Minerals composition of *Solanum aethiopicum* L. and *Amaranthus Hybridus* L. leaves from Burkina Faso

Abstract

Aim: Malnutrition remains a public health problem in children aged under five years in Burkina Faso. Research to find indigenous vegetables with high content of minerals can contribute to fight malnutrition in children. The aim of this study was to assess minerals composition of *Solanum aethiopicum* L. and *Amaranthus hybridus* L. leaves grown in Burkina Faso.

Methodes: The leaves have been collected in three markets of Ouagadougou. For the two plants, the dry leaves have been analysed for the following minerals content: Potassium (K), Calcium (Ca), Magnesium (Mg), Sodium (Na), Phosphor (P), Iron (Fe) and Zinc (Zn). The analyses have been done using the atomic absorption spectrophotometer and flam photometer methodes.

Results: The results showed high mean concentration in K, Ca and Mg in the leaves of the two plants. For *Solanum aethiopicum* leaves, the concentration in K, Ca and Mg was respectively 3064; 1048 and 666 mg/100 g. The trace elements content were also high: Fe (12 mg/100 g) and Zn (20 mg/100 g). For *Amaranthus hybridus* leaves, the concentration in K, Ca and Mg was respectively 3573; 606 and 475 mg/100 g. The leaves of *Solanum aethiopicum* had the highest content of following minerals: Ca, Mg, Na, P, Fe and Zn compared to *Amaranthus hybridus* leaves.

Conclusion: This study showed that both plants are good sources of important minerals. They are essential to be included in the diet of children to promote growth and contribute to fight against malnutrition.

Keys words: Indigenous vegetables, minerals, diets, children, nutrition

Introduction

Malnutrition in children aged under five years remains a public health problem in Burkina Faso. A nutritional survey in 2021 showed prevalence of 9.7% and 21.6% for moderate acute malnutrition and chronic malnutrition, respectively [1]. The prevalence of anemia was 72 % [2]. In Burkina Faso, malnutrition is an underlying cause of 35% death among children aged under five years [3]. The factors contributing to malnutrition are poverty associated with the lack of health care [4]. This malnutrition is due to a low level of minerals in food consumed such as Potassium (K), Magnesium (Mg), Calcium (Ca), Sodium (Na), Phosphor (P), Iron (Fe) and Zinc (Zn) [5]. To contribute to fight against malnutrition, it is important to add indigenous vegetables with rich content in minerals in the diet [6]. Indigenous vegetables available in Burkina Faso such as *Solanum aethiopicum* and *Amaranthus hybridus* could be potential sources of these minerals. The current food composition table from Burkina Faso provides insufficient information on the minerals composition of *Solanum aethiopicum* and *Amaranthus hybridus* [7]. Data on the content of minerals such as Mg, Na and P for *Amaranthus hybridus* leaves or K, Mg, Na, P and Zn for *Solanum aethiopicum* leaves are not available. Also, many studies on minerals composition of *Solanum aethiopicum* are focused on the fruits of this plant, but not the leaves. Then, research must be done to determine minerals content of these two leaves which are not provided in the food composition table from Burkina Faso.

Solanum aethiopicum is a herbaceous plant which is from the Solonaceae family. It is approximately 1.5 m of height. The leaves and fruits are consumable and can be consumed raw or mixed in sauce [8]. *Amaranthus hybridus*, is a herbaceous plant from the

Amaranthaceae family. It is approximately 2.5 m in height. The leaves are consumed mixed in sauce [9, 10].

The objective of the study is to determine the minerals composition of *Solanum aethiopicum* and *Amaranthus hybridus* grown in Burkina Faso.

Matarials and Methodes

Sampling

The samples of cool leaves of *Solanum aethiopicum* and *Amaranthus hybridus* have been collected in three markets of Ouagadougou, Burkina Faso. These cool samples have been washed and dried to the laboratory temperature during one month and reduced in powder with a grinder (mark NIMA, model NO: BL - 888A, Japan). The powder has been filtered by a filter with meshes of 0.5 millimeter of diameter and then, kept in plastic sachets at the laboratory temperature (25 °C) until analyses. The minerals analyses have been done in triplicate with the samples.

Minerals content analyses

The following minerals: P, K, Na, Mg and Ca from the dried leaves of *Solanum aethiopicum* and *Amaranthus hybridus* have been analysed after mineralization of samples according to Houba et al. [11]. In three tubes, 0.5 g of sample ground to 0.5 mm was weighed and 5 ml of the extraction solution (sulphuric acid - selenium - salicylic acid: 7.2%) was added in each tube. A Blanc solution was prepared with 5 ml of the extracted solution. The samples have been let to rest during 2 h at least. After this time, they have been heated with temperatures between 100-340 °C. The mixture obtained after heating has been cooled to the ambient temperature during 24 h and then diluted to 2/3 of the tubes, stirred, cooled down again and completed to 75 ml with the distilled water. After stirring and emptying, a quantity of the solution has been used for:

- the dosage of the total phosphor with the autosensor (model SKALAR 1000) to 880 nm using the ammonium molybdate as indicator.

- the dosage of Magnesium and Calcium after dilution in the Lanthane [(La $(NO_3)_3$ $6H_2O$)] respectively to 285.2 nm and 422.7 nm with an atomic absorption spectrophotometer (model PERKIN ELMER A100).

- the dosage of Sodium and Potassium with a flame photometer (model CORNING 400).

Ranges of standards solutions were prepared for the dosage of minerals. These ranges are provided as follows:

- Phosphor (P): a solution (300 ppm) of potassium hydrogenophosphate (K_2HPO_4) permitted to achieve a range of concentration between 3 and 15 ppm.

- Potassium (K) and Sodium (Na): a standard solution of Sodium-potassium (100 ppm) permitted to prepare a range concentration between 0 and 10 ppm.

- Magnesium (Mg) and Calcium (Ca): standards solutions of Magnesium (1000 ppm) and Calcium (1000 ppm) permitted to prepare concentration ranges between 5 and 30 ppm for the Calcium, 0.5 and 3 ppm for Magnesium.

For Zin (Zn) and Iron (Fe) analyses, 0.5 g of sample ground to 0.5 mm has been weighed in three tubes. Then, 5 ml of the extraction solution with nitric acid (HNO_3; 65%), sulphuric acid (H_2SO_4; 96%) and perchloric acid ($HClO_4$; 70%) have been added in each tube. A blanc solution has been prepared with 5 ml of the extraction solution. The samples have been let to rest during 2 h at least. After this time, they have been heated with temperatures varying between 75-240 °C. The mixture obtained after heating has been cooled down to the ambient temperature during 24 h and subsequently, has been diluted to 2/3 of tubes, stirred, cooling down again and completed to 75 ml with the distilled water. After stirring and emptying, a quantity of the solution has been used to analyse Fe and Zn in atomic absorption, respectively to 219.9 nm and 248.3 nm. A concentration range of standard solution has been 6 to 36 ppm for Fe and 1 to 6 ppm for Zn.

Statistical analysis

The data analysis has been performed using the software SPSS version 22.0. Data were expressed as mean (± standard deviation). The differences between the mean content of minerals have been tested using the one way analysis of variance. The Significant difference between the mean was set to 5% level.

Results

The study of minerals composition of *Solanum aethiopicum* showed high concentration in K from the sample collected in the three markets as shown in the table 1.

Table 1: Content of minerals in dry leaves of *Solanum aethiopicum* L. (mg/100g)

Minerals	**Market 1** (Mean ± SD)	**Market 2** (Mean ± SD)	**Market 3** (Mean ± SD)	**P-value for difference**
Ca	1107 ± 8	995 ± 9	1041 ± 9	< 0.05
Mg	657 ± 7	677 ± 9	665 ± 5	< 0.05
Na	63 ± 2	95 ± 5	74 ± 8	<0.05
K	3146 ± 3	2985 ± 5	3062 ± 7	< 0.05
P	421 ± 5	239 ± 9	321 ± 5	< 0.05
Fe	13 ± 3	11 ± 2	10 ± 4	< 0.05
Zn	18 ± 4	23 ± 1	20 ± 5	< 0.05

SD: standard deviation

These concentrations for K were 3146; 2985 and 3062 mg/100 g respectively for the sample of market 1, market 2 and market 3. The Ca is the second mineral with high concentration (1107; 995; 1041 mg/100 g), following by Mg (657; 677; 665 mg/100 g). Fe and Zn, known as trace elements, were in high concentration with 13; 11 and 10 mg/100 g for Fe from market 1, market 2 and market 3, respectively. For Zn, we found 18; 23 and 20 mg/100 g for market 1, market 2 and market 3, respectively. Significant differences for all minerals have been found between the samples of the three markets (Table 1). From Table 2, the mean concentration in K, Mg and Ca for all the samples were 3064; 666 and 1048 mg/100 g, respectively. For trace elements Fe and Zn, the mean concentration for all the samples was 12 and 20 mg/100 g, respectively (Table 2).

Table 2: Mean content of minerals in dry leaves of *Solanum aethiopicum* L. for the three markets (mg/100g)

Minerals	**Mean ± SD for three markets**
Ca	1048 ± 56
Mg	666 ± 10
Na	77 ± 16
K	3064 ± 81
P	327 ± 91
Fe	12 ± 2
Zn	20 ± 3

SD: standard deviation

Minerals composition of *Amaranthus hybridus* also showed high concentration of K. This concentration was 3549; 3600 and 3571 mg/100 g, for the leaves from market 1, market 2 and market 3 as shown in Table 3, respectively.

Table 3: Content of minerals in dry leaves of *Amaranthus hybridus* L. (mg/100g)

Minerals	**Market 1 (Means ± SD)**	**Market 2 (Means ± SD)**	**Market 3 (Means ± SD)**	**P-value for difference**
Ca	633	581	604	< 0.05
Mg	488	467	470	< 0.05
Na	37	42	35	<0.05
K	3549	3600	3571	< 0.05
P	201	246	218	< 0.05

Fe	5	5	6	< 0.05
Zn	2	2	4	< 0.05

SD: standard deviation

Also, Ca was second high mineral concentered with 633; 581; 604 mg/100 g for market 1, market 2 and market 3, respectively, followed by Mg with 488; 467; 470 mg/100 g. Fe showed levels of 5; 5 and 6 mg/100 g from market 1, market 2 and market 3, respectively. For Zn, concentrations were 2; 2 and 4 mg/100 g for market 1, market 2 and market 3, respectively. Comparison of minerals between the samples for the three markets showed significant differences (Table 3). For all the samples, the mean concentration in K, Mg and Ca was 3573; 606; and 475 mg/100 g, respectively. Trace elements Fe and Zn mean concentration for all the samples was 5 and 2 mg/100 g, respectively (table 4).

Table 4: Mean content of minerals in dry leaves of *Amaranthus hybridus* L. for the three markets (mg/100g)

Minerals	**Mean ± SD for three markets**
Ca	606 ± 26
Mg	475 ± 11
Na	38 ± 4
K	3573 ± 25
P	222 ± 22
Fe	5 ± 0.4
Zn	2 ± 0.4

SD: standard deviation

The concentration level of minerals showed that leaves of *Solanum aethiopicum* had highest content in Ca, Mg, Na, P, Fe and Zn compared to leaves of *Amaranthus hybridus* (Table 5).

Table 5: Levels of Minerals between *Solanum aethiopicum* L. and *Amaranthus hybridus* L. dry leaves (mg/100 g)

Minerals	***Solanum aethiopicum L.*** **(**Mean ± SD)	***Amaranthus hybridus L.*** **(**Mean ± SD)
Ca	1048 ± 56	606 ± 26
Mg	666 ± 10	475 ± 11
Na	77 ± 16	38 ± 4
K	3064 ± 81	3573 ± 25
P	327 ± 91	222 ± 22
Fe	12 ± 2	5 ± 0.4
Zn	20 ± 3	2 ± 0.4

SD: standard deviation

Discussion

This study was conducted to investigate minerals composition in two indigenous vegetables. Results showed high content in K, Ca, Mg and in traces elements such as Fe and Zn in the leaves. Significant content in P and Na has also been demonstrated in this study. These findings demonstrate that leaves of *Solanum aethiopicum* and *Amaranthus hybridus* are important sources of minerals. The current food composition table from Burkina Faso has been established since 2005. This table present data on Ca, K, Fe and Zn for *Amaranthus hybridus* leaves and only Ca, Fe for *Solanum aethiopicum.* Therefore, findings from this study provide new data on Ca, K, Fe, Zn for *Amaranthus hybridus* leaves, but also new data on K, Mg, P, Na and Zn for *Solanum aethiopicum* leaves which were not available on the current food composition table. In this study, we found that leaves of *Solanum aethiopicum* have high content of Ca, Mg, P, Na, Fe and Zn compared to *Amaranthus hybridus* leaves. Also, analyses between the minerals content for each vegetable showed significant differences from the different markets. These differences are linked to the composition of the soil which can have minerals variation [12, 13]. *S. aethiopicum and S. melongena* fruits are also indigenous vegetables consumed in Burkina Faso. The content in Ca, Mg, P and Zn of *S. aethiopicum* leaves were found to be highest than those found in the fruits reported in our previous study (14). Also, the content in Ca, Mg, K, Fe and Zn were found to be highest compared to the content for *S. melongena* fruits (14). Variation in minerals content for these vegetables are also found when data are compared with those from other countries. Studies conducted in Nigeria, and South Africa, showed a rich contents in Ca, Mg, P, Na, Fe and Zn from leaves of *Amaranthus hybridus.* Finding from our study showed low content in Ca (606 mg/100 g), Mg (475 mg/100 g), Fe (5 mg/100 g) and Zn (2 mg/100 g) compared to a study from South Africa with other levels of Ca (2363 mg/100g), Mg (1317 mg/100 g), Fe (21 mg/100 g) and Zn (18 mg/100 g) [15]. However, our study demonstrated high levels in Ca, Mg and K compared to those found by Akubugwo et al. from Nigeria [16], where the following levels were found: Ca (44.15 mg/100 g), Mg (231.22 mg/100 g), K (54.20 mg/100 g). Due to lack of data on *Solanum aethiopicum* Leaves content in minerals, we compared our data with those of the fruits of the plant. The study from Nigeria using fruits, showed low contents in Ca (31 mg/100 g), Mg (59.5 mg/100 g), K (447.5 mg/100 g), P (109.1 mg/100 g), Zn (7.7 mg/100 g) and Fe (2.5 mg/100 g) [17], compared to the leaves found in our study. Another study from Cameroon using *Solanum aethiopicum* fruits from Ghana showed lower content of Ca (170 mg/100 g), K (2150 mg/100 g), Mg (190 mg/100 g) P (260 mg/100 g), Fe (3.97 mg/100 g) and Zn (1.06 mg/100 g) [6], compared to our study with Ca (1048 mg/100 g), K (3064 mg/100 g), Mg (666 mg/100 g) P (327 mg/100 g), Fe (12 mg/100 g) and Zn (20 mg/100 g). The difference of the results from Nigeria and our study is due to agro-climatic and soil composition difference. These are factors modifying the content of nutrients from one country to other.

The findings from our study show that these two indigenous vegetables are important source of minerals which are essential for children growth and development [18]. These minerals are involved in functions such as maintenance of heart rhythm, muscles contractibility, development of bone and teeth, acid-base balance, regulation of cellular metabolism and enzymatic reactions [17]. Sodium and Potassium are two important minerals for cells live in the body. They are responsible for body water regulation and the electrolyte balance [17, 19]. Zinc contributes in the recovery of child malnutrition because it is involved in the major metabolic pathways including proteins, lipid carbohydrate and energy [19]. It is also involved in immunity, in cells divisions for tissues growth and development [19, 20]). Incidences of diarrhea, pneumonia and malaria are reduced with balanced intake of zinc [20]. The presence of iron also demonstrates the value of these indigenous vegetables. Iron deficiency in children under five years can impair their immunity and reduce efficacy to fight pathogens agents [20]. Therefore, the consumption of these indigenous vegetables by children under five years will contribute to fight anemia, malnutrition, and infection. The availability, low cost, accessibility and ease of preparation of these two leaves shows they can be used to improve children nutritional status.

Conclusion

The study shows that *Solanum aethiopicum* and *Amaranthus hybridus* leaves are good sources of minerals (Ca, K, Mg, Na, P, Fe, Zn). They must be included in the diet of children aged under five years to improve their intake in minerals. This can have a beneficial effect on their growth, development and prevent diseases and malnutrition.

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Competing interests

Authors have declared that no competing interests exist.

Authors contributions

C W Y designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. F G managed the analyses of the study. All authors managed the literature searches, read and approved the final manuscript.

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