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Influence of Plant Leaf Locations on the Bioaccumulations of Phytotoxins and Nutrients in *Corchorus olitorius* at Market Maturity

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Abstract

Experiment was performed in a pot to examined the effect of leaf locations on the concentrations of some plant toxins (cyanide, nitrate, soluble and total oxalates), and nutrients viz; β-carotene (provitamin A), vitamin C and mineral elements (Fe, Mg, Cu, Zn, Ca Na and K) at market maturity (vegetative phase) of *Corchorus olitorius* grown in nitrogen and non – nitrogen treated soil. The leaves of *Corchorus olitorius* were harvested at three different leaf locations (basal, middle and upper positions) and they were subjected to chemical analysis. The result showed that there was no significant differences in the cyanine concentration between basal and middle leaves, however, the leaves obtained from upper leaf location was significantly ($p < 0.05$) lower in cyanide concentration than those leaves obtained each from basal and middle leaf regions in control and nitrogen treated *Corchorus olitorius*. The nitrate content in *Corchorus olitorius* was significantly ($p < 0.05$) highest in the basal leaves closely followed by middle leaves and least in the upper leaves in control, however, with the application of nitrogen fertilizer, no significant variation in the nitrate concentration was observed between leaves obtained from middle and upper leaf locations, but leaves obtained from each of these locations were significantly ($p < 0.05$) lower than those from basal leaf region. Both soluble and total oxalate concentrations increased with leaf age in *Corchorus olitorius* irrespective of soil nitrogen levels. The concentration of β-carotene was significantly ($p < 0.05$) higher in middle leaves compared to basal and upper leaves each in nitrogen and non-nitrogen fertilized *Corchorus olitorius*. While the concentration of vitamin C was significantly highest in middle leaves followed by upper leaves and least in the basal leaves of *Corchorus olitorius* irrespective of soil nitrogen levels. The Fe, Cu and Ca contents were generally concentrated in basal and middle leaves of the vegetable. Leaf location had no significant enfluence on the accumulation of Na and Mg in *Corchorus olitorius*, except that the concentration of Mg in basal and middle leaves was significantly elevated than upper leaves with the application of nitrogen fertilizer. While the concentration of K in *Corchorus olitorius* was significantly ($p < 0.05$) elevated in upper and middle leaves compared basal leaves, the concentration of Zn was significantly ($p < 0.05$) higher in the middle leaves than those obtained each from basal and upper leaf locations. The result concludes that the concentrations of phytoxins (cyanide, nitrate, soluble and total oxalates) are elevated in older leaves than younger ones of *Corchorus olitorius*.Thus avoiding the consumption of older leaves of the vegetables will reduced the health problems associated with high intake of these plant toxins.

Keywords: *Corchorus olitorius*, phytotoxins, nutrients, plant leaf locations, market maturity

1. Introduction

Corchorus olitorius is a popular vegetable in either dry or semi-arid regions and in the humid areas of Africa. The genus *Corchorus* consists of 50 - 60 species, of which about 30 are found in Africa. The plant is mainly known for its fibre product, jute and for its leafy vegetables (Schippers, 2000). Several species of *Corchorus* are used as vegetable, of which *Corchorus olitorius* is most frequently cultivated.

The plant grows well in light (sandy), medium (loamy) and heavy (clay) soils. *Corchorus olitorius* does well in acid, neutral and basic (alkaline) soils (Facciola, 1990). The vegetable is widely consumed as a health vegetable in Japan, because it contains abundant carotenoids, vitamins B_1, B_2, C and E, and mineral elements. Despite these huge nutritional benefits of this widely consumed leafy vegetable, *Corchorus olitorius* also bioacummulates some phytotoxins such as cyanide, oxalates, cyanide, cardiac glycoside, nitrate which are detrimental to health at high concentrations (Shinobu et al., 2000; Musa et al., 2011a). High ingestion of oxalate and phytate are known to chelates mineral elements in the body and reduce their bioavailability. Oxalate combines with calcium to form calcium oxalate which is responsible for kidney stone (Okon & 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 & Barcelonx, 1988) while nitrate is a culprit for cancer and methaemogloneamia (Waclaw & Stefan, 2004; Oyesom & Okoh, 2006; Ogbadoyi et al., 2011).

The amount of nutrients and phytotoxins in the leaves of plants are known to be influenced by the location of leaf on the mother - plant (Musa et al., 2011b). This research is therefore designed to investigate the effect of plant leaf locations on the levels of some phytotoxins and micronutrients with a view of identifying the leaf location with lower phytoxins and therefore reduce the likely health problems 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 of Nigeria. Niger State has a Savannah climate characterized by maritime. The geographical location of Minna is at longitude 9^{o} 40’N and latitude 6^{o} 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^{o}C with peaks temperature of 40^{o}C in February /March and 30^{o}C in November /December. Wet season average temperature is about 29 ^{o}C. The Dry season occurs between November and March while harmattan which is characterised by dry air is between November and February (Osunde & Alkassoun, 1998). The map of the study area is shown in Figure 1 below.

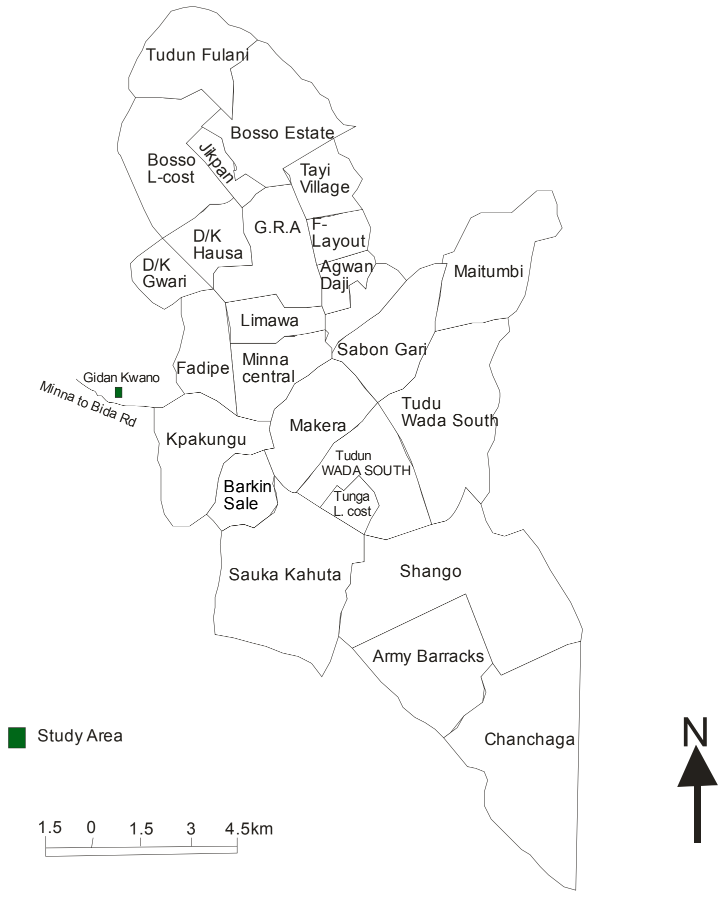

Figure 1. Map of the study area

Source: Niger State Land and aurvey, 2006.

2.2 Soil Sampling and Analysis

The soil used in this research was collected from Kidan kwano, the main campus of Federal University of Technology, Minna, Nigeria. 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 (E.A 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 Macrokjedal procedure and available phosphorus by Bray No 1 method (Juo, 1979).

2.3 Planting, Experimental Design and Greenhouse Management

About ten seeds of *Corchorus olitorius* were planted in a polythene bag filled with 10.00 kg of top soil and after germination the seedlings were thinned to two plants per pot. The factorial design was adopted to determine the effect of three leaf age/positions (basal, middle and upper locations) in control and nitrogen treated *Corchorus olitorius*. 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 plant 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

The fertilizer treatments for *Corchorus olitorius* are stated below:

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

F_2: 30mgN/kg soil, 30mg P_2O_5/kg soil and 30mg K_2O/kg soil

2.5 Harvesting

The leaves of *Corchorus olitorius* grown in pot experiment in 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.

2.6 Plant Tissues Analysis

The soluble and total oxalates concentration in the leaves of *Corchorus olitorius* obtained from the three different leaf locations were determined by titrimetric method of Oke (1966). Nitrate concentration in the samples was determined by the colourimetric method (Sjoberg & 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 samples were determined according to the method of Ezeonu et al. (2002). The ascorbic acid concentration was determined by 2, 6-dichlorophenol indophenols method of Eleri and Hughes (1983). Estimation of β-carotene was done by ethanol and petroleum ether extraction method as described by Musa et al. (2010).

2.7 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 obtained from 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. Also the soil pH indicated that the soil is slightly acidic.

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

Parameters	Values
Sand (%)	74.40
Silt (%)	18.00
Clay (%)	7.60
pH (in H_2O)	6.51
pH (in 0.1M C_aCI_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 Influence of Plant Leaf Locations on Phytotoxin and Vitamin Concentrations

The determination of cyanide concentration in the different leaf locations of *Corchorus olitorius* at market maturity showed that there was no significant differences in its concentration between basal and middle leaves, however, each of the two leaf locations had significant ($p < 0.05$) higher concentration of cyanide than leaves obtained from upper leaf location irrespective of soil nitrogen levels. The amount of cyanide in the basal leaves in control (769.43 ± 58.44 mg/kg) and nitrogen applied *Corchorus olitorius* (799.24 ± 71.42 mg/kg) were not significantly ($p > 0.05$) different from the concentration in the middle leaves (723.46 ± 70.54 mg/kg and 849.26 ± 71.82 mg/kg, respectively). The cyanide concentration in the upper leaves for control (497.13 ± 77.79 mg/kg) and nitrogen applied (204.31 ± 73.25 mg/kg) was significantly ($p < 0.05$) lower than the level obtained from each of the two leaf positions (Table 2).

The nitrate concentration in *Corchorus olitorius* was significantly ($p < 0.05$) highest in the basal (3633.30 ± 83.30 mg/kg) closely followed by middle (1544.40 ± 100.50 mg/kg) and lowest in the upper (905.60 ± 38.50 mg/kg) leaf regions in control. With the application of nitrogen fertilizer, no significant differences in the nitrate concentration was observed between middle (2105.50 ± 35.40 mg/kg) and upper (1955.60 ± 371.30 mg/kg) leaves, however, the leaves obtained each from the two leaf locations had lower nitrate concentration than the basal (4088.90 ± 657.10 mg/kg) leaves (Table 2).

Analysis of soluble oxalate content in control *Corchorus olitorius* showed that there was no significant differences in oxalate concentration between basal (2.07 ± 0.23 g/100g) and middle (1.78 ± 0.17 g/100g) leaves, however, the soluble oxalate concentration in the leaves obtained from upper leaf location (1.20 ± 0.16 g/100kg) was significantly ($p < 0.05$) lower in the antinutrient content than those obtained each from basal and middle leaf regions. However, with the application of nitrogen fertilizer, the leaves from middle (1.80 ± 0.45 g/100g) and upper (1.80 ± 0.23 g/100g) leaf regions each had significant ($p < 0.05$) lower concentration of soluble oxalate than those obtained from basal leaf (2.94 ± 0.05 g/100g) region (Table 2). There was no significant differences in the total oxalate concentration between middle (3.13 ± 0.04 g/100g) and upper (2.85 ± 0.16 g/100g) leaves, and between middle and basal (3.47 ± 0.22 g/100g) leaves, but basal leaves had higher significant ($p < 0.05$) amount of the oxalate than upper in the control. With the application of nitrogen fertilizer, the total oxalate concentration in the basal leaves (3.77 ± 0.24 g/100g) and middle leaves (3.24 ± 0.34 g/100g) were each significantly ($p < 0.05$)

higher than upper leaves (2.57 ± 0.11 g/100g). However, the total oxalate concentration in the leaves of *Corchorus olitorius* obtained from basal and middle leaf locations were significantly the same (Table 2).

The concentration of β-carotene in the basal leaves in control (2364.70 ± 166.10 µg/100g) and nitrogen applied *Corchorus olitorius* (9910.00 ± 202.00 µg/100g) were significantly the same with those in the upper leaves (2117.70 ± 60.30 µg/100g and 9670.00 ±232.00 µg/100g, respectively). However, the β-carotene concentration in the middle leaves for control (33940.30 ± 81.40 µg/100g) and nitrogen applied (11201.00 ± 101.00 µg/100g) were significantly ($p < 0.05$) higher than in those leaves obtained each from basal and upper leaf locations (Table 2).

Vitamin C concentration in *Corchorus olitorius* was significantly ($p < 0.05$) highest in the in middle leaves, followed by upper leaves and least in the basal leaves irrespective of the fertilizer levels. The concentrations of the vitamin C in the basal, middle and upper leaves in control were 53.98 ± 5.18, 112.54 ± 3.67 and 91.62 ± 2.79 mg/100g, respectively. While the corresponding values obtained with the application of nitrogen fertilizer was 74.89 ± 3.47, 129.71 ± 3.67 and 106.53 ± 7.10 mg/100g (Table 2).

Table 2. Influence of plant leaf locations on phytotoxins and vitamins concentration in *Corchorus olitorius* at market maturity

Phytotoxins and vitamins	Leaf location		
	Basal leaves	Middle leaves	Upper leaves
Cyanide (mg/kg DW), Control	769.43 ± 58.44^{b}	723.46 ± 70.54^{b}	497.13 ± 77.79^{a}
Cyanide (mg/kg DW), N applied	799.24 ± 71.42^{b}	849.26 ± 71.82^{b}	204.31 ± 73.25^{a}
Nitrate (mg/kg DW), Control	3633.30 ± 83.30^{c}	1544.40 ± 100.50^{b}	905.60 ± 38.50^{a}
Nitrate (mg/kg DW), N applied	4088.90 ± 65.10^{b}	2105.50 ± 35.40^{a}	1955.60 ± 371.30^{a}
Soluble oxalate (g/100g DW), Control	2.07 ± 0.23^{b}	1.78 ± 0.17^{b}	1.20 ± 0.16^{a}
Soluble oxalate (g/100g DW),N applied	2.94 ± 0.05^{b}	1.80 ± 0.45^{a}	1.80 ± 0.23^{a}
Total oxalate (g/100g DW), Control	3.47 ± 0.22^{b}	3.13 ± 0.04^{ab}	2.85 ± 0.16^{a}
Total oxalate (g/100g DW), N applied	3.77 ± 0.24^{b}	3.24 ± 0.34^{b}	2.57 ± 0.11^{a}
β-carotene (µg/100g FW), Control	2364.70 ± 166.10^{a}	33940.30 ± 81.40^{b}	2117.70 ± 60.30^{a}
β-carotene (µg/100g FW), N applied	9910.00 ± 202.00^{a}	11201.00 ± 101.00^{b}	9670.00 ± 232.00^{a}
Vitamin C (mg/100g FW), Control	53.98 ± 5.18^{a}	112.54 ± 3.67^{c}	91.62 ± 2.79^{b}
Vitamin C (mg/100g FW), N applied	74.89 ± 3.47^{a}	129.71 ± 3.67^{c}	106.53 ± 7.10^{b}

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

3.3 Influence of Plant Leaf Locations on Mineral Elements Concentration

The analysis of the effect of leaf locations on the concentration of listed minerals in *Corchorus olitorius* showed that leaf position had no significant effect on the distribution of Fe in the leaves of the vegetable in control. However, with the application of nitrogen fertilizer, though, no significant variations in Fe concentration was observed between basal (10.21 ± 1.42 mg/kg) and middle (13.13 ± 1.63 mg/kg) leaves and between basal and upper (7.53 ± 1.00 mg/kg) leaves, middle leaves had significant ($p < 0.05$) higher concentration of the mineral element than upper leaves (Table 3).

Leaf positions had no significant effect on Mg concentration in *Corchorus olitorius* in control. However, when the vegetable received nitrogen fertilizer, the Mg concentration in the basal (19.25 ± 1.17 mg/kg) and middle (20.49 ± 1.59 mg/kg) leaves were significantly the same while the upper leaves (16.49 ± 0.69 mg/kg) had significant ($p < 0.05$) lower concentration of Mg than the leaves obtained each from basal and middle locations (Table 3).

The Zn concentration in basal and upper leaves of *Corchorus olitorius* were significantly the same, however, the Zn concentration in the middle leaves was significantly ($p < 0.05$) higher than the level found each in the two leaf positions irrespective of soil nitrogen levels (Table 3).

Determination of Cu concentration in the control and nitrogen treatd *Corchorus olitorius* showed that there was no significant differences in Cu concentration between middle and upper leaves, but leaves obtained each from the two leaf regions had significant lower Cu content than basal leaves (Table 3).

The concentration Ca in basal leaves was significantly the same with middle leaves; however, the leaves obtained from the two leaf positions each had significant higher Ca conconcentration than upper leaves irrespective of the nitrogen levels (Table 3). Leaf locations had no significant effect on the concentration Na in the control and nitrogen fertilized *Corchorus olitorius* (Table 3).

Similarly analysis of K in *Corchorus olitorius* showed that concentration of the element in upper leaves was not significantly different from middle leaves. However, the leaves obtained from the two leaf positions each had significant higher concentration of K than basal leaves in control and nitrogen fertilized *Corchorus olitorius* (Table 3).

Table 3. Influence of plant leaf locations on mineral elements concentration in *Corchorus olitorius* at market maturity

Minerals	Leaf locations		
	Basal leaves	Middle leaves	Upper leaves
Fe (mg/kg), Control	18.57 ± 5.76^{a}	20.71 ± 6.12^{a}	14.63 ± 5.54^{a}
Fe (mg/kg) , Nitrogen applied	10.21 ± 1.42^{ab}	13.13 ± 1.63^{b}	7.53 ± 1.00^{a}
Mg (mg/kg), Control	18.67 ± 2.49^{a}	19.38 ± 0.23^{a}	18.14 ± 0.41^{a}
Mg (mg/kg), Nitrogen applied	19.25 ± 1.17^{b}	20.49 ± 1.59^{b}	16.49 ± 0.69^{a}
Zn (mg/kg), Control	0.02 ± 0.01^{a}	0.05 ± 0.03^{b}	0.01 ± 0.01^{a}
Zn (mg/kg), Nitrogen applied	0.02 ± 0.01^{a}	0.04 ± 0.03^{b}	0.01 ± 0.01^{a}
Cu (mg/kg), Control	19.30 ± 5.03^{b}	10.90 ± 0.31^{a}	10.30 ± 0.97^{a}
Cu (mg/kg), Nitrogen applied	8.40 ± 0.80^{b}	5.99 ± 2.85^{a}	5.38 ± 2.97^{a}
Ca (mg/kg), Control	19.76 ± 3.06^{b}	17.23 ± 2.81^{b}	9.25 ± 2.19^{a}
Ca (mg/kg), Nitrogen applied	15.29 ± 2.10^{b}	12.49 ± 2.38^{b}	5.66 ± 0.74^{a}
Na (mg/kg), Control	7.37 ± 0.88^{a}	6.40 ± 0.41^{a}	6.25 ± 0.09^{a}
Na (mg/kg), Nitrogen applied	6.22 ± 0.96^{a}	5.42 ± 0.85^{a}	5.42 ± 0.55^{a}
K (mg/kg), Control	164.00 ± 40.45^{a}	250.03 ± 86.36^{b}	239.61 ± 8.77^{b}
K (mg/kg), Nitrogen applied	132.47 ± 16.82^{a}	190.61 ± 32.53^{b}	177.36 ± 36.59^{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 ($P > 0.05$).

4. Discussion

This study has revealed that the location of leaf on the mother- plant had significant influence on the bioaccumulation of some phytotoxins and nutrients in the leaves of *Corchorus olitorius*. The significantly higher cyanide concentrations in the basal than upper leaves of *Corchorus olitorius* at market maturity (vegetative phase) corroborates the findings of the following authors (Cleveland & Soleri, 1991; Carmen et al., 2007; Musa et al., 2011b; Musa & Ogbadoyi, 2012) that the cyanide concentration increased with leaf age in cassava, crucifers, *Amaranthus cruentus* and *Telfairia occindentalis*, respectively. This higher cyanide concentration in basal leaves than the upper leaves may be ascribed to the higher metabolic activities of enzymes responsible for synthesis of the cyanide in the fully developed leaves than the newly formed immatured leaves (Musa & Ogbadoyi, 2012). These results however, disagree with the submission of Richard (1991), who observed that the concentration of this respiratory poison is concentrated more in younger leaves of sorghum than the older leaves. The variations observed in the distribution of cyanide concentration into the different leaf positions of *Corchorus olitorus* from those of the previous work reported by different authors may be due to differences in cultivar and environmental factors.

The higher nitrate concentration in basal leaves followed by middle and then, least in the upper leaves of *Corchorus olitorius* revealed that nitrate concentration in the leaves of the vegetable increased with leaf age. This result is in accordance with the report of Anjana et al. (2007) and Musa et al. (2012b). Anjana et al. (2007) stressed further that the higher accumulation of nitrate concentration in older leaves than younger ones is due to lower activity of nitrate reductase enzyme in the older leaves than younger ones. This enzyme is responsible for the reduction of nitrogen to amino acid for the synthesis of proteins. Low activity of the enzyme in the older leaves reduce the rate of protein formation from nitrogen and this may led to the bioaccumulations of nitrogen and its conversion to nitrate in the affected leaf regions. This verdict may be correct since Anjana et al. (2007) has also reported a significant negative correlation between nitrate concentration and nitrate reductase activity. However, the lowest nitrate concentration in the upper leaves than in the two leaf regions is in accordance with the submission of Anjana et al. (2007). This result however, disagree with the finding of Shigeru et al. (2003), Carmen (2007) and Musa and Ogbadoyi (2012) that the nitrate conconcentration decreased with leaf age in cassava, setaria grass and *Telfairia occindentalis*, respectively. In general, the higher and lower nitrate concentrations observed in the different leaf locations may be due to the lower and higher nitrate reductase activity, respectively in those leaf regions. These two fashions of results may suggest that the bioaccumulation of nitrate in the different leaf locations which is a fuction of the concentration and activity of nitrate reductase may varies from cultivar to cultivars and this is genetically determined. It is therefore necessary not to generalise the result of this nature.

The higher concentration of soluble and total oxalates in basal and middle leaves than in the upper leaves of *Corchorus olitorius* at vegetative phase is in harmony with the submission of Beis et al. (2007), Musa et al. (2011) and Musa and Ogbadoyi (2012) to the effect that the antinutrients (soluble and total oxalates) were concentrated more in older leaves than younger ones in *Spinacia oleracea, Amaranthus cruentus* and *Telfairia occidentalis,* respectively. The reason for this observation could be that the older leaves are fully matured with optimum metabolic activity leading to the production of oxalates. More also oxalates are secondary plant metabolites thus their higher concentrations in older leaves than the younger ones is justifiable.

This research have clearly demostrated that the concentrations of phytotoxins (cyanide, nitrate, soluble and total oxalates) are higher is older leaves than the youger leaves of *Corchorus olitorius*. It therefore follows that avoiding the consumption of older leaves of *Corchorus olitorius* will significantly reduce health problems or disease conditions associated with high intake of these plant toxins. For example, cyanide is a respiratory poison and inhibition of ATP synthesis in respiratory chain while oxalate is responsible for kidney stone, and nitrate is one of the causes of cancer and methaemoglobineamia (Antia et al., 2006; Proph et al., 2006; Ellenborn & Barcelonx, 1988; Waclaw & Stefan, 2004; Ogbadoyi et al., 2011)

The significantly higher concentration of β-carotene in the middle leaves than upper leaves in *Corchorus olitorius* at market maturity agrees with the report of Bergquist et al. (2007) and Musa et al. (2011b) to the effect that β-carotene concentration was higher in the older leaves than the younger ones in baby spinach and *Amaranthus cruentus*, respectively. However, the significant higher concentration of the provitamin A in the middle than basal leaves in this study contrasts with the results of Bergquist et al. (2007), but corroborates the findings with Musa and Ogbadoyi (2012).

The significant highest concentration of vitamin C in the middle leaves followed by upper leaves and least in the basal leaves in *Corchorus olitorius,* at market maturity corroborates with the report of Musa et al. (2011b). The observed higher levels of β-carotene and vitamin C in middle leaves than the basal and upper leaves of the vegetable could suggest that the leaves in the middle region of plants are fully matured with optimum physiological and metabolic activities leading to the production of β-carotene and vitamin C. Whereas in the in basal leaves, though they are fully matured, the leaves in this region are withdrawing some oxidizable nutrients due senescence induced by aging (Taiz & Zeiger, 2002). Wilting which occurs in older lower leaves may also be responsible for the lower concentration of these antioxidants in basal leaves compared to middle leaves. This observation may be correct because wilting decreases the vitamin C content (Ado, 1983; Keshinro & Ketiku, 1983; Olaofe, 1992). Leaves in the upper region of the plants are still developing and are immature with low physiological and metabolic activities leading to the formation of the vitamin. This higher concentration of vitamin C in the middle leaves of *Corchorus olitorius* does not have much nutritional advantage over the upper leaves. This is beause the vitamin C concentration in the leaves from upper leaf locations of the vegetable is well above the adult recommended daily allowance of 60mg (Olaofe, 1992; George, 1999). However, the significantly higher concentration of this water soluble vitamin with antioxidant properties in the upper leaves than the basal ones of the vegetable support the higher nutritional values of younger leaves of *Corchorus olitorius* than the older leaves.

The generally higher Fe, Cu and Ca concentrations in the basal and middle leaves than the upper leaves of *Corchorus olitorius* concur with the findings of the following authors (Taiz & Zeiger, 2002; Hochmuth et al., 2004; Bassey et al., 2004; Musa et al., 2011b; Musa & Ogbadoyi, 2012) who reported that these mineral elements in plant are higher in older leaves than the younger ones. Taiz and Zeiger (2002) and Hochmuth et al. (2004), attributed the higher concentrations of the mineral elements in the older leaves than the younger ones due to their low mobility in plants. The low mobility of the mineral elements in plant is probably due to their precipitation in the older leaves as insoluble oxides or phosphates or to the formation of complexes with plant proteins. For instance, phytoferritin, an iron- binding protein found in the leaf and other plant parts may be responsible for higher concentration of Fe in older leaves than the younger leaves (Oh et al., 1996; Taiz & Zeiger, 2002).

The higher concentration of K and Zn in younger leaves than older leaves in *Corchorus olitorius,* justify the high mobility of the mineral elements that play important roles in regulation of the osmotic potential of plant cell and cofactor in some metabolic pathway, respectively (Taiz & 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 location (Taiz & Zeiger, 2002; Hochmuth et al., 2004).

5. Conclusion

The lower concentration of phytotoxins (cyanide, nitrate, soluble and total oxalates) and higher content of some micronutrients in younger leaves of *Corchorus olitorius* compared to older leaves may suggest that the nutritional benefits abound in *Corchorus olitorius* can be fully maximised by consumption of younger leaves of the vegetable. This practice will reduce the health hazard in connection with high intake of the phytotoxins and contribute to the improvement of health conditions of the society.

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References

Addo, A. A. (1983). Ascorbic acids contents of food commonly consumed in the Northen States of Nigeria. *Nigerian Food Journal, 1*(1), 129-133.

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

Anjana, S. U., Muhammed, I., & Abrol. Y. P. (2007). Are nitrate concentrations in leafy vegetables within safe limits? *Current Science, 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 Journal of Nutrition, 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 for Human Nutrition*, *56* (1), 7-12.

Beis, G. H., Simos, A. S., & Dogras, C. C. (2007). Spinach composition as affected by leaf age and plant part. *International Society for Horticultural Science*.

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. *International Society of Horticutural Science*.

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.

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.

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

Ellenhorn, M. J., & Barcelonx, D. G. (1988). Dical toxicology; Diagnosis and treatment of human poisoning. New York. *Elsevier Science Publishing Co*, 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. *The Environmentalist,* 22, 237-240.

Facciola, S. C. (1990). *A source book of edible plants*. Kampony Publications, pp. 10-15.

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, 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, 1-79.

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. *Agriculture and Biological Chemistry, 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.

Keshinro, O. O., & Ketiku, A. O. (1983). Effect of traditional cooking on ascorbic acid content of some Nigeria leafy vegetables. *Food Chemistry, 3*, 303-309.

Musa, A., & Ogbadoyi, E. O. (2012). Effect of plant leaf positions on some micronutrients, anti-nutrients and toxic substances in *Telfairia occidentalis* at the vegetative phase. *American journal of experimental. Agriculture, 2*(2), 219232.

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. *African iournal of agricultural research, 5*(22), 3075-3081.

Musa, A., Oladiran, J. A., Ezenwa, M. I. S., Akanya, H. O., & Ogbadoyi. E. O. (2011b). Effects of applied nitrogen fertilizer and leaf positions on level of micronutrients, anti-nutrients and toxic substances in *Amaranthus hybridus*. *African journal of biotechnology, 10*(48), 9857-9863.

Musa, A., Oladiran, J. A., Ezenwa, M. I. S., Ogbadoyi, E. O., & Akanya, H. O. (2011a). Effect of fruiting on some micronutrients, antinutrients and toxic substances in *Corchorus olitorius* grown in Minna, Niger State, Nigeria. *African journal.of food science, 5*(5), 411-416.

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 journal of expimental biology, 1*(2), 61-68.

Oh, S. H., Cho, S. W., Kwon, T. H., & Yang, M. S. (1996). Purification and characterization of Phytoferritin. *Journal of Biochemistry and Molecular Biology, 29*, 540-544.

Oke, L. O. (1966). Chemical Composition of some Nigeria leafy vegetables. *Journal of American Dietetic Association, 53*, 130 -132.

Okon, E. U., & Akpanyung, E. O. (2005). Nutrients and antinutrients in selected brands of malts drink products in Nigeria. *Pakistan Journal of Nutrition, 4*(5), 352-355.

Olaofe, O. (1992). Vitamin C content of Nigerian food – stuffs. *Nigerian Journal of Nutritional Science, 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 Journal of Nutrition,* 96(5), 902-905.

Osunde, A. O., & Alkassoum, A. (1988). Growth, natural nodulation, and nutrient yield of selected multipurpose tree species in a Nigerian moist savana 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 Journal of Nutrition, 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 indegenous 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. *Journal of Veterinary Diagnosis, 15*, 480-483.

Shinobu, S., Makoto, C., Yukihiro, G., Masatake, J., & Mitsuharus, T. (2000). Relationship between cardiac glycoside contents and colour of *Corchorus olitorius* seeds. *Journal of Health Science, 47*(2), 120-125.

Sjoberg, A. M. K., & Alanka, T. A. (1994). Spectrophotometric determination of nitrate in baby food: Collaborative study. *Journal of AOAC International, 77*(2), 425-430.

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 Journal of Nutrition,* 3(6), 357-361.