high ash content is a reflection of the mineral salt content in the food. Further study would be needed to determine the types of mineral elements as they are essential for the functioning of tissues and necessary for daily needs.

The average carbohydrate content of *L. multiflora* was 0.46% for leaves and 12.53% for flowers. These results are similar to those reported in Ivory Coast by Kane et al. (2010). The leaves of *C. crepidioides* (42.22%), *C. rubens* (43.11%), *Talinum triangulare* (10.87%) and *O. dicellandroides* (11.73%) are relatively richer in carbohydrates than those of *L. multiflora* (Adjatin et al., 2013; Aja et al., 2010; Emebu and Anyika, 2011). Most vegetables are not generally good sources of carbohydrates. Some of them are richer while others contain trace (Andzouana and Mombouli, 2012), which means that *L. multiflora* is not a good source of carbohydrate.

Mineral and vitamins compositions

Figures 3 and 4 show variations of mineral and vitamins compositions of leaves and flowers of studied areas. The mineral elements (mg/100 g) in the leaves and flowers from Bantè, Dassa-Zoumè, Djidja, Glazoué, Savalou and Savè was as follows: phosphorus: leaves (from 393.3 to 723.9 mg) and flowers (from 243.07 to 318.4 mg), calcium: leaves (from 2494 to 3270 mg) and flowers

(from 1923 to 3270 mg), magnesium: leaves (from 513 to 860 mg) and flowers (from 424 to 620 mg), potassium: leaves (from 1748 to 2246 mg) and flowers (from 1620 to 1910 mg), sodium: leaves (from 49 to 92 mg) and flowers (from 25 to 52 mg), iron: leaves (from 41.85 to 85.92 mg) and flowers (from 39.26 to 56.72 mg), copper: leaves (from 1.86 to 4.8 mg) and flowers (from 1.1 to 1.25 mg) and manganese: leaves (from 5.98 to 9.8 mg) and flowers (from 3.6 to 5.1 mg). (Figures 3 and 4).

The provitamin A content varied from 54 to 79.6 mg/100 g in leaves and from 32.6 to 56.6 mg/100 g in flowers. Vitamin C content ranges from 2442 to 3521 mg/100 g in leaves and from 3248 mg/100 g to 3870 mg/100 g in flowers. This variation could be explained by phenology. These results are similar to those reported in Ivory Coast by Kouassi et al. (2013) on okra varieties. These authors have shown that there is a variation in magnesium, potassium, manganese and sodium contents depending on the growing areas.

The results in Table 3 show that the phosphorus, calcium, magnesium, potassium, iron, copper, manganese, provitamin A and vitamin C contents of leaves and flowers are significantly different between areas ($p < 0.05$). The difference between sodium contents were not significant ($p > 0.05$). These results differ from those reported in Ivory Coast by Kouassi et al. (2013). These authors have shown that there is no significant difference in magnesium, potassium, and manganese content of okra varieties by growing area. A significant difference ($p < 0.05$) between phosphorus, calcium, magnesium, potassium, sodium, iron, copper, manganese, provitamin A and vitamin C contents in leaves and flowers in the same area was observed. This significant difference could be due to the particular metabolism of these organs. In addition Dougnon et al. (2012) have shown that there is a significant difference in mineral and vitamin content between leaves and fruits of *S. macrocarpon*. In terms of zone-Organ interaction, the difference is significant ($p < 0.05$) for phosphorus, calcium, magnesium, potassium, sodium, iron, copper, manganese, provitamin A and vitamin C contents. This justifies that the contents of these minerals and vitamins were specific to the area in which the species were found.

The results presented in Table 4 show that *L. multiflora* was a leaf vegetable rich in provitamin A, vitamin C, and minerals. The main minerals found in leaves and flowers were calcium (Ca), potassium (K), magnesium (Mg), Iron (Fe), copper (Cu) and manganese (Mn). Sodium (Na) and phosphorus (P) were found in low quantity. Leaves were richer in provitamin A and minerals than the flowers. However, flowers were richer in vitamin C.

Calcium contents of leaves and flowers of *L. multiflora* were 2872 and 2755.83 mg/100 g, respectively. These values are higher than those reported by Agbankpé et al. (2015) on *V. amygdalina* (1180 mg/100 g), *C. adansonii* (2400 mg/100 g) and *S. radiatum* (1520 mg/100 g).

These values are also higher than those reported on *C. crepidioides* (1012 mg/100 g) by Adjatin et al. (2013) and lower than that of *C. rubens* (3845.88 mg/100 g) reported by the same authors. This leafy vegetable could then be considered as a potential source of calcium. Calcium is the most abundant mineral in body and is involved in blood clotting, muscle contraction, neurological function, bone and tooth formation (Senga et al., 2013). It is also an important factor in enzymatic metabolic processes (Karau et al., 2012).

The average phosphorus contents were 570 and 283.868 mg/100 g in leaves and flowers of *L. multiflora*, respectively. According to results reported by Agbankpé et al. (2015) as well as those reported by Adjatin et al. (2013), these contents are lower than those of *V. amygdalina* (873 mg/100 g), *C. adansonii* (693 mg/100 g), *S. radiatum* (650 mg/100 g), *C. crepidioides* (1039.2 mg/100 g) and *C. rubens* (1409 mg/100 g). The recommended daily intake of phosphorus for adults and children is 800 mg/day (Pillai and Nair, 2013). Phosphorus associated with calcium, helps strengthen bones and teeth, especially in children and nursing mothers (Andzouana and Mombouli, 2012). The phosphorus content obtained from leaves and flowers of *L. multiflora* is below the recommended norm. Therefore, *L. multiflora* is not a good source of phosphorus.

The average contents of potassium in leaves and flowers were 2009.83 and 1722 mg/100 g, respectively. These values are lower than those reported by Agbankpé et al. (2015) on *V. amygdalina* (4820 mg/100 g), *C. adansonii* (2810 mg/100 g) and Adjatin et al. (2012) on *C. crepidioides* (2291.86 mg/100 g) and *C. rubens* (4469.91 mg/100 g). Potassium is important in regulating heart rate, body water balance and neurotransmission (Alinnor and Oze, 2011). A high quantity of potassium in body increases iron use (Nair et al., 2012) and is beneficial for people taking diuretics to control high blood pressure (Nair et al., 2012).

The average magnesium content in leaves and flowers were 683.5 and 530.16 mg/100 g respectively. These values are higher than those reported by Agbankpé et al. (2015) on *C. adansonii* (670 mg/100 g) and *S. radiatum* (510 mg/100 g) as well as those reported by Adjatin et al. (2012) on *C. crepidioides* (336.46 mg/100 g) and *C. rubens* (434.13 mg/100 g). According to the results reported by Agbankpé et al. (2015), these values are lower than that of *V. amygdalina* (900 mg/100 g). The recommended dietary allowance for magnesium is 350 mg/100 g for adults and 170 mg/100 g for children. From these results, it emerges that *L. multiflora* is rich in magnesium and could meet the daily needs of adults and children. Magnesium is known to prevent cardiomyopathy, muscle degeneration, growth retardation, alopecia (premature hair loss), dermatitis, immune system dysfunction, gonad atrophy, impaired spermatogenesis, birth defects and coagulation disorders (Andzouana and Mombouli, 2012). According to Alinnor and Oze (2011),

Table 3. Analysis of variance of mineral and vitamins compositions of leaves and flowers from *L. multiflora* according to area collection.

Source	DF	Model	Zone	Part	Zone-Part
		11	1	5	5
Phosphor	MS	53796.780	15065.338	491227.984	15801.322
	F	295.261	82.685	2696.078	86.725
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Calcium	MS	321383.278	98962.167	80968.167	656005.367
	F	48.875	15.050	12.313	99.762
	Pr > F	< 0.0001	0.000	0.005	< 0.0001
Magnesium	MS	29510.500	13163.867	141066.667	29434.667
	F	169.306	75.523	809.318	168.871
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Potassium	MS	76032.042	38915.767	497088.167	44141.367
	F	30.828	15.779	201.552	17.898
	Pr > F	< 0.0001	0.000	< 0.0001	< 0.0001
Sodium	MS	860.389	61.500	6600.167	673.767
	F	15.938	1.139	122.260	12.481
	Pr > F	< 0.0001	0.396	< 0.0001	0.000
Iron	MS	319.610	505.527	661.343	129.246
	F	1487.064	2352.090	3077.058	601.347
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Copper	MS	3.221	1.520	22.885	1.635
	F	14719.773	6944.463	104571.224	7468.733
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Manganese	MS	8.249	2.690	73.395	2.429
	F	5732.348	1869.422	51001.511	1687.883
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Vitamin A	MS	471.755	304.974	3441.615	138.707
	F	226.229	146.249	1650.415	66.516
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Vitamin C	MS	506126.958	261735.067	3220802.667	308788.267
	F	34402.038	17790.437	218921.705	20988.698
	Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001

magnesium plays an essential role in calcium metabolism and in bone formation and is also involved in the prevention of diseases related to the circulatory system. It helps regulate blood pressure and insulin secretion.

Sodium is an important mineral that helps regulate blood flow and maintain electron potential in body tissues (Alinnor and Oze, 2011). The sodium content average in leaves and flowers were 68.83 and 35.66 mg/100 g,

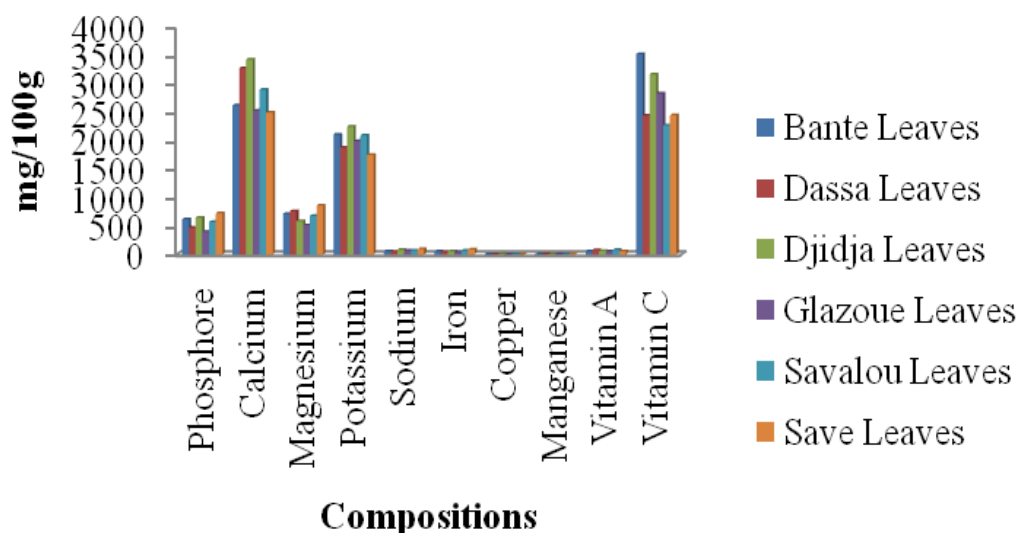
respectively. These contents are much lower than those reported by Adjatin et al. (2013) on *C. crepidioides* (2291.86 mg/100 g) and *C. rubens* (2921.04 mg/100 g). They are higher than those reported by Sanoussi et al. (2016) on *Ipomoea Batatas* (29 and 34 mg/100 g).

The average iron content was 57.25 mg/100 g in leaves and 46.75 mg/100 g in flowers of *L. multiflora* (Table 4). This content is much higher than that recommended by

Table 4. Average composition of mineral elements, provitamins A and vitamin C of leaves and flowers from *L. multiflora* in mg/100 g of dry matter.

Composition (mg)	<i>L. multiflora</i>		Norm/WHO
	Leaves	Flowers	
Phosphor (P)	570 ± 110.99 ^b	283.868 ± 26.64 ^a	800
Calcium (Ca)	2872 ± 371.13 ^b	2755.83 ± 427.7 ^a	800
Magnesium (Mg)	683.5 ± 113.35 ^b	530.16 ± 71.17 ^a	350
Potassium (K)	2009.83 ± 167.12 ^b	1722 ± 94.55 ^a	2000
Sodium (Na)	68.83 ± 16.09 ^b	35.66 ± 10.04 ^a	500
Iron (Fe)	57.25 ± 14.97 ^b	46.75 ± 6.36 ^a	10-15
Copper (Cu)	3.12 ± 1.16 ^b	1.66 ± 0.05 ^a	3
Manganese (Mn)	7.58 ± 1.37 ^b	4.09 ± 0.5 ^a	-
Ca/P	5.03 ^a	9.7 ^b	> 1
Na/K	0.034 ^b	0.02 ^a	< 1
Vitamin A	64.47 ± 10.73 ^b	40.52 ± 8.47 ^a	-
Vitamin C	2778.83 ± 444.66 ^a	3511.5 ± 200.03 ^b	-

Number of repetition n=3; significant difference $p \leq 0.01$.

**Figure 3.** Mineral and vitamins composition of *L. multiflora* leaves from six areas.

WHO, which is 10 to 15 mg/day (Senga et al., 2013).

According to Andzouana and Monbouli (2012), iron as a trace element plays many biochemical roles and is a fundamental element in the metabolism of almost all living organisms. In humans, iron is an essential constituent of several types of proteins and enzymes (Andzouana and Monbouli, 2012). It is important for the normal functioning of the central nervous system (Alinnor and Oze, 2011) and facilitates the oxidation of carbohydrates, proteins and lipids. Iron is necessary for formation of hemoglobin contained in blood and is an important component in diet of pregnant women, nursing mothers, infants and the elderly who often suffer from

anemia and other illnesses related to blood (Alinnor and Oze, 2011).

The average copper content was 3.12 mg/100 g in leaves and 1.66 mg/100 g in flowers. Copper content in leaves is higher than that reported by Adjatin et al. (2013) on *C. crepidioides* (1.4 mg/100 g) and *C. rubens* (2.6 mg/100 g). Copper is necessary for enzymes production and electrons transport in body (Alinnor and Oze, 2011).

The average manganese content was 7.58 mg/100 g in leaves and 4.09 mg/100 g in flowers. These values are lower than those reported by Adjatin et al. (2013) on *C. crepidioides* (7.7 mg/100 g) and *C. rubens* (8.22 mg/100 g). Manganese is a trace element that plays an important

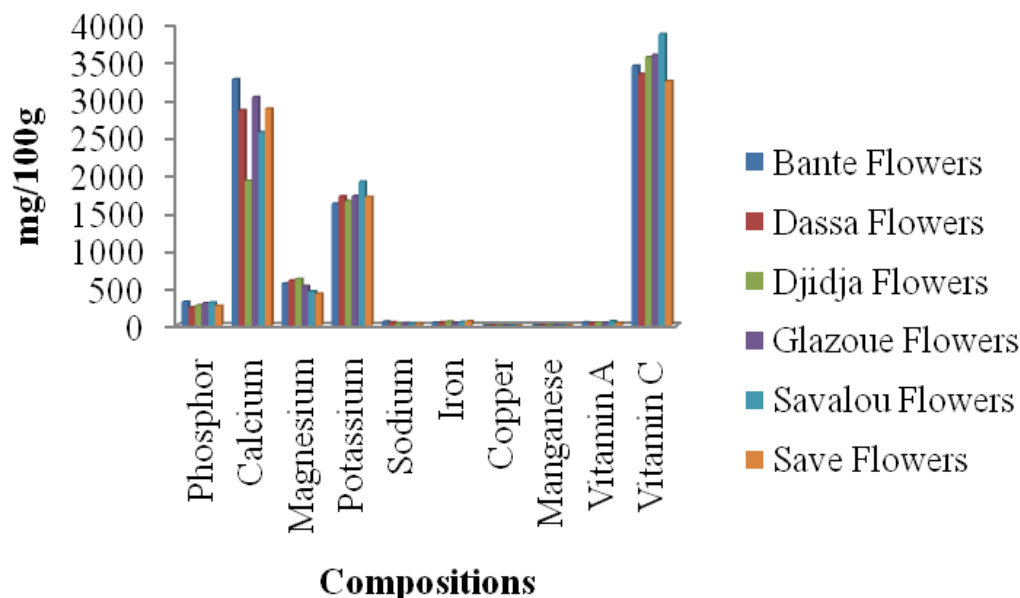


Figure 4. Mineral and vitamins composition of *L. multiflora* flowers from six areas.

role in synthesis of bones, amino acids and metabolism of carbohydrates. It contributes to the proper functioning of thyroid gland and serves to heal inflammation and sprains (Erikson et al., 2005). Manganese deficiency can lead to problems with infertility, diabetes, and joint pain. It is an antioxidant which protects body against damage caused by free radicals. Despite its essential character, the accumulation of manganese in blood is toxic to central nervous system (Sidoryk and Aschner, 2013).

The value of Ca/P ratio was, respectively 5.03 and 9.7 for leaves and flowers. According to Adeyeye and Aye (2005) and Alinnor and Oze (2011), a Ca/P ratio greater than 2 helps to increase the absorption of calcium in small intestine. Diet is considered good if Ca/P ratio is greater than 1 and poor if the ratio is less than 0.5. Therefore, *L. multiflora* appears to be a good source of food. Furthermore, Na/K ratio of leaves and flowers were, respectively 0.034 and 0.02. Alinnor and Oze (2011) reported that Na/K ratio promotes blood pressure control and a Na/K ratio less than 1 lowers blood pressure. So *L. multiflora* could be used as a food to treat or prevent blood pressure problems.

The results of Table 4 have shown that the average of provitamin A content was 64.47 mg/100 g in leaves and 40.52 mg/100 g in flowers. These values are higher than those reported by Millogo-Koné et al. (2010) on *M. oleifera* leaves (39 mg/100 g) and lower than those reported by Tchiégang and Aissatou (2004) on *Hibiscus cannabinus* (60 mg/100 g) and *Cerathotheca sesamoides* (90 mg/100 g). Vitamin A is involved in the synthesis of bones, teeth, hair and reproduction (Wardlaw and Kessel, 2002). It is mainly involved in the processes of vision maintenance, regulation of gene expression and cell

differentiation (Herrero et al., 2012). According to Vanisha et al. (2008), the vitamin A requirements for an adult weighing 70 kg are 1000 µg/d which means that *L. multiflora* could be considered as a potential source of provitamin A.

The average vitamin C content was respectively 2778.83 and 3511.5 mg/100 g in leaves and flowers of *L. multiflora*. These values are much higher than those reported by Millogo-Koné et al. (2010) on *M. oleifera* (210 mg/100 g), *C. crepidioides* (9.17 mg/100 g) and Adjatin et al. (2013) on *C. rubens* (3.60 mg/100 g). According to Tchiégang and Aissatou (2004), these values are less than 4590 mg/100 g in *T. triangulare* and 4920 mg/100 g in *Vigna unguiculata*. Daily vitamin C requirements vary between 40 and 90 mg/day (Vanisha et al., 2008). So this leafy vegetable would be a very good source of vitamin C. Vitamin C plays an important role in maintaining good health and preventing disease. It has immunostimulating, anti-allergic and antioxidant effects and protects the cardiovascular system and eyes. Vitamin C is necessary for the synthesis of collagen, the intercellular substance that provides the structure of muscles, vascular tissues, bones, tendons and ligaments (Olayinka et al., 2012).

Conclusion

The results of this work provided data on the nutritional composition of leaves and flowers of *L. multiflora* in Benin. Leaves and flowers of *L. multiflora* are rich in fiber, ash, calcium, magnesium, potassium, copper and especially iron, provitamin A and vitamin C. So this plant

is a good source of nutrients. So it is important to use it in improving the health status of populations and in the fight against malnutrition.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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