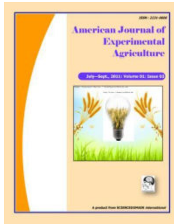

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Effect of Plant Leaf Positions on Some Micronutrients, Anti-nutrients and Toxic Substances in *Telfairia occidentalis* at the Vegetative Phase

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Research Article

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ABSTRACT

Pot experiment was conducted to determine the effect of leaf positions on the concentrations of some phytotoxins (cyanide, nitrate, soluble and total oxalates), micronutrients namely; vitamin C, β-carotene (provitamin A) and mineral elements (Fe, Mg, Cu, Zn, Ca Na and K) at vegetative phase of *Telfairia occidentalis* grown in nitrogen and non – nitrogen treated soil. The leaves of *Telfairia occidentalis* were harvested and analysed at three different leaf locations, namely; basal, middle and upper positions. The result obtained showed that no significant differences was observed in the cyanide concentration between basal and middle leaves and between middle and upper leaves, however, basal leaves had significant ($p< 0.05$) higher concentration of cyanide than upper leaves irrespective of soil nitrogen levels. The concentrations of nitrate and β-carotene in control and nitrogen fertilized *Telfairia occidentalis* were significantly ($p<0.05$) highest in upper, followed by middle and lowest in the basal leaf position. The soluble and total oxalates content in *Telfairia occidentalis* were significantly ($p<0.05$) higher in the basal and middle leaves than the upper leaves irrespective of soil nitrogen levels. While the vitamin C concentration in the vegetable was significantly elevated in basal leaves than the leaves obtain from middle and upper leaf locations. Analysis of mineral elements showed that Fe, Mg, Zn and Ca were concentrated more in the basal and middle leaves than the upper leaves while the K concentration was significantly ($p<0.05$) higher in the middle and upper leaves than the basal leaves in control and nitrogen treated *Telfairia occidentalis.* The results conclude that concentrations of most

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of the plant toxins are higher in the older leaves than younger ones. Thus inclusion of the younger leaves of *Telfairia occindentalis* in our meal will reduce the negative health effect associated with high ingestion of the phytotoxins.

Keyword: Telfairia occidentalis; plant leaf position; micronutrients; phytotoxins; vegetative phase.

1. INTRODUCTION

Fluted pumpkin (*Telfairia occidentalis*) (called "ugwu" by Igbos in Eastern Nigeria) is a creeping leafy vegetable that spread low across the ground with large lobed leave, and long twisting tendrils (Syndenham, 1985; Horsfall and Spiff, 2005; Christian, 2006; Ojiako and Igwe, 2008). The vegetable is of commercial importance grown across the low land humid tropic in West Africa (Nigeria, Ghana and Sierra Leone) being the major producers (Nkang et al., 2003). *Telfairia occidentalis* prefers a loose, friable sufficient humus and shaded position. Nitrogen is essential for adequate vegetation and should ideally be given in the form of manure (Schippers, 2000). Harvesting of fluted pumpkin takes place 120 - 150 days after planting (Horsfall and Spiff, 2005). The leaves and seeds *Telfairia occidentalis* are widely eaten as they are good sources of minerals (potassium, magnesium, sodium, phosphorus and iron), vitamins, fibres, fats (Schipper, 2000; Nkang et al., 2003; Christian, 2006). *Telfairia occidentalis* also bioaccumulates some secondary metabolites such as cyanogenic glycoside, nitrate, oxalate and phytate which are responsible for various diseases condition in man and animals at high concentrations (Ekpedema et al., 2000; Ojokoh et al., 2002; Ogbadoyi et al., 2011). For example oxalate and phytate chelates some mineral elements and reduce their bioavailability. Oxalate in combination with calcium is responsible for kidney stone (Nataka, 2003; Okon and Akpanyung, 2005; Antia et al., 2006: Proph et al., 2006). Cyanide from cyanogenic glycoside in plants is a respiratory poison and inhibition of ATP synthesis in electron transport chain (Ames et al., 1981; Ellenborn and Barcelonx, 1988) while nitrate is a culprit for cancer and methaemogloneamia (Waclaw and Stefan, 2004; Oyesom and Okoh, 2006; Ogbadoyi et al., 2011). The amount of these phytotoxins and the nutrients in the leaves of *Telfairia occidentalis* like other leafy vegetables are influenced by the leaf positions on the mother – plant. This research is therefore conducted with the aim of determining the leaf position in which the derivable nutritional potential of *Telfairia occidentalis* can be fully utilized with low level of phytotoxins and thereby reducing the disease condition associated with high intake of phytotoxins.

2. MATERIALS AND METHODS

2.1 The Study Area

The pot experiment was conducted in the greenhouse of the School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Niger State, Nigeria. Niger State has a Savannah climate characterized by maritime. The geographical location of Minna is at longitude 9°40´N and latitude 6°30´E. Minna lies in the Southern Guinea Savannah zone of Nigeria and has a sub - humid semi arid tropical climate. The raining season is between April and October. About 90% of the total rainfall occurs between the month of June and September. The mean annual rainfall is in the range of 1200 – 1300 mm. The temperature of this zone rarely falls below 22℃ with peaks temperature of 40℃ in February /March and 30℃ in November /December. Wet season average temperature is about 29℃. The Dry season occurs between November and March while harmattan which is characterised by dry air is between November and February (Osunde and Alkassoun, 1998). Figure 1 below shows the map of the study area.

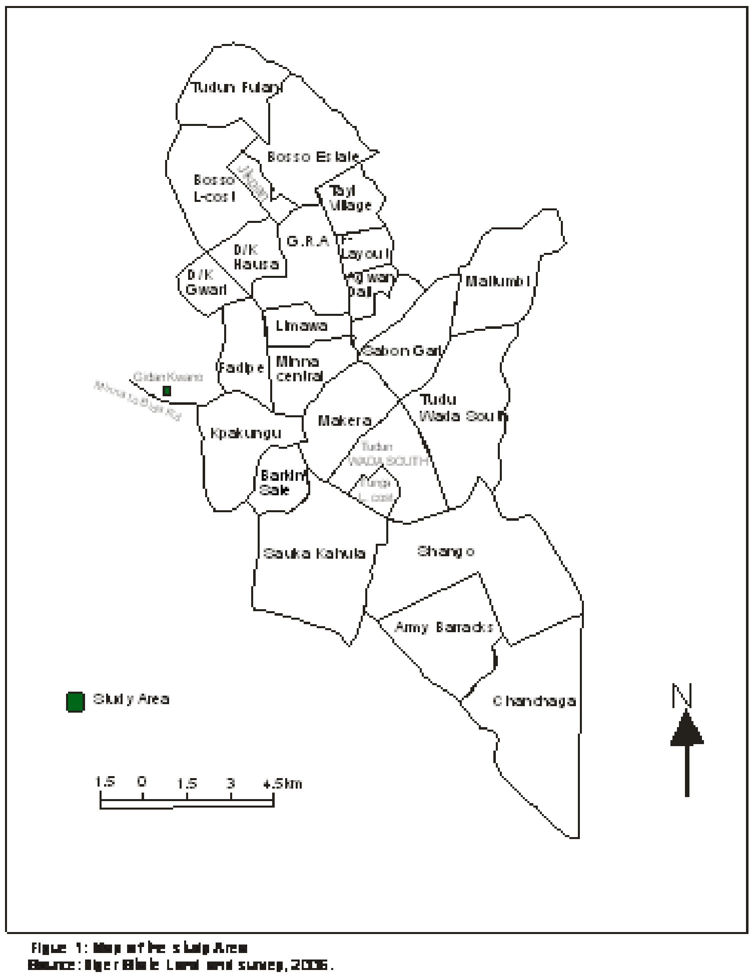

Fig. 1: Map of the study area

2.2 Soil Sampling and Analysis

The soil used in this study was collected from Minna, at Kidan kwano the main campus of Federal University of Technology, Minna. The soil has been classified as Inseptisol (FDALR, 1985). The bulked sample was collected during the dry season from the field which has been under fallows for about four years. The bulked soil sample was passed through 2 mm sieve. Sub-sample of the soil was subjected to routine soil analysis using procedure described by Juo (1979). The soil particle sizes were analyzed using hydrometer method; pH was determined potentiometrically in the water and 0.01M $CaCl_2$ solution in a 1:2 soil/liquid using a glass electrode pH meter and organic carbon by Walkey-Black method (Juo, 1979). Exchange acidity (EA H^+ and Al^{3+}) was determined by titration method (Juo, 1979). Exchangeable Ca, Mg, K and Na were leached from the soil sample with neutral 1N NH_4OAc solution. Sodium and potassium were determined by flame emission spectrophotometry while Mg and Ca were determined by E.D.T.A versenate titration method (Juo, 1979). Total nitrogen was estimated by Macrokjeldahl procedure and available phosphorus by Bray No 1 method (Juo, 1979).

2.3 Planting, Experimental Design and Greenhouse Management

Two seeds of fluted pumpkin (*Telfairia occidentalis*) were obtained from Schools of Agriculture and Agricultural Technology's Farm/greenhouse of Federal University of Technology, Minna were planted in a polythene bag filled with 20.00 kg of top soil and after emergence the seedlings were thinned to one plant per pot. The factorial design was adopted to determine the effects of three leaf age/positions (basal, middle and upper locations) in the control and nitrogen treated vegetable. Each treatment had 10 pots replicated three times. This gave a total of 60 pots for the vegetable. The seedlings were watered twice daily (morning and evening) using watering can and weeded regularly. The experimental area and the surroundings were kept clean to prevent harbouring of pest. The pots were lifted from time to time to prevent the roots of the plants from growing out of the container. Insects were controlled using Sherpa plus (Saro Agro Sciences) four weeks after planting at the rate of 5 ml per 5 litres of water.

2.4 Fertilizer Treatment and Harvesting

The fertilizer treatments for *Telfairia occidentalis* are stated below:

F_1 (control): 0N, 30mg P_2O_5/kg soil and 22mg K_2O/kg soil
F_2: 30mgN/kg soil, 30mg P_2O_5/kg soil and 22mg K_2O/kg soil

The leaves of *Telfairia occidentalis* grown in pot experiment in the control and nitrogen fertilized soil were harvested at three different locations on the plant (basal, middle and upper locations) at the vegetative phase of the plant development.

2.5 Samples Analyses

The soluble and total oxalates concentration in the leaves of *Telfairia occidentalis* obtained from the three different leaf positions were determined by titrimetric method of Oke (1966). Nitrate content in the test samples was determined by the colorimetric method (Sjoberg and Alanka, 1994). Alkaline picrate method of Ikediobi et al. (1980) was used to analyse the cyanide concentration in the samples. The mineral elements (Fe, Mg, Zn, Cu, Ca, Na and K) in the test samples were determined according to the method of Ezeonu et al. (2002), involving the use of atomic absorption spectrophotometer (Alpha 4A AAS) and flame photometer (Jenway PFP7) for Na and K only. The ascorbic acid concentration in the samples was determined by 2, 6-dichlorophenol indophenol titrimetric method (Eleri and Hughes, 1983). The estimation of β-carotene concentration in the test samples was done by ethanol and petroleum ether extraction method as described by Musa et al. (2010).

2.6 Statistical Analysis

Analysis of variance (ANOVA) was carried out using statistical package Minitab to determine variation between three levels of age of plant leaves. The DUNCAN's Multiple Range Test (DMRT) was used for comparison of means.

3. RESULTS

3.1 Physical and Chemical Properties of Soil

Result of analysis of the soil used for pot experiment is presented in Table 1. The texture class of the soil is sandy loam signifying that the water holding capacity is moderate. The organic matter content, total nitrogen and available phosphorus are low. Sodium and calcium contents are moderate while magnesium and potassium contents are high. The CEC (cation exchange capacity) is moderate while base saturation percentage is high. Soil pH shows that the soil is slightly acidic.

Table 1. Some physical and chemical properties of the soil (0 – 20 cm) used for pot experiment

Parameters	Values
Sand (%)	74.40
Silt (%)	18.00
Clay (%)	7.60
pH (in H_2O)	6.51
pH (in 0.1M C_aCl_2)	5.25
Organic Carbon (%)	0.83
Organic Matter (%)	1.43
Total nitrogen (%)	0.05
Available phosphorus (mg/kg)	6.69
K (cmol/kg)	0.92
Na (cmol/kg)	0.68
Mg (cmol/kg)	4.80
Ca (cmol/kg)	8.00
E. A (H^+ +AL^{3+})(cmol/kg)	1.50
CEC (cmol/kg)	15.90
Base saturation (%)	90.57
Texture class	sandy loam

**Values represent means of triplicate determinations.*

3.2 Effect of Plant Leaf Positions on Antinutrients and Vitamin Concentrations

The effects of plant leaf positions on antinutrients and vitamin concentrations in *Telfairia occidentalis* in the control and nitrogen treated soil are presented in Table 2. The results showed that no significant ($p>0.05$) differences was observed in the cyanide concentration between basal and middle leaves and between middle and upper leaves, however, basal leaves had significant ($p<0.05$) higher concentration of cyanide than upper leaves (Table 2). The amount of cyanide in basal, middle and upper leaves in control were 549.26 ± 59.39, 414.70 ± 63.10 and 351 ± 105.53 mg/kg, respectively while the corresponding mean values in nitrogen fertilized *Telfairia occidentalis* were 813.60 ± 59.89, 723.90 ± 110.60 and 560.20 ± 58.50 mg/kg, respectively.

The levels of nitrate in control and nitrogen fertilized *Telfairia occidentalis* was significantly ($p<0.05$) highest in upper, followed by middle and lowest in the basal leaf positions. The mean values of nitrate in basal, middle and upper leaves in control were 272.22 ± 50.92 mg/kg, 466.66 ± 28.87 mg/kg and 911.11 ± 41.94 mg/kg, respectively. While the corresponding concentrations of nitrate in the nitrogen applied vegetable were 355.60 ± 134 mg/kg, 627.80.00 ± 122.90 mg/kg and 1105.60 ± 160.20 mg/kg, respectively.

There was no significant difference in soluble oxalate content between basal (1.77 ± 0.02 g/100g) and middle (1.67 ± 0.22 g/100g) leaves and between middle, and upper (1.49 ± 0.13 g/100g) leaves, but basal leaves had significant ($p<0.05$) higher content of the antinutrient than upper leaves in the control. With the application of nitrogen fertilizer no significant differences in soluble oxalate concentration was observed between basal (2.05 ± 0.30 g/100g) and middle (2.04 ± 0.11 g/100g) leaves, however, the mean value of the soluble oxalate in the upper leaves (1.36 ± 0.31 g/100 g) was significantly ($p<0.05$) lower than the leaves obtained each from the two leaf positions.

The analysis of total oxalate indicated that no significant differences ($p>0.05$) was observed in its content between basal and middle leaves, however, the two leaf positions each were significantly elevated ($p<0.05$) in the total oxalate concentration than upper leaf position irrespective of soil nitrogen levels. The mean values for basal leaves in control (2.40 ± 0.08 g/100 g) and nitrogen applied (2.59 ± 0.10 g/100 g) were not significantly different from the levels in middle leaves (2.28 ± 0.14 g/100 g and 2.42 ± 0.14 g/100 g, respectively). However, the mean values of the total oxalate in the upper leaves for control (1.98 ± 0.14g/kg) and nitrogen applied (1.60 ± 0.18 g/100 g) were significantly lower ($p<0.05$) than the mean values obtained each from the two leaf positions.

The concentrations of β-carotene was significantly ($p<0.05$) highest in upper followed by middle and lowest in the basal leaf positions in control and nitrogen fertilized *Telfairia occidentalis*. The concentrations of β-carotene in the basal, middle and upper leaves in control were 13.70 ± 0.35 mg/100 g, 15.09 ± 0.18 mg/100 g and 17.70 ± 0.15 mg/100g respectively. While the corresponding mean values of β-carotene in the nitrogen treated *Telfairia occidentalis* were 14.92 ± 0.54 mg/100 g, 16.45 ± 0.45 mg/100 g and 21.43 ± 1.17 mg/100 g, respectively.

Similarly results obtained from the determination of vitamin C content in *Telfairia occidentalis* showed that the amount of the vitamin in the middle leaves in control (205.61 ± 11.50 mg/100 g) and nitrogen applied vegetable (173.83 ± 23.70 mg/100 g) were not significantly different from the level in upper leaves (185.71 ± 10.13 mg/100 g and 162.24 ± 5.85 mg/100g respectively). The vitamin concentration in the basal leaves for control (233.92 ± 5.86 mg/100 g) and nitrogen applied (238.69 ± 8.44 mg/100 g) were significantly ($p<0.05$) elevated than in any of the two leaf positions.

3.3 Effect of Plant Leaf Positions on Mineral Elements Concentration

The effects of leaf positions on minerals content in *Telfairia occidentalis* at vegetative phase are presented in Table 3. The results showed that the concentration of Fe in the middle leaves in control (10.70 ± 4.71 mg/kg) and nitrogen treated vegetable (12.73 ± 3.34 mg/kg) were not significantly different from the level in upper leaves (10.07 ± 10.13 mg/kg and 11.00 ± 2.00 mg/kg respectively). However, the Fe concentration in the basal leaves for control (15.50 ± 1.95 mg/kg) and nitrogen applied (17.17 ± 4.02 mg/kg) was significantly ($p<0.05$) higher than the leaves obtained each from other two leaf positions.

Results obtained from analysis of Mg and Zn showed that the mineral concentrations in basal leaves were not significantly different from middle leaves, but both leaf positions each had significant higher amount of the mineral elements than levels found in the upper leaves in control and nitrogen fertilized *Telfairia occidentalis*. Similarly results obtained from the determinations of Cu and Na in control and nitrogen applied vegetable showed that leaf positions had no significant effect on these minerals.

The concentration of Ca in basal leaves (23.02 ± 5.57 mg/kg) was not significantly different from middle leaves (23.29 ± 8.57 mg/kg); however, the two leaf regions had significantly ($p<0.05$) higher content of Ca than upper leaf (6.98 ± 2.72 mg/kg) region in the control. When the plant received nitrogen fertilizer, the concentration of Ca was significantly highest in the basal (29.28 ± 0.93 mg/kg) followed by middle (25.62 ± 2.46 mg/kg) and lowest in the upper (7.77 ± 0.22 mg/kg) leaves.

The results obtained from the investigation of K content in *Telfairia occidentalis* showed that the levels of the mineral in upper leaves was not significantly different from middle leaves, but the two leaf positions had significant higher concentration of the mineral element than basal leaves in the vegetable irrespective of soil nitrogen levels . The mean values of K in basal, middle and upper leaves in control were 100.92 ± 11.31 mg/kg, 124.55 ± 10.42 mg/kg and 116.74 ± 5.84 mg/kg, respectively. While the corresponding mean values of K in the nitrogen treated *Telfairia occidentalis* were 91.73 ± 9.28 mg/kg, 128.44 ± 23.36 mg/kg and 118.48 ± 14.37 mg/kg, respectively.

4. DISCUSSION

This study has revealed that leaf age (which is linked to position on mother- plant) had significant effect on the accumulation of nutrients, antinutrients and toxic substances in the leaves of *Telfairia occidentalis*. The Significantly higher cyanide concentrations in the basal than upper leaves in *Telfairia occidentalis* is in harmony with the report of Cleveland and Soleri (1991) and Carmen et al. (2007), which revealed that the cyanide content increased with age in cassava leaves and crucifers, respectively. The reason for higher level cyanide in basal leaves than the upper leaves could be that the enzymes responsible for synthesis of the cyanide may be more active in fully developed leaves where the metabolic activities are at maximum than the immature leaves. These results however, disagree with the report of Richard (1991) and Rodney and Elba (2006), who observed that the level of this respiratory poison is concentrated in younger leaves of sorghum than the older leaves. The observed variations in the cyanide concentration in the different leaf location of *Telfairia occidentalis* from those of the previous work reported by different authors may be due to differences in cultivars and environmental factors.

Table 2. Effect of plant leaf positions on antinutrients and vitamins content in *Telfairia occidentalis* at vegetative phase

Antinutrients and vitamins	Plant leaf positions		
	Basal leaves	Middle leaves	Upper leaves
Cyanide (mg/kg DW), Control	549.26 ± 59.39[b]	414.70 ± 63.10[ab]	351.03 ± 105.53[a]
Cyanide (mg/kg DW), Nitrogen applied	813.60 ± 59.89[b]	723.90 ± 110.60[ab]	560.20 ± 58.50[a]
Nitrate (mg/kg DW), Control	272.22 ± 50.92[a]	466.66 ± 28.87[b]	911.11 ± 41.94[c]
Nitrate (mg/kg DW), Nitrogen applied	355.60 ± 134.70[a]	627.80 ± 122.90[b]	1105.60 ± 160.20[c]
Soluble oxalate (g/100 g DW), Control	1.77 ± 0.02[b]	1.67 ± 0.22[ab]	1.49 ± 0.13[a]
Soluble oxalate (g/100 g DW), Nitrogen applied	2.05 ± 0.30[b]	2.04 ± 0.11[b]	1.36 ± 0.31[a]
Total oxalate (g/100 g DW),Control	2.40 ± 0.08[b]	2.28 ± 0.14[b]	1.98 ± 0.14[a]
Total oxalate (g/100 g DW),Nitrogen applied	2.59 ± 0.10[b]	2.42 ± 0.14[b]	1.60 ± 0.18[a]
β-carotene (mg/100 g FW), Control	13.71 ± 0.35[a]	15.09 ± 0.18[b]	17.71 ± 0.15[c]
β-carotene (mg/100 g FW), Nitrogen applied	14.92 ± 0.54[a]	16.45 ± 0.45[b]	21.43 ± 0.17[c]
Vitamin C (mg/100 g FW), Control	233.92 ± 5.86[b]	205.61 ± 11.50[a]	185.71 ± 10.13[a]
Vitamin C (mg/100 g FW), Nitrogen applied	238.69 ± 8.44[b]	173.83 ± 23.70[a]	162.24 ± 5.85[a]

DW = Dry weight, FW = Fresh weight, Control = No nitrogen applied. Values represent means of triplicate determinations. Row mean values carrying the same superscripts do not differ significantly from each other (P > 0.05).

Table 3. Effect of plant leaf positions on minerals content in *Telfairia occidentalis* at vegetative phase

Minerals	Plant leaf positions Basal leaves	Middle leaves	Upper leaves
Fe (mg/kg), Control	15.50 ± 1.95[b]	10.70 ± 4.71[a]	10.07 ± 1.38[a]
Fe (mg/kg) , Nitrogen applied	17.17 ± 4.02[b]	12.73 ± 3.34[a]	11.00 ± 2.00[a]
Mg (mg/kg), Control	20.49 ± 1.11[b]	22.10 ± 3.08[b]	17.12 ± 2.85[a]
Mg (mg/kg), Nitrogen applied	21.45 ± 0.91[b]	22.19 ± 1.30[b]	17.37 ± 0.77[a]
Zn (mg/kg), Control	0.05 ± 0.02[b]	0.06 ± 0.02[b]	0.00 ± 0.00[a]
Zn (mg/kg), Nitrogen applied	0.05 ± 0.03[b]	0.06 ± 0.02[b]	0.02 ± 0.01[a]
Cu (mg/kg), Control	3.64 ± 0.21[a]	3.74 ± 0.16[a]	3.62 ± 0.66[a]
Cu (mg/kg), Nitrogen applied	2.48 ± 1.18[a]	2.94 ± 2.89[a]	2.56 ± 0.43[a]
Ca (mg/kg), Control	23.02 ± 5.57[b]	23.29 ± 8.57[b]	6.98 ± 2.72[a]
Ca (mg/kg), Nitrogen applied	29.28 ± 0.93[c]	25.62 ± 2.46[b]	7.77 ± 0.22[a]
Na (mg/kg), Control	6.55 ± 2.34[a]	4.37 ± 1.04[a]	5.28 ± 0.42[a]
Na (mg/kg), Nitrogen applied	5.42 ± 0.53[a]	5.06 ± 0.73[a]	5.14 ± 0.12[a]
K (mg/kg), Control	100.92 ± 11.31[a]	124.55 ± 10.42[b]	116.74 ± 5.84[b]
K (mg/kg) , Nitrogen applied	91.73 ± 9.28[a]	128.44 ± 23.36[b]	118.48 ± 14.37[b]

Control = No nitrogen applied. Values represent means of triplicate determinations. Row mean values carrying the same superscripts do not differ significantly from each other (P > 0.05)

The significantly higher concentration of nitrate in the upper leaves (youngest) followed by middle leaves (younger) and least in the basal leaves (oldest) in *Telfairia occidentalis* revealed that the nitrate content in the leaves of this widely consumed vegetable in West Africa decreased with leaf age. This result is in harmony with the finding of Shigeru et al. (2003) and Carmen (2007) that the nitrate content in cassava leaves and setaria grass decrease with leaf age. The likely reason for this observation could be that the nitrate reductase, the enzyme responsible for reduction of nitrogen to amino acid required for protein formation in plant may be higher and more active in the older leaves than the younger ones. The likely low level and activity of this enzyme in the newly formed leaves (younger leaves) could lead to bioaccumulation of nitrogen and its subsequent oxidation to nitrate and accumulation in the affected leaf regions. This result is however; disagree with the finding of Musa et al. (2011) that nitrate concentration in *Amaranthus cruentus* increase with leave age. Anjana et al. (2007) observed that the higher accumulation of nitrate in any leaf position is due to low activity of nitrate reductase as the author found a significant negative correlation between nitrate and nitrate reductase activity. It therefore mean that the higher and lower nitrate concentrations observed in the different leaf positions may be due to the lower and higher nitrate reductase activity, respectively in those leaf regions. These findings thus suggest that the concentration and activity of nitrate reductase enzyme in the different leaf locations may vary from cultivar to cultivars. This justifies the variations in nitrate concentration observed in the different leaf positions in different species of the vegetable reported. The lower level of nitrate in basal leaves than the leaves obtained from other leaf locations have no nutritional advantage over other, this is because the nitrate concentrations in the leaves obtained from the three leaf positions are within the acceptable daily intake (ADI) of 3.65 mg/kg for 60 kg body weight (219.00 mg/day) if 100 g samples are consumed per day (Anjana et al., 2007).

The higher accumulation of soluble and total oxalates in basal and middle leaves than upper leaves in *Telfairia occidentalis* at vegetative phase are in harmony with the submission of Beis et al. (2007) that the oxalates (soluble and total) were higher in older leaves than younger ones in *Spinacia oleracea*. The reason for this observation might be that the leaves obtained from basal and middle leaf location are fully matured with most favourable metabolic activity leading to the formation higher concentration of the antinutrients. The results however, are in variance with the finding of Bassey et al. (2004) and Oscarson and Savarge (2007). These authors independently observed that oxalate contents in younger leaves are slightly higher than in the older leaves in *Diplazium sammatil* and *Colocasia esculenta* respectively. The results of this present study with those of previous ones may suggest that the distribution of this antinutrient responsible for kidney stone, electrolyte imbalance and irritation of digestive system in man and animal into the three different leaf locations depends on plant species which is genetically determined.

Highest β-carotene concentration in the upper leaves followed by middle and least in the basal leaves of *Telfairia occidentalis* at market maturity showed that the concentration of the provitamin A decreased with leaf age. Although this observation disagreed with the submission of Bergquist et al. (2007) to the effect that β-carotene concentration was highest in the oldest leaves than the younger ones in baby spinach. Our finding that β-carotene declined with leaf age may suggest that senescence induced by aging of leaves on the mother – plant may be responsible for this observation. However, the variations on β-carotene content observed in the present work from the works of these researchers may be due to environmental and cultivars differences.

The significant higher concentration of vitamin C in the basal leaves than the leaves obtained from middle and upper leaf regions in *Telfairia occidentalis* at vegetative phase disagrees with the report of Bergquist et al. (2007) which show that vitamin C concentration was highest in younger leaves of spinach than the older leaves. The significantly elevation of this water soluble vitamin that promote wound healing, boosting of immune system and a powerful antioxidant in the basal leaves of *Telfairia occidentalis* than leaves from obtained from middle and upper leaf positions do not justify the preference of the leaves from basal than those obtained other leaf regions. This is because the vitamin C concentrations in the leaves from middle and upper leaf positions are more than adult recommended daily allowance of 60 mg (Olaofe, 1992; George, 1999) if 100 g of the leaves of the vegetable are consumed.

The significantly higher concentration of Ca and Cu in the basal and middle leaves compared to upper leaves and the significant higher content of Fe in the basal leaves than the leaves obtained from other leaf locations is in accordance with the submission of the following authors (Taiz and Zeiger, 2002: Hochmuth et al., 2004: Bassey et al., 2004) who observed that these minerals in plants are concentrated in older leaves than the younger ones. Taiz and Zeiger (2002) and Hochmuth et al. (2004), further stressed that the higher concentration of these minerals in the older leaves compared to the younger leaves is due to their low mobility in the plant. Thus the low mobility of Fe in the plant is probably due to its precipitation in the older leaves as insoluble oxides or phosphates or to the formation of complexes with phytoferritin, an iron- binding protein found in the leaf and other plant parts (Oh et al., 1996; Taiz and Zeiger, 2002).

The observed higher concentration of K in upper than basal leaves in *Telfairia occidentalis* give good reason for the highly mobile nature of this mineral element that play an important role in regulation of the osmotic potential of plant cell (Taiz and Zeiger, 2002). Since K can be mobilized readily to younger leaves, the concentration appears to be higher in the upper leaf region than the basal leaf position (Taiz and Zeiger, 2002; Hochmuth et al., 2004). Magnesium is a highly mobile mineral element in plants (Taiz and Zeiger, 2002; Hochmuth et al., 2004), however, the concentration of this element in the vegetative phase of *Telfairia occidentalis* was significantly higher in the basal than in the upper leaves. This observation may suggest that in addition the degree of mobility of the mineral element that are known to influence their distributions into the different leaf positions on the mother – plant, other factors such as cultivar and some unknown factors could equally influence the nutrient distributions in the plants. These factors may be responsible for the observed variations in the distribution of Mg into the different leaf locations.

5. CONCLUSION

The disease conditions associated with high intake of cyanide (respiratory paralysis, dizziness, cellular hypoxia, heart blockage and even death) and oxalates (kidney stone, electrolytes imbalance and irritation of digestive system) can be averted by consumption of younger leaves (especially those from upper leaf position) of *Telfairia occidentalis*. The leaves from the upper leaf location of *Telfairia occidentalis* at this stage of development (vegetative phase) in addition to their low levels of most phytotoxins, they still provides micronutrients in amount to meet our nutritional requirements.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Ames, M.A., Moyer, T.P., Kavash, J.S., Moertel, C.G., Rubin, J. (1981). Pharmacology of amygdalin (Laetrile) in cancer patients. Cancer Chemotherapy and Pharmacology, 6, 51 – 57.

Anjana, S.U., Muhammed, I., Abrol. Y.P. (2007). Are nitrate concentrations in leafy vegetables within safe limits? Current Sci., 92(3), 355 – 360.

Antia, B.S., Akpan, E.J., Okon, P.A., Umoren, I.U. (2006). Nutritive and antinutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. Pakistan J. Nutr., 5(2), 166 – 168.

Bassey, M.E., Etuk, U.I., Ibe, M.M., Ndon, B.A. (2004). Diplazium sammatii: Anthyracea (Nyama idim): Age – related nutritional and antinutritional analysis. Plant Foods Human Nutr., 56 (1), 7 – 12.

Beis, G.H., Simos, A.S., Dogras, C.C. (2007). Spinach composition as affected by leaf age and plant part. Int. Soc. Hortic. Sci. *http://www.actahort.org/members/showpdf?Booknrarnr*=579_115.

Bergquist, S.A.M., Gertsson, U.E., Olsson, M.E. (2007). Biotive compounds and visual quality of baby spinach – changes during Plant growth and storage. Acta Hort., 744, 343 – 348.

Carmen, W., Angelita, D.S., Henrique, V. P. (2007). Antinutrients in the cassava (*Manihot esculenta crantz*) leaf powder at three ages of the plant. Ciencia e Technologia de Alimentos. http;//www.Scielo.br/Scielo.php? Script = Sci- arttext & pid = S 0101-20612007000100019 & Ing = e ---.

Christian, A. (2006). Studies of selected Physico chemical properties of fluted pumpkin (*Telfaria occidentalis* Hook F.) Seed oil and tropical almond (*Terminalia catappia, L.*) seed oil. Pakistan J. Nutr., 5 (4), 306 – 307.

Cleveland, D.A., Soleri, D. (1991). Food from dry land garden: An ecological, nutritional and social approach to small scale house food production. Publ. Centre for People. Food and Environment (CPFE) USA. Pp 26 – 28.

Ekpedema, U.A., Bassy, A.N., Ekaete, U.E. (2000). Minerals and antinutrients in fluted pumpkin (*Telfairia occidentalis Hook f.*). Food Chem., 70(2), 235 – 240.

Eleri, T., Hughes, R.E. (1983). Foliar ascorbic acid in some Angiosperms. Phytochem., 2(11), 2493.

Elllenhorn, M.J., Barcelonx, D.G. (1988). Dical toxicology; Diagnosis and treatment of human poisoning. New York. Elsevier Science Publishing Co. PP- 204 – 207.

Ezeonu, F.C., Musa, A., Stanly, C.D., Oswald, C.E. (2002). Iron and zinc status in soils, water and stable food cultivars in Itakpe, Kogi state of Nigeria. Environmentalist., 22, 237-240.

FDALR. (1985). The reconnaissance soil survey of Niger State. Soil report. Federal Department of Agricultural Land Resources, Pp 195.

George, D.P.R. (1999). Newlife style: Enjoy it. Editorial Safeliz, Spain, Pp. 39, 65 – 100.

Hochmuth, G., Maynard, D., Vavrina, C., Hanlon, E., Simonne, E. (2004). Plant tissue analysis and interpretation for vegetable crops in Florida: University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS). Pp. 1 – 79.

Horsfall, M.J., Spiff, I.A. (2005). Equilibrium sorption study of $A1^{3+}$, CO^{2+} and Ag^{+} in aqueous solution by Fluted Pumpkin (*Telfaria occidentalis* Hook F) Waste Biomass. Acta Chemistry of Slovia.

Ikediobi, C.O., Onyia, G.O.C., Eluwah, C.E. (1980). A rapid and inexpensive enzymatic assay for total cyanide in cassava (*Manihot esculenta crantz)* and cassava product. Agric. Biol. Chem., 44, 2803 – 2808.

Juo, A.S.R. (1979). Selected methods of soils and plants analysis: Farming systems program – Manual series No. 1. Ibadan, IITA. Pp 3 – 15.

Musa, A., Ezenwa, M.I.S., Oladiran, J.A., Akanya, H.O., Ogbadoyi, E.O. (2010). Effect of soil nitrogen levels on some micronutrients, antinutrients and toxic substances in *Corchorus olitorius* grown in Minna, Nigeria. Afr. J Agric. Res., 5 (22), 3075 – 3081.

Musa, A., Oladiran, J.A., Ezenwa, M.I.S., Akanya, H.O., Ogbadoyi, E.O. (2011). Effects of applied nitrogen fertilizer and leaf positions on levels of micronutrients, antinutrients and toxic substances in *Amaranthus cruentus*. Afr. J. Biotechnol., 10(48), 9857–9863.

Nakata, P.A. (2003). Advances in our understanding of calcium oxalate crystal formation and function in plants. Plant Sci*.,* 164, 901 – 909.

Nkang. A., Omokaro. D., Egbe A., Amanke, G. (2003) Variations in fatty acid proportions during desiccation of *Telfairia Occidentalis* seeds harvested at physiological and agronomic maturity. Afr. J. Biotechnol, 2 (2), 33 – 39.

Ogbadoyi, E.O., Musa, A., Oladiran, J.A., Ezenwa, M.I.S., Akanya, H.O. (2011). Antinutrient and micronutrient contents in leaves of *Telfairia occidentalis* Hook.f.: The effects of cooking and sun drying. South Asian J. Exp. Biol., 1(2), 61 – 68.

Oh, S.H., Cho, S.W., Kwon, T.H., Yang, M.S. (1996). Purification and characterization of Phytoferritin. J. Biochem. Mol. Biol., 29, 540 – 544.

Ojiako, O.A., Igwe, C.U. (2008). The nutritive, anti-nutritive and hepatotoxic properties of *Trichosanthes anguina* (Snake tomato) Fruits from Nigeria. Pakistan J. Nutr., 7 (1), 85 – 89.

Ojokoh, V.O., Adetuye, F.A., Akinyosoye, E., Oyetayo, O. (2002). Fermentation studies on roselle (*Hibiscus Sabdariffa*) calyces neutralized with trona. J. Food Technol. Afr., 7, 75 – 78.

Oke, L.O. (1966). Chemical Composition of some Nigeria leafy vegetables. J. Am. Dietetic Assoc., 53, 130 – 132.

Okon, E.U., Akpanyung, E.O. (2005). Nutrients and antinutrients in selected brands of malts drink products in Nigeria. Pakistan J. Nutr., 4(5), 352 – 355.

Olaofe, O. (1992). Vitamin C content of Nigerian food – stuffs. Nigerian J. Nutr. Sci., 13(1 and 2), 1 – 7.

Onyesom, I., Okoh, P.N. (2006). Quantitative analysis of nitrate and nitrite contents in vegetables commonly consumed in Delta state, Nigeria. British J. Nutr., 96 (5), 902 – 905.

Oscarsson, K.V., Savage, G.P. (2007). Composition and availability of soluble and insoluble oxalates in raw and cooked taro (*Colocasia esculents var. Schott*) leaves. Food Chem., 101(2), 559 – 562.

Osunde, A.O., Alkassoum, A. (1988). Growth, natural nodulation, and nutrient yield of selected multipurpose tree species in a Nigerian moist Savannah soil. Agronomic Africaine Numero Special. 1, 361 – 373.

Prohp, T.P., Ihimire, I.G., Madusha, A.O., Okpala, H.O, Erebor, J.O., Oyinbo. C.A. (2006). Some Antinutritional and mineral contents of Extra – cotyledonous deposit of pride of barbados (*Caesalpina pulcherrima*). Pakistan J. Nutr, 5(2), 114 – 116.

Richard, D.W. (1991). Cooperative Extension Service: Cooperative Extension work acts may 8 and June 30, 1914, as amended, Kansas State University, County Extension Councils. Extension Districts and U.S. Department of Agriculture Cooperating.

Schippers, R.R. (2000). African indigenous vegetables: An overview of the cultivated species. University Greenwwish. England, Pp. 193 – 205.

Shigeru. M., Noriko, Y., Keerthis, S.G. (2003). Simple capillary electrophoretic determination of soluble oxalate and nitrate in forage grasses. J. Vet. Diagn.Investig., 15, 480 – 483.

Sjoberg, A.M.K., Alanka, T.A. (1994). Spectrophotometric determination of nitrate in baby food: Collaborative study. J. AOAC Int., 77(2), 425 – 430.

Syndenham, D. (1985). Success in vegetable production. 1st edition. Macmillam London. Pp 23.

Taiz, L., Zeiger, E. (2002). Plant physiology. Sinauer Associates, Inc. Sunderland. Massachusetts. 3rd edition. Pp. 370 – 372.

Waclaw, M., Stefan, S. (2004). Effect of culinary processes on the content of nitrates and nitrites in potatoes. Pakistan J. Nutr., 3(6), 357 – 361.
