

Full Length Research Paper

Nutrient composition of cat's whiskers (*Cleome gynandra* L.) from different agro ecological zones in Malawi

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The aim of the present study was to determine the nutrient composition of *Cleome gynandra* L. Nutrient content determination of *C. gynandra* was limited in the previous studies done in Malawi. *C. gynandra* is a readily available vegetable used for relish and medicine. The study was done from February to March 2014. Nutrient analysis was done on *C. gynandra* L. leaf samples collected from different agro-ecological zones in Malawi. Nutrient analyses included moisture, protein, crude fibre, ash, iron, calcium and zinc. All the analysis of the nutrients was done on dry weight basis. Results obtained indicated significant differences ($p < 0.05$) in ash, iron and calcium contents ranging from 5.2 to 6.88, 22.93 mg/100 g – 44.7 and 1667.0 – 2497.5 mg/100 g, respectively. However *C. gynandra* from different agro ecological zones did not differ significantly ($p > 0.05$) in moisture content ranging from 79.28– 83.58 g/100 g, protein content ranging from 3.85– 5.80 g/100 g, crude fibre content ranging from 1.76– 2.06 g/100 g, vitamin C ranging from 214.31– 319.12 mg/100 g and zinc ranging from 2.28 – 2.9 mg/100 g. This study revealed that *C. gynandra* contains macro and micro nutrients which are essential for the growth and maintenance of the human body. Hence, it can be promoted for consumption to contribute some nutrients to the diet. The values generated by this study can contribute to Malawi Food Composition database.

Key words: Agro ecological zone, *Cleome gynandra*, Malawi, nutrients.

INTRODUCTION

Spider plant/cat's whiskers (*Cleome gynandra* L.) is one of the indigenous vegetables found in Malawi. Kwapata and Maliro (1997) reported that *C. gynandra* was fourth in the top ten of indigenous vegetables consumed around Karonga Agricultural Development Division in Malawi.

Furthermore, in the National Nutrition Education and Communication Strategy for preventing child stunting in Malawi (2011 to 2016), *C. gynandra* was amongst vitamin A rich vegetables being promoted to be consumed for prevention and control of vitamin A deficiency

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(Government of Malawi, 2012). This vegetable is readily available since it grows as a weed in crop fields and also in road sides and in open grass lands including around households (Mishra et al., 2011). Usually, *C. gynandra* does not require any formal cultivation (Nnamani et al., 2009). Hence, it can be a readily available source of relish, providing nutrients to the household. Narendhirakannan (2005) reported that *C. gynandra* is a rich source of nutrients such as vitamins A, C and minerals (calcium and Iron). In addition, Omale and Ugwu (2011) also reported that vegetables contribute to the mineral, vitamin and fibre contents of diets.

In terms of botany, *C. gynandra* is an erect herbaceous annual with branched stems in the family Cleomaceae. Leaves are alternate, digitately palmate and petiolate. Inflorescences are showy, many flowered, terminal racemes. The fruits are long-stalked, dry, dehiscent siliques. The plants inhabit wasteland and arable land (Mishra et al., 2011). Its nutritional value may vary with soil fertility, environment, variety, plant age and the production techniques used (Chweya, 1997). This vegetable grows as a weed in most tropical countries, but is a semi cultivated tropical leafy vegetable in many parts of sub-Saharan Africa, especially in eastern and southern Africa. The leaves and shoots are gathered from the wild or are cultivated.

Nutrient content of *C. gynandra* is affected by environment. Greenfield and Southgate (2003) reported geographical location, season, physiological state and maturity and cultivar/breed as major sources of nutrient variability. Geographical location causes variation in terms of soils and climatic conditions while physiological state and maturity affects the concentration of sugars, organic acids and vitamins in many plants. In terms of season, plant foods are especially prone to variation, particularly in their water, carbohydrate and vitamin content. In relation to this, Van Der Walt et al. (2009) reported differences in nutrients of *C. gynandra* from different districts in South Africa due to geographic and climatic conditions.

In a related study, Tidemann-Andersen et al. (2011) reported differences in iron and zinc of vegetable leaves including *C. gynandra* from two districts. These differences were attributed to soil differences and soil contamination.

The available literature on *C. gynandra* especially in Malawi, suggest limited research work on nutrient composition of *C. gynandra* from different agro-ecological zones in Malawi.

The current study was done to find the nutrient composition of *C. gynandra* from three different agro-ecological zones in Malawi. The hypothesis was that nutrient composition is different in *C. gynandra* from different agro-ecological in Malawi. The information generated by the current study can highlight the nutrients found in the *C. gynandra* from different agro ecological zones and can contribute to the production of Malawian

Food Composition database.

MATERIALS AND METHODS

Study area

Samples of *C. gynandra* leaves were collected from Dedza (14.3817°S, 34.7741°E), Lilongwe (13.9626°S, 33.7741°E) and Salima (13.7796°S, 34.4586°E) districts representing high plateau and hilly area, medium altitude and lakeshore and low shading agro ecological zones in Malawi respectively. High plateau and hilly area zone has altitude of >1500, annual rainfall of >1200 mm and mean temperature range of 10 – 26°C. Medium altitude zone has altitude of 1000 – 1500, annual rainfall range of 800 – 1200 mm and mean temperature of 16 – 26°C. Lake shore and low shading area zone has altitude of 400 – 1000, annual rainfall of 600 – 800 mm and mean temperature of 20 – 29°C (Ministry of Agriculture and Food Security, 2003).

Sample collection

Collection of the samples was done from February to March 2014. The samples were collected around households and in the wild by the researcher. The samples collected were growing wild as weeds (not cultivated). The young leaves (those growing on the tips) of *C. gynandra* were the ones that were sampled and collected across all the sampled districts. This was done to minimise variation. After collection, *C. gynandra* samples were put in Ziploc™ bags to prevent moisture loss and any outside interference causing moisture loss. In each sampled district, 1500 g of fresh samples was collected for chemical analysis. Chemical analysis was done on the *C. gynandra* leaves collected across the districts.

Sample preparation

The collected samples were kept in Ziploc™ bags and put in a cooler box to maintain the fleshiness. The samples were transported using private transport from the sampled areas to the laboratory. Moisture content determination of the fresh samples was done soon after arrival at the laboratory. After moisture content determination the remaining *C. gynandra* samples were oven dried for 1 day at 60°C (Odhav et al., 2007).

Chemical analyses

Moisture content

Moisture content was determined using the oven drying method as indicated in AOAC (1984). A 2 gram sample for each of the sampled leaves was dried at 105°C for 5 h to constant weight and was placed in a dessicator to cool to room temperature. Three replications were done for each samples and moisture content was calculated as the loss in weight expressed as a percentage of the initial weight of the sample.

Protein content

Protein was determined by the method of the Association of Official Analytical Chemists (AOAC, 1990). Two grams of the sample was weighed into a digestion flask and 0.5 g of selenium catalyst was added. 25 ml of concentrated H₂SO₄ was added and the flask was shaken to mix the contents. The flask was then placed on a

digestion burner for 8 h and heated until the solution turned green and clear. The sample solution was then transferred into a 100 ml volumetric flask and made up to the mark with distilled water. Twenty five millilitres of 2% boric acid was pipetted into a 250 ml conical flask and two drops of mixed indicator (20 ml of bromocresol green and 4 ml of methyl red) solution was added; and into the decomposition chamber of the distillation apparatus was added 15 ml of 40% NaOH solution. Ten millilitres of the digested sample solution was then introduced into a Kjeldahl flask. The condenser tip of the distillation apparatus was then dipped into the boric acid contained in the conical flask. The ammonia in the sample solution was then distilled into the boric acid until it changed completely to bluish green. The distillate was then titrated with 0.1 N HCl solution until it became colourless. The percent total nitrogen and crude protein were calculated using a conversion factor of 6.25.

Crude fibre content

Crude fibre was determined by the method of the Association of Official Analytical Chemists (AOAC, 1990). The defatted sample was transferred into a 750 ml Erlenmeyer flask and 0.5 g of asbestos was added. Two hundred millilitres of boiling 1.25 % H_2SO_4 was added and the flask was immediately set on a hot plate and condenser connected to it. The content was brought to boil within 1 min and the sample was digested for 30 min.

At the end of the 30 min, the flask was removed and the content was filtered through a linen cloth in a funnel and subsequently washed with boiling water until the washings were no longer acidic. The sample was washed back into the flask with 200 ml boiling 1.25% NaOH solution. The condenser was again connected to the flask and the content of the flask was boiled for 30 min. It was then filtered through the linen cloth and thoroughly washed with boiling water until the washings were no longer alkaline. The residue was transferred to a clean crucible with a spatula and the remaining particles washed off with 15 ml ethanol into the crucible.

The crucible with its content was then dried in an oven overnight and cooled in a desiccator and weighed. The crucible with its content was then ignited in a furnace at 600°C for 30 min, cooled and reweighed. The loss in weight gave the crude fibre content and was expressed as a percentage of the initial weight of the sample.

Ash content

Ash was determined by the method of Association of Official Analytical Chemists (AOAC, 1990). A 2.0 g sample was weighed into a previously dried and weighed porcelain crucible. The crucible with its content was placed in a furnace preheated to 600°C for 2 h. The sample was allowed to cool in the furnace to 250°C. The crucible and the ash were then transferred into an oven at 100°C for 30 min cooling. After this period, the crucible with its content was cooled in a desiccator. The crucible with its content was weighed. The weight of the ash was expressed as a percentage of the initial weight of the sample.

Vitamin C content

Vitamin C was determined using spectro photometric method (Azra et al., 2012). Potassium iodide (2.0 g) and iodine (1.3 g) were dissolved in 100 ml distilled water to make iodine solution (0.005 mol/l). This solution was diluted ten times. The concentration of prepared iodine solution was determined by titration with a standard solution of ascorbic acid. Soluble starch (0.25 g) was added to 50 ml of near boiling distilled water to make starch indicator solution (0.5 %). Stock solution of ascorbic acid containing 0.1 mol/l of ascorbic acid was prepared by dissolving appropriate amount of

ascorbic acid in distilled water and stored in a glass stopped bottle at 4°C in the dark. Solutions of variable concentrations were prepared by diluting the stock standard solution in water before use. Methylene blue solution (0.4 mmol/l) was prepared by dissolving 0.0128 g of methylene blue in 100 ml distilled water.

For ascorbic acid determination, 2.5 g *C. gynandra* leaf samples were coarsely ground and glacial acetic acid (2 ml) was added. The mixture was stirred for about 20 min and rapidly filtrated using a suction pump and Buchner funnel. After that, the volume of the sample was made up to 100 ml with distilled water. Analysis with spectrophotometric method used T 90 UV/VIS Spectrometer (England serial number 20-1901-01-0351) to determine the amounts of AA in the samples. Fifty microliters of a sample solution was mixed with 125 μL of MB ($c=0.4$ mmol/l) solution and diluted up to 10 ml with distilled water. Decrease of absorption was measured at $\lambda_{\text{max}} = 665$ nm. All analysis was carried out in triplicates. Results were expressed in mg of ascorbic acid per 100 g of dry sample.

Minerals determination

Calcium, iron and zinc

Calcium, iron and zinc were determined by atomic absorption spectrophotometry (AAS-6200 model) at wave length of 213.9 nm and range of 0.5-5 with flame rich air C_2H_2 (Norhaizan and Ain, 2009). One gram of the sample was dry ashed in a muffle furnace at 550°C for 5 h until a white residue of constant weight was obtained. The minerals were extracted from the ash by adding 20.0 ml of 2.5% HCl, heated to reduce the volume to 7.0 ml, and this was transferred quantitatively to a 50 ml volumetric flask. It was diluted to the mark (50 ml) with distilled water, stored in clean polyethylene bottles and calcium, iron and zinc content determined using atomic absorption spectrophotometer. All the chemical analysis were carried out on dry weight basis and expressed per 100 g edible portion.

Statistical analysis

Data on nutrient and mineral composition was entered in Microsoft excel and analysed for analysis of variance (ANOVA) in Genistat software version 15 where means and standard deviations were generated at 95% confidence interval level. Means were compared using Fisher's Protected Least Significant Difference and Fisher's unprotected Least significant difference at 5% level of significance.

RESULTS AND DISCUSSION

Nutrient content of raw cats whiskers (per 100 g)

Significant differences ($p < 0.05$) were found in ash content (total measure of mineral content) among *C. gynandra* from the three districts representing agro-ecological zones in Malawi (Table 1). Ash content increased with a decrease in altitude across the agro-ecological zones. The differences in the ash contents might be attributed to the differences in amount of the minerals present in the *C. gynandra*. The differences in minerals might also be attributed to the differences in soil types from the different districts, which affects minerals present for example Salima district contains calcimorphic alluvial soils and medium textured sandy clay loam soils,

Table 1. Nutrient content of raw *C. gynandra* (g/100 g) collected from Dedza, Lilongwe and Salima districts in Malawi.

Districts nutrients	Dedza	Lilongwe	Salima	Mean for all districts
Moisture content	83.2 ± 1.45	83.6 ± 3.42	79.3 ± 3.38	82.0
Protein content	4.8 ± 1.67	3.9 ± 0.97	5.8 ± 1.37	4.8
Crude fibre content	2.1 ± 0.39	1.8 ± 0.01	1.9 ± 0.25	1.9
Ash content	5.2 ± 0.07 ^a	6.3 ± 0.11 ^b	6.9 ± 0.27 ^c	6.1
Vitamin C (mg/100 g)	319.1 ± 107.82	262.1 ± 77.87	214.3 ± 37.97	265.2
Calcium (mg/100 g)	2497.5 ± 316.43 ^b	1667.0 ± 518.66 ^a	2465 ± 749.76 ^b	2209.8
Iron (mg/100 g)	22.9 ± 2.04 ^a	44.7 ± 11.46 ^b	39.4 ± 13.0 ^{ab}	35.7
Zinc (mg/100 g)	2.7 ± 1.1	2.3 ± 0.25	2.9 ± 0.45	2.6

Values are triplicate mean value ± standard deviation. Values on the same row with different superscript are significantly different ($p < 0.05$).

Lilongwe district contains ferruginous latosol soil, clay loam soil while Dedza district contain leached latosols (Saka et al., 2003). High ash content in samples from Salima district, might also be attributed to warmer conditions which generally accelerates plant growth (Whiting, 2014). The samples from Salima might have accumulated higher biomass than the samples collected in Dedza and Lilongwe which have cooler conditions. However, the ash content of *C. gynandra* reported in the present study is lower than 11.2 g/100 g reported by Mibei et al. (2011).

Significant differences were also observed in calcium and iron contents of *C. gynandra* from the different agro-ecological zones. This might also be attributed to the differences in the soil types from different districts. Joy et al. (2015) in their study in Malawi reported differences in concentrations of Ca, Cu, Fe and Se in leafy vegetables grown on calcareous soil than non-calcareous soil. In addition to that, mineral and trace element content of plant leaves is a function of the environment and in leafy vegetables which is strongly influenced by the chemical composition of the soil and the climate (Modi, 2007). Iron content found in this study are higher than 14.4 mg/100 g and 6.3 mg/100 g iron content of *C. gynandra* reported by Maroyi (2013) and Hilger (2005), respectively. However, the calcium values found in the present study are higher than 288 mg/100 g calcium content of *C. gynandra* reported by Mbugua et al. (2008). Differences in minerals calcium and iron from the 3 districts reported in the study agree with van der Walt et al. (2009), who reported significant differences in iron and zinc from Rustenburg and Capricorn districts. Minerals are important for vital body functions such as acid-base and water balance (Omale and Ugwu, 2011).

No significant differences ($p > 0.05$) were found in protein content among *C. gynandra* from the three districts representing the three agro-ecological zones (Table 1). In addition, no significant differences were found in crude fibre content, moisture content, vitamin C and zinc of *C. gynandra* samples from the three districts. The finding of no significant differences in moisture, protein, crude fibre, vitamin C and zinc was not expected by the current study. However, the values of nutrients

found by this study are similar to other previously reported studies. Moisture contents of *C. gynandra* for Dedza and Salima found in this study are within the range of 81.8 to 89.6% reported by Chweya and Mnzava (1997). Moisture content determines the freshness of food. In the present study, all the leaf samples had high percentage of moisture content, this is an indication that they possess large number of cell saps. Water is clearly the most important nutrient and the most abundant substance in the human body (Adeniyi et al., 2012).

Protein content of *C. gynandra* found by this study are similar to those by Oldhav et al. (2007) and Mbugua et al. (2008) who reported 5 and 4.8 g/100 g protein contents, respectively. Protein values of vegetables might be of low quality and low bioavailability because of phenolic compounds which might be found within the vegetable (Chweya and Mnzava, 1997). The non-significance in protein contents of *C. gynandra* among districts found by this study disagrees with the findings of Modi (2007) who indicated that cool environmental conditions are associated with high total protein in leafy vegetables while hot temperatures had a significant decrease in leaf protein content. Protein is necessary for building the structural components of human body, such as muscles and organs (Omale and Ugwu, 2011).

Crude fibre contents found in this study were lower than the results found by Hassan et al. (2007) who indicated 6.0 to 6.3% of crude fibre in *C. gynandra*. However, crude fibre values found by this study are higher than 0.8 g/100 g reported by Mibei et al. (2011). The differences of fibre contents found in this study and those reported in literature are expected. This is because the total dietary fibre content of African leafy vegetables may vary due to differences in stages of plant maturity, seasonal variation, fertilizers or chemicals used, variety of plant, geographical location and the method used for analysis (Punna and Parachuri, 2004). The fibre content ranging from 1.7 to 2.1 g/100 g found in the current study are very low as compared to the adequate intake (AI) of total fibre for a normal adult which is 38 and 25 g/day for males and females, respectively (Food and Nutrition Board, Institute of Medicine, 2003). Hence, *C. gynandra* is a poor source of fibre to human beings.

Vitamin C values of *C. gynandra* found in this study are higher than 107 and 13 mg/100 g found by Mibei et al. (2011) and Maroyi (2013), respectively. These differences were expected because the amount of vitamin C in plants varies greatly due to variety, environment grown weather and level of maturity (age) of the plants (Mibei et al., 2011). In agreement with that, Ayua et al. (2016) reported vitamin C concentration in the three *C. gynandra* varieties to be significantly higher in the mature leaves than in immature ones. This was because young leaves have more demand for vitamin C and cannot accumulate enough vitamin C to meet their physiological processes. Vitamin C is important to humans because it is an anti-oxidant and has health promoting properties.

The study findings of zinc contents of *C. gynandra* are lower than 8.4 mg/100 g reported by van der Walt et al. (2009). The zinc values found by the study is also lower than 6 and 6.3 mg/100 g, reported by Tidemann-Andersen et al. (2011). The lower zinc concentrations obtained by this study are supported by Gibson (1994), who reported that vegetables and fruits have much lower concentrations of zinc due to their high water content. In terms of bioavailability, zinc from animal sources has higher bioavailability as compared to plant sources due to phytates and fibres that inhibit zinc uptake by intestines (FAO/WHO, 2002). The differences in the nutrient composition of *C. gynandra* reported in this study and those reported in literature might be linked to species, climate, growing conditions, nature of soil, application of natural or artificial manure and period of analysis (Adeniyi, 2012).

Conclusions

In this study, there are significant differences in ash, iron and calcium contents of *C. gynandra* leaves collected from different agro ecological zones (high plateau and hilly area, medium altitude and lakeshore and low shading agro ecological zones) in Malawi. In addition, it can also be concluded that *C. gynandra* from different agro ecological zones do not have significant differences in moisture content, protein content, crude fibre content, vitamin C and zinc. Hence, promotion of this vegetable to achieve dietary diversity and food security in these different agro ecological zones will not have discrepancies in terms of some of the nutrients. It can also be concluded that *C. gynandra* contains some macro and micro nutrients which are essential for the human body. Therefore, *C. gynandra* can be a readily available cheap source of relish and contribute some of these nutrients to the human diet.

Conflicts of Interests

The authors have not declared any conflict of interests.

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