

MINERAL NUTRIENT CONTENT OF COMMONLY CONSUMED LEAFY VEGETABLES IN NORTHERN GHANA

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ABSTRACT

Leafy vegetables serve as the base of soups, a significant component of Ghanaian food recipes. The varying climatic conditions across Ghana and inefficient food distribution channels have resulted in the existence of different food crops in different regions. Anecdotally, Ghanaians generally believe that the consumption of *Colocasia esculenta* leaf improves iron status. In this study, the levels of mineral nutrients: calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na) and zinc (Zn) in the leaves of *Hibiscus sabdariffa*, *Amaranthus spinosus*, *Hibiscus cannabinus*, *Solanum macrocarpon* and *Vigna unguiculata* that are popularly used in food recipes in northern Ghana (compose of the Northern, Upper East and Upper West Regions), were compared with the levels in *Colocasia esculenta* leaf. The leafy vegetables/greens consumed in northern Ghana were sourced from market centres in the Northern and Upper East Regions (savannah zone); *Colocasia esculenta* leaf was obtained from market centres in Ashanti Region (forest zone). The leaves were shredded and air-dried for 7 days. The dried leaves were ground and analysed for the mineral nutrients using Instrumental Neutron Activation Analysis. The Ca content of *Hibiscus sabdariffa* was significantly higher than that of *Colocasia esculenta* by 1.07-fold difference ($p < 0.05$). However, compared with *Amaranthus spinosus*, *Hibiscus cannabinus*, *Solanum macrocarpon* and *Vigna unguiculata*, the level of Ca in the *Colocasia esculenta* leaf was 1.23- to 1.84-fold significantly higher ($p < 0.05$). The Fe level in the leafy vegetables commonly consumed in northern Ghana was significantly lower (2.92- to 70.60-fold difference, $p < 0.0001$) compared with the *Colocasia esculenta* leaf. Significant differences ($p < 0.05$) were also observed in the levels of K, Mg and Zn between the other greens studied and the *Colocasia esculenta* leaf. The differences were between 1.17- to 1.48-fold (K), 1.08- to 1.54-fold (Mg) and 1.15- to 2.59-fold (Zn). This study shows that the leafy vegetables commonly consumed in northern Ghana contain lower levels of the selected mineral nutrients analysed compared with those of *Colocasia esculenta* leaf. There is a need to find alternative greens that are available or could be cultivated in this part of the country.

Key words: Ghana, greens, leafy, mineral nutrient, vegetables

INTRODUCTION

Leafy vegetables play a vital role in human wellbeing. It has been established that greens contribute significantly to the daily dietary requirements of calcium and iron among children (2 to 5 yr) [1]. A meta-analysis of 2006 human epidemiological studies and 22 animal studies by Steinmetz and Potter [2], showed a consistent protective effect against gut cancer from the consumption of fruits and vegetables. Dark green vegetables have been suggested to be a significant source of vitamin A in Africa [1, 3-5].

Ghana has varying climatic conditions across the country; this, coupled with inefficient food distribution channels has resulted in the existence of different food crops in the different regions. People in a given location become accustomed to the food crops available, and this contributes significantly to their nutritional status. Leafy vegetables serve as the main source of mineral nutrients, particularly in resource-poor households in low-income countries, since intake of dietary supplements is low. This is the case of the residents of northern Ghana, which comprises the Northern, Upper East and Upper West regions. These regions have a prolonged dry season with 90% of the annual rainfall from April to September, and the rest of the months being virtually dry [6]. The area has a sub-Saharan climate [7]. Residents of northern Ghana, typically of most poor regions in low-income countries, consume significant quantities of greens gathered from their surroundings/farms. Their food recipes include an insignificant proportion of animal food sources because most families cannot afford the appropriate quantities. The Ghana Demographic and Health survey conducted in 2003 showed that about 10% of pregnant women develop night blindness, a consequence of vitamin A deficiency, while 78 to 83% of children (6 to 59 mo old) most of whom are fed family diets were anaemic (haemoglobin <7.0 g/dl) [8]. The prevalence of anaemia among women aged 15 to 49 yr ranged from 49 to 51% in northern Ghana, the nationwide average being 49%. This observation is not different from earlier findings [9]. Malnutrition prevalence was 64% among pre-school children in northern Ghana. The prevalence of these nutritional deficiencies calls for consideration of the major ingredients used in food preparation because they serve as the main source of nutrients.

Although greens constitute a significant proportion of the food recipes of northern Ghanaians, the levels of mineral nutrients such as calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na) and zinc (Zn) of the commonly consumed leafy vegetables: *Amaranthus spinosus* ["Alefu" (local name), *Amaranthus* (common name)], *Solanum macrocarpon* ("Biovo", Garden egg), *Hibiscus cannabinus* ("Kanzaga", Kenaf), *Hibiscus sabdariffa* ("Suule/Bra/Vio", Rosella), and *Vigna unguiculata* ("Saawo", Cowpea) are not covered in the literature.

In this study, the levels of mineral nutrients (Ca, Fe, K, Mg, Mn, Na and Zn) in the leaves of *Hibiscus sabdariffa*, *Amaranthus spinosus*, *Hibiscus cannabinus*, *Solanum macrocarpon* and *Vigna unguiculata* popularly used in food recipes in northern Ghana were compared with the levels in *Colocasia esculenta* ("Kontomire", Cocoyam) leaf.

Anecdotally, Ghanaians generally believe that the consumption of *Colocasia esculenta* leaf improves iron (Fe) status.

MATERIALS AND METHODS

Sampling and sample preparation

Fresh leafy vegetable samples of amaranthus (*Amaranthus spinosus*), garden egg (*Solanum macrocarpon*), kenaf (*Hibiscus cannabinus*), roselle (*Hibiscus sabdariffa*) and cowpea (*Vigna unguiculata*) commonly used for culinary preparations in the regions of northern Ghana (savannah zone) were sourced from market centres in Navrongo (Upper East Region) and Tamale (Northern Region). Cocoyam (*Colocasia esculenta*) leaf was purchased from market centres in Kumasi and Sunyani (both cities are in the forest belt of Ghana, where cocoyam grows well). In the laboratory, the samples were mixed per variety, washed under tap water and distilled water to remove debris. They were shredded into smaller pieces (0.5 cm by 1.5 cm), air-dried for 7 days and pulverised using mortar and pestle. The ambient temperature was about 38°C, relative humidity 22% and average sunshine per day 70%. The samples obtained were sieved using a strainer of 500 µm apertures to obtain finely ground homogenised samples and were stored in clean polyethylene bags in a refrigerator at 4°C. Portions of the finely ground homogenised samples were analysed for the mineral nutrients content.

Laboratory analysis

The Instrumental Neutron Activation Analysis was used to determine Ca, Fe, K, Mg, Mn, Na and Zn levels in the samples. A detailed description of the reactor used and efficiency of the assay have been reported elsewhere [10]. Approximately 100 mg of powdered samples were weighed separately using a Mettler AE 163 analytical balance onto a clean polyethylene foil. The foil was wrapped with forceps and sealed with hot-air from a dryer. Triplicate samples together with certified reference material (NIST 1571, orchard leaf) were packed together into a clean irradiation capsule, and sealed by soldering.

The capsules were sent into the inner irradiation sites of the reactor by means of pneumatic transfer system operating at a pressure of 65 psi. The samples were irradiated for 5 minutes, 1 hour, and 6 hours for short-lived, medium-lived and long-lived radionuclide, respectively. At the end of each irradiation process, the samples were taken out from the reactor, allowed to decay for 5 minutes and counted for 10 minutes for short-lived radionuclide. For medium-lived and long-lived radionuclide, samples were allowed to cool for 4 and 14 days, respectively. Samples were counted for 10 minutes for medium-lived radionuclide and 15 hours for long-lived radionuclide. Counting of samples was done on a PC-based gamma-ray spectroscopy system, which uses an N-type High Purity Germanium detector. During the counting period, the spectra intensities of the sample accumulated on a computer by means of ACCUSPEC Multichannel Analyser. The gamma-ray spectrum obtained provided meaningful results on all radionuclide in the sample. The accumulated spectra intensities were analysed to determine the elements present. The area under the photo

peak of the identified mineral nutrients of interest was converted into concentration using the Gamma Spectra Analysis software.

Data analysis

The data collected was analysed using General Linear Model Procedure for analysis of variance (ANOVA) using SAS 9.1(SAS Institute, Cary, NC, USA). The dependant variables were the mineral nutrients analysed and the leafy vegetables were the independent variable in the model term. Tukey's Studentized Range (HSD) test ($\alpha=0.05$) was used to compare means when the F-test was significant ($p<0.05$). Results are reported as means \pm standard deviations of three independent measurements on dry weight basis.

RESULTS

The results (Table 1) obtained for a standard reference material (NIST 1571, orchard leaf) correlated significantly ($r=1.00$, $p<0.0001$) with the certified standard values for some of the mineral nutrients determined. Data in Table 2 showed that with the exception of Ca, cocoyam leaf had significantly ($p<0.0001$) higher level of Fe, K, Mg and Zn than the greens consumed in northern Ghana. Fe content of cocoyam leaf was 10.59 ± 0.48 mg/kg. This was 2.92-fold to 70.60-fold higher compared with the other leafy vegetables studied. Amaranthus leaf had the highest iron (3.63 ± 0.25 mg/kg) content among the greens used in this part of the country. Potassium and Zn were 1.17 to 1.48 and 1.15 to 2.59 times more in cocoyam leaf. Also, Mg was 1.08-fold to 1.54-fold lower in the other leafy vegetables compared with cocoyam. Roselle had the highest Ca content which differed significantly (1.07-fold difference, $p<0.05$) from the level in cocoyam leaf. However, cocoyam leaf exceeded the Ca content of the other leaves by 1.23-fold to 1.84-fold. There were no differences ($p\geq 0.05$) for Mn content among cocoyam, garden egg, roselle and cowpea leaves.

The estimated percentage of Dietary Reference Intakes (DRI) met by consumption of 30 g (dry weight basis) per serving based on findings of Barminas *et al.* [11] was higher for cocoyam leaf (0.13%–20%) for all the mineral nutrients compared with the other leafy vegetables (0.12% to 15%) (Table3). This estimation was based on the requirements for children aged between 1–8 yr old. Fe content in cocoyam leaf was found to be, respectively, 14.64-fold and 26.72 fold lower than that in sweet potato (*Ipomoea batatas*) and moringa (*Moringa oleifera*) leaves (Figure 1).

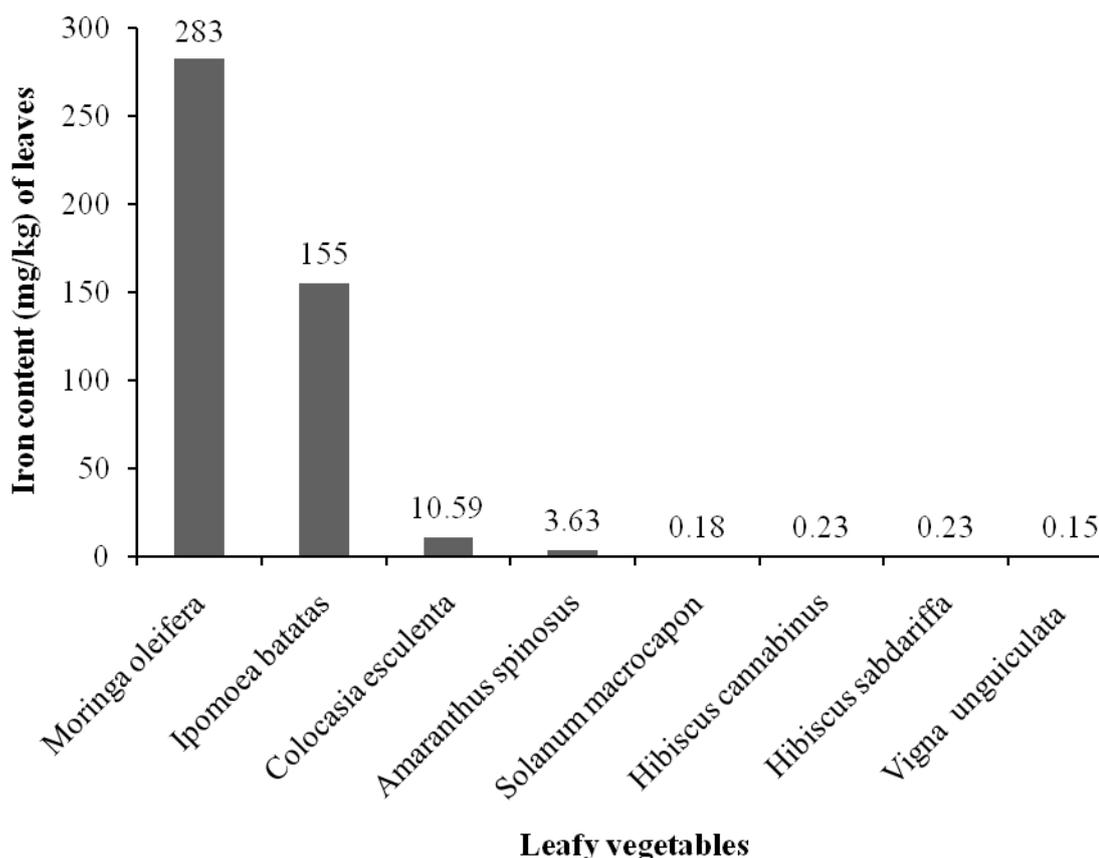


Figure 1: Iron content (mg/kg) of some leafy vegetables in Ghana[‡]

[‡]Data on *Moringa oleifera* (moringa) and *Ipomoea batatas* (sweet potato) were extracted from Oduro *et al.* [12];

Value for sweet potato is the average of the means of seven varieties:

Colocasia esculenta (Cocoyam), *Amaranthus spinosus* (Amaranthus), *Solanum macrocarpon* (Garden egg), *Hibiscus cannabinus* (Kenaf), *Hibiscus sabdariffa* (Roselle), *Vigna unguiculata* (Cowpea).

DISCUSSION

The strong correlation between the present study data for the reference values indicates the reliability of the assay method used for determining the levels of mineral nutrients of leafy vegetables. From these results, cocoyam leaf is a better source of Fe, K, Mg and Zn compared with the commonly used leafy vegetables in northern Ghana. Iron an essential nutrient and a component of haemoglobin, was too low in the leaves of amaranthus, garden egg, kenaf, roselle and cowpea used in culinary preparations of the regions of northern Ghana compared with cocoyam leaf (Table 2 and Figure 2). This could partly account for the ever-prevailing relatively high number of anaemia cases among the populace of this region compared to the occurrence nationwide.

Therefore, there is urgent need to find alternative leafy vegetables. Oduro *et al.* [12] recommended the use of the leaves of moringa and sweet potato in food preparations of Ghanaians because they are richer in nutrients compared with cassava, pumpkin and taro leaves, amaranth and mushrooms. Families in northern Ghana should be encouraged to include moringa leaves among the greens consumed in this part of the country since it has been reported that moringa and sweet potato are available in the region [13-15]. The leaves of sweet potato have also been reported to be relatively high in β -carotene (precursor of vitamin A), vitamin B₁₂, vitamin C and vitamin E compared with other vegetables [16]. These nutrients may contribute to the reduction of nutritional deficiencies (for example, iron and vitamin A) in that part of the country. However, efforts by nutrition researchers are required in promoting the consumption of the suggested leafy vegetables.

The low levels of sodium in the leafy vegetables used in this study lends support to earlier findings that vegetables can help prevent or control hypertension and reduce the subsequent risk of stroke and heart diseases [2]. The low level of zinc was expected because unlike red meat, plants are not good sources of this mineral nutrient [17].

It is worth mentioning that the culinary preparations of most people in northern Ghana would also include other foods like fish or meat, and legumes that will invariably contribute some of the mineral nutrients. Hence, the results of this study should be interpreted with caution since the assay was not done on home-prepared leafy vegetable meals. Also, losses through food preparation methods were not addressed in this paper. The DRI values are over-estimated because children aged between 1 and 8 yr are not able to consume the total volume of soup prepared using 30 g of leafy vegetables on a dry weight basis. Nonetheless, findings of this study suggest that the commonly used leafy vegetables in northern Ghana may be implicated in the high prevalence of micronutrient deficiencies among the people, as these greens form a major component of their food recipes.

CONCLUSION AND RECOMMENDATION

Cocoyam leaf has higher levels of most of the mineral nutrients sought, compared with commonly used leafy vegetables in northern Ghana. The greens consumed in this part of the country are very low Ca, Fe, K, Mg, Mn and Zn; therefore leaves of sweet potato and moringa could be promoted as these crops are reported to be higher in mineral nutrients. However, nutrition education by nutrition researchers and health workers are required in promoting the consumption of the suggested leafy vegetables.

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Table 1: Analysis of reference material NIST SRM-1571 (orchard leaf) (mg/kg) ‡

Mineral nutrient	NIST Certified value	This study
Ca	2.09 ± 0.03	1.87 ± 0.04
K	1.47 ± 0.03	1.83 ± 0.06
Mn	91.00 ± 4.00	94.08 ± 2.14
Na	82.00 ± 6.00	79.57 ± 1.87
Zn	25.00 ± 0.30	26.02 ± 0.25
Correlation coefficient (r)	1.00	
p-value	< 0.0001	

‡ Values (means±SD, n=3) reported on dry weight basis.

Table 2: Mineral nutrients content (mg/kg) on dry weight basis of selected leafy vegetables in Ghana[‡]

Leafy vegetable	Mineral nutrient (mg/kg)						
	Ca	Fe	K	Mg	Mn	Na	Zn
<i>Colocasia esculenta</i> [*] Cocoyam	759.24±3.54 ^b	10.59 ± 0.48 ^a	1574.00 ± 3.87 ^a	703.05 ± 4.34 ^a	6.75 ± 0.58 ^a	48.12 ± 1.52 ^a	3.88 ± 0.24 ^a
<i>Amaranthus spinosus</i> [#] Amaranthus	617.00 ± 4.54 ^c	3.63 ± 0.25 ^b	1343.00 ± 4.17 ^b	456.19 ± 2.14 ^f	4.20 ± 0.16 ^c	41.30 ± 2.34 ^{a,b}	2.48 ± 0.06 ^c
<i>Solanum macrocarpon</i> [#] Garden egg	413.00 ± 5.12 ^f	0.18 ± 0.03 ^c	1240.00 ± 5.66 ^d	486.10 ± 4.15 ^d	6.38 ± 0.41 ^{a,b}	50.07 ± 4.13 ^a	2.31 ± 0.08 ^c
<i>Hibiscus cannabinus</i> [#] Kenaf	486.54 ± 8.54 ^e	0.23 ± 0.04 ^c	1061.22 ± 6.48 ^e	508.28 ± 2.53 ^c	4.93 ± 0.91 ^{b,c}	50.07 ± 4.13 ^a	1.50 ± 0.12 ^d
<i>Hibiscus sabdariffa</i> [#] Roselle	812.01 ± 7.25 ^a	0.23 ± 0.01 ^c	1269.33 ± 8.02 ^c	651.13 ± 7.42 ^b	7.32 ± 0.63 ^a	50.07 ± 4.13 ^a	2.29 ± 0.05 ^c
<i>Vigna unguiculata</i> [#] Cowpea [#]	504.00 ± 5.12 ^f	0.15 ± 0.03 ^c	1280.00 ± 8.11 ^c	472.00 ± 5.16 ^e	7.55 ± 0.31 ^a	35.62 ± 2.10 ^b	3.38 ± 0.05 ^b
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001

[‡]Values (means±SD, n=3) reported on dry weight basis

Means in a column with the same letter are not significantly different (p≥0.05)

^{*}A generally accepted leafy vegetable by Ghanaians to improve iron status

[#]Leafy vegetables commonly consumed in northern Ghana

Table 3: Percent of Dietary Reference Intakes (DRIs) met by consumption of 30 g (dry weight basis) of some leafy vegetables in Ghana for children (1–8 yr old) ‡

Mineral nutrients	DRI (mg/day)*	Consumption of 30 g (dry weight basis) of leafy vegetable [‡]	
		Average daily intake (mg/30 g/day)	Percentage of DRI met
Ca	<i>650.0</i>	17.00 (22.78)	2.62 (3.50)
Fe	8.5	0.03 (0.32)	0.35 (3.76)
K	<i>3400.0</i>	37.16 (47.22)	1.09 (1.39)
Mg	105.0	15.44 (21.09)	14.70 (20.09)
Mn	1.4	0.18 (0.20)	12.86 (14.29)
Na	<i>1100.0</i>	1.36 (1.44)	0.12 (0.13)
Zn	4.0	0.07 (0.12)	1.75 (3.00)

‡Consumption of 30 g per serving was based findings by Barminas *et al.* [11] as the average of leafy vegetables used for culinary preparation;

*Italicised figures are Adequate Intakes (AIs), otherwise, Recommended Dietary Allowances (RDAs) *Source:* Food and Nutrition Board, Institute of Medicine, and National Academies [18]; Values are means of the recommended values specified for the age groups 1-3 yr and 4-8 yr

[‡]Means of all green leafy vegetables consumed in northern Ghana (**mean of the generally accepted leafy vegetable by Ghanaians to improve iron status**).

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