ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2017; **17(3):** 12362-12376 **DOI: 10.18697/ajfand.79.15410**

MINERAL PROFILE AND THE EFFECT OF PROCESSING OF SOME LEAFY VEGETABLES INDIGENOUS TO CAMEROON

Ejoh AR[1]*, Djuikwo NRV[2] and CM Mbofung[1]

Richard Ejoh

*Corresponding author email: ejohrab@yahoo.com

[1]College of Technology, The University of Bamenda, Bambili, NWR, Cameroon.

[2]Department of Biochemistry, University of Yaounde 1, Yaounde, Cameroon

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

ABSTRACT

Leafy vegetables form part of the diet of most people of tropical Africa. The contribution of these leafy vegetables to their mineral needs has not been well elaborated. The aim of this study was to determine the effects of different processing methods on the mineral composition and anti-nutritional components of some tropical leafy vegetables. Twenty-one species of different vegetables locally grown and consumed in the northern region of Cameroon were collected and analyzed for their iron, copper, manganese, zinc, magnesium, calcium, sodium and potassium content. The levels of anti-nutrients like phytates, oxalates, tannins and saponins that are likely to affect the bioavailability of these minerals were also determined. The effects of processing methods on the mineral composition and anti-nutritional components of these leafy vegetables were also determined. Amongst these species, *Moringa oleifera, Hibiscus canabinum, Solanum nigrum, Cucurbita maxima and Vernonia calvoana* that are used for soup, and found in relative abundance in the region were subjected to two cooking methods (boiling plus squeeze-washing and a combination of boiling in alkaline salt (kanwa) plus squeeze-washing). The levels of iron, zinc, manganese, copper, magnesium, calcium, sodium and potassium varied in the different vegetables. In all vegetables studied, magnesium was the most abundant mineral. The iron levels ranged from 14.99±2.00mg/100g dry weight (DW) in *M. oleifera* to 167.42 ± 18.63mg/100g DW in *H. sabdariffa*. Boiling and squeeze-washing led to significant losses of minerals with sodium being the most affected. On the contrary, higher values of iron, calcium and sodium were found in samples that were boiled in alkaline salt and squeeze-washed. The levels of antinutrients were also reduced as a consequence of processing. Percentage losses during boiling with or without alkaline salt were between 25.4 and 55.5% for phytates, 11.1 and 80% for oxalates, 16.4 and 68.5% for saponins and 25 and 26.44% for tannins. Boiling, therefore, with or without alkaline salt is an effective means of reducing the levels of these antinutrients in vegetables to tolerable levels.

Key words: Leafy-vegetables, Processing methods, Mineral, Antinutrients, Saponins, Tannins, Oxalates, Kanwa

DOI: 10.18697/ajfand.79.15410

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Many people in tropical Africa depend largely on a large number of leafy vegetables as sources of minerals and vitamins [1]. Leafy vegetables contain substantial quantities of minerals like iron, calcium, phosphorus, potassium, magnesium and zinc [2]. Studies on the nutritional composition of vegetables of the northern part of Cameroon are limited: some of them have focused on the ethno-nutritional data of eight different species of leafy vegetables consumed in the Adamawa region of Cameroon [3] and others on the different processing and preservation methods affecting the vitamin A and C levels of four varieties of *Vernonia* [4]. Many types of leafy vegetables consumed in Cameroon have been studied with little or no emphasis on their mineral composition [4]. Up to date nutritional information on these leafy vegetables will be very useful for nutrition education of the public and also to improve their nutritional status. The presence of antinutrients in leafy vegetables is known to severely limit their nutritional benefits if they are not removed or reduced to a minimum level [5]. Phytates, oxalates, saponins and tannins are the most commonly present antinutrients. Oxalate and phytates are known to chelate minerals (Ca^{2+}, $Fe^{2+,}$) thus, limiting their bioavailability and reducing their metabolic use in the body. Oxalate in combination with calcium leads to the formation of insoluble calcium oxalate which can be precipitated and deposited in the kidney to form kidney stones [6]. Various processing methods like cooking and blanching reduce the levels of some of these harmful and antinutrient substances in vegetables [4, 5]. Little is known about the effect of processing on the mineral composition of species like *M. oleifera, H. canabinum, S. nigrum, C. maxima and V. calvoana.*

The aim of this study was to quantify the major minerals in processed and unprocessed tropical leafy vegetables indigenous to Cameroon.

MATERIAL AND METHODS

Sample collection and preparation

A total of 21 species of leafy vegetables within the Adamawa region of Cameroon were collected and identified in the Botany unit of the University of Ngaoundere. Between 600g to 2000g of each leafy vegetable were randomly obtained from 3 different farms in Ngaoundere early in the morning (temperatures between 11 and 15˚C), and within an hour, transported in open baskets to the Biochemistry laboratory at the University of Ngaoundéré for preparation and subsequent analysis.

Each of the 21 species of vegetables for the determination of mineral composition were sliced to smaller sizes, rinsed under tap water and left to drain for 10 minutes.

Amongst these vegetables, 5 species, that is *V. calvoana, M. oleifera, C. maxima, H. cannabinus,* and *S. nigrum* that were used for soup and found in relative abundance were subjected to either squeeze-washing and boiling, or a combination of boiling in kanwa (a local alkaline salt obtained from the Ngaoundéré market) and squeeze-washing before being oven dried at 45˚C.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3 July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

The rest of the 16 vegetables were left (unprocessed) to dry at 45˚C in an electric air oven for 24 hours when all the samples are completely dry. For the five species, 450g portions of fresh samples were boiled in 1L of tap water containing 10g of kanwa for 10 minutes before squeeze-washing and rinsing. Squeeze-washing and rinsing is a traditional process which involves crushing the vegetable with hands and squeezing out the juice and foam. This is followed by rinsing with water, and squeezing out the juice. All dried vegetable samples were ground to powder using a grinder (Culatti polymix, France) and then passed through a mesh screen (500 microns). The powder obtained from each vegetable was sealed in polyethylene bag, labeled and stored at 2^0C for subsequent laboratory analysis. All analyses were done in triplicate samples and results expressed on dry weight basis.

Analyses

The sodium and potassium contents were determined by flame photometry (Corning M410) [7]. The other minerals were determined using Atomic Absorption Spectrophotometer (AALAE S11) after wet digestion of the samples with mixture of nitric, sulphuric and hydrochloric acids [8]. The phytate content was determined using the method adopted by Mohammed *et al.* [9]. Oxalates were determined by the AOAC method [10], and tannins determined as described by Bainbridge *et al*. [11]. The quantification of saponin levels was done using afrosimetric method [12].

Statistical analysis

Statistical Analysis System software (SAS Institute Inc. Version 8.2, Cary, NC, USA; 2001) was used for data analyses. Processed and unprocessed samples were compared using Analysis of Variance (ANOVA). Differences between treatments were determined using Fisher's Least Significant Difference (LDS) test. $P < 0.05$ was considered significant.

RESULTS

Minerals

The mineral composition of the vegetable species is shown in Table 1. Magnesium (Mg) was the predominant mineral in the studied vegetables. Its contents ranged from 0.47g/100g DW for *V. amygdalina* to 6.98g/100g DW for *C. olitorus*. The sodium and potassium levels were generally lower than those of magnesium. The potassium contents ranged from 0.2g/100g DW to 1.12g/100g DW in *H. sabdariffa* and *C. maxima* spotted morphotype T., respectively. *H. canadense* showed the highest sodium contents (0.3g/100g DW) while the lowest was recorded in *C. sesamoides* (0.01g/100g DW). The highest levels of iron were found in *H. sabdariffa* (167.42 ± 18.08mg/100g DW), in *S. macrocarpon* (164.58±18.69 mg/100 g DW) and followed by *C. maxima* spotted morphotype (148.44±5.97mg/100g DW). The iron contents were lowest in *M. Oleifera* (14.99 ± 2.00mg/100g DW) and *V. calvoana* (19.01mg/100g DW).

The levels of zinc in all the leafy vegetable samples ranged from 0.45 to 3.8mg/100g DW. Copper levels in all the leafy vegetable samples ranged from 2.01 in *V. amygdalina* to 4.39mg/100g in *H. canadense.*

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

The results showed that there are significant differences in the mineral contents of the different species of leafy vegetables. With the exception of vegetables in the Fabaceae family {*V. unguculata* (27.92 ± 2.12mg/100g DW) and *C. obtusifolia* (26.83 ± 4.2mg/100g DW} that have similar levels of iron; other families have vegetables with very different levels of iron.

Anti-nutritional factors

For all the species analyzed, the oxalic acid levels are shown in Table 2. Tannin values for these species ranged from 0.03g/100g DW in *A. digitata* to 1.86g/100g DW in *T. triangulare*. The phytic acid values for the different leafy vegetables ranged from 0.03g//100g DW in *S. nigrum* to 1.53/g100g DW in *H. canadense*.

The influence of boiling on minerals

Iron content of *V. calvoana* was reduced from 19.01 to 13.13mg/100g DW that is about 30.93% after boiling, while it remained almost stable in other species.

There were increases in iron levels of 57.75% in *V. calvoana*, and 39.06% in *S. nigrum* in these vegetable species boiled with kanwa. *H. cannabinus*, a vegetable with a sour after-taste had no significant change in iron levels when boiled with kanwa**.**

No significant difference was observed between the different boiling methods applied to *H. cannabinus*. On the contrary, the zinc content of *C. maxima* had significant losses of 33.33% and 35.55% when boiling with and without kanwa were applied, respectively ($p<0.05$). Treatments (boiling with or without kanwa) had no significant effect on the levels of manganese in *M. oleifera*, and *V. calvoana.* On the other hand, reductions in this mineral were observed in other species. Boiling without kanwa caused a loss of 24.78% and 40.59% and boiling with kanwa caused a reduction of 20.23% and 28.33%, respectively for *S. nigrum* and *H. cannabinus.*

Losses of calcium were observed for vegetables that were boiled without kanwa, with a maximum of 34.91% observed in *S. nigrum*. For samples boiled with kanwa, increases of 51.04%, 50.11% and 17.58% for *C. Maxima*, *V. calvoana and H. cannabinus,* respectively were observed. Boiling with kanwa caused an increase of 7.32% in the samples of *M. oleifera* and 21.28% in samples of *C. maxima* while the same treatment caused a reduction in the levels of magnesium. Magnesium losses of 55.38%, 23.32%, 16.65% and 15.02% for *C. maxima, M. oleifera, H. cannabinus* and *V. calvoana,* respectively were observed.

The method of boiling modified potassium levels regardless of the vegetable species. In *C. maxima* and *H. cannabinus*, there were significant reductions in potassium levels in samples boiled without kanwa ($p<0.05$). These reductions were more pronounced, with a maximum of 43.28% in *H. cannabinus*. Increases were observed in *V. calvoana* (14.68 %) and *S. nigrum* (27.69%) after boiling with kanwa and squeeze-washing. The sodium content of samples boiled without kanwa increased significantly compared to the raw samples. The greatest reduction was observed in *V. calvoana* with 57.69%, followed by *S. nigrum*, *H. cannabinus, C. maxima* and *M. oleifera* with 45.23 %, 44.55 %, 38.23 %, and 7.97%, respectively. All the samples boiled with kanwa experienced a significant increase in sodium levels ranging from

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3 July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

59.15% for *H. cannabinus* to 94.44% for *S. nigrum*. The kanwa contributed significantly to this increase in sodium levels in the different vegetables.

The influence of boiling on anti-nutritional factors
Boiling with or without kanwa resulted in losses in saponin for all the vegetables studied at $P<0.05$ (Table 4). The highest loss was obtained in *S. nigrum* with percentage loss of 51.6% when the vegetable was boiled with kanwa and 45.8% for *C. maxima* when boiled without kanwa. The same effect was shown in tannins content though the level of losses was not as high as in saponins. *M. oleifera* had a reduction of 24.1% when boiled simply and of 26.1% when boiled with kanwa ($p<0.05$) while *S nigrum* had 35.4 and 44.2 % reduction, respectively when boiled without and with kamwa.

The phytate content of boiled leafy vegetables were significantly lower than the raw vegetables ($P<0.05$). In *V. calvoana*, losses of 76.2% and 72% were obtained after boiling simply and with kanwa, respectively. Boiling with or without kanwa caused a reduction of 54 and 41%, respectively of the oxalates in *H. canabinus*.

DISCUSSION

Minerals
For all the minerals analyzed in these leafy vegetables, magnesium was the predominant. The levels were higher than values obtained by Aletor *et al.* [13] for *Heinsia pulchella* and *Solanum nudiflorum*. Its abundance is mainly due to the presence of chlorophyll which contains magnesium in its structure. The calcium values in these vegetables are close to the 1.17% found by Tchiègang and Aïssatou for raw *M. charantia* obtained from the northern region of Cameroon [3].

Similar values were obtained for iron in some Nigerian and Senegalese leafy vegetables [14, 15]. With high levels of iron in these vegetables, many women can benefit from consuming them. Iron is an important element in the human body, playing crucial roles in haemopoietic control of infection and cell mediated immunity [16]. Iron deficiency is the most prevalent nutritional deficiency that has been known to decrease resistance to infection especially amongst Africans [16, 17]. Intake (about 100g) of these vegetables could contribute enormously to the provision of the body's recommended daily intake of 18mg/day of dietary iron for healthy adults if all dietary factors that favor its bio efficacy are available.

Previous studies obtained 3.73mg/100g DW of zinc for Indian spinach [18], which were lower than values obtained in this study. Zinc is an essential micronutrient for human growth and immune functions. In general, genetics, soil content and plant type affect the mineral composition in leafy vegetables. Potassium content was found to be within the same range of values obtained in the halophytic vegetables [19].

Anti -nutritional factors
For all the species, the oxalic acid levels were generally low and thus posed no risk of complexing with minerals like calcium [21]. The consumption of oxalic acid may result in kidney stones [22], with toxic levels set at 2 - 5g/day [23]. Other studies have shown that tannins have the ability to interact with proteins and minerals and thus

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

reduce protein digestibility and bioavailability [5]. Generally, in foods, values for phytates vary from 0.1% to 6% [5]. The values for this study were similar. It is known that phytic acid reduces the bioavailability of calcium, magnesium, iron and zinc and its consumption (4 to 9 mg) reduces by 4 to 5 times the absorption of iron [5].

The influence of boiling on minerals

Loss of iron in the case of *V. calvoana* boiled without kanwa in this study can be explained by the fact that this vegetable was squeeze-washed to reduce the bitterness of the vegetable after boiling, thereby enhancing the leaching of iron. The increases observed in *V. calvoana* and *S. nigrum* was justified by the addition of kanwa, which is known to contain 173.46 ± 1.88mg/100DW of iron. *H. cannabinus*, a vegetable with a sour after-taste had no significant change in iron levels when boiled with kanwa**.** Leafy vegetables iron is generally known to have low bioavailability, thus limiting the contribution of iron to the needs of humans [24]. The iron content of all vegetables used in this study would significantly contribute to the Recommended Daily Allowance (RDA) of iron (10mg/day) for children between 1 to 10 years, if consumed regularly [25]. The decreases observed for zinc levels follow the same trends as those of other researchers [26], which showed that zinc levels decreased in the cooked vegetables when compared to raw samples. The zinc level in all the vegetables used in this study can contribute to the RDA of 15mg/day for men and 12mg/day for women. Consumption of these vegetables can help to alleviate zinc deficiency in developing countries, known to decrease growth and increase morbidity in infants and children [1]. Loss of calcium was observed for vegetables that were boiled without kanwa. This can be attributed to leaching of these minerals during cooking [22]. On the other hand, some vegetables had higher values when boiled with kanwa, which is justified by the presence of calcium in the kanwa added during boiling (812.38 ± 38.73mg/100DW). Calcium content of the vegetables is inadequate to meet the Recommended Daily Allowance (RDA) of 800mg/day for adults.

The values of magnesium obtained in this study were high for all the vegetables, thus can contribute significantly to the RDA of 400mg/day for men 19-30years old and 310mg/day for women 19-30 years old, if consumed on a regular basis [25]. Losses in magnesium and potassium due to processing in some of the species studied could be explained by the fact that these minerals, could possibly be diffused into the boiling water. Sodium and potassium are necessary to maintain the osmotic balance of body fluids. They are also necessary for maintenance of the pH of the body, control glucose absorption and retention of protein for growth [26]. The RDA of potassium and sodium of an adult male is 2500mg [27] and regular consumption of diets based on leafy vegetables will help increase their levels in the body.

The solubility of sodium in water is also well established. Sodium present in the vegetables diffused in water, thereby reducing its content in the samples. The low sodium contents obtained after boiling leafy vegetables qualifies them as good for health and suitable for use in sodium restricted diets like those for hypertensive patients [28]. Another study showed an increase in sodium after boiling some leafy vegetables consumed in Nigeria; the increases were due to addition of salt during boiling [26]. Excessive consumption of sodium increases calcium loss through urine

DOI: 10.18697/ajfand.79.15410

and also contributes to hypertension in some people [30]. Other works observed significant reductions (P<0.05) in potassium, sodium, calcium, phosphorus and iron content of boiled *V. calvoana* leaves [2]. Boiled samples of the vegetable could only meet the recommended daily intake of these important minerals involved in cellular metabolism if the water used in boiling is retained and consumed.

The influence of boiling on anti–nutritional factors

Tannin levels were significantly reduced in this study due to processing and this is justified as tannins are water soluble, thus can be reduced significantly in the processes of boiling and soaking [31]. The reduction observed for phytates may be due to the formation of insoluble complexes of phytic acid (phytic acid-protein or phytic acid-protein- mineral) or due to hexaphosphate inositol hydrolyzed in penta and tetra phosphates [5]. Higher phytate content reduces the availability of minerals [5], whereas a low level of this substance may have a beneficial role in health; its reduction may improve the bioavailability of proteins and minerals like iron, calcium and zinc [31].

Boiling leafy vegetables as in the present study causes a reduction in the content of total oxalates [5]. The total oxalate levels in raw or boiled samples of the vegetables in the present study are lower than the permissible levels of 250mg/100g in foods [31]. Therefore, regular consumption of these vegetables is not dangerous as the antinutrients present are below toxic limits to the body.

CONCLUSION

These tropical green leafy vegetables in unprocessed and processed forms are good sources of many minerals. The studied species contained substantial quantities of magnesium, calcium, sodium, potassium and iron and low levels of copper, zinc and manganese. Magnesium was the most predominant mineral in all leafy vegetables investigated. The highest levels of iron were found in *S. macrocarpon* and *C. maxima T.* These species also contain high levels of some antinutritional factors like phytic acids, tannins and saponins, which need to be removed or reduced to minimal quantities to improve the nutritional quality of these leafy vegetables.

Household methods of vegetable preparations lead to significant losses in minerals, especially iron and calcium. On the contrary, the increase in iron content after boiling the vegetables with kanwa was due to the presence of some iron in the raw kanwa used. Boiling with or without kanwa had no significant effect on the levels of manganese in *M. oleifera*, and *V. calvoana*. The vegetables can contribute greatly towards meeting mineral needs of consumers and thus prevent malnutrition.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the International Foundation for Sciences for their financial support.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Mineral profile of leafy vegetables

Vegetables	Fe (mg/100g DW)	Zn (mg/100g DW)	Mn (mg/100g DW)	Cu (mg/100g DW)	K+ (g/100gDW)	Na+ (g/100gDW	Mg (g/100gDW)	Ca (g/100gDW)
T. triangulare	44.48 ± 3.73^{cd}	2.74± 0.16^{k}	8.90 ± 0.01^{f}	2.22^{b}	0.7 ± 0.01^{d}	0.1±0.01^{gh}	2.5 ±0.2^{ab}	1.1 ± 0.03^{j}
C. maxima	89.98 ± 7.47^{f}	3.35 ± 0.11^{l}	9.75 ± 1.29^{f}	2.25±0.01^{b}	1.12±0.00^{i}	0.2 ± 0.01^{j}	3.4 ±0.5^{bcdef}	0.2±0.00^{c}
M. charantia	56.56 ± 2.35^{de}	3.80 ± 0.19^{m}	6.64 ± 0.04^{de}	2.21 ± 0.0^{b}	0.9 ± 0.1^{fg}	0.1 ±0.01^{gh}	4.8 ±0.3^{hi}	1.2 ± 0.02^{k}
M. oleifera	14.99 ± 2.00^{a}	1.97 ± 0.24^{j}	3.11±0.02^{ab}	ND	1.0 ± 0.1^{gh}	0.1 ± 0.01^{cde}	4.04 ±0.4^{defg}	0.8±0.00^{i}
H. cannabinus	27.60 ± 3.46^{ab}	1.86 ± 0.09^{ij}	12.07 ±1.19^{g}	2.07±0.01^{a}	0.7 ± 0.07^{d}	0.09 ± 0.01^{bcd}	6 ±0.3^{j}	0.73± 0.03^{h}
V. calvoana	19.01 ± 4.12^{a}	1.70 ± 0.09^{hi}	8.20 ± 1.63^{ef}	2.14±0.01^{b}	0.6±0.00^{d}	0.1 ± 0.01^{g}	2.6 ±0.7^{abc}	0.4 ± 0.02^{d}
V. amygdalina	27.52±2.91^{ab}	2.16±0.03^{k}	11.16±1.95^{g}	2.01±0.01^{a}	0.31±0.11^{ab}	0.29±0.01^{l}	0.47±0.03^{hi}	0.78±0.08^{h}
C. maxima T.	148.44 ± 5.97^{h}	0.90 ± 0.09^{d}	2.76 ± 0.60^{ab}	2.07±0.01^{a}	0.8 ± 0.06^{e}	0.2 ± 0.01^{i}	4.6 ±0.5^{ghi}	0.4± 0.02^{de}
S. nigrum	26.85 ± 2.01^{ab}	1.62 ± 0.16^{h}	32.92 ± 1.22^{i}	2.10±0.01^{a}	0.6±0.00^{d}	0.1 ±0.01^{gh}	5.2 ±0.7^{hij}	0.6 ±0.01^{g}
V. unguculata	27.92 ±2.12^{ab}	1.18 ±0.00^{efg}	8.38 ± 0.63^{f}	2.18±0.00^{b}	1±0.00^{h}	0.1 ± 0.01^{f}	5.5 ±0.7^{ij}	0.6 ± 0.02^{g}
S. macrocarpon	164.58 ± 18.69^{i}	1.18 ± 0.17^{fg}	12.80 ±0.61^{g}	2.19 ± 0.01^{b}	0.9±0.00^{fg}	0.2 ±0.03^{j}	4.8 ±0.3^{hi}	0.6 ± 0.03^{g}
C. obtusifolia	26.83 ± 4.20^{ab}	1.80 ± 0.26^{hij}	5.49 ± 0.01^{cd}	2.20±0.00^{b}	0.4±0.00^{c}	0.1 ± 0.01^{f}	4.6 ± 0.1^{ghi}	1.2± 0.02^{k}
A. digitata	28.06 ± 4.20^{ab}	1.35±0.01^{g}	1.83 ± 0.63^{a}	2.20±0.00^{gh}	0.4 ± 0.06^{c}	0.1 ± 0.01^{ef}	4.6 ± 0.4^{ghi}	0.7± 0.02^{h}
C. olitorius	141.52 ± 11.26^{h}	0.96 ± 0.10^{de}	5.49 ± 0.02^{cd}	2.20 ± 0.01^{b}	0.6 ± 0.06^{d}	0.2 ± 0.01^{gh}	6.98 ± 0.5^{j}	0.5 ± 0.01^{f}
C. sesamoïdes	146.95 ± 5.58^{h}	0.62 ± 0.10^{bc}	12.02 ± 1.08^{g}	ND	0.3 ± 0.03^{ab}	0.01 ± 0.01^{def}	5.5 ±0.3^{ij}	0.3 ± 0.02^{c}
M. esculenta	35.10 ± 2.25^{bc}	1.01 ± 0.01^{def}	9.08 ± 0.70^{f}	ND	0.3 ± 0.06^{bc}	0.1 ± 0.01^{def}	3.9 ±0.2^{efg}	0.2 ± 0.02^{b}
T. indica	64.20 ± 8.28^{e}	0.95 ± 0.10^{d}	2.18 ± 0.01^{a}	2.18 ± 0.01^{b}	0.2 ±0.00^{a}	0.078±0.00^{abc}	2.4 ±0.5^{a}	0.5 ± 0.04^{ef}
A. hybridus	87.24 ± 0.27^{f}	1.01±0.00^{def}	4.00 ± 0.62^{bc}	2.18 ± 0.01^{b}	0.8 ±0.00^{e}	0.2 ± 0.01^{k}	3.2 ±0.8^{abcde}	0.7± 0.03^{h}
H. esculentus	80.96 ± 6.73^{f}	0.45 ± 0.10^{ab}	41.58 ± 2.00^{k}	2.21 ± 0.02^{b}	0.4 ±0.0 6^{c}	0.105 ± 0.01^{ef}	2.8 ±0.3^{abcd}	1.3± 0.05^{l}
***H.sabdariffa* thin**	167.42 ± 18.63^{i}	0.57 ± 0.10^{bc}	41.67 ± 1.67^{k}	2.23±0.00^{b}	0.2 ± 0.03^{ab}	0.1 ±0.0^{a}	3.5 ±0.7^{cdef}	0.4 ± 0.01^{de}
H. canadense	103.65 ± 10.55^{g}	1.07 ± 0.10^{def}	38.05 ± 1.67^{j}	4.39±0.00^{c}	0.8 ± 0.08^{ef}	0.3 ± 0.01^{l}	5.2 ±0.7^{hij}	0.3±0.00^{c}

DOI: 10.18697/ajfand.79.15410

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 2: Anti nutrient profile of leafy vegetables

Vegetables	Tannins (g/100gDW)	Phytates (g/100gDW)	Oxalates (g/100gDW)	Saponins (g/100gDW)
T. triangulare	1.86 ± 0.1^{f}	0.28 ± 0.01^{cd}	0.24 ± 0.16^{bcd}	6.01 ± 0.02^{k}
C. maxima	1.00 ± 0.03^{cd}	0.18 ± 0.01^{b}	0.12 ± 0.08^{a}	4.94 ± 0.81^{j}
M. charantia	0.03 ± 0.01^{a}	0.91 ± 0.01^{j}	0.27 ± 0.02^{d}	2.44 ± 0.21^{f}
M. oleifera	1.21 ± 0.04^{e}	0.04 ± 0.01^{a}	0.56 ± 0.03^{i}	5.04 ± 0.13^{j}
H. cannabinus	1.17 ± 0.17^{e}	1.24 ± 0.01^{l}	0.39 ± 0.16^{e}	5.82 ± 0.08^{k}
V. calvoana	0.04 ± 0.01^{a}	1.18 ± 0.01^{k}	0.42 ± 0.14^{ef}	3.61 ± 0.16^{g}
V. amygdalina	0.91 ± 0.01^{c}	1.38 ± 0.04^{m}	0.21 ± 0.15^{b}	4.48 ± 0.35^{h}
C. maxima T.	0.05 ± 0.01^{a}	$0.060.01^{a}$	0.3 ± 0.01^{d}	4.7 ± 0.07^{i}
S. nigrum	0.03 ± 0.01^{a}	$0.030.01^{a}$	0.43 ± 0.01^{efg}	4.82 ± 0.07^{i}
V. unguculata	0.49 ± 0.03^{b}	0.76 ± 0.01^{i}	0.18 ± 0.05^{d}	2.81 ± 0.63^{f}
S. macrocarpon	0.06 ± 0.01^{a}	$0.27\pm.01^{d}$	0.48 ± 0.01^{gh}	1.71 ± 0.11^{bc}
C. obtusifolia	0.05 ± 0.01^{a}	0.34 ± 0.01^{ef}	0.21 ± 0.01^{bc}	1.63 ± 0.09^{d}
A. digitata	0.03 ± 0.01^{a}	0.36 ± 0.01^{f}	0.11 ± 0.01^{a}	1.14 ± 0.07^{b}
C. olitorius	1.19 ± 0.05^{e}	0.31 ± 0.01^{de}	$0.180.01^{b}$	4.44 ± 0.12^{h}
C. sesamoïdes	0.05 ± 0.01^{a}	$0.290.01^{cd}$	$0.090.01^{a}$	1.38 ± 0.16^{c}
M. esculenta	0.04 ± 0.01^{a}	$0.340.01^{ef}$	$0.470.01^{fgh}$	1.25 ± 0.13^{b}
T. indica	0.11 ± 0.01^{a}	0.45 ± 0.01^{g}	$0.250.01^{cd}$	0.09 ± 0.01^{a}
A. hybridus	1.06 ± 0.04^{d}	$0.690.01^{h}$	$0.520.01^{hi}$	2.88 ± 0.52^{f}
H. esculentus	0.05 ± 0.01^{a}	0.21 ± 0.1^{c}	0.24 ± 0.01^{bcd}	1.22 ± 0.02^{ab}
H.sabdariffa thin	0.04 ± 0.01^{a}	0.21 ± 0.01^{bc}	0.5 ± 0.01^{gh}	1.14 ± 0.10^{b}
H. canadense	0.05 ± 0.01^{a}	1.53 ± 0.05^{n}	0.43 ± 0.03^{efg}	2.12 ± 0.23^{e}

Mean with same superscript letter in the same column for the same antinutrient are not different at P > 0.05
DW.=dry weight

DOI: 10.18697/ajfand.79.15410

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3 July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: The influence of boiling on minerals

		K (g/100g DW	Na (g/100g MS	Mg (g/100g MS	Ca (g/100g	Fe (mg/100gDW)	Zn (mg/100gDW)	Mn (mg/100gDW)	Cu (mg/100gDW)
M. oleifera	R	0.95 ± 0.07^{b}	0.09 ± 0.01^{a}	4.04±0.13^{b}	0.87±0.00^{b}	14.99 ±2^{a}	1.97 ± 0.24^{a}	3.11± 0.02^{a}	ND
	B	0.97 ± 0.08^{b}	0.08 ± 0.01^{a}	4.36±0.0 8^{c}	0.66 ± 0.01^{a}	15.32±2.2^{a}	1.22 ± 0.13^{a}	3.89 ± 0.84^{a}	ND
	Bk	0.65 ± 0.05^{a}	0.3 ± 0.02^{b}	3.1±0.1^{a}	0.979 ±0.03^{c}	20.82±1.12^{b}	1.58 ± 0.27^{a}	3.76 ± 0.59^{a}	4.11 ± 0.21^{b}
H.canabinus	R	0.66 ± 0.07^{b}	0.09 ± 0.01^{b}	5.82±0.03^{c}	0.73±0.03^{b}	27.60±3.46^{a}	1.86 ± 0.09^{a}	12.07 ±1.19^{b}	2.07± 0.01^{a}
	B	0.38 ± 0.59^{a}	0.05± 0.01^{a}	4.13±0.11^{a}	0.68±0.03^{a}	30.74±3.42^{a}	1.42 ± 0.16^{a}	7.17± 1.01^{a}	3.42 ± 1.18^{a}
	Bk	0.42± 0.01^{a}	0.22 ± 0.01^{c}	4.85± 0.03^{b}	0.89±0.04^{b}	27.69±3.46^{a}	1.60 ± 0.16^{a}	8.65 ± 0.60^{a}	2.08 ± 0.01^{a}
V. calvoana	R	0.64± 0.01^{c}	0.14 ± 0.01^{b}	3.61±0.16^{b}	0.38±0.02^{b}	19.01±4.12^{b}	1.70 ± 0.09^{b}	8.20 ± 1.63^{a}	2.14± 0.01^{b}
	B	0.75± 0.01^{b}	0.06 ± 0.01^{a}	3.6±0.121^{b}	0.26± 0.04^{a}	13.13±2.07^{a}	1.54 ± 0.10^{b}	7.16 ± 0.62^{a}	4.30± 0.01^{c}
	Bk	0.42± 0.01^{a}	0.52 ± 0.03^{c}	3.1±0.06^{a}	0.77 ±0.01^{c}	29.99±2.01^{c}	0.91 ± 0.09^{a}	7.96 ± 0.60^{a}	2.08± 0.01^{a}
C. maxima T	R	0.76 ± 0.05^{b}	0.17 ± 0.01^{a}	4.66±0.07^{b}	0.42±0.02^{b}	148.44±5.97^{a}	0.90± 0.09^{b}	2.76 ± 0.60^{a}	2.07± 0.01^{a}
	B	0.466± 0.01^{a}	0.10 ± 0.01^{a}	5.92±0.13^{c}	0.38±0.02^{a}	157.00 ±9.94^{a}	0.58 ± 0.05^{a}	3.46 ± 0.60^{a}	2.07± 0.01^{b}
	Bk	0.533 ± 0.09^{a}	0.44 ± 0.05^{b}	2.08±0.17^{a}	0.86±0.26^{c}	178.6±5.38^{b}	0.60 ± 0.07^{a}	3.49± 0.62^{a}	2.14 ± 0.00^{c}
S. nigrum	R	0.63± 0.01^{a}	0.14 ± 0.01^{a}	5.2±0.07^{b}	0.62±0.01^{c}	26.85±2.01^{a}	1.62 ± 0.16^{b}	32.92 ± 1.22^{b}	2.10± 0.01^{b}
	B	0.87 ± 0.06^{b}	0.08 ± 0.01^{a}	2.6±0.14^{a}	0.40 ±0.01^{a}	27.20±2.02^{a}	0.91 ± 0.09^{a}	24.76 ± 0.60^{a}	2.09± 0.01^{a}
	Bk	0.63± 0.01^{a}	2.5 ± 0.16^{b}	5.36±0.7^{c}	0.43±0.02^{b}	37.34±7.28^{b}	1.94 ± 0.28^{b}	26.26 ± 1.82^{a}	4.20± 0.06^{c}

R= Raw; B = boiled and squeeze-washed; Bk.= boiled in kanwa and squeeze-washed; Means with the same superscript letter in the same column for a single vegetable are not different at $P > 0.05$. DW.=dry weight

DOI: 10.18697/ajfand.79.15410

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 4: The influence of boiling on anti-nutritional factors in g/100g DW

Samples	Treatment	Phytates (g/100gDW)	Oxalates (g/100gDW)	Saponins (mg/100gDW)	Tannins (g/100gDW)
M. oleifera	R	0.04 ± 0.01[a]	0.09 ± 0.01[b]	5.04 ± 0.13[b]	0.87 ± 24.51[b]
	B	0.02 ± 0.01[a]	0.08 ± 0.01[a]	3.36 ± 0.0 8[c]	0.66 ± 0.01[a]
	Bk	0.03 ± 0.05[a]	0.05 ± 0.02[b]	3.1 ± 0.1[a]	0.69 ± 0.02[c]
H. canabinus	R	0.68 ± 0.04[b]	0.09 ± 0.01[b]	5.82 ± 0.08[c]	0.73 ± 0.03[a]
	B	0.40 ± 0.12[a]	0.05 ± 0.01[a]	4.13 ± 0.11[a]	0.68 ± 03[b]
	Bk	0.44 ± 0.01[a]	0.04 ± 0.01[c]	4.85 ± 0.01[b]	0.65 ± 0.01[b]
V. calvoana	R	0.64 ± 0.01[c]	0.14 ± 0.01[b]	3.61 ± 0.16[b]	0.38 ± 0.02[b]
	B	0.55 ± 0.01[b]	0.09 ± 0.01[a]	3.3 ± 0.02[b]	0.26 ± 0.04[a]
	Bk	0.42 ± 0.01[a]	0.11 ± 0.03[c]	3.1 ± 0.06[a]	0.36 ± 0.01[a]
C. maxima	R	0.76 ± 0.05[b]	0.17 ± 0.01[a]	4.7 ± 0.07[b]	0.42 ± 0.02[b]
	B	0.46 ± 0.01[a]	0.10 ± 0.01[a]	3.92 ± 0.13[c]	0.38 ± 0.02[a]
	Bk	0.53 ± 0.09[a]	0.14 ± 0.02[b]	2.08 ± 0.17[a]	0.36 ± 0.03[a]
S. nigrum	R	0.63 ± 0.01[a]	0.14 ± 0.01[a]	4.82 ± 0.07[b]	0.62 ± 0.01[c]
	B	0.47 ± 0.04[b]	0.08 ± 0.01[a]	2.6 ± 0.14[a]	0.40 ± 0.01[a]
	Bk	0.61 ± 0.01[a]	0.09 ± 0.01[b]	2.86 ± 0.7[c]	0.43 ± 0.02[b]

R= Raw; B = boiled and squeeze-washed; Bk. boiled in kanwa and squeeze-washed; Mean with same superscript letter in the same column for a single vegetable are not different at P > 0.05

REFERENCES

1. **Ilelaboye NOA, Amoo IA and OO Pikuda** Effect of cooking methods on mineral and anti-nutrient composition of some green leafy vegetables *Arch Appl Sci Res* 2013; **5 (3):** 254-260.

2. **Ejoh AR, Djuikwo VN, Gouado I and CM Mbofung** Effect of the Method of Processing and Preservation on Some Quality Parameters of Three Non-Conventional Leafy Vegetables. *Pak J. Nutr* 2007; **6 (2)**: 128-133.

3. **Tchiégang C and K Aissatou** Données ethno nutritionnelles et caractéristiques physico-chimiques des légumes-feuilles consommés dans la savane de l'Adamaoua (Cameroun) *Tropicultura* 2004; **22(1)**: 11-18.

4. **Ejoh AR, Tanya AN, Djuikwo NV and CM Mbofung** Effect of processing and preservation methods on vitamin C and total carotenoid levels of some Vernonia (bitter leaf) species. *AJFAND* 2005; **5 (2)**: 105 – 117.

5. **Ogbadoyi OE, Amanabo M, Johnson AO, Matthew ISE and H Funmilayo Akanya** Effect of processing methods on some nutrients, antinutriments and toxic substances in *Amaranthus cruentus*. *Intern J Appl Biol Pharm Techn* 2011; **2 (2)**: 487 – 502.

6. **Prien JT** Dietary changes and the incidence of urinary Calculi in the U.K. between 1986 and 1991, *Journal of Chronic Diseases* 1991; **32**: 469 – 476.

7. **Rodier J** L'analyse de l'eau: chimie, physico-chimie, bactériologie 6ème édition du Dunod. Technique, Paris, France, 1978 ; 1136.

8. **Kawashima LM, Soares L and M Valente** Mineral profile of raw and cooked leafy vegetables consumed in Southern Brazil *Journal of Food Comp Anal* 2003; **16**: 605–611.

9. **Mohammed AI, Ponnamperuma AJP and SH Youssep** New chromophore method for phytic acid determination. *Cereal Chem* 1986; **63**: 475- 478.

10. **AOAC (Association of Official Analytical Chemists** Official methods of analysis 13th ed. Washington DC 1990.

11. **Bainbridge Z, Tomlins K, Willings K and A Westby** Methods for assessing quality characteristics of non grain starch staple. Part 4 advanced methods. National Resources Institute. University of Greenwich, 1996; **400**: 143–479.

12. **Koziol MJ** Afrosimetric estimation of threshold saponin concentration for bitterness in quinoa. *J Sci Food Agric* 1990; **54**: 211-220.

13. **Aleotor VA and OA Adeogun** Nutrient and antinutrient components of some tropical leafy vegetables. *Food Chem* 1995; **53 (4):** 375–379.

14. **Barminas JT, Charles M and D Emmanuel** Mineral composition of non-conventional leafy vegetables. *Plant Foods for Hum Nutri* 1998; **53**: 29–36.

15. **Moussa N, Wade S, Dossou N, Amadou TG and DG Rokhaya** Valeur nutritionnelle du *Moringaoleifera*, étude de la biodisponibilité du fer, effet de l'enrichissement de divers plats traditionnels sénégalais avec la poudre des feuilles. *AJFAND* 2007; **7** (**3**).

16. **Bhaskaran P** Immunobiology of mild nutrient deficiency *British J Nutr* 2001; **85**:7-80.

17. **Trowbridge F and M Martorell** Forging effective strategies to combat iron deficiency. Summary and recommendations *J Nutr* 2002; **85**: 875-880.

18. **Dioxon BM and EM Haris** Nigeria food consumption and nutrition survey, 2004: 2001-2003.

19. **Guerrero JL, Guil JJ, Gimenez M and ME Torija** Mineral Nutrient Composition of Edible Wild Plants. *J Food Comp Analys* 1998; **11**: 322–328.

20. **Asaolu SS, Adefemi OS, Oyakilome IG, Ajibulu KE and MF Asaolu** Proximate and Mineral Composition of Nigerian Leafy Vegetables. *J Food Res* 2012*;* **1(3)**: 214-218.

21. **Abakr A and A Ragaa** Trials to reduce nitrate and oxalate content in some leafy vegetables; Interactive effect of manipulating of the soil nutrient supply, different blanching media and preservation methods followed by cooking process. *J. Sci. Food. Agric.*1996; **97**: 169 – 178**.**

22. **Hassan LG, Umar KJ and Z Umar** Antinutritive factors in *Tribulus terrestris* (Linn) leaves and predicted calcium and zinc bioavailability. *J Trop Biosc* 2007; **7**: 33-36.

23. **Hassan LG and KJ Umar** Antinutritive Factors in African Locust Beans (Parkia biglobosa). Proceedings of the 27th *International Conference of the Chemical Society of Nigeria* 2004; 322-326.

24. **Minihane AM and G Rimbach** Iron absorption and the iron binding and antioxidant properties of phytic acid. *Int J Food Sci Tech* 2002; **37**: 741-748.

25. **FNB.** Food and Nutrition Board, Institute of Medicine. Dietary Reference intakes or calcium, phosphorus, magnesium, vitamin and fluoride. Washington D C, National Academy Press1997.

DOI: 10.18697/ajfand.79.15410

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

26. **Onyeike NE, Ihugba CA and G Chinyere** Influence of heat processing on the nutrient composition of vegetable leaves consumed in Nigeria. *Plant Foods Hum Nutr* 2003; **58**: 1–11.

27. **National Research Council.** Recommended dietary allowances. Washington: National Research Press. Osler, M., Heitmann, B. L., Gerdes, L. U., Jorgensen, L. M., & Scroll, M. (2001). Dietary patterns and mortality in Danish men and women: A perspective observational study. *British J Nutr* 1989; **85**: 219–225.

28. **NRC/NAS.** ''National research council committee on dietary allowances'', Recommended Dietary Allowance 1980**.**

29. **Adepoju O T and EO Oyewole** Nutritional importance and micronutrient potentials of two non-conventional indigenous green leafy vegetables from *Nigeria Agric Journal* 2008; **3(5)**: 362-365.

30. **Wardlaw GM and MW Kessel** Perspectives in Nutrition 5thedn, McGraw-Hill Companies Inc 2002: 418-464.

31. **El-Adawy TA** Nutritional composition and antinutritional factors of chickpeas (Cicerarietinum L.) undergoing different cooking methods and germination. *Plant Foods Hum Nutr* 2002; **57**: 83–97.

DOI: 10.18697/ajfand.79.15410