COMPARATIVE ANALYSIS OF NUTRTIONAL QUALITY OF *Capsicum annuum* (*Pepper*) AND *Allium cepa* L. (Onion) CULTIVATED FROM THREE DIFFERENT LOCATIONS WITHIN YOBE STATE.

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Abstract
Vegetables have become an integral part of human's diet due to their nutritional values thus any form of contamination especially by heavy metals is of great concern. This study aims to assess the heavy metal concentration and proximate composition on Capsicum annuum (Pepper) and Allium cepa L. (Onion) cultivated from three different locations within Yobe state, Nigeria. The results revealed that the concentrations of lead, arsenic, cadmium and chromium in both onions and pepper exceeded WHO-recommended limits, with war liberated communities having significantly higher values compared to normal communities. On the other hand, proximate composition analysis shows both onion and pepper to be of good nutritional value with percentage of parameters falling within the FAO/WHO standard ranges for most parameters. The findings call for more comprehensive research in other to regulate the use of pesticide and monitoring of heavy metals in agricultural soil and water to mitigate health risks associated with consuming contaminated onions and pepper.
Keywords: *Allium cepa (Onion); Capsicum annuum (Pepper); Heavy Metals; Proximate Analysis; Yobe and Nigeria.*
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1.0 Introduction

Pollution of the natural environment by heavy metals is a universal problem because these metals are indestructible and most of them have toxic effect on living organisms, when permissible concentration levels are exceeded. Heavy metals frequently reported in literature with regards to potential hazards and occurrences in contaminated soil are cadmium, copper, zinc and lead (Akoto et al., 2008., Alloway, 1995). The vehicular exhausts, as well as several industrial activities emit these heavy metals so that soils, plants and even residents along roads with heavy traffic loads are subjected to increasing levels of contamination with heavy metals (Ghrefat and Yusuf, 2006). However, heavy metals are natural components of the earth's crust and cannot be degraded nor destroyed. They enter the human body through food, water and air.

Heavy metals are ubiquitous; therefore, they tend to bio accumulate, thus causing an increase in their concentration in a biological system. Chronic heavy metal toxicity has been the result of long term low level exposure to pollutants and is associated with many chronic diseases. Heavy metals are given significant interest throughout the globe due to their toxic, mutagenic and teratogenic effects even at very low concentrations.

Vegetables constitute an important part of the human diet since they are rich in carbohydrates, proteins as well as vitamins, minerals and trace elements however; they contain both essential and toxic elements over a wide range of concentrations. Metals accumulation in vegetables may pose a direct threat to human health. Heavy metals are one of a range of important types of contaminants that can be found on the surface and in tissue of dry vegetables. Vegetables are also part of daily diets in many households forming an important source of vitamins and minerals required for human health. They are made up of chiefly cellulose, hemi-cellulose and pectin substances that give them their texture and firmness (Sobukola and Sairo, 2007).

Vegetables takes up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Sobukola et al., 2010). Vegetable plants growing on heavy metal contaminated medium can accumulate high concentrations of trace elements to cause serious health risk of consumers. Regular monitoring of these heavy metals from effluents, sewage, in vegetables and in other food materials is essential for preventing excessive buildup of the metals in the food chain.

Heavy metals depositions are associated with a wide range of sources such as small scale industries (including battery production, metal products, metal smelting and cable coating industries); brick kilns; vehicular emissions; re-suspended road dust and diesel generator sets. These can be important contributors to the contamination found in vegetables.

Food is essential for the upkeep and growth of living things especially humans. Due to the nutritional values of vegetables, people are encouraged to add vegetables to their meals. Capsicum annuum (Pepper) and Allium cepa L. (Onion) are vegetables that are consumed in almost every house in Yobe state. However, some of these vegetables were cultivated from different communities and contamination with heavy metals lead to the malfunctioning of some human organs as well as loss in nutritional quality of cultivated crop.

2.0 Materials and methods

2.1. Study Area

The study was conducted in Yobe State, Nigeria which lies between latitude 12°52′N and longitude 11°02′E in the northeastern part of Nigeria. The area has a semi-arid climate characterized by long dry seasons and short wet seasons (June–September). The average annual rainfall ranges between 400–600 mm, with temperatures often exceeding 38°C during the dry season. The region is known for rice cultivation along the Komadugu–Yobe River floodplains, where farmers commonly use chemical and organic fertilizers to boost yield. The soil is typically sandy loam, and irrigation is mainly from river

2.2 Collection of Sample

2.2.1 Vegetable Sampling

The same varieties of the two species of vegetables Capsicum annuum (Pepper) and Allium cepa L. (Onion) were sampled in from ten (10) farms; ten (05) from war liberated communities and (05) from normal communities within Yobe state. The samples were collected from the farmlands during harvesting season. Three sampling plots of 9 m^2 was demarcated within each farmland. Each plot served as replicate. Within each plot samples of six plants of each vegetable Capsicum annuum (Pepper) and Allium cepa L. (Onion) were randomly collected. The samples were placed into separate polythene bags and labelled according to their plant type and farmland. They will be taken to the laboratory for preparation and analysis.

2.2.2 Soil Sampling

Soil samples (5 g) around the roots (rhizosphere) of the plants harvested from each plot were collected when the plants were uprooted. These samples were mixed together (homogenize) to get a uniform sample.

2.3 Laboratory Analysis of Samples

2.3.1 Digestion of Sample and Heavy Metals Analysis

The collected samples were separated and cleaned with tap water then with distilled water to eliminate suspended particles. The calyx and pedicel were removed from all fruit samples and added to their respective shoots. Samples were cut into smaller pieces with a plastic knife. The samples were put in different crucibles and ash in a furnace at 650^{o}C for two hours. A quantity of the ash (0.4 g) from each plant sample was weighed separately into a beaker. To each beaker, 3 ml of concentrated HCl and 1 ml of concentrated HNO_3 was added, and heated on a hot plate at 100^{o}C for 10 minutes to destroy any oxidizable materials and carbonates. The solutions were topped with deionized water to the 30 ml mark and filtered using a Whatman filter paper. The filtrate was analyzed for the presence and concentration of heavy metals.

2.3.2 Proximate Composition

The method described by A.O.A.C (2020) was adopted for proximate analysis

2.3.3 Data Analysis

Means and standard deviations of the concentrations of the heavy metals for the various samples were calculated and presented. Data obtained will be subjected to Analysis of Variance (ANOVA) using SPSS.

3. Results

Table 1 shows heavy metal concentration in onion from war liberated communities and normal communities within Yobe state. The result shows that with the exception of Arsenic, higher level of heavy metals from onions cultivated in war liberated communities compared to normal communities. However, with the exception of zinc, all heavy metals were above the tolerable WHO limits.

Table 1: Heavy metal concentration in Onion cultivated from war liberated communities and normal communities within Yobe state

S/N	Heavy Metals	War liberated communities Onion (mg/kg)	Normal communities Onion (mg/kg)	WHO Reference
1	Lead	25.44±1.74[a]	20.11±0.90[a]	0.1 - 0.3
2	Arsenic	1.07±0.05	1.97±0.03	0.1 - 0.5
3	Cadmium	8.55±0.56[a]	3.05±0.37[a]	< 0.05
4	Chromium	11.49±0.07[a]	5.36±0.90[a]	0.1 - 1.3
5	Zinc	49.23±3.07[a]	21.85±2.08[a]	< 50

Values are presented as Mean ± standard deviation, (n=3). Values with the same superscripts in a row are significantly different compared to each other (P<0.05)

Table 2 shows heavy metal concentration in pepper cultivated from war liberated communities and normal communities within Yobe state. The result shows that all heavy metals from pepper cultivated in war liberated communities are significantly higher compared to normal communities. However, all heavy metals were above the tolerable WHO limits

Table 2: Heavy metal concentration in pepper cultivated from war liberated communities and normal communities within Yobe state

S/N	Heavy Metals	War liberated communities Pepper (mg/kg)	Normal communities Pepper (mg/kg)	WHO Reference
1	Lead	15.05±2.44[a]	10.11±1.00[a]	0.1 - 0.3
2	Arsenic	3.33±0.08[a]	4.007±0.55[a]	0.1 - 0.5
3	Cadmium	6.67±0.92[a]	3.52±0.57[a]	< 0.05
4	Chromium	10.88±2.10[a]	5.56±0.07[a]	0.1 - 1.3
5	Zinc	119.35±18.45[a]	98.34±8.82[a]	< 50

Values are presented as Mean ± standard deviation, (n=3). Values with the same superscripts in a row are significantly different compared to each other (P<0.05)

Table 3 below shows the results obtained from the proximate analysis of onion cultivated from the two different community under study. The proximate parameters analyzed include moisture content, ash, crude fat, crude protein, crude fiber, and carbohydrate contents. All the parameters are within the required WHO range.

Table 3: Proximate Composition of Onion Cultivated from War Liberated Communities and Normal Communities Within Yobe State

Constituent	War liberated communities Onion (%)	Normal communities Onion (%)	FAO/WHO Standard (%)
Moisture Content	5.90 ± 0.03	6.65 ± 0.24	< 10
Ash Content	3.69 ± 0.08	2.41 ± 0.09	2 – 3
Fat Content	43.73 ± 0.18	48.03 ± 0.52	40 – 50
Crude Protein Content	28.24 ± 0.15	23.24 ± 0.60	23 – 25
Crude Fiber Content	7.58 ± 0.12	3.50 ± 0.10	3 – 6
Carbohydrate Content	15.05 ± 2.72	16.15 ± 1.23	

Values are presented as Mean ± standard deviation, (n=3). Values with the same superscripts in a row are significantly different compared to each other (P<0.05)

Table 3 below shows the results obtained from the proximate analysis of pepper cultivated from war liberated communities and normal communities within Yobe state. The proximate parameters analyzed include moisture content, ash, crude fat, crude protein, crude fiber, and carbohydrate contents. All the parameters are within the required WHO range.

Table 4: Proximate Composition of Pepper Cultivated from War Liberated Communities and Normal Communities Within Yobe State

Constituent	War liberated communities Onion (%)	Normal communities Onion (%)	FAO/WHO Standard (%)
Moisture Content	6.20 ± 0.50	5.65 ± 0.45	< 10
Ash Content	3.92 ± 0.58	3.41 ± 0.22	2 – 3
Fat Content	44.00 ± 0.13	49.74 ± 5.33	40 – 50
Crude Protein Content	29.54 ±2.15	22.54 ± 2.60	23 – 25
Crude Fiber Content	9.88 ± 0.12	4.50 ± 1.10	3 – 6
Carbohydrate Content	13.05 ± 3.22	14.15 ± 4.23	

Values are presented as Mean ± standard deviation, (n=3). Values with the same superscripts in a row are significantly different compared to each other (P<0.05)

4. Discussion

The study was undertaken to investigate the concentration levels of heavy metals and proximate composition in onion and pepper from two forms of communities within Yobe state, Nigeria. Five heavy metals were analysed which include Lead (Pb), Arsenic (As), Cadmium (Cd), Chromium (Cr) and Zinc (Zn).

The concentration of lead in the onion sample is extremely high compared to the WHO-recommended limit. Lead is toxic even at low concentrations, and this level far exceeds the permissible limit, posing serious health risks such as neurological damage, especially in children. Chronic exposure to lead can result in kidney and reproductive system damage.

The arsenic concentration in the onion samples exceeds the WHO reference range, indicating a potentially hazardous level. Arsenic is known for its carcinogenic effects, and chronic exposure can lead to skin lesions, cardiovascular diseases, and cancer, especially when ingested in high amounts over a long period.

The cadmium level is far beyond the safe threshold of 0.05 mg/kg, making this a significant health concern. Cadmium is highly toxic, and exposure to elevated levels can lead to kidney damage, skeletal damage, and lung disease. It is also classified as a human carcinogen. Long-term exposure, even at lower levels, can result in bioaccumulation in the body.

The chromium concentration is much higher than the recommended limit, indicating excessive contamination. The toxicity of chromium depends on its form—hexavalent chromium Cr(VI) is highly toxic and carcinogenic, while trivalent chromium Cr(III) is less harmful. However, at this concentration, regardless of form, it poses a health risk. Chronic exposure to high levels of chromium can affect the respiratory system, liver, and kidneys.

The zinc concentration is just below the upper limit of the WHO reference range (50 mg/kg). Zinc is an essential trace element for human health, but excessive amounts can lead to toxicity, affecting the gastrointestinal system and causing nausea, vomiting, and abdominal cramps. While the level is close to the limit, it is still within the acceptable range, but continued exposure could lead to health concerns.

The high concentrations of Arsenic are similar to the findings of Lawal et al., (2021) who reported high level of Arsenic from vegetables collected in Katsina in their study titled "Estimation of Heavy Metals in leafy vegetables along Katsina – Dutsinma – Funtua Highway in Katsina State of Nigeria" but not in the agreement of the findings of Joseph et al., (2013) who reported least levels of Arsenic in vegetables collected from the University of Maiduguri. The high levels of Arsenic and Chromium in this study may be as a result of heavy metals contamination in the soil which tends to be enter the onion through absorption.

The proximate composition analysis shows that both onion and pepper possess valuable nutritional qualities when compared with FAO/WHO standards. The moisture contents are both below the FAO/WHO maximum standard of 10%, indicating good storage stability and reduced susceptibility to microbial spoilage.

Ash content varied between the two samples; slightly above the FAO/WHO standard range of 2–3%, which suggests a higher mineral content, while pepper comfortably within the standard range.

In terms of fat composition, both onion and pepper from the two communities fall within the FAO/WHO acceptable range of 40–50%, confirming their potential as excellent oil seeds.

Crude protein content was higher in onion compared to pepper in both communities, with the former exceeding the FAO/WHO standard range of 23–25%, thereby indicating its superior protein contribution, while pepper falls within the expected range.

For crude fiber, onion was above the FAO/WHO range of 3–6%, which may enhance digestive health but could affect nutrient digestibility if consumed in excess, while pepper lies within the standard.

Finally, the carbohydrate contents of both onion and pepper are within the FAO/WHO recommended range of 10–20%, reflecting their capacity to serve as reliable energy sources.

Overall, both samples meet nutritional standards, with onion showing higher protein and fiber values, while pepper is slightly richer in fat and maintains a balanced nutrient profile.

5. Conclusion

In conclusion, this study highlights significant health and environmental concerns due to the excessive levels of heavy metals detected in both onions and pepper. These findings underscore the urgent need for stricter regulations and monitoring of agricultural practices, as well as the importance of addressing environmental pollution to safeguard public health.

Competing interests

Authors have declared that no competing interests exist.

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