Determination of Antinutrients and Toxic Substances of Selected Fresh Leafy Vegetables Obtained from Minna Town, Nigeria

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ABSTRACT: Determination of antinutrients and toxic substances in leafy vegetables is an imperative facet in nutritional studies as it establishes the baseline concentrations index for phytotoxins in the vegetables. Concentrations of cyanide, nitrate, soluble and total oxalates were quantitatively determined in the common leafy vegetables (Amaranthus cruentus, Hibiscus sabdariffa, Corchorus olitorius, Telfairia occidentalis and Vernonina amygdalina) consumed in Minna, Niger State, Nigeria, using colourimetric and titrimetric methods. The results show that the concentration of cyanide in the leafy vegetables is within the permissible level of 200 mg/kg fresh weight while the concentration of nitrate in V. amygdalina and H. sabdariffa is within the acceptable daily intake of 219.00 mg/day, those of A. cruentus, C. olitorius and T. occidentalis is enough to induce toxicity in man. The soluble and total oxalates content in the vegetables are higher than the permissible level except that the concentration of soluble oxalate in H. sabdariffa is within the acceptable level of 250 mg/100 g. The results suggest that while the concentrations of cyanide in the analysed vegetables and nitrate in V. amygdalina and H. sabdariffa are safe for consumption, the concentrations of soluble and total oxalates in the vegetables and nitrate in A. cruentus, C. olitorius and T. occidentalis may contribute to nutritional problems if ingested without proper processing.

Keywords: Leafy vegetables, toxic substances, cyanide, nitrate, oxalates

INTRODUCTION
Leafy vegetables such as Amaranthus cruentus (amaranthus), Hibiscus sabdariffa (roselle), Corchorus olitorius (jute mallow), Telfairia occidentalis (fluted pumpkin) and Vernonina amygdalina (bitter leaf) are the major sources of phytonutrients such as vitamins and mineral elements require for normal metabolic activities of the body. Vegetables also contain dietary fibres for bowel movement (Lola, 2009; Musa and Ogbadoyi, 2012 a, b). Although, nutritional benefits abound in leafy vegetables, they bioaccumulate phytotoxins such as trypsin inhibitors, phytoxides, oxalates, nitrates, alkaloids, tannins and cyanogenic glycosides with attendant health problems at high concentrations (Macrae et al., 1997; Oboh, 2005; Antia et al., 2006; Weerakkody, 2006; Adeniji et al., 2007; Musa and Ogbadoyi, 2012 a, b). The antinutrients and toxic compounds in leafy vegetables sometimes make them inferior (Weerakkody, 2006). The non-nutrient constituents of vegetables (called phytotoxins) are of great concern because if present above the tolerable levels in our food, they can cause serious threat to health (Proph et al., 2006). For instance ingestion of high concentration of cyanogenic glycoside leads to respiratory poisoning and inhibition of ATP synthesis in electron transport chain (Ellenborn and Barcelonx, 1988; Musa et al., 2011; Musa, 2012; Musa and Ogbadoyi, 2012 c). Nitrate is one of the major culprits in cancer and methemoglobinemia (Macrae et al., 1997; Anjana et al., 2007) while oxalates and phytoxides chelate mineral elements and form complexes with proteins and thereby reduce their bioavailability and nutritive values. Combination of oxalate with calcium forms calcium oxalate which may be precipitated in the kidney to form kidney stone (Evans and Bandemer, 1967; Proph et al., 2006; Musa et al., 2011; Musa, 2012; Musa and Ogbadoyi, 2012 a, b, c). Generally people are advised to include a lot of leafy vegetables in their meals because of the nutrient contents in the vegetables. In most cases this advice undercut the presence of antinutrients and toxic substances in vegetables. Therefore, evaluating the concentrations of cyanide, nitrate and oxalates in the commonly consumed leafy vegetables in Minna, Nigeria, is very important in establishing the baseline levels and safety of the vegetables for human consumption with respect to the toxic substances.

MATERIALS AND METHODS
Sources of leafy vegetables
The fresh samples of A. cruentus, H. sabdariffa, C. olitorius, T. occidentalis and V. amygdalina were bought each in three sets at different time from Maikunkele,
Bosso and Chanchanga markets in Minna town, Nigeria.

Chemicals
All the chemicals used in this work were of analytical grade and were purchased from BDH and Sigma Chemical Companies, England.

Analytical procedure
The soluble and total oxalates concentrations in the fresh leaves of the vegetables were determined by titrimetric method of Oke (1966). Nitrate content in the test samples was determined by the colourimetric method of Sjoberg and Alanka (1994) while alkaline picrate method of Ikediobi et al. (1980) was used to analyse the cyanide content in the samples.

Statistical analysis
Analysis of variance (ANOVA) was used to determine the differences in the concentrations of the antinutrients and toxic substances in the fresh leaves of the vegetables using Minitab statistical package. P-values < 0.05 were accepted as significant while the DUNCAN’s Multiple Range Test (DMRT) was used for comparison of mean.

RESULTS
Cyanide concentration
Analyses of cyanide concentration in the different fresh leafy vegetables shows that there is no significant difference (p>0.05) between T. occidentalis, C. oltiorius and V. amygdalina, however, the concentration of cyanide in V. amygdalina is significantly (p < 0.05) higher than C. oltiorius. Similarly, there was no significant difference in the cyanide concentration between A. cruentus and H. sabdariffa, however, the concentration of this compound each in these vegetables is significantly (p < 0.05) lower than in other vegetables analysed (Figure 1).

Nitrate concentration
The mean concentration of nitrate in the fresh leaves of A. cruentus, H. sabdariffa, C. oltiorius, T. occidentalis and V. amygdalina is presented in Figure 2. Data analysis showed that concentrations of nitrate in A. cruentus was significantly (p < 0.05) higher than all the fresh leafy vegetables analysed. While the concentration nitrate in H. sabdariffa is significantly (p < 0.05) lower than in C. oltiorius and T. occidentalis, there is no significant (p > 0.05) difference with V. amygdalina. Similarly, C. oltiorius and T. occidentalis have no significant (p > 0.05) difference.

Soluble oxalate concentration
The soluble oxalate in the leaves of the selected leafy vegetables shows that the concentration is significantly (p < 0.05) lower in H. sabdariffa than in all the fresh leafy vegetable studied. Although the concentration of soluble oxalate in C. oltiorius is not significantly (p > 0.05) different from A. cruentus, T. occidentalis and V. Amygdalina, the oxalate content in A. cruentus was significantly (p < 0.05) higher than T. occidentalis and V. Amygdalina (Figure 3).

Total oxalate concentration
Results from the determination of total oxalate in the different leafy vegetables showed that the concentration in A. cruentus was significantly (p < 0.05) higher than in all the leafy vegetables investigated. However, the concentration of total oxalate in H. sabdariffa, C. oltiorius, T. occidentalis and V. amygdalina are not
significantly (p > 0.05) different from each other (Figure 4).

DISCUSSION

The cyanide concentration in the fresh samples of the vegetables is \( V.\text{amygdalina} > T.\text{occidentalis} > C.\text{olitorius} > H.\text{sabdariifa} > A.\text{cruentus} \). The concentration of the cyanide in the leafy vegetables is within the permissible level of 200 mg/kg fresh weight of vegetables or forages (Everist, 1981; Richard, 1991). The results thus suggest that the leaves of any of these vegetables are safe for consumption with respect to cyanide content.

Generally, vegetables with nitrate concentrations in the range of 1000 – 4000 mg/kg are classified as high nitrate containing vegetables (JECFA, 2003; Anjana et al., 2007). Consequently, the analysed leafy vegetables with nitrate concentrations of 1281.50 – 4335.21 mg/kg are high nitrate containing vegetables (Ogbadoyi et al., 2011; Musa and Ogbadoyi, 2012 b, c). The nitrate concentration in fresh leaves of these vegetables except \( H.\text{sabdariifa} \) and \( V.\text{amygdalina} \) are more than 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). Therefore regular consumption of raw leaves of \( A.\text{cruentus}, C.\text{olitorius}, \) and \( T.\text{occidentalis} \) may possibly over load the body with nitrates with attendant health problems of methaemoglobinemia and cancers (Waclaw and Stefan, 2004; Anjana et al., 2007; Ogbadoyi et al., 2011; Musa and Ogbadoyi, 2013).

The higher concentration of soluble and total oxalates in fresh sample of \( A.\text{cruentus} \) than in any of the studied vegetables corroborate the work of other researchers (Abakr and Ragaa, 1996), to the effect that \( A.\text{cruentus} \) is one of the major leafy vegetables with high oxalate content. The soluble and total oxalates content in the vegetables are higher than the permissible level except that the concentration of soluble oxalate in \( H.\text{sabdariifa} \) is within the acceptable level of 250 mg/100 g fresh sample (Oguchi et al., 1996). Regular consumption of fresh raw samples of the vegetables without proper processing could deliver toxic levels of these antinutrients into the body with attendant health problems of oxalate toxicosis (Ogbadoyi et al., 2006). This can lead to hypocalcaemia, kidney stone, electrolytes imbalance and reduction of bioavailability of minerals in the body (Okon and Akpanyung, 2005; Antia et al., 2006; Proph et al., 2006; Musa et al., 2011). This finding questions the safety of these vegetables for human consumption with respect to oxalates content.

The variations in the concentrations of antinutrients and toxic substances in the different fresh leafy vegetables is in line withprevious report (Aliyu and Morufu, 2006; Adeboye and Babajide, 2007), which also shows that the bioaccumulation of chemical substances in plant is greatly influenced by plant species / cultivars.

CONCLUSION

The cyanide levels in the analysed vegetables and nitrate in \( V.\text{amygdalina} \) and \( H.\text{sabdariifa} \) are safe for consumption. However, the concentrations of oxalates in the vegetables and nitrate in \( A.\text{cruentus}, C.\text{olitorius}, \) and \( T.\text{occidentalis} \) may contribute to nutritional problems. This study therefore, suggests that while leafy vegetables are widely consumed because of their nutritional benefits, we should be mindful of the
presence of inherent antinutrients and toxic substances in them and their attendant health problems.

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REFERENCES


