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Accumulation of Heavy Metals by Vegetables Grown in Kembu Farms, Gombe, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BM and FFY designed, supervised and reviewed all the drafts of the manuscript. Author SYS carried out the research and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Background: Contamination of vegetables with heavy metals is a health concern. Therefore, monitoring levels of heavy metals in vegetables can provide useful information for promoting food safety. The level of heavy metals (Cd, Cu, Pb and Zn in mg/kg) in vegetable samples from different farms in Kembu, Gombe, North Eastern Nigeria were assessed by using atomic absorption spectrophotometry method.
Methods: Samples of vegetables including tomato (*Lycopersicon esculentum)*, lettuce (*Lactuca sativa*) and spinach (*Spinacia oleracea*) were collected from production/farming sites in Kembu and analyzed for presence of Cd, Cu, Pb and Zn by atomic absorption spectrophotometer (AAS) after extraction by drying, grounding and acid digestion.
Results: The level of Zn, Cu, Pb and Cd did not indicate excessive contamination that could be considered a serious health hazard to the consumers except for the tomato samples in which the level of Pb was higher than the minimum Pb permissible level for human consumption approved by WHO/FAO (2007) and EU (2006) and are thus, considered unsafe to be used.

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1. INTRODUCTION

Heavy metals are found naturally in the earth, and become concentrated as a result of human activities such as industrial production, mining, agriculture and transportation [1]. These metals have both positive and negative roles in human life [2]. For instance, heavy metals such as copper (Cu), chromium (Cr), cobalt (Co), manganese (Mn) and zinc (Zn) are essential micronutrients for higher animals and for plant growth [3]. However, at higher concentrations can lead to poisoning. On the other hand, lead (Pb), cadmium (Cd), arsenic (As) and nickel (Ni) are significant environmental pollutants [4]. Studies have revealed that fruits and leafy vegetables are vulnerable to heavy metal contamination from soil, waste water and air pollution. [5,6]. Heavy metals such as Cd, Cu, Pb, Cr, Zn, Ni, As, Co and Hg cannot be degraded or destroyed and can be accumulated in living tissues through food chain, causing various diseases and disorders [5]. This fact necessitates frequent determination of heavy metals in fruit, vegetables and soil to ensure that their levels meet the agreed international standard for consumers' safety. Fruits, vegetables and other foods are among pathways by which heavy metals enter the human tissues leading to the deterioration of health [7]. Gombe State has several regions where fruits, vegetables and other horticultural products are grown. These regions among others include Kembu, which is located in Akko L.G.A and is the place where determination of heavy metals of interest was conducted. These fruits and vegetables are sold through different chains of markets, including supermarkets while others are sold to the neighboring states.

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, vitamins as well as trace elements. The contamination of vegetables with heavy metals due to soil and atmospheric contamination poses a threat to its quality and safety. Dietary intake of heavy metals also poses risk to animals and human health. High concentrations of heavy metals, in fruits vegetables were related to high prevalence of upper gastrointestinal cancer [8].

Heavy metals are substances with a specific gravity of greater than 4.0 or 5.0 g/km^3. Heavy metals refer to any metallic element that has a relatively high density and is toxic or poisonous at high concentration. Heavy metals are natural components of the earth's crust; they cannot be destroyed or degraded. They enter our bodies via food, drinking water and air. [9]. Vegetables are part of daily diets in many households since they are important source of vitamins and minerals which are required for human health. They also act as neutralizing agents for acidic substances formed during digestion [10].

Consumers demand for better quality vegetable is increasing, this perception of what is regarded as better quality are however subjective. Some consumers consider undamaged, dark green and big leaves as characteristics of good quality leafy vegetables. However, the external morphology of vegetables cannot guaranty safety from contamination. Vegetables take up metals by absorbing them from contained soils, as well as polluted environments [11]. This is why it is very important to determine heavy metals in vegetables to ensure that they are within the safety limits as approved by the international standard. Therefore, this research work aims to determine the concentration of some heavy metals in tomato, lettuce and spinach from Kembu farms, Gombe, Nigeria.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Samples of tomato, lettuce and spinach were collected from 3 different locations in Kembu vegetable farms between November, 2019 and January, 2020. About two kilograms of each sample of tomato, lettuce and spinach were randomly collected at each site, wrapped in clean aluminium foil, package in polyethylene bags and transported to Chemistry Department, Gombe State University.

2.2 Vegetable and Tomato Preparation

The methods of Chove et al. [12] and Usman et al. [13] were followed with minor modifications. The collected samples were first washed with tap water and rinsed three times with distilled water to eliminate dusts, pesticides, fertilizers, mud and airborne pollutant. The washed samples were sliced into smaller pieces and dried in an open air indoor on paper for days to eliminate excess

moisture. Each sample was weighed and dried in an oven at 800°C for several hours and weighed to constant weight. The dried sample was then ground in a mortar until it could pass through a 2 mm mesh sieve and stored in clean and dry polyethylene bags.

2.3 Sample Digestion – Dry Ashing

2 g of ground tomato and vegetables placed in a clean porcelain crucible and kept in a muffle furnace. The sample was then ashed at 450 - 500°C overnight. The ashed sample was cooled in a desiccator and dissolved in a 5 ml of 20% hydrochloric acid. The solution was warmed slowly to dissolve any residues. The solution was then filtered through an acid-washed What man filter paper into a 50 ml volumetric flask. The filter paper was washed with distilled water and the resulting solution was collected in a volumetric flask. The resulting solution was diluted to the mark with distilled water, well mixed and used for determination of heavy metals in vegetable samples as described by Usman et al. [13].

2.4 Determination of Heavy Metals

Determination of heavy metals (Cu, Pb, Zn and Cd) in tomato and vegetables from the filtrates was done by using AAS (Model 210VGP BULK SCIENTIFIC).

3. RESULTS AND DISCUSSION

3.1 Zinc (Zn)

Zn is the least toxic among all heavy metals, and is an essential element in the human diet as it is required to maintain the proper functioning of the immune system, normal brain activity and is fundamental in the growth and development of the foetus. Excessive Zn in the diet e.g. prolonged daily intake of Zinc raging at 150-450 mg/day is also detrimental to human health [14]. In the present study, a very low level of Zn was recorded in tomato samples and none was recorded in that of lettuce and spinach. According to WHO/FAO [15] and EU [16], the maximum permissible Zn limit for human consumption is between 60 and 80 $mgkg^{-1}$ dry weights. Thus, the concentrations of Zn in tomato and vegetable samples were less than the recommended levels (Table 1).

3.2 Copper (Cu)

Copper is an essential micronutrient element, which functions as biocatalysts, required for body pigmentation, maintain a healthy central nervous system prevent anaemia and interrelated with the function of Zn and iron in the body [11]. The Cu concentration found in the tomato samples are presented in Table 1. The maximum permissible concentration of Cu in the edible parts for human consumption is 40 mg/kg dry weight [15,16]. Therefore, the edible parts of these plants are safe to be used by human beings and animals which is in agreement with the work done by Usman et al. [13].

3.3 Lead (Pb)

Lead is a toxic heavy metal which causes health problems such as cognitive function, neuro behavioural disorders, hypertension and renal impairment [17]. According to WHO/FAO [15] and EU [16] the maximum Pb permissible level for human consumption is 0.3 mg/kg dry weight. The obtained results in Table 1 indicate that the concentration of Pb is higher than this permissible level for Tomato 1 (4.46 mg/kg) and Tomato 2 (0.51 mg/kg) respectively.

3.4 Cadmium (Cd)

Cadmium is one of the most toxic heavy metals, because it bioaccumulates and has a long half-life of about 30 years thereby causing health disorders such as lung cancer, kidney damage (neurotic protein precipitation), metabolic

Table 1. Concentrations of heavy metals in the farms (mg/kg)

Metals (mg/kg)	T1	T2	T3	L1	L2	L3	S1	S2	S3
Zn	0.24	0.09	0.03	N.D	N.D	N.D	N.D	N.D	N.D
Cu	0.90	0.68	0.93	0.91	0.89	1.62	N.D	0.06	N.D
Pb	0.46	0.51	0.31	0.36	0.36	0.31	N.D	N.D	N.D
Cd	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D

Note: Sample 1 are samples collected from sites of the farm close to the river, Sample 2 are samples collected from the middle of the farm while, Sample 3 are samples collected from sites of the farm farthest from the river for all the samples. N.D: Means Not Detected

anomalies caused by enzyme inhibitions, reproductive failure, damage of central nervous system and DNA [18].The WHO/FAO [15] and EU [16] indicated that the maximum permissible level of Cd for human consumption is 0.2 mg/kg dry weight. The data of the current study (Table 1) indicates that Cd was not detected for all the samples which is similar to the work reported by Usman et al. [13]. Thus, no risk of Cd contamination.

4. CONCLUSION

The level of heavy metals (Cd, Cu, Pb and Zn in mg/kg) in vegetables samples obtained from Kembu farms were assessed. The results indicate that out of the four metals analyzed, only Pb exceeds the permissible limit of 0.3 mg/kg in $Tomato_1$ (0.46 mg/kg) and $Tomato_2$, (0.51 mg/kg) as given by WHO/FAO [15] and EU [16].Therefore, vegetables grown in the area where samples of tomato (1 and 2) were collected are not safe for consumption.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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