# Nutrient content of dried leaves of *Zanthoxylum chalybeum* Engl. growing in semi-arid areas of Iringa region, Tanzania

**[1]Balama, C., [2]Makatta, A.A., [1]Maduka, S.M. and [3]Tewele, C.**

[1]Tanzania Forestry Research Institute, P. O. Box 1854, Morogoro.
[2]Forestry Training Institute, Olmotonyi, P.O. Box 943, Arusha.
[3]Ministry of Agriculture, Livestock and Fisheries, P.O. Box 3047, Morogoro.

## ABSTRACT

Dried leaves of *Zanthoxylum chalybeum* Engl. have been used as a vegetable in powder form by local communities in semi-arid areas of Iringa Region for decades. However, there is limited knowledge on its nutritional content. This study was carried out to assess nutrient content of dried leaves of *Z. chalybeum* growing in semi-arid areas of Iringa, Tanzania. Specifically, using fresh (control), locally and solar dried leaves of *Z. chalybeum*, the study determined laboratory proximate composition (moisture content, ash, crude fibre, crude protein, crude fat and carbohydrate), vitamin A and C and mineral *contents (Calcium, Iron, Phosphorus, Potassium and Sodium). Analysis of variance was used to compare mean values of nutrient contents of fresh, locally and solar dryer dried *Z. chalybeum* leaves. Results indicated that both locally and solar dryer dried leaves contained sufficient concentration of nutrients that were within the Recommended Daily Allowance (RDA) except for Vitamins Aand C. Attainment of the RDA for Vitamins A and C could be achieved through intake of green vegetables in the diet. Concentration of nutrients in both locally and solar dried leaves increased after drying except for Vitamin C. The study recommends local communities to dry well *Z. chalybeum* leaves locally or using solar dryer equipment before grinding in order to increase nutrient concentration.

**Keywords:** *Zanthoxylum chalybeum*, proximate composition, vitamins, minerals, Tanzania

## INTRODUCTION

Food security has remained to be among major challenging issues in global sustainability discourses. According to Azam-Ali and Battcock (2001), about 1.2 billion people worldwide suffer food felicities while 2 billion people, mostly from developing countries including Tanzania face shortage of some micronutrients. About 70% of the population in Tanzania live in rural areas where majority of them depend on rain-fed agriculture for grains and vegetable production. Local communities in rural areas are adapted to use native varieties of vegetables available in their farms or cultivate them in home gardens production systems all year-round. They are also adapted to locally dried vegetables which are preserved using indigenous knowledge. This enables them keep harvests made during rain season and use them during dry season (Keller 2004). Due to unreliable supplies of fresh vegetable from farms, people particularly from semi-arid areas of Tanzania have adopted use of wild vegetables. For instance, people in semi-arid areas of Iringa region use *Z. Chalybeum* Engl. (locally known as *mkunungu*) dried leaves (in powder form) as vegetable, especially during dry season (MEMA 2000). *Z. chalybeum* is a spiny deciduous tree to 8 m in height with a rounded but opencrown (Ruffo *et al.* 2002).

Increasing scarcity of vegetables grown in near urban areas and increasing prolonged dry spell periods in areas that experience good rains have increased demands for powered *Z. chalybeum* leaves vegetable. However, in these areas, the vegetablecan now be found in local market places inIringa Region (MEMA 2000). In 2010, *Z. chalybeum* powder weighing 0.5 kg was sold at TZS 5,000/= (US$ 3.5) by vendors in Iringa town market (*communication with Mr. Yuda Msigala, Mawala Village Chairman*). Most of the vendors are women who pack the product in polythene bags which weigh 250 g to 1 kg. These African indigenous vegetables play a significant role in food security in urban and rural areas (Schippers 1997, Keller 2004). The vegetables are valuable sources of energy, vitamins and micronutrients in the diets of rural communities (Grivetti and Ogle 2000; Keller 2004)). These vegetables are more vulnerable to advese effects of changing climatic conditions and it is anticipated to worsen in the future (Cowie 2007). Improvement of the community livelihoods through use of the wild vegetable can be sustained through in-situ management practices and on farm cultivation of the plant.

The *Z. chalybeum* vegetable is usually harvested from woodlands and on farms, dried and powdered for final consumption. Although the vegetable has been in use for decades, there is limited information on its nutrient contents. It is against this background that a study was carried out to assess nutrient content of dried leaves of *Z. chalybeum* vegetable growing in semi-arid areas of Iringa, Tanzania. Specifically, the study determined proximate composition (moisture content, ash, crude fibre, crude protein, crude fat and carbohydrate); Vitamin A and C; and mineral contents of locally and solar dryer dried leaves of the species.

## METHODOLOGY

### Study area

The study was carried out in Iringa Region. Two villages namely Kinywang'anga (35°50'55"E; 7°24'29"S) and Mangawe (35°50'55"E; 7°34'40"S) in Iringa Rural district and Irole (35°54'56"E; 7°40'54"S) and Mawala in Kilolo district (35°52'40"E; 7°43'23"S) were purposively selected for study (Figure 1).

The climate in Iringa Rural District varies with altitude. Depending on the altitute range, the district lies in midland and lowland landscape zones. The selected villages (Kinywang'anga and Mangawe) lie in the lowland zone (900 – 1 000 m a.s.l.), which is a semi-arid area (the northern part of the district). The annual rainfall in this zone ranges between 500 and 600 mm,while the daily temperature ranges between $20^0$C and $25^0$C, with a uni-modal rain season extending from December to April (URT 2013).

The climate in Kilolo District varies with altitude as it differs in highlands and lowland areas. The selected villages (Irole and Mawala) are situated in the lowland areas (900 – 1 300 m a.s.l.), located in the north east of the district. The zone is characterised by semi-arid condition with unreliable unimodal rainfall with annual mean of 542 mm (Birch-Thomsen *et al*. 2001, 2007).

Temperature ranges between $22^0$C and $28^0$C, with a uni-modal rain season extending from December to April (URT 2013).

The main socio-economic activities in the study villages are subsistence agriculture, livestock keeping and petty trade. Food crops that are produced include: maize, cowpeas, sorghum, beans, and groundnuts. Cash crops include maize, sunflower and millet. Other crops that can be grown in the villages include sesame, cotton and sweet potatoes. Vegetables grown include pumpkins, cowpeas and amaranths. Wild leafy vegetable are obtained from *Z. chalybeum* (mkunungu) and *Maerua angolensis* (mtosi) trees which are found growing on farms and in woodlands in the study areas. The vegetation in the study areas is characterised by dry Miombo woodlands with some patches of *Commiphora* and *Acacia* woodlands.

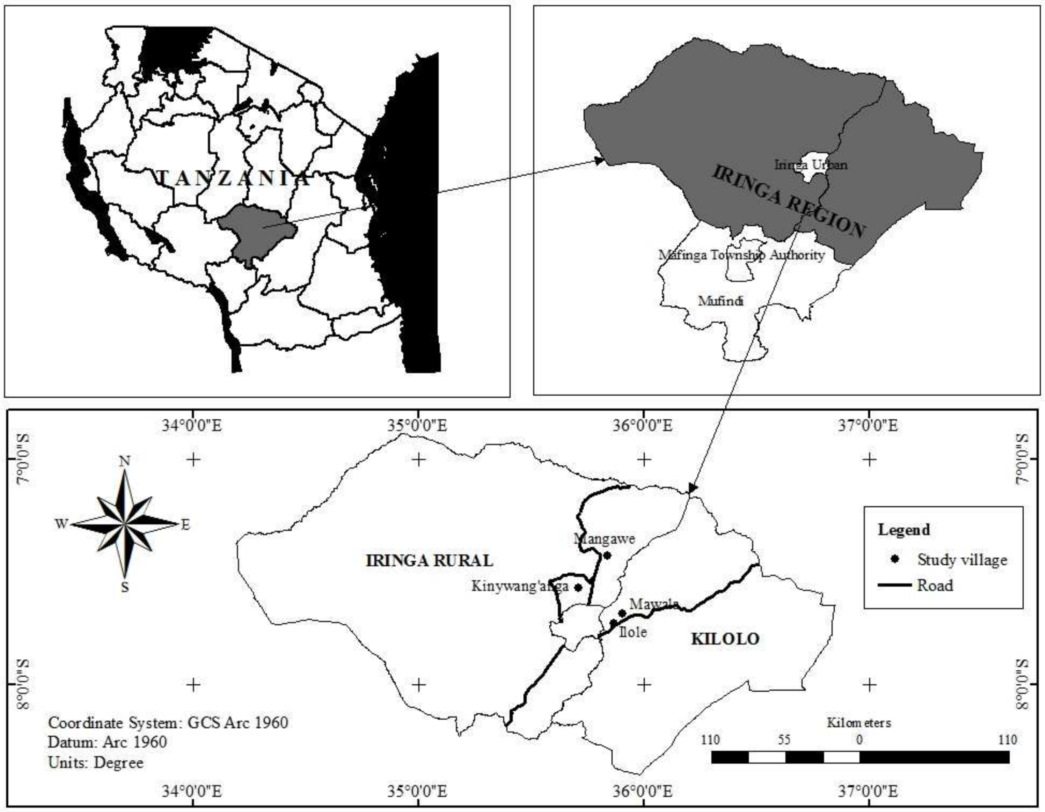


Figure 1. Map showing location of study areas (Source: NBS 2012)

**Data Collection**

Fresh leaves of *Z. chalybeum* trees growing on farms and woodlands were collected from different stems at the same location around 6:00 pm. Normally, fresh leaves are collected either in the morning or evening hours when solar energy intensity is low, and therefore evaporation is minimal. Since vitamins are water soluble, collection during high solar energy intensity makes green leaves to have low amounts of vitamins (Emmanuel *et al*. 2011, Kwenin *et al.* 2011). The leaves were kept in cool boxes separately and transported in the morning from 6:00 to 11:00 am to the Department of Food Science laboratories, Sokoine University of Agriculture (SUA), Morogoro for analysis. Also, locally dried *Z. chalybeum* leaves were collected for laboratory analysis. Fresh leaves, locally and solar dryer dried leaves of *Z. chalybeum* were prepared in the laboratory from 11:00 am to 6:00 pm ready for laboratory analysis. The locally dried leaves of *Z. chalybeum* were dried under shade (inside houses) for at least one week after harvesting. The shade dried leaves were dried again under the sunlight for about three to four hours before grinding. A solar dryer is an equipment used to dry vegetables and fruits. It is covered with materials that retain temperature. It shortens the drying time by increasing temperatures and air current. The faster drying reduces the risk of spoilage, improves quality of the product and gives a higher throughput, so reducing the drying area that is needed.

**Laboratory Analysis**

Laboratory analysis involved proximate analysis (moisture content, ash, crude fibre, crude protein, crude fat and carbohydrate) and Vitamins A and C analysis, as well as mineral content (Calcium (Ca), Iron (Fe), Phosphorus (P), Potassium (K) and Sodium (Na) from fresh leaves, locally and solar dryer dried *Z. chalybeum* powder. Samples of fresh leaves were considered as control in order to observe loss of nutrients that might have occured during processing (from harvesting to grinding).

***Proximate composition***

*Moisture content*

A total of 5 grammes (g) of fresh leaves, locally and solar dryer dried powder were oven dried at 105$^{o}$C to constant weight. The moisture content was calculated using equation 1:

$$\%W = \frac{(\text{Wt of wet sample}) - (\text{wt of oven dry sample})}{\text{wt of wet sample}} \text{ x } 100 \text{ ......................................(1)}$$

Where
W = moisture content
Wt = weight

*Dry matter*

The dry matter of *Z. chalybeum* sample was determined by oven drying method method 925.10 (AOAC 1995). One gramme of *sample* was dried at 105$^{0}$C to constant weight. Dry matter was calculated using equation 2:

*% Dry matter = [(C - B)/A] x 100* ……………………………………………….....................(2)

Where

| | | |
|---|---|---|
| A | = | Sample weight (g) |
| B | = | Weight of dry crucible (g) |
| C | = | Weight of crucible and dry sample (g) |
| C - B | = | Weight of dry sample (g) |

*Ash content*

Ash content of *Z. chalybeum* samples was determined using muffle furnace as described in the standard method 923.03 (AOAC 1995). Duplicate one-gramme samples were oven dried at 105$^{o}$C to constant weight. The dried samples were weighed and placed in muffle furnace at 550$^{o}$C for 3 hours until white or grey ash was obtained. Ash was calculated using equation 3:

*% Ash = [Weight of ash (g)/ Weight of sample (g)] x 100* ………………..…………(3)

*Crude protein content*

Crude protein content of the *Z. chalybeum* samples was determined by using the micro-Kjeldahl method 920.87 (AOAC 1995). A sample size of 0.25 g was used for analysis.

Nitrogen (N) content was calculated using equation 4:

$$\% \text{ N} = \frac{14.01 \text{ x } (\text{Titre - blank}) \text{in ml } (0.1\text{N HCL})}{\text{Weight of sample (g) x 100 mls}} \text{ x } 100 \quad \ldots\ldots(4)$$

Crude protein content was calculated using equation 5:

$$\% \text{ Protein} = \% \text{ N x } 6.25 \ldots\ldots(5)$$

*Fat content*
Fat content of *Z. chalybeum* samples was determined by ether extraction using the Soxhlet system (Tecator Soxtec System HT 1043 Tecator AB, Sweden) detailed in method 920.65 (AOAC 1995). A 3 g sample in triplicate was used for analysis. Crude fat content was calculated using equation 6:

$$\% \text{ Crude fat} = [\text{Weight of crude fat (g)/ Weight of drysample (g)] x100} \ldots\ldots(6)$$

*Crude fibre*
Ankom Fibre Analyzer (Model Ankom 220 USA) was used to determine crude fibre content as outlined by AOAC (1995) method 920.86. One gramme of sample was used for crude fibre determination. Total fibre content was calculated as shown in equation 7:

$$\% \text{ Crude fibre} = [(W_1 - W_2)/ W] \text{ x } 100 \ldots\ldots(7)$$

Where:
$W_1$ = Weight of dry residue before incineration (g)
$W_2$ = Weight of ash residue after incineration (g)
W = Weight of dry sample taken for determination (g)

*Carbohydrate content*
Carbohydrate content of *Z. chalybeum* leaves was calculated as percentage difference (AOAC 1995). Equation 8 was used to calculate carbohydrate content.

$$\% \text{ carbohydrate} = 100 - (\% \text{ Protein} + \% \text{ Crude fibre} + \% \text{ Crude fat} + \% \text{ Ash}) \ldots\ldots(8)$$

***Vitamins A and C contents***
Vitamin A (Beta carotene) was determined according to Delia and Mieko (2004). Samples of 0.5 g were used for analysis. Equation 9 was used to estimate the Beta carotene.

$$\text{Beta carotene } (\mu g) = \frac{(A \times \text{volume of extract (mls)} \times 10000)}{E \times \text{sample weight (g)}} \ldots\ldots(9)$$

Where:
A = Sample absorbance as read at 450 nm
E = Absorbance coefficient of ß-Carotene in Petroleum spirit (2592).

Samples weighing 0.5 – 2.5 g were used for determination of Vitamin C content (AOAC 1995). Vitamin C content was calculated using equation 10:

$$\text{Vitamin C content in mg/100g of the sample} = \frac{(A - B) \times C \times V}{D \times S} \times 100 \quad \ldots\ldots(10)$$

Where: A = volume in ml of the Indophenol solution used for sample
B = volume in ml of the Indophenol solution used for blank
C = mass in mg of ascorbic acid equivalent to 1.0 ml indophenols solution
S = mass of sample in grammes taken for analysis
V = total volume of extract in millilitres
D = volume of sample filtrate in millilitres taken for analysis.

***Mineral content***

The individual ash samples obtained during ash determination were dissolved in 2 mls of concentrated Hydrochloric acid. The suspension was then diluted with distilled water (mineral free) and filtered using No. 1 Whatman ash-less filter papers. The filtrate was diluted to 50 mls with distilled water and analysed for mineral content using Atomic Absorption Spectrophotometer (UNICAM 919).

**Data analysis**

Analysis of variance (ANOVA) in Statistical Analysis Software (SAS) package was used to compare means of nutrient contents of *Z. chalybeum* samples. Significant nutrient content means were separated by Duncan's Multiple Range Test.

## RESULTS

**Proximate composition**

Table 1 shows results of proximate analysis of *Z. chalybeum* samples which indicate that the nutrient content did not vary much with other green vegetables consumed in everyday life.

**Vitamin A and C contents**

Results in Table 1 indicate that Vitamin A content of *Z. chalybeum* differed significantly among the three samples types. The vitamin was highest in locally dried leaves followed by solar dried and fresh leaves. Vitamin C content of *Z. chalybeum* differed significantly among the three sample types. Fresh leaves had the highest content of the vitamin (Table 1).

Table 1. Mean values of nutrient contents of *Z. chalybeum* leaf samples

| Sample name | %Moisture | %Ash | %Crude Fibre | %Crude Protein | %Crude Fat | %Available Carbohydrate | %Total Carbohydrate | Beta carotene (μg/g) | Vitamin C (mg/100g) |
|---|---|---|---|---|---|---|---|---|---|
| Fresh leaves | 51.023a (2.65) | 9.398a (2.11) | 4.057a (2.89) | 4.909a (1.73) | 2.433a (0.96) | 28.181a (3.03) | 37.579a (2.26) | 404.020a (47.67) | 44.992a (3.22) |
| Locally dried leaves | 10.773b (2.73) | 11.908b (2.57) | 11.234b (3.16) | 13.741b (2.12) | 2.320a (1.62) | 50.025b (4.22) | 61.932b (3.76) | 710.370b (87.23) | 18.985b (3.98) |
| Solar dryer dried leaves | 10.678b (1.03) | 9.146b (1.02) | 9.397b (1.87) | 14.354b (1.05) | 2.176a (1.14) | 54.250b (2.31) | 63.396b (3.11) | 529.866c (66.54) | 9.255c (3.15) |

Numbers in brackets are standard error (±). Values followed by the same letter within the column are not significantly different at 5% probability level.

## Mineral contents

Results showed that *Z. chalybeum* leaves contained larger amounts of minerals than the RDA of most of the studied minerals except Na and K (Table 2).

Table 2. Mean values of mineral contents in *Z. chalybeum* leaf sample

| Sample name | Minerals analyzed and amounts in mg/Kg (ppm) | | | | |
|---|---|---|---|---|---|
| | **Calcium** | **Iron** | **Phosphorous** | **Potassium** | **Sodium** |
| Fresh leaves | 1 084.89a (131.24) | 16.09a (1.22) | 626.54a (36.34) | 2 976.925a (154.76) | 792.63a (44.66) |
| Locally dried leaves | 1 358.63b (152.56) | 26.93b (3.75) | 988.985b (58.25) | 4 613.245b (176.14) | 944.54b (88.22) |
| Solar dryer dried leaves | 1 439.94b (116.14) | 28.09b (1.02) | 843.89b (45.12) | 4 577.78b (168.35) | 982.74b (54.21) |

Numbers in brackets are standard error (±). Values followed by the same letter within the column are not significantly different at 5% probability level.

## DISCUSSION

### Proximate composition

Locally and solar dryer dried leaves had low moisture content which is important in the preservation of the vegetable for long time as high moisture content favour deterioration of the vegetable due to growth of micro-organisms. Locally and solar dryer dried *Z. chalybeum* leaves contained high content of carbohydrate compared with fresh leaves (Table 1). Table 1 further shows that the protein content in fresh leaves was lower compared to dried leaves. This could be due to concentration of the nutrient in the leaves as water evaporates. Locally and solar dryer dried leaves contained slightly higher protein than the RDA. Similar observation was also reported by Rand *et al.* (2003). Fat contents of locally and solar dryer dried *Z. chalybeum* leaves did not differ significantly from fresh leaves (Table 1), indicating that drying had no significant effect on fat content. According to Kris-Etherton *et al.* (2002), a diet providing 1 - 2% fat is considered sufficient to human beings. Therefore, fat content of this vegetable is not higher than the reguired range.

The fibre content of locally and solar dryer dried leaves were significantly higher than those of fresh leaves (Table 1). The results of locally and solar dried *Z. chalybeum* leaves concur with those of amarath reported by Kwenin *et al.* (2011) and Karmakar *et al.* (2013). Fibre content values found in this study were however higher than those of amaranth reported by Sarah and Maina (2008) and Asaolu *et al.* (2012).

### Vitamin A and C contents

Vitamin A content in the dried leaves of *Z. chalybeum* found in this study meets the RDA for females but not for males (Bellows and Moore 2003). The observed differences in Vitamin C content among the three *Z. chalybeum* leaf samples could be attributed to exposure to sunlight which results in loss of this vitamin by evaporation since it is water soluble (Emmanuel *et al.* 2011, Kwenin *et al.* 2011, Karmakar *et al.* 2013). Vitamin C contents found in this study are similar to other green leafy vegetables such as amaranth (Sarah and Maina 2008). The Vitamin Ccontent found in this study are however lower than RDA for both males and females (Bellows and Moore 2003).

**Mineral contents**

Results show significant differences in mineral contents between fresh and dried leaves (locally and solar dryer) of *Z. chalybeum* (Table 2). This is an indication that drying led to concentration of nutrients after dehydration (Kwenin *et al.* 2011, Karmakar *et al.* 2013). Iron content which is among the essential elements for humans was slightly higher than the RDA.

## CONCLUSIONS AND RECOMMENDATIONS

Results indicated that *Z. chalybeum* vegetable contained sufficient nutrient contents that were within the RDA except for Vitamins A and C. Attainment of the RDA for the vitamins could be done through intake of green vegetables in the diet. Concentration of nutrients in both locally and solar dried *Z. chalybeum* leaves increased after drying except Vitamin C. The study recommends local communities to dry well *Z. chalybeum* leaves locally or using solar dryer equipment before grinding in order to increase nutrient concentration.

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