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Research Article

Evaluation of the mineral composition of four species of the *Corchorus spp* genus consumed as leafy vegetables in Burkina Faso

Sawadogo Zakaridja*[1], Kiebre Mariam[1], Sawadogo Pingawinde[2], Kiebre Zakaria[1] and **Bationo-Kando Pauline[1]**

1. Equipe Génétique et Amélioration des Plantes, Laboratoire Biosciences, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso.
2. Centre Universitaire de Tenkodogo/Université Thomas Sankara, Tenkodogo, Burkina Faso.

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Corresponding Author
Prof. Dr. Sawadogo Zakaridja
E-mail:
sawazakaria@gmail.com
Tel: (+226) 71957142/
75858657

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Abstract

Species of *Corchorus* genus are used as leafy vegetables and medicinal plants in Burkina Faso. However, the nutritional value of most of these plants is not well known. In order to lay the foundations for the valorisation of these species, an assay of six essential minerals was carried out on the dry leaves of six genotypes belonging to the species *C. aestuans* (G 1 and G 2), *C. fascicularis* (G 3), *C. olitorius* (G 4 and G 5) and *C. tridens* (G 6). Minerals assayed were calcium, copper, iron, magnesium, potassium and zinc. Results show that the genotype G 2 with a content of 327.70 mg/100 g DW is the richest in calcium. Regarding magnesium content, genotypes G 2 (198.74 mg/100 g DW), G 4 (163.208 mg/100 g DW), G 5 (129.44 mg/100 g DW) and G 3 (100.28 mg/100g DW) had the highest magnesium contents. All genotypes had a copper content below 1 mg each. This content varies from 0.20 mg/100 g DW for genotype G 4 to 0.56 mg/100 g DW for genotype G 3. Each of the six genotypes had a potassium content above 1500 mg/100 g DW. Genotypes G 1 (96.20 mg/100 g DW) and G 6 (71.34 mg/ 100 g DW) were the richest in iron. Genotype G 3 had the highest zinc content of 3.36 mg/100 g DW. Given the high nutritional value the leaves of these plants, they could be potential source for the fight against malnutrition and mineral deficiencies in Burkina Faso.

1. Introduction

In West Africa, malnutrition is a public health problem, with 50 % of women of puberty age being anemic and suffering from deficiencies in iron, zinc and vitamin A, among other things [1]. In Burkina Faso, 23% of children under the age of five are chronically malnourished and 56% of women aged 15-49 are anemic [2]. Many local plants used as leafy vegetables could help improve this situation if their nutritional potential is sufficiently explored and exploited. These local species are well adapted to soil and climatic conditions are rich in mineral elements, vitamins, nutritional factors and are free of inhibiting anti-nutritional factors [3-5]. However, with the introduction of exotic vegetables, these leafy vegetables have long been neglected in programs fighting against malnutrition. In recent years, there has been a renewed interest in these local plants, which are generally used locally. Thus, to better explore their nutritional potential, research has been conducted in several countries of the world to evaluate the nutritional value of these species. For example, in India according to Shashi [6], edible

Figure 1. Different genotypes of *Corchorus* belonging to the four species: **a**) G 1; **b**) G 2; **c**) G 3; **d**) G 4; **e**) G 5; **f**) G 6

Corchorus species are sourced important of β-carotene, potassium and iron. In Ivory Coast, a study on *Amaranthus hybridus*, *Celosia argentea*, *Corchorus olitorius*, *Cleome gynandra*, and *solanum nigrum* revealed that the leaves of these species are a significant source of soluble and insoluble fiber, β-carotene, oxalic acid, vitamin C [7]. In Burkina Faso, according to Kiebre [8] *Cleome gynandra* is sourced important in iron, copper, manganese, zinc, nitrogen, potassium, phosphorus, β-carotene and magnesium.

In Burkina Faso, a collection survey followed by an ethnobotanical survey identified four species *(C. olitorius, C. tridens, C. aestuans and C. fascicularis)* of the *Corchorus* genus used in the preparation of several local dishes [9, 10]. However, most of these local vegetables are generally considered welding foods due to the lack of knowledge about their nutritional potential. Indeed, of these four species, only the nutritional profile of *C. olitorius* has been studied [11]. The nutritional value of the other species is unknown in Burkina Faso. In addition, field observations have revealed the existence of morphological types within certain species. In order to better valorize these species, an evaluation of the mineral composition was carried out. Specifically, the aim was (i) to determine the mineral composition of the leaves of these four species and (ii) to compare the mineral contents of the different genotypes.

2. Materials and methods

2.1 Materials

The plant material consists of six genotypes belonging to four species of the *Corchorus* genus (Table 1). These are two genotypes of *C. aestuans* named G 1 and G 2 (Fig. 1a and 1b), one genotype of *C. fascicularis* named G 3 (Fig. 1c), two genotypes of the botanical variety *C. olitorius var incisifolius* and *C. olitorius var olitorius* named respectively G 4 and G 5 (Fig. 1d and 1e), and one genotype of *C. tridens* named G 6 (Fig. 1f).

Table 1. List of plant materials used

N°	Species	Number of genotypes	Code
1	*Corchorus aestuans*	2	G1, G 2
2	*Corchorus fascicularis*	1	G 3
3	*Corchorus olitorius var incisifolius*	1	G 4
	Corchorus olitorius var olitorius	1	G 5
4	*Corchorus tridens*	1	G 6

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These genotypes were selected taking into account the species, the existence of several morphotypes within the same species and their leaf biomass yield.

2.2. Methods

2.2.1. Methods of mineral analysis of Corchorus spp.

Six minerals, namely calcium (Ca), magnesium (Mg), copper (Cu), potassium (K), iron (Fe) and zinc (Zn) were determined from young dry leaves from the six genotypes. The content of these minerals was evaluated by atomic absorption spectrometry using the classical ATQA-AAS method of the Bureau des Mines et de la Géologie du Burkina (BUMIGEB) laboratory in 2022. To do this, the sample was first mineralized. Thus, 1 g of leaf powder from each sample was weighed in a porcelain crucible and placed in an oven at a temperature between 100 and 340°C in the presence of nitric acid of 7.5% concentration and hydrochloric acid of 2.5% concentration. The substance thus obtained after mineralization was recovered in a flask, distilled water was added to the substance for a final solution of 200 ml and the mineral elements were determined by atomic absorption.

2.2.2. Data analysis

Data were analyzed using XLSTAT software. Thus, the analysis of variance (ANOVA) followed by the Newman-Keuls comparison test at the 5% threshold was performed to compare the mineralogical composition of the leaves of these four *Corchorus* species. In order to characterize the six genotypes using their nutritional profile, a principal component analysis (PCA) was performed using, only the minerals that discriminated the six genotypes. The Excel 2016 spreadsheet was used to construct the graphs from the weighted averages.

3. Results

3.1 Calcium content per 100 g leaf dry matter of Corchorus spp.

The results of the analysis of variance followed by the Newman-Keuls comparison test performed on the weighted averages show significant differences at 1 % threshold (P<0.001) between the G 2 genotype of the *C. aestuans* species and the other five genotypes. With a mean value ranging from 92.46 mg/100 DW for genotype G 5 to 327.70 mg/100 g DW for genotype G 2, the results of the mineralogical composition analysis showed that the leaves of the *Corchorus* species studied are rich in calcium (Fig. 2).

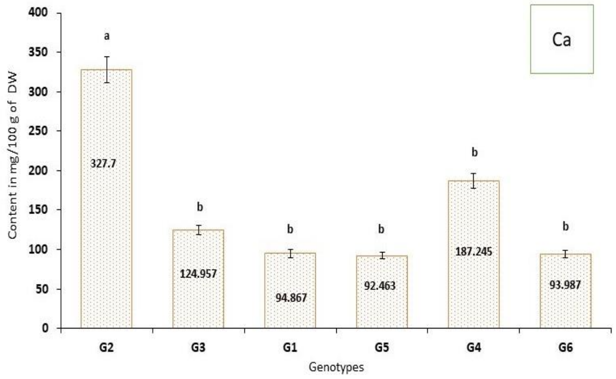

Figure 2. Leaf calcium content of genotypes of four species of the *Corchorus spp.* genus (Means with different letters are significantly different at the 5 % threshold. Means followed by the same letter are not significantly different at the 5 % threshold)

3.2 Magnesium content per 100 g leaf dry matter of Corchorus spp.

The difference was observed at the 5 % threshold (p<0.036) between the magnesium contents of the six Corchorus genotypes. The weighted mean magnesium value varies from 47.6 mg/100 g DW for genotype G 1 to 198.74 mg/100 g DW for genotype G 2 (Fig. 3). Genotypes G 3, G 4 and G 5 showed statistically the same magnesium content.

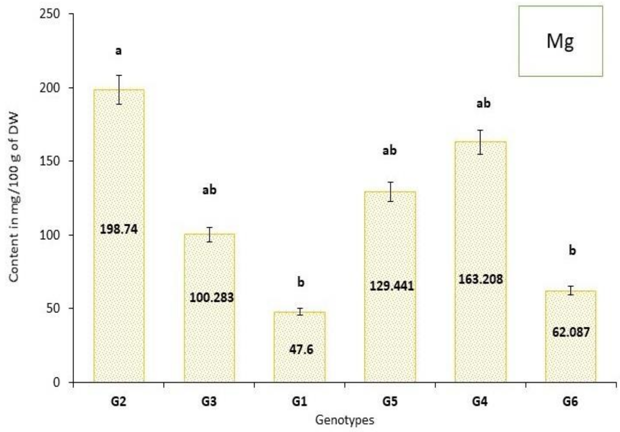

Figure 3. Leaf magnesium content of genotypes of four species of the *Corchorus spp.*genus (Means with different letters are significantly different at the 5 % threshold. Means followed by the same letter are not significantly different at the 5 % threshold)

3.3 *Copper content per 100 g leaf dry matter of Corchorus spp.*

For copper content, the results of the analysis of variance showed a highly significant difference (P<0.000) between the six genotypes. The mean value varies from 0.20 to 0.56 mg/100 g DW (Fig. 4). Moreover, a highly significant difference (P<0.000) was observed between the two genotypes of *C.*

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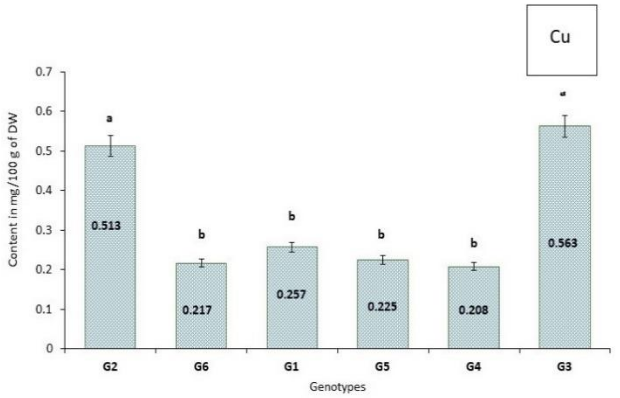

Figure 4. Leaf copper content of genotypes of four species of the *Corchorus spp.* genus (Means with different letters are significantly different at the 5 % threshold. Means followed by the same letter are not significantly different at the 5 % threshold).

aestuans species for copper content. The Newman-Keuls comparison test was used to discriminate genotypes based on copper content. Genotypes G 2 and G 3 had the highest copper content. The other genotypes had statistically the same copper content.

3.4 Potassium content per 100 g leaf dry matter of Corchorus spp.

The results of the analysis of variance did not reveal any significant difference between the six genotypes for potassium concentration (Fig. 5).

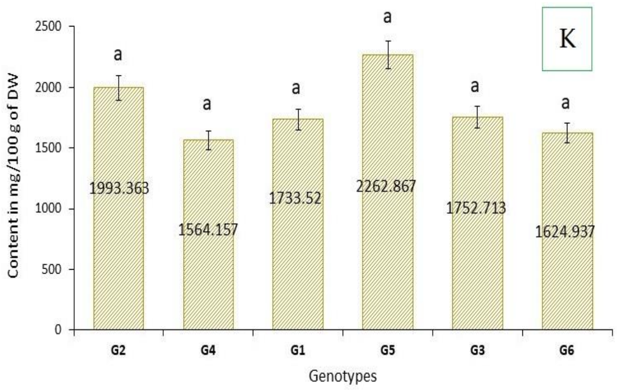

Figure 5. Leaf potassium content of genotypes of four species of the *Corchorus spp.* genus

3.5 Iron content per 100 g leaf dry matter of Corchorus spp.

The results of the analysis of variance revealed a highly significant difference (P< 0.0001) between the six genotypes for iron content. This content varies from 13. 01 mg/100 g DW for genotype G 4 (*C. olitorius var incisifolius*) to 96.20 mg/100 g DW for genotype G 1 (*C. aestuans*). The Newman-Keuls mean separation test for iron content discriminated all genotypes (Fig. 6).

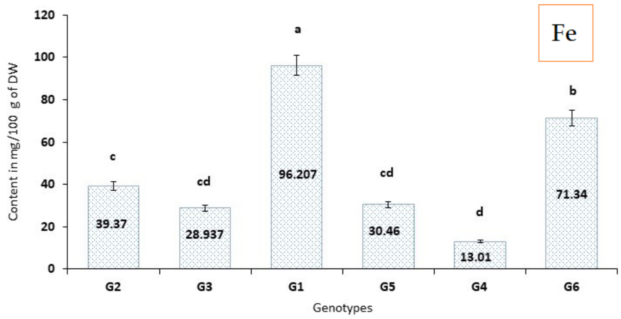

Figure 6. Leaf iron content of genotypes of four species of the *Corchorus spp.*genus (Means with different letters are significantly different at the 5 % threshold. Means followed by the same letter are not significantly different at the 5 % threshold).

3.6 Zinc content per 100 g dry leaf material of Corchorus spp.

For zinc content, results of the analysis of variance showed a highly significant difference (p<0.000) between genotype G 3 and the other five genotypes. The zinc content value varied from 1.87 mg/100 g DW for genotype G 5 (*C. olitorius var olitorius*) to 3.36 mg/100 g DW for genotype G 3 (*C. fascicularis*). The Newman-Keuls mean separation test discriminated the six genotypes for zinc content. However, the zinc content between genotypes G 2 (2.61 mg/100 g DM), G 1 (2.43 mg/100 g DM), G 4 (2. 24 mg/100g DM), G 5 (1.87 mg/100g MS) and G 6 (1.98 mg/100 g MS) was not significant (Fig. 7).

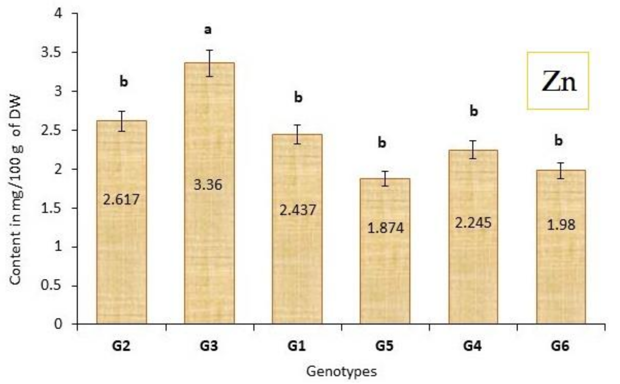

Figure 7. Leaf zinc content of genotypes of four species of the Corchorus spp genus (Means with different letters are significantly different at the 5 % threshold. Means followed by the same letter are not significantly different at the 5 % threshold)

3.7 Identification of Corchorus genotypes with high mineral content

The results of the principal component analysis revealed that axes 1 and 2 explain 85.86 % of the

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correlations between the genotypes and the mineral elements analyzed (Fig. 8). Indeed, positive and significant correlations on axis 2 were revealed for the contents of copper, zinc and the G 3 genotype. This genotype is thus characterized by higher zinc and copper concentrations than the other genotypes. The G 2 genotype and mineral elements such as calcium and magnesium are positively and very significantly correlated to axis 1. This genotype is characterized by high calcium and magnesium content. On the other hand, the G 1 genotype and iron are negatively correlated to axis 1. This G 1 genotype therefore has the high iron content. The principal component analysis also showed a negative correlation of the G 6 genotype with axis 1 and the G 4 and G 5 genotypes with axis 2. However, no correlation was revealed between the G 4, G 5 and G 6 genotypes with the contents of the mineral elements analyzed.

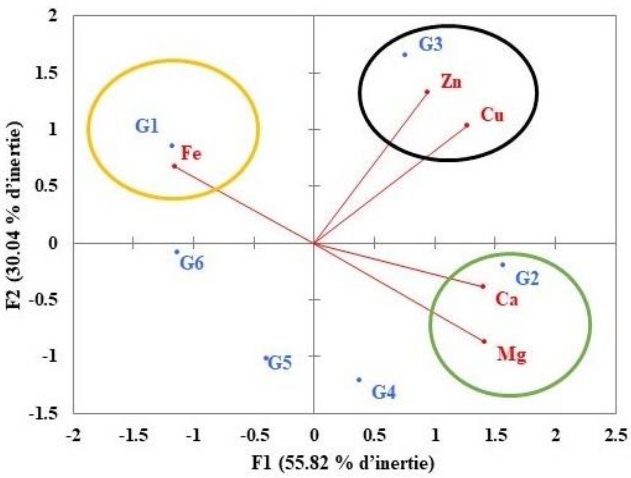

Figure 8. Correlations between *Corchorus* genotypes and mineral element content.

4. Discussion

The calcium, potassium, magnesium, copper, iron and zinc contents obtained by the six genotypes belonging to the four species of the *Corchorus* genus consumed in Burkina Faso show that the leaves of these species are an important source of mineral elements, which can contribute to fight against nutritional deficiencies. Indeed, well adapted to the pedoclimatic conditions of the country, the efficient exploitation of the nutritional potential of these species could be an endogenous solution of nutrient supply in Burkina Faso. Shashi [6], also showed in India that these species are a good source of β-carotene, potassium and iron. The significant differences observed between genotypes for the content of different mineral salts reveal that the nutritional potential of the leaves varies according to the genotypes or species of the *Corchorus* genus. As the species were put under the same experimental conditions, this difference would be related to the genotype. Thus, the high levels of mineral salts in the species C. *aestuans* (G 1 and G 2) shows that promoting this species as a vegetable could contribute fighting against certain nutritional deficiencies. Indeed, the use of this species as a vegetable remains very little known by the local population [10]. A previous study conducted on species of the *Corchorus* genus consumed in Ivory Coast reported that the species *C. aestuans* is very rich in mineral salts compared to other species [12].

Genotypes G 6 (71.34 mg/100g DW) and G 1 (96.20 mg/100 g DW) belonging to *C. tridens* and *C. aestuans* species respectively have high iron contents compared to *Adansonia digitata* whose iron content is 15.4 mg/100 g edible matter [13]. This shows that the iron content of some of these species are much higher than that of *Adansonia digitata*, which is generally recommended in the fight against iron deficiency. These two genotypes of *Corchorus* could therefore be used as a nutritional supplement in the fight against anemia in children and pregnant women who are most exposed to nutritional deficiencies. According to INSD [2], the prevalence rate of malnutrition remains high and is approximately 72 % among children aged 6 to 59 months, 58 % among women in rural areas and 50 % among women in urban areas. Moreover, the variation in iron content from 13.01 mg/100 g DW for genotype G4 (*C. olitorius var incisifolius*) to 96.20 mg/100 g DW for genotype G 1 (*C. aestuans*) is much higher than those obtained in Mali by Diarra [14], on *C. tridens* (0.01 mg/g), by Ta- Bi [12], on *C. tridens* (29.29 mg/100 g) and *C. aestuans* (6.83 mg/100 g) in Ivory Coast. Thus, the species of the *Corchorus* genus present in Burkina Faso would be richer in iron than those of Mali and Ivory Coast. This situation could be linked to the genotypes or the variations in pedoclimatic conditions between Burkina Faso and these two countries. Indeed, the variation of the biochemical composition would be linked to the genotypes and the physicochemical composition of the culture medium [6].

Moreover, the magnesium content which is higher than 100 mg/100 g DW for the G 2, G 4 and G 5

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genotypes shows that these genotypes are a good source of magnesium. According to [15], a species is considered a good source of magnesium when its magnesium content is higher than 100 mg/100 g DW. These genotypes are richer in magnesium than other vegetables such as *Amaranthus hybridus* (93 mg/100), *Moringa oleifera* (68.8 mg/100 g), *Phaseolus vulgaris* L. (25 mg/100 g) [13, 16]. The G 2, G 4 and G 5 genotypes of *Corchorus* could replace *Amaranthus hybridus*, *Moringa oleifera* and *Phaseolus vulgaris* for their abundance in Burkina Faso.

Zinc content varied from 1.87 mg/100 g DW for the G 5 genotype to 3.360 mg/100 g DW for the G 3 genotype. Zinc is a trace element that stimulates the immune system and allows the release of insulin from the pancreas [17, 16]. The recommended dietary intake of this element varies from 6 - 7 mg/day for children aged 0 to 6 years and 10 -14 mg/day for women aged 16 to 55 years [18]. Therefore, the consumption of 208-300 mg of *C. fascicularis* by children and women may be an endogenous solution to nutritional zinc deficiency.

The copper content (0.217 to 0.563 mg/100 g DW) of the six *Corchorus* genotypes is higher than that of *Amaranthus hybridus* (0.15 mg/100g), *Phaseolus vulgaris* (0.08 mg/100) and *Brassica oleracea var capitata* (0.02 mg/100 g) [13], all vegetables consumed in Burkina Faso. The recommended daily copper intake is 0.8 mg to 2 mg [18]. Thus, consumption of 190 mg and 380 mg DW of *C. fascicularis* could cover the daily copper requirements of children 0-6 years old and pregnant women, respectively.

The calcium content of genotype G 2 (327.7 mg/100 g DW) is higher than that of *Adansonia digitata* (313mg/100g), and *Amaranthus hybridus* (150.8 mg/100 g). Also, the potassium content of the six *Corchorus* genotypes is higher than that of *Adansonia digitata* (1550 mg/100 g), *Amaranthus hybridus* (602 mg/100 g), *Brassica oleracea var capitata* (317 mg/100 g) and *Moringa oleifera* (280 mg/100 g) [13, 16]. Calcium and potassium have an important role in muscle contraction, bone accretion, blood clotting, nerve conduction, and ensure proper body function [19, 20]. The consumption of species of the *Corchorus* genus endogenous leafy vegetables at the expense of exotic vegetables can strongly contribute to improving the health of the population by strengthening the immune system.

5. Conclusions

The results obtained show that the species of the *Corchorus* genus are an important source of iron, copper, magnesium, potassium, calcium, and zinc. Genotypes G 2 (*C. aestuans*) and G 4 (*C. olitorius var incisifolius*) are the richest in calcium and magnesium. Genotypes G 2 and G 3 are the rich in copper compared to the other genotypes. However, all genotypes are rich in potassium. For iron content, genotypes G 1 and G 6 showed the highest levels. For zinc content, genotype G 3 (*C. fascicularis*) had the highest content. In general, the genotypes of *C. aestuans* species showed the highest contents of the six characterized mineral elements. Given the high nutritional performance of *C. aestuans*, its domestication and improvement can be initiated to better exploit its nutritional potential. It would be interesting to evaluate the bioavailability of the different nutrients by estimating the anti-nutritional factors such as phytates, phenols and tannins whose high presence prevents the use of some mineral salts.

Authors' contributions

Conceptualization, S.Z and K.M.; Methodology, S.Z.; K.M and K.Z.; Software, S.Z.; Formal Analysis, S.Z.; Resources, K.M and S.Z.; Data curation, S.Z.; Writing original draft preparation, S.Z.; Writing-review and editing, K.M.; S.P.; Reading and Validation of the study protocol, B.K.P.

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Availability of data and materials

All data will be made available on request according to the journal policy.

Conflicts of interest

The authors have declared that there is no potential conflict of interest exist.

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