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

Abstract

Aim: Malnutrition remains a public health problem in children under five years in Burkina Faso. Research to find indigenous vegetables with high content of micronutrients can contribute to fight malnutrition in children. The aimof this study is to assess micronutrients 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 micronutrients 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 methods.

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 wasrespectively 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 wasrespectively 3573; 606 and 475 mg/100 g. The leaves of *Solanum aethiopicum* had the highest content of following micronutrients: Ca, Mg, Na, P, Fe and Zn compared to *Amaranthus hybridus* leaves.

Conclusion: This study showed that both plants known as indigenous vegetables are good sources of important micronutrients. They are essential to be included in the dietof children under five years of age to promote growth and contribute to fighting malnutrition.

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

Introduction

Malnutrition in children under five years of age remain a public health problem in Burkina Faso.Anutritional survey in2021 showed prevalenceof 9.7% and 21.6% for moderate acute malnutrition and chronic malnutrition, respectively[1].The prevalence of anemia was72 % [2]. In Burkina Faso, malnutrition is an underlying cause of 35% death among less than five years children [3].The factors contributing to malnutritionare poverty associated withthe lack ofhealth care [4]. This malnutrition is due to a low level ofnutrients in food consumed such asPotassium (K), Magnesium (Mg), Calcium (Ca), Sodium(Na), Phosphor (P), Iron (Fe)and Zinc (Zn)[5]. To contribute to fight malnutrition in children, it is important to addindigenous vegetables with rich content in micronutrients in the diet[6]. Indigenous vegetables available in Burkina Faso such as*Solanum aethiopicum*and *Amaranthus hybridus* could bepotential sources of thesemicronutrients. The currentfood compositiontable from Burkina Faso providesinsufficient information on the micronutrients composition of*Solanum aethiopicum*and*Amaranthus hybridus*[7]. Data on the content of micronutrients 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 micronutrients composition of *Solanum aethiopicum*are focused on the fruits of these plants, but not the leaves.For the purpose of validating indigenous vegetables asimportant sources of micronutrients, research must be done to determinethe content of micronutrients which currently are not provided in the food composition table from Burkina Faso.

Solanum aethiopicum is a herbaceousplant 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 herbaceousplant 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 micronutrients 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 of0.5 millimeter of diameter and then, kept in plastic sachets at the laboratory temperature (25 °C) until analyses. The micronutrientsanalyses have been done in triplicate with the samples.

Micronutrients content analyses

The following micronutrients:P, K, Na, Mg and Ca from the dried leaves of *Solanum aethiopicum* and *Amaranthus hybridus* have been analysed after mineralization of samplesby humid voice according to Houba et al.[11]. In three tubes, 0.5 g of sample ground to 0.5 mm has been weighed and 5 ml of the extraction solution (sulphuric acid - selenium - salicylic acid: 7.2%) have been added in each tube. A Blanc solution has been 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 beenheated with temperatures varying between 100-340 °C. The mixture obtained after heating has been cooled to the ambient temperature during 24 h and then, has been dilutedto 2/3 of the tubes, stirred, cooled down again and completed to 75 ml with the distilled water. After stirring andemptying, 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 have been prepared for the dosage of micronutrients. 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 varying 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 varying 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 forFe and 1 to 6 ppm forZn.

Statistical analysis

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

Results

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

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

Micronutrients	**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 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 micronutrient 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 micronutrients 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 was12 and 20 mg/100 g, respectively (Table 2).

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

Micronutrients	**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

Micronutrients 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 micronutrients in dry leaves of *Amaranthus hybridus*L. (mg/100g)

Micronutrients	**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, Cawas secondhigh micronutrient concenteredwith 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 micronutrients between the samples for the three markets showed significant differences (Table 3). For all the samples, the mean concentration in K, Mg and Ca was3573; 606; and 475 mg/100 g, respectively. Trace elements Fe and Zn mean concentration for all the samples was5 and 2 mg/100 g, respectively (table 4).

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

Micronutrients	**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 micronutrients 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 Micronutrients between *Solanum aethiopicum* L. and *Amaranthus hybridus*L. dry leaves (mg/100 g)

Micronutrients	***Solanum aethiopicumL.*** **(**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 micronutrients 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 Nahasalso been demonstrated in this study. These findingsdemonstrate that leaves of *Solanum aethiopicum* and *Amaranthus hybridus* are important sources of micronutrients.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 newdata on K, Mg, P, Na and Znfor *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 micronutrient content for each vegetable showed significantly difference from the different markets. This difference is linked to the composition of the soil which can vary

in terms of minerals [12, 13].Variation in micronutrients 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 andZn 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 withother levels ofCa (2363mg/100g), Mg (1317 mg/100 g), Fe (21 mg/100 g) and Zn (18 mg/100 g)[14].However, our study demonstrated high levels in Ca, Mg and Kcompared to those found by Akubugwo et al.from Nigeria [15], 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 micronutrients, 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)[16], compared to the leaves found in our study.Another study from Cameroonusing *Solanum aethiopicum* fruits from Ghanashowed 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 findingsfrom our study showthat these two indigenous vegetables are important source of micronutrients which are essential for children growth and development [17]. 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 [16]. Sodium and Potassium are two important micronutrients for cells

livein the body. They are responsible for body water regulation and the electrolyte balance [16, 18]. Zinc contributesin the recovery of child malnutritionbecause it is involved in the major metabolic pathways including proteins, lipid carbohydrate and energy [18]. It is also involved in immunity, in cells divisions for tissues growth and development [18, 19]).Incidences ofdiarrhea, pneumonia and malaria are reduced with balanced intake of zinc [19]. The presence of iron alsodemonstrates the value of these indigenous vegetables.Iron deficiency in children under five years can impair their immunity and reduce efficacy to fight pathogens agents[19]. Therefore, the consumption of these indigenous vegetables by children under five years will contribute to fightanemia, 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 micronutrients (Ca, K, Mg, Na, P, Fe, Zn). They must be included in the diet of children under five years to improve their intake in micronutrients. 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.

References

1. Ministry of Health/ Direction of the Nutrition. National nutritional survey. Final report. MS/DN. 2021; 1-112.
2. National Institute of Statistics and Demography. Burkina Faso Demographic and Health Survey 2021. INSD/ICF. 2022; 1- 41.
3. Rice A., Black R., Hyder A., Sacco L. Malnutrition: the underlying cause of childhood deaths from infectious diseases in developing countries. WHO Bulletin. 2000;78(10):1207-1270.
4. .WHO. Worldwide Prevalence of anemia 1993-2005: WHO Global Database on anemia. Geneva: WHO. 2008; 1- 40.
5. Annan R.A., Webb P., Brown R. Management of moderate malnutrition (MAM): current knowledge and practices. UNICEF. 2014 ; 1- 46.
6. Kamga R.T., Kouame C., Atangana A.R., Chagomoka T., Ndango R. Nutritional Evaluation of Five Indigenous Vegetables. Journal of Horticultural Research. 2013; 21(1): 99-106.
7. Ministry of Health/ Direction of the Nutrition. Edition and popularization of a table of composition of foods commonly consumed in Burkina Faso. MS/DN. 2005; 1 - 39.
8. Han M., Opoku K.N., Bissa N.A.B., Su T. Solanum aethiopicum: The Nutrient-Rich Vegetable Crop with Great Economic, Genetic Biodiversity and Pharmaceutical. Horticulture. 2021; 126 (7): 1-17.
9. Oke o.L. Amaranthus. Handbook of tropical foods, Marcel Dekker, Inc., New York. 1983; 1-2.

10. Mepha H.D., Eboh L., Banigbo D.E.B. Effects of processing treatments on the Nutritive Composition and Consumer acceptance of some Nigeria edible leafy vegetables. Afr. J. Food Agric. Nutr. Dev. 2007; 7 (1):1-18.
11. Houba V.J.G, van Vark W., Walinga I, Vander Lee J.J. Plant analysis procedure (part 7, chapter 2. 3). Department of soil sciences and analysis, Wageningen, The Netherlands, 1989.
12. Yaméogo C.W., Bengaly M.D., Savadogo A., Nikiema P.A., Traoré A.S., Determination of Chemical Composition and Nutritional Value of Moringa oleifera Leaves. Pakistan Journal of Nutrition. 2011; 10 (3): 263-268.
13. . Okeke H. C., Okeke O., Nwanya K.O., Offor C.R., Aniobi C.C. Comparative Assessment of the Proximate and Mineral Composition of Cucumis sativus L. and Solanum aethiopicum L. Fruit Samples Grown in South Eastern and North Central Regions of Nigeria Respectively. NaturalResources. 2021; 12(8): 237-249.
14. . Odhav B., Beekrumb S., Akulaa U.S., Baijnath H. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu_Natal, South Africa. J. Food Comp. Anal. 2007; 20(5): 430 - 435.
15. Akubugwo I.E., Obasi N.A., Chinyere G.C., Ugbogu A.E. Nutritional and Chemical value of Amaranthus hybridus L. leaves from Afikpo, Nigeria. African J. Biotechnol. 2007; 6(24): 2833-2839.
16. Michael U., Banji A., Abimbola A., David J., Oluwatosin S., Aderiike A., Ayodele O., Adebayo O. Assessment of variation in mineral content of ripe and unripe African eggplant fruit (Solanum aethiopicum L .) Exocarps. J. Pharmacog. Phytochem. 2017; 6(5): 2548 - 2551.
17. FAO. Vitamins and minerals requirements in human nutrition: report of a joint FAO/WHO, Second edition. 1998; 1- 20.
18. Sunday E.K., Hartline O.O. Nutrient Composition of Common Fruits and Vegetables in Nigeria. Journal of Biotechnology. 2012; 15: 1336-1392.
19. UNICEF. The state of the world children. UNICEFhouse. 1998; 1-74.