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RESEARCH ARTICLE

ASSESSMENT OF ANTI-NUTRIENT AND TOXIC SUBSTANCES LEVEL IN SELECTED ROOT CROPS OF DOKO, NIGER STATE, NIGERIA

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ABSTRACT

Evaluation of anti-nutrient and toxic substances in tuber crops is crucial for nutritional studies, establishing baseline concentrations of cyanide, nitrate, phytate, and oxalate in human foods. Quantitative analysis was conducted on selected tuber crops namely *Dioscorea alata* (Cassava), *Manihot esculenta* (Yam), *Xanthosoma sagittifolium* (coco yam), *Solanum tuberosum (*Irish potato*), and Ipomoea batatas* (Sweet potato), commonly consumed in Doko, Niger State, Nigeria. Cyanide and nitrate concentrations were determined using colorimetric methods, while phytate and oxalate were measured using titrimetric methods. Results indicate that cyanide levels in most tuber crops were within the permissible limit of 200 mg/kg fresh weight, except for *Manihot esculenta* and *Ipomoea batatas,* which exceeded this limit. Nitrate concentrations across all samples were within tolerable levels. Phytate content ranged from 1.27±0.02 to 2.17±0.13 mg/100g, with yam and cocoyam showing the lowest and highest concentrations, respectively. Oxalate mean values varied among *Dioscorea alata, Manihot esculenta, Xanthosoma sagittifolium, Solanum tuberosum, and Ipomoea batatas*. The study underscores the nutritional benefits of tuber crops while highlighting the presence of inherent antinutrients and toxic substances. Proper processing methods are essential to mitigate potential health risks associated with their consumption.

KEYWORDS

Tuber crops, Toxic substances, Cyanide, Nitrate, Phytate, Oxalates.

1. INTRODUCTION

Root crops like yam (*Dioscorea alata*), cassava (*Manihot esculenta*), cocoyam (*Xanthosoma sagitifolium*), Irish potato (*Solanum tuberosum*), and sweet potato (*Ipomoea batatas*) are essential sources of carbohydrates, energy, and phytonutrients vital for metabolic activities (Anita and Shweta, 2022; Marolt, and Kolar, 2021; Kumar, and Sharma, 2017). However, they also contain natural anti-nutrients that diminish nutritional value by hindering mineral bioavailability and nutrient digestibility (Okaka, 2011; Ames et al., 1990). These antinutrients, including oxalates which can cause urinary tract stone formation and cyanogenic glycosides found in cassava that produce hydrogen cyanide, pose health risks such as respiratory poisoning and metabolic disruptions (Nweke, 2011; Ellenborn and Barcelonx, 1988; Musa et al., 2011). Phytates, while considered antinutrients, may offer health benefits like reducing the risk of heart disease and diabetes (Holloway and Bradbury, 1999). Conversely, nitrates in root crops are linked to health issues such as cancer and methemoglobinemia, affecting nutrient absorption and overall nutritional quality (Macrae et al., 1997; Anjana et al., 2007). Given these concerns, evaluating cyanide, nitrate, phytate, and oxalate levels in commonly consumed root crops in Doko, is crucial to establish safety standards for human consumption (Musa, 2012).

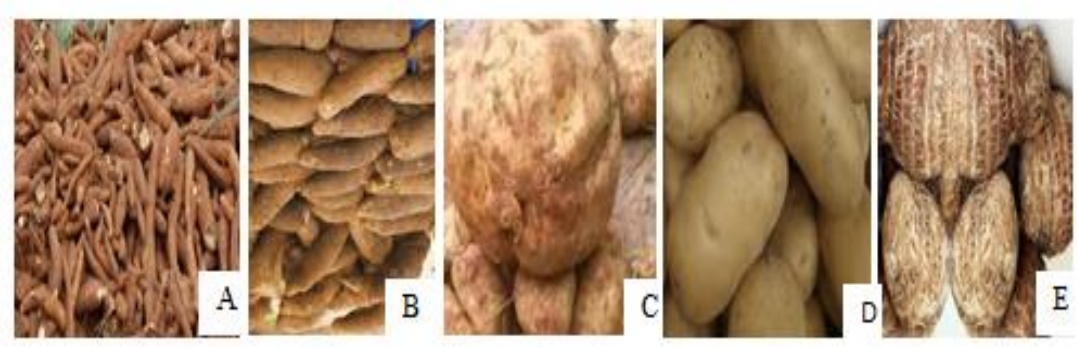

Figure1: Tubers of [A] *Manihot esculenta*; [B] *Dioscorea alata*; [C] *Ipomoea Batatas*; [D] *Solanum tuberosum*; [E] *Xanthosoma sagittifolium*.

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The aim of the study is to evaluate the level of some anti-nutrient and toxic substances in some commonly consumed root crops in Doko, for the establishment of baseline concentration index.

2. Materials and Methods

Fresh samples of *Manihot esculenta* (cassava),*Dioscorea alata* (yam), *Solanum tuberosum.(*Irish potato),*Ipomoea Batatas.*(Sweet potato),and *Xanthosoma sagittifolium.*(cocoyam) was purchased in three different market namely; Doko market, Gaba market and Danchitagi market in Lavun Local government area, Niger State, Nigeria.

2.1 Determination of Phytic Acid

This was determined according to (Marolt and Kolar, 2021).2g of sample each was weighed into a 250ml conical flask Follow by adding 100ml of 2% HCl and allowed to stay for 3 hours. The solution was then filtered through double layer Whitman No.1filter paper. The filtrate was then transfer into 250ml conical flask and 107ml distilled water was added in each case to give acidity follow by adding 10ml of 0.3% ammonium thiocyanate (NH_4SCN) solution into each of the solution to serve as indicator. The solutions were then titrated against standard iron (III) chloride ($Fecl_3$) solution containing 0.00195g/ml (1.95g/l). The end-point was slightly brownish-yellow which persisted for about 5mins. The percentage phytic acid or phytic acid g/100g sample was calculated using the formula:

$$\%\text{Phytic acid} = \frac{\text{Titre value X 0.00195 X 1.19 X 100 X 3.55}}{\text{Weight of sample}}$$

2.2 Determination of Oxalate

Oxalate was determined through the colorimetric method (AOAC. 2009). 1g of grounded samples were weighed into a crucible dish and 10ml of distilled water was added, followed by addition of 1ml concentrated H_2SO_4. This was allowed to stand for an hour and made up to 50ml with distilled water. 25ml of the solutions was pipette into a conical flask and warmed at 90°c, and titrated against 0.1M potassium permanganate in a burette immediately. A change of colour indicates the end point and the reading of the burette is taken after the red colour become steady for some seconds. The concentration of oxalate (mg g^{-1}) in each of the sample was calculated by multiplying the burette reading by 11.5.

2.3 Estimation of Nitrate

2.3.1 Preparation of The Samples

The nitrate content in the tubers samples were determined by the method of Sjoberg and Alanka (1994). 2g of each of the tubers were weighed, ground and transferred into 100cm^3 volumetric flask. The 75cm^3 of hot distilled water and 5cm^3 of saturated borax solution were added to precipitate the protein. The volumetric flask was warmed in boiling water bath for 15 minutes and 2cm^3 of $ZnSO^4$ solution was added slowly while shaking. The solution obtained was cooled to the room temperature in a cool water bath. The resulting solution was diluted to mark with distilled water, mixed and filtered. Blank sample material was treated the same way.

2.3.2 Reduction of Nitrate to Nitrite

0.6g of zinc powder was weighed into a 50cm^3 volumetric flask and spread over the bottom of the flask. Then 4cm^3 of cadmium sulphate ($CdSO_4$) solution was added to the zinc powder in flask to obtain homogenous mixture. The spongy metallic cadmium formed was allowed to stand for 10 minutes. 2cm^3 of 25% NH_4OH and 10cm^3 of each prepared samples solution above were added to the flask. The flask was shaken for one minutes and then diluted to volume with distilled water and filtered. The standard nitrate concentrations (containing 0, 50, 100, 150 and 200mg N_aNO_3) were prepared by reading 10cm^3 of each standard solution to a separate volumetric flask prepared with spongy cadmium and treated the same way as sample solution.

2.4 Nitrite Determination

10cm^3 of filtrate samples, blank and standard solutions (equivalent to 0, 10, 20, 30 and 40mg of sodium nitrate) were pipette into boiling test tubes. 10cm^3 of colour reagent consisting of equal mixture of N-(I-naphthyl) ethylendiammonium chloride reagent and Sulphanilic acid solution was then added. The resulting solution was mixed for one minute and absorbance taken at 530nm. The concentrations of nitrite in the samples were determined by comparing the absorbance of the samples with that of the standards concentration of nitrite in the samples in mg extrapolated from standard curve.

Calculations:-

Mg $NaNO_3$/Kg sample = (b x 100/M)

Where: b = NaNO3 from standard curve (µg) and M = weight of sample homogenate.

2.5 Estimation of Cyanide

Alkaline picrate method of was used to determine the cyanide content in the test samples (Ikedobi et al., 1980).

2.5.1 Preparation of Standard Curve for Cyanide Estimation

A stock solution potassium cyanide (KCN) was prepared by dissolving 4mg of dried KCN in 100cm^3 volumetric flasks containing some quantity of distilled water and was made to mark with distilled water after dissolution. From this stock solution, a series dilution containing 0 – 2mg of KCN concentration were made in ten 15cm^3 tightly stopper test tubes. Each tube was made up to 2cm^3 with distilled water. To each of the test tubes, 4cm^3 of alkaline picrate was added and the solutions obtained were incubated for 5 minutes in water bath at 95°C. After cooling to room temperature, the absorbance was read at 490nm using spectrophotometer. The values were used to plot the standard curve.

2.5.2 Determination of Cyanide

Extraction:1g of each samples of fresh, and processed (5 and 10 minutes boiling and sun drying) root tubers were weighed separately, ground and extracted thrice with 5cm^3 of aliquots of 0.1M sodium phosphate buffer, pH 6.8. The extracts obtained were used to determined cyanide concentration.

2.5.3 Test for Cyanide

1cm^3 of the tubers extract was pippeted into 15cm^3 stopper test tubes. This was followed by the addition of 1cm^3 of 0.1M NaOH solution and incubated at room temperature for 30 minutes for total hydrolysis of the extracted Cyanogenic glycoside (dhurrin, prunasin and amygdalin). The HCN liberated (as CN) after this hydrolysis, was determined by addition of alkaline picrate and the solution incubated for another 5 minutes in water bath at 95°C. The absorbance was read after cooling to room temperature by using spectrophotometer (Spectronic 20D' Milton Roy) at wave length of 490nm.

3. Results and Discussions

Table 1: Showed the Concentrations of anti-nutrient and toxic substance in selected root crops of *D. alata, M. esculenta, X. sagitiffolium, S. tuberosum and I. Batatas.*

Table 1: Concentration of antinutrient and toxic substances in selected root crops

Samples	Cyanide (mg/kg)	Nitrate (mg/kg)	Phytate (g/100g)	Oxalate (mg/g)
D. alata	151.70 ± 8.25^b	166.67 ± 30.05^b	1.27 ± 0.02^b	29.13 ± 3.56^a
M. esculenta	648.69 ± 65.55^a	225.00 ± 104.08^b	0.87 ± 0.11^c	23.77 ± 0.58^a
X. sagitiffolium	112.52 ± 33.06^b	350.00 ± 175.59^b	2.17 ± 0.13^a	25.30 ± 2.55^a
S. tuberosum	66.20 ± 25.29^b	1725.00 ± 76.38^a	1.28 ± 0.05^b	24.92 ± 1.89^a
I. batatas	371.39 ± 128.72^a	275.00 ± 14.43^b	1.17 ± 0.08^b	30.15 ± 1.22^a

Means value on the same column with different superscript shows significantly different ($p \leq 0.05$)

The concentration of the cyanide in Dioscorea *alatas, Xanthosoma sagitiffolium* and *Solanum tuberosum* were within the acceptable level of 200mg/kg fresh weight of tuber crops with exception of *Manihot esculenta* and *Ipomoea batatas* tuber crops that were higher than the permissible level (Everist, 1981; Richard, 1991). Cyanide concentrations above the permissible level of 200 mg/kg are classified as hazardous or toxic (Ogbadoyi et al., 2006; Musa and Ogbadoyi 2012 b, c). The results thus suggest that the tuber of any of these crops, i.e.*Solanum tuberosum, Dioscorea alata, Xanthosoma sagitiffolium* are safe for consumption with respect to cyanide content and regular consumption of raw tuber of

Manihot esculenta and *Ipomoea batatas* without proper processing may possibly overlord the body with cyanide with attendant health problems of dysfunction of the central nervous system, respiratory failure and cardiac arrest (D'mello, 1989).

The tuber crops with nitrate concentration in the range of 1000-2000mg/kg are classified as high nitrate content in tuber crops (JECFA, 2003; Anjana et al., 2007). Therefore, the results of tuber crop with nitrate concentration of 1725mg/kg are classified as high nitrate content tubers (Ogbadoyi et al., 2011; Musa and Ogbadoyi, 2012b, c). The nitrate concentration in the entire samples of tuber crops are within the acceptable daily intake of 3.65mg/kg for 60kg body weight (219.00mg/day) if 100g of sample are consumed per day (Anjana et al., 2007). Therefore, regular consumption of raw tubers without proper processing may possibly overload the body with nitrates, leading to serious health problems such as cancers and methemoglobinemia (Teigiserova et al., 2019; Anjana et al., 2007; Ogbadoyi et al., 2011; Musa and Ogbadoyi, 2013).

The concentrations of phytate in all the analyzed samples are within the tolerable level and can therefore be considered safe for consumption. The samples mentioned, including *Ipomoea batatas, Dioscorea alatas, Xanthosoma sagittifolium, Solanum tuberosum*, and *Manihot esculenta*, are within the permissible level of 600-800 mg/day if 100g are consumed (Oguchi et al., 1996).

While regular consumption of tuber crops with respect to phytate content without proper processing could deliver toxic levels of these antinutrients into the body with attendant health problem of diabetes mellitus, cancer kidney stone formation, atherosclerosis, and coronary heart diseases (Grases et al., 2000; Thompson 1993; Kaufman et al., 1971).

The concentrations of the oxalate in all the selected tuber crops are within the permissible level of 250mg/100g fresh sample (Oguchi et al., 1996). The analyzed tuber crops are *Ipomoea batatas, Dioscorea alatas, Xanthosoma sagitiffolium, Solanum tuberosum, Manihot esculenta*. The research findings show the tubers of these plants are safe for consumption concerning their oxalate content. However, regularly consuming raw tubers without proper processing could lead to toxic levels of this antinutrient in the body, potentially causing health issues related to oxalate toxicities (Musa and Ogbadoyi, 2013). This particularly can result in hypocalcaemia, kidney rock, electrolytes discrepancy and decrease associated with bioavailability associated with mineral deposits in your body (Okon and Akpanyung, 2005; Antia et at, 2006; Musa et al., 2011). The consistency in oxalate levels among different tuber plants aligns with earlier research, which also indicate that the type of plant significantly affects the bioaccumulation of chemical compounds by (Aliyu and Morufu, 2006; Adeboye and Babajide, 2007).

4. Conclusions

The cyanide levels in the studied tuber crops, including *Dioscorea alata, Xanthosoma sagittifolium, and Solanum tuberosum,* as well as the nitrate levels in all analyzed samples, are within safety limits for consumption. Additionally, the concentrations of oxalate and phytate in these tuber crops are also deemed safe. This study concludes that while tuber crops are widely consumed for their nutritional benefits, it is essential to be aware of the presence of inherent antinutrients and toxic substances, which can pose health risks if not properly managed. Therefore, appropriate processing methods should be employed to mitigate these risks and ensure safe consumption.

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