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Impact of Water Cooking on Nutritive Characteristics of *Justicia galeopsis* Leaves Consumed in Côte d'Ivoire

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A B S T R A C T

This study aimed at determining the effect of cooking time on nutritive characteristics of *Justicia galeopsis* leaves. *J. galeopsis* leaves were collected from cultivated farmlands located at Abobo and boiled at 100 °C respectively during 30, 45 and 60 min. Then, nutrients and antinutrients compositions were investigated using standard methods. Some molar ratios between antinutrients and mineral were also calculated and mineral bioavailability predicted. The results revealed that longer time of cooking (higher than 30 min) led to 5-14 % drop in protein level, 21-36 % in ash, 95-97 % in Vitamin C, 4-42 % in polyphenol, 19-63 % in flavonoids, 18-59 % in tannin, 10-46 % in oxalate and 12-34 % reduction in phytate content in *J. galeopsis* leaves. However, cooking improved lipids contents to 12-13 %, carbohydrate 6-11 %, fiber 13-44 %, and the mineral bioavailability with iron, zinc, calcium and magnesium. Further more, *J. galeopsis* leaves boiled during 30 min had the highest residual contents in proteins (13,33 %), lipids (2.24 %), ashes (12.33 %), carbohydrates (72.09 %), phosphorus (16.83 g/kg), potassium (314.75 g/kg), calcium (30.66 g/kg), magnesium (5.20 g/kg), sodium (10.58 mg/kg), iron (458.98 mg/kg), polyphénols (79.91 mg EAG/100 g), flavonoïds13.39 mg EQ/100 g), tannins (54.44 mg EC/100 g). The recommended cooking time of *J. galeopsis* leaves must be less than 30 min in order to contribute efficiently to the recovery of anemic patients and the food security of Ivorian population.

Introduction

The interest in plant foods has increased following epidemiological studies relating eating habits and the prevalence of certain diseases (cancers, obesity, cardiovascular diseases). Salkeld (1991) reports that, according to epidemiologists, 25 to 60 % of cancers could be prevented by modifying eating habits. The main nutritional interest of vegetables lies in their supply of minerals, vitamins and dietary fiber. Leafy vegetables constitute essential components of human diet in Africa generally and particularly in West Africa (Kubmarawa *et al.,* 2009). They provide more minerals than other vegetables. Their daily consumption allows a satisfactory dietary balance. In addition to their nutritional importance, leafy vegetables are considerable economic and social interest because of their relatively low cost and the ease and speed of their preparation (Gupta and Wagle, 1988).

Justicia galeopsis T. Anderson ex C.B. Clarke belongs to leafy vegetables family. It has been discovered in Côte d'Ivoire by Yao *et al* (2014). The *Justicia galeopsis* leaves are known for mainly its medicinal purpose and its high amount of total phenolics. In Abengougou Division, all the population has already consumed the leaves of this plant (Loukou *et al.*, 2018).

According to Loukou *et al.* (2018), *J. galeopsis* fresh leaves are very nutritive. They could help cover people's nutritional needs and contribute to food security. These leaves were very rich in fiber (33.85 %), protein (21.11 %), vitamin B12 (4173.09 mg/kg) and vitamin C (892.17 mg/kg of fresh leaf) but low in fat (4.06 %). The mineral elements contents were high (17.76%) with remarkable amount of potassium (103.08 g/kg), phosphorus (77.66 g/kg), calcium (59.87 g/kg), sodium (28.30 g/kg), iron (373.01 mg/kg), zinc (177.84 mg/kg) and manganese (128.57 mg/kg). Despite the presence of phytate (33.83 mg/100g), oxalate (740.67 mg/100g) and tannin (66.33 mg/100g), the calcium, zinc, iron and magnesium in this plant have a high bioavailability.

In Côte d'Ivoire, more than twenty (20) species of leafy vegetables like *Justicia galeopsis* leaves are consumed by populations through confectionary soups using boiling or blanched processing (CNRA, 2011) like *Justicia galeopsis* leaves. Cooking vegetables improves digestibility by changing the structure of dietary fiber. However, it also causes a more or less marked decrease in the nutritional value, either by defusing water-soluble constituents in the cooking water, or by destruction of thermolabile and / or oxidizable substances. Losses are generally higher for leafy vegetables than for roots and tubers. They increase with the volume of water used and the duration of cooking (Causeret, 1986).

Several works and reports have revealed that cooking or preparation methods and period of cooking may affect the nutritional value as well as the bioavailability of many nutrients in leafy vegetables (Gupta and Bains, 2006; Leskova *et al.*, 2006). However, the literature does not mention nutritional value of cooked leaves of *Justicia galeopsis* leaves.

The aim of this work was to assess the effect of cooking on the physicochemical and nutritive properties of *Justicia galeopsis* leaves in order to as certain its nutritional suitability as well as health benefits.

Materials and Methods

Sampling

Justicia galeopsis leaves, commonly known in the local language "Agni" as *Assiaploua* were collected fresh and at maturity from cultivated farmlands located at Abobo. Abobo is one of thirteen communes of the district of Abidjan, Côte d'Ivoire. It is located in Abidjan north between 5°42 north latitude and -4°02 west longitude and at an altitude of105 meters above sea level (Aka *et al.*, 2013). Plants were identified and authenticated by National Floristic Center (University Felix Houphouët Boigny, Abidjan-Côte d'Ivoire).

Samples processing

The fresh leaves were destalked, washed with distilled water, drained at ambient temperature. Collected leaves were divides into four lots. The first lot is that of the fresh leaves. An amount of fresh leaves was mixed with water in the proportion described by Agbemafle *et al*. (2012) such 40 g of leafy vegetables for 200 mL of water. Then, the mixture was lyophilized. The other three lots were cooked at 100 °C respectively during 30, 45 and 60 min by using the method of Randrianatoandro (2010) in the proportion 40 g of leafy vegetables immerged in 200 mL of boiled water. Boiled samples were cooled, ground with a laboratory crusher (Culatti, France) and also lyophilized. All lyophilized samples were ground again in fine powder and store in a clean dry air-tight bottle in a refrigerator (4°C) until required for analyses.

Nutritive characterization

Proximate composition analysis

Moisture, ash, proteins, and lipids were determined by AOAC method (AOAC, 1990). Total fiber content was determined using Weende method (Wolf, 1968). The amount of carbohydrates was determined by difference using FAO method (FAO, 1998) as follows:

% Carbohydrates = 100 – (% moisture + % proteins + % lipids + % ash). Total sugar was determined by Dubois *et al.* (1956). The amount of reducing sugars was estimated by the method of Bernfeld (1955).

Minerals and Vitamin C determination

Mineral content was estimated by dry ashing of dried powdered sample (5 g) in a muffle furnace (Pyrolabo, France). Ash obtained was dissolved in 5 mL of HCl/HNO and analyzed using the atomic absorption spectro-photometer (AAS model, SP9). The studied minerals were calcium (424.7 nm), magnesium (285.2 nm), phosphorus (178.2 nm), potassium (766.5 nm), sodium (589.6 nm), iron (248.3 nm)**,** and zinc (213.9 nm).

The amount of vitamin C in analyzed samples was determined by titration using the method described by Pongracz *et al.* (1971). About 10 g of ground fresh leaves were soaked into 40 mL metaphosphoric acid-acetic acid (2 %, w/v) for 10 min. 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 with dichlorophenol-indophenol (DCPIP) 0.5 g/L.

Polyphenolic compounds, tannins and flavonoids determination

Polyphenols were extracted and determined by the method described by Singleton et al (1999) using Folin–Ciocalteu's reagent. A quantity (1 g) of lyophilized sample was soaked in 10 mL of methanol 70 % (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin–Ciocalteu's reagent and neutralized by 1 mL of 20 % (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at ambient temperature and absorbance was measured at 745 nm by using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve of gallic acid (1 mg/mL) as standard.

Tannins of samples were quantified according to Bainbridge *et al.* (1996). In a test tube, 1 mL of the methanolic extract was mixed with 5 mL of vanillin reagent. The mixture was incubated in obscurity at ambient temperature for 30 min. There after, the absorbance was read at 500 nm by using a spectrophotometer (PG Instruments, England). Tannins content of samples was estimated using a calibration curve of tannic acid (2 mg/mL) as standard.

The total flavonoids content was evaluated using the method reported by Meda *et al.* (2005). In a test tube, 0.5 mL of the methanolic extract was mixed with 0.5 mL methanol, 0.5 mL of aluminium chloride (10%,w/v), 0.5 mL of potassium acetate (1 M) and 2mL of distilled water. The mixture was incubated in obscurity at ambient temperature for 30 min. Then, the absorbance was measured at415 nm by using a spectrophotometer (PG Instruments, England). The total flavonoids were determined using a calibration curve of quercetin (0.1 mg/mL) as standard.

Oxalates and phytates determination

Oxalates content was performed using a titration method of Day and Underwood (1986). One (1) g of lyophilized sample was weighed into 100 mL conical flask. A quantity of 75 mL of sulphuric acid (3 M) was added and stirred for 1 h with a magnetic stirrer. The mixture was filtered and 25 mL of the filtrate was titrated while hot against KMnO solution (0.05 M) to the end point (persistent pink).

Phytates contents were determined using the Wade's reagent colorimetric method of Latta and Eskin (1980). A quantity (1 g) of lyophilized sample was mixed with 20 mL of hydrochloric acid (0.65 N) and stirred for 12 h with a magnetic. The mixture was centrifuged at 12000 rpm for 40 min. An aliquot (0.5 mL) of supernatant was added with 3 mL of Wade's reagent. The reaction mixture was incubated for 15 min and absorbance was measured at 490 nm by using a spectrophotometer (PG Instruments, England). Phytates content was estimated using a calibration curve of sodium phytate (10 mg/mL) as standard.

Determination of molar ratio of antinutrients to minerals

The molar ratio between antinutrient and mineral was obtained after dividing the mole of antinutrient with the mole of mineral (Woldegiorgis *et al.,* 2015). The mole of antinutrients and minerals was determined by dividing the weight of antinutrients and minerals with its atomic weight (phytate: 660 g/mol; Oxalate: 90 g/mol; Fe: 56 g/mol; Zn: 65 g/mol; Ca: 40 g/mol; mg: 24 g/mol).

Cooking losses of nutrients

The losses of nutrients during cooking were calculated using the following equation (1):

$$\text{Cooking losses (\%)} = \frac{\text{Nutrient content in cooked leaves - Nutrient content in fresh leaves}}{\text{Nutrient content in fresh leaves}} \text{ X } 100$$

Statistical Analysis

All chemical analyses data were statistically analyzed by one-way analysis of variance (ANOVA). Means were compared by HSD test. The analyses were performed using the R statistical package (R Development Core Team, 2011).

Results and Discussion

Proximate composition

The results of proximate composition of uncooked and cooked *Justicia galeopsis* leaves are shown in Table 1. The cooking had significant effect on the proximate composition of *Justicia galeopsis* leaves. The quantity of protein and ash in *Justicia galeopsis* leaves decreases with the increase in boiling time. High proteins and ash contents were observed in the leaves cooked during 30 minutes. Losses of protein and ash in *Justicia galeopsis* leaves were observed after 30 minutes of water cooking. These losses increase up to 14.20 % for proteins and 36.18 % for ashes. Lipid content increase with the increase in boiling time until it reached a maximum (2.2 %) for leaves cooked during 30 and 45 min and then decreased. The gain increases up to 12.25 %. The fiber and carbohydrate contents increase with the increase in boiling time. The lowest level of these nutrients was observed when the leaves are cooked during 30 minutes. For these nutrients, nutrients gain was observed.

Minerals and Vitamin C determination

The results of minerals and vitamin C composition of raw and cooked *Justicia galeopsis* leaves are shown in Table 2. Cooking had significant effect on the leaves of this plant.

When compared with the uncooked leaves, cooking resulted in significant decrease in phosphorus (11.88 to 26.02 %), potassium (5.84 to 11.05 %), magnesium (14.75 to 32.13 %), sodium (6.21 to 18.35 %) and vitamin C (94.75 to 96.84 %).The losses in these micronutrients increase with the increase in boiling time. But the lowest loss percentages (11.88 % for phosphorus, 5.84 % for potassium, 14.75 % for magnesium, 6.21 % for sodium and -94.75 for vitamin C) were observed when the leaves were cooked during 30 minutes.

Compared to fresh leaves, a significant increase had been observed in the calcium (32.84 %), iron (0.84 %) and zinc (6.87 %) content when *Justicia galeopsis* leaves were cooked during 30 minutes. Thus, the highest content of these minerals was revealed after 30 minutes of cooking (30.66 g/kg of calcium, 458.98 mg/kg of iron, and 160.33 mg/kg of zinc). However, these contents decreased after 45 and 60 minutes of water cooking.

Polyphenolic compounds, tannins and flavonoids

Results obtained from the determination of polyphenolic compounds, tannins and flavonoïds content in *Justicia galeopsis* leaves showed that cooking decreased significantly these compounds (Table 3).

Fresh leaves polyphenolic compounds (83.00 mg EAG/100 g), tannins (16.57 mg EG/100 g) and flavonoids (66.33 mg EC/100 g) were higher than those of cooked leaves. Among the cooked leaves, those cooked during 30 minutes contained the highest amounts of polyphenolic compounds (79.91 mg EAG/100 g), flavonoids (13.39 mg EG/100 g) and tannins (54.44 mg EC/100 g).

The loss percentages increase up to42.24 % for polyphenolic compounds, 62.70 mg % for flavonoids and 58.65 % for tannins when the leaves are cooked during 60 minutes.

Oxalates and phytates determination

Results of antinutrient factors contents of *Justicia galeopsis* uncooked and cooked leaves are indicated in Table 4. These results had showed that cooking time significantly decrease oxalates and phytates levels in *Justicia galeopsis* leaves. The uncooked leaves and the leaves cooked during 30 minutes were presented the highest amount of oxalates (740.67 and 667.33 mg/100 g) and phytates (33.83 and 29.83 mg/100 g). The loss percentages increase up to 45.55 % for oxalates, and 33.55 % for phytates when the leaves are cooked during 60 minutes.

Molar ratio of antinutrients to minerals

The molar ratios between antinutrients and minerals of uncooked and cooked *Justicia galeopsis* leaves were showed in Table 5. The results indicated that molar ratio of [Phytate]/[Fe] (0.04 to 0.06), [Phytate]/[Zn] (0.17 to 0.22), [Phytate]/[Ca] (0.0 to 0.0), [Ca][Phytate]/[Zn] (0.08-0.14), [Oxalate]/[Ca] (0.09 to 0.14) and [Oxalate]/[(Ca + Mg)] (0.11 to 0.18) for *J. galeopsis* leaves were low compared with their corresponding critical value.

Table.1 Proximate composition of uncooked and cooked *Justicia galeopsis* leave

Parameters	Cooking times			
	CT_0	CT_{30}	CT_{45}	CT_{60}
Protein (%)	14.08 ± 0.52**a**	13.33 ± 0.29**ab**	12.75 ± 0.00**bc**	12.08 ± 0.14**c**
Loss after cooking(%)		-5,33	-9.45	-14.20
Lipid (%)	2.00 ± 0.04**b**	2.24 ± 0.10**a**	2.25 ± 0.00**a**	2.00 ± 0.01**b**
Loss after cooking(%)		12	12.5	0
Ash (%)	15.67 ± 1.15**a**	12.33 ± 0.58**b**	10.00 ± 0.00**c**	10.00 ± 0.00**c**
Loss after cooking(%)		-21.31	-36.18	-36.18
Carbohydrate (%)	68.25 ± 0.64**c**	72.09 ± 0.5**b**	75.00 ± 0.00**a**	75.92 ± 0.14**a**
Loss after cooking(%)		5.63	9.89	11.24
Fibers (%)	30.00 ± 0.86**d**	33.83 ± 0.29**c**	38.67 ± 0.29**b**	43.33 ± 1.04**a**
Loss after cooking(%)		12.77	28.90	44.43

Data are represented as means ± SD (n=3). Different letters within the same line indicate significant differences among cooking times (P <0.05)

Table.2 Minerals and vitamin composition of uncooked and cooked *Justicia galeopsis* leaves

Parameters	Cooking times			
	LC_0	LC_{30}	LC_{45}	LC_{60}
Phosphorus (g/kg)	19.10 ± 0.00**a**	16.83 ± 0.06**b**	16.13 ± 0.11**c**	14.13 ±0.06**d**
Loss after cooking (%)		-11.88	-15.55	-26.02
Potassium (g/kg)	334.28 ± 7.04**a**	314.75 ± 1.01**b**	304.41 ±0.36**c**	297.33 ± 1.93**c**
Loss after cooking (%)		-5.84	-8.94	-11.05
Calcium (g/kg)	23.08 ± 0.08**b**	30.66 ± 0.01**a**	22.22 ± 0.01**c**	20.22 ± 0.02**d**
Loss after cooking (%)		32.84	-3.73	-12.39
Magnesium (g/kg)	6.10 ± 0.03**a**	5.20 ± 0.05**b**	4.14 ± 0.03**c**	4.27 ± 0.08**c**
Loss after cooking (%)		-14.75	-32.13	-30.00
Iron (mg/kg)	455.17 ± 0.01**b**	458.98 ± 0.01**a**	453.93 ± 0.01**c**	453.63 ± 0.01**d**
Loss after cooking (%)		0.84	-0.27	-0.34
Zinc (mg/kg)	150.02 ± 0.09**b**	160.33 ± 0.04**a**	135.41 ± 0.05**b**	132.23 ± 0.01**b**
Loss after cooking (%)		6.87	-9.74	-11.86
Sodium (mg/kg)	11.28 ± 0.01**a**	10.58 ± 0.01**b**	9.36 ± 0.01**c**	9.21 ± 0.01**d**
Loss after cooking (%)		-6.21	-17.02	-18.35
Vitamin C (mg/100g)	90.47 ± 0.54**a**	4.75 ± 1.60**b**	3.80 ± 1.62**b**	2.86 ± 0.03**b**
Loss after cooking (%)		-94.75	-95.80	-96.84

Data are represented as means ± SD (n=3). Different letters within the same line indicate significant differences among cooking times (P <0.05)

Table.3 Antioxydants composition of uncooked and cooked *Justicia galeopsis* leaves

Parameters	Cooking times			
	LC_0	LC_{30}	LC_{45}	LC_{60}
Polyphenols (mg EAG/100 g)	83.00 ± 2.29**a**	79.91 ± 0.52**a**	64.48 ±0.00**b**	47.94 ± 0.29**c**
Loss after cooking (%)		-3.72	-22.31	-42.24
Flavonoids (mg EQ/100 g)	16.57 ± 0.80**a**	13.39 ± 0.25**b**	8.46 ± 0.32**c**	6.18 ± 0.32**c**
Loss after cooking (%)		-19.19	-48.94	-62.70
Tannins (mg EC/100 g)	66.33 ± 2.31**a**	54.44 ± 2.41**b**	41.55 ± 0.35**c**	27.43 ± 2.31**d**
Loss after cooking (%)		-17.93	-37.36	-58.65

Data are represented as means ± SD (n=3). Different letters within the same line indicate significant differences among cooking times (P <0.05)

Table.4 Antinutrients composition of uncooked and cooked *Justicia galeopsis* leaves

Parameters	Cooking times			
	LC_0	LC_{30}	LC_{45}	LC_{60}
Oxalates (mg/100 g)	740.67 ±12.70**a**	667.33 ± 12.70**b**	440.00 ± 0.00**c**	403.33 ± 12.70**d**
Loss after cooking (%)		-9.90	-40.59	-45.55
Phytates (mg/100 g)	33.83 ± 2.45**a**	29.83 ± 0.35**b**	26.07 ±0.77**c**	22.48 ± 0.63**d**
Loss after cooking(%)		-11.82	-22.94	-33.55

Data are represented as means ± SD (n=3). Different letters within the same line indicate significant differences among cooking times (P <0.05)

Table.5 Molar ratio between phytate and minerals, oxalate and minerals

Parameters	Cooking times				Critical level
	LC_0	LC_{30}	LC_{45}	LC_{60}	
Antinutrient/mineral ratio					
[Phytate]/[Fe]	0.06	0.06	0.05	0.04	0.4
[Phytate]/[Zn]	0.22	0.18	0.19	0.17	<1.5
[Phytate]/[Ca	0.00	0.00	0.00	0.00	0.5
[Ca][Phytate]/[Zn	0.13	0.14	0.11	0.08	<0.5
[Oxalate]/[Ca]	0.14	0.10	0.09	0.09	2.5
[Oxalate]/[(Ca + Mg)]	0.18	0.13	0.11	0.12	2.5

Fe: iron; Zn: Zinc, Ca: calcium; Mg: magnesium

The quantity of protein and ash in *Justicia galeopsis* leaves had decrease with the increase in boiling time with high proteins and ashes contents in the leaves cooked during 30 minutes. Comparatively, *J. galeopsis* leaves cooked during 30, 45 and 60 min had a higher protein and ash content than the sweet potato (1.9 and 0.6 %), spinach Ceylon (1.6 and 1.5 %) edible hibiscus (3.4 and 1.1 %) and cassava (3.9 and 1.1 %) cooked leaves (WHO, 2004).This makes the leaves of this plant a good source of protein, essential for the synthesis of body tissues and regulatory substances such as enzymes and hormones (Vaughan and Judd, 2003).

Lipid content of cooked leaves had reached a maximum of 2.2 %. This content was higher when compared to those cited by WHO (2004) such as the sweet potato leaves (0.7 %), spinach Ceylon (0.1 %), edible hibiscus (0.8 %) and cassava leaves (1.1 %).The fat in this plant are far better than those mentioned in animal fat such as lard, butter and beef fat (Estelle and Karen, 1999).A diet including *J. galeopsis* should be more palatable than that of green leafy vegetables mentioned above because dietary fats enhance palatability by absorbing and retaining flavors and by influencing the texture of foods (Press, 1985).

The crude fiber content of cooked *J. galeopsis* leaves was higher than that of sweet potato leaves (3 %), spinach Ceylon (3.7 %) and cassava leaves (4.6 %). This makes it a more favorable vegetable since high fiber contents in foods help in digestion, prevention of colon cancer (UICC/WHO, 2005) and in the treatment of diseases such as obesity, diabetes and gastrointestinal disorders.

Phosphorus, potassium, magnesium, sodium, vitamin C contents had decreased after 30 min of cooking while those of calcium, iron and zinc increase then decrease after 45 min of cooking. The high level of these minerals was observed in leaves cooked during 30 min.

Mineral losses during *J. galeopsis* leaves cooking could be caused by oxidation of water-soluble mineral and thermal destruction but not leaching as mentioned in Oulai *et al.*, (2014) study on some leafy vegetables. Indeed, cooking water in this study was not discharged after cooking.

The remaining quantity of these nutrients in *J. galeopsis* leaves was higher than those of sweet potato leaves (potassium (98 mg/100 g), magnesium (22 mg/100 g), sodium (7 mg /100 g), vitamin C (3 mg/100 g), calcium (125 mg/100 g), iron (1.2 mg/100 g) and zinc (0.1 mg/100g)) indicated by WHO (2004). Considering, the recommended dietary allowance for minerals (WHO, 2004): calcium (1000 mg/day), phosphorus (800 mg/day), magnesium (400 mg/day), iron (8 mg/day) and zinc (6 mg/day), the consumption of 46 g of *J. galeopsis* leaves cooked during 30 min could cover at least 50%of nutritional intake in calcium, phosphorus, magnesium, iron and zinc.

The polyphenol, flavonoid and tannin contents of *J. galeopsis* leaves decreased with increasing cooking time with high level in the leaves cooked during 30 min. The decrease in tannins, polyphenols and flavonoids during cooking is due to thermal degradation. Contrasting results were found in the levels of polyphenols and flavonoids in white caya (*Cleome gynandra*) leaves (Moyo *et al.*, 2016). The percent gain in the total phenols contents during cooking may be due to there lease of phenolic compounds trapped in the fibers of leafy vegetables.

The oxalate and phytate contents decrease with increasing cooking time. These results are identical to those of Oulai *et al.,* (2014) in the *Hibiscus sabdariffa* leaves. The reduction of the levels of oxalates and phytates in these leafy vegetables is due to their thermosensitivity. Cooking is advantageous and appears as a detoxification procedure by removing these anti-nutritional factors and improving the health status of consumers (Ekopand Eddy, 2005). Indeed, oxalates and phytates are anti-nutrients which chelate divalent cations such as calcium, magnesium, zinc and iron, thereby reducing their bioavailability (Sandberg, 2002).The oxalate and phytate contents of cooked *Justicia galeopsis* leaves are higher than those found in cooked *Hibiscus sabdariffa* leaves. This result is due to the cooking water of *Justicia galeopsis* leaves which was not discard in contrary to *H. sabdariffa* cooking water which fresh leaves contained more oxalates and phytates. However, the level of oxalate in *J. galeopsis* leaves is not major concern for a normal healthy person, as about 298-335 g of cooked leaves during 30 min would needs to be consumed to acquire 2-5 g of oxalate, which is thought to be toxic level for humans (Hassan and Umar, 2004).But also, it takes only an average of 46 g of cooked leaves to made *J. galeopsis* sauce for a normal person of 65 kg.

From the result, it was observed that in *J. galeopsis*,[oxalate]/[Ca] ratio (0.09 to 0.14), [oxalate]/[(Ca+Mg)] ratio (0.11 to 0.18), [phytates]/[Ca] ratios (0.00), [phytates]/[Fe] ratios (0.04 to 0.06) and [phytates]/[Mg] ratios (0.17 to 0.22) are below the critical level known to impair divalent minerals bioavailability (Umar *et al.*, 2007). The present of oxalate and phytate in *J. galeopsis* leaves don’t affect t he bioavailability of calcium, iron, magnesium and zinc.

In conclusion this study had evaluated the effect of cooking on the biochemical, phytochemical and mineral composition of *Justicia galeopsis* edible leaves. The results showed that a prolonged cooking time decreased significantly the content of nutrients such as proteins, ashes, vitamin C and antioxidant components. Therefore, the optimal cooking time for *J. galeopsis* leaves would be 30 min. Indeed, the content of vitamins C, polyphenolic compounds, tannins, flavonoids are acceptable. In addition, the iron, calcium, zinc and magnesium contents in the cooked leaves presented a high bioavailability. It should be noted that the anti-nutrient (phytates and oxalates) contents after this cooking time remain within the physiologically tolerable limit.

In the final, the cooked leaves of *J. galeopsis* contain a good quantity of nutrients which could help to cover the deficit of nutrients of the populations. Also, its high iron content could be beneficial for anemic patients.

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