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Elemental analysis of spring onion grown around the industrial area of Jos-South local government and sold as food in Bukuru market of Plateau State, Nigeria

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Abstract
There is an increased risk of consuming vegetables and fruits grown around industrial areas globally. Scientific documentation of evidence of the high risk of heavy metals that may be absorbed by these plants should be made public. Heavy metals such as copper (Cu), zinc (Zn), cadmium (Cd), iron (Fe), nickel (Ni), and Lead (Pb), alkaline metals such as sodium (Na) and potassium (K), and alkaline earth metal like calcium (Ca) were analysed using atomic absorption flame photometer from a sample of spring onions planted and harvested around the industrial area of Jos-South Local Government and sold for consumption in Bukuru market of Plateau State, Nigeria. Results showed that zinc, iron, nickel, copper, sodium and calcium were found in toxic concentrations, potassium level was reduced, while lead and cadmium levels were below detection levels when the values were compared to the official recommended standard for daily body intake. Vegetables should be consumed from safe areas of cultivation as contaminations with heavy metals may result in serious metal poisoning.

Keywords: Nigeria, Jos, Spring onion, metals, atomic absorption flame photometer.

Introduction
Vegetables are consumed as food because they contain vitamins, minerals, fibres, water and important elements like calcium, iron, and etch needed by the body for healthy growth [1]. These foods may also contain toxic elements that where their presence is not noticed early, could have serious effects on public health [2]. Among these poisoning elements are heavy metals such as zinc, lead, iron, copper, etc. which are abundant in the industrial environments and contribute largely to the sustainability and equilibrium of ecosystem processes at low concentrations. However, due to their bioaccumulation and subsequent large amounts and non-degradability, these metals infiltrate the food chain and eventually become an important source of toxicity to humans, top predators in the food web, and the entire ecosystem [3]. These heavy metals are notably found in the leaves of vegetables and in other tissues [4-6]. The exponential rise in human populations and food insecurity especially in Nigeria have heightened the demand to meet one of man's basic needs; cultivation occurs about anywhere a piece of land is available irrespective of the potential hazards of the area. It is therefore essential to evaluate the typology of heavy metals found in cultivated crops that contaminate a number of staple foods that are generally eaten by the public within specific geographical contexts [3, 6, 7]. Heavy metals contaminated foods pose serious harm and have become a public concern to scientists as they are finding scientific evidence of their harmful effects on humans and profiling solutions to the threats [3, 7]. The presence of heavy metals in the environment stems from nature and human activities. Weathering of parent rocks and volcanic eruptions are natural sources of heavy metals while metallurgical activities like mining, and agricultural activities which include the use of agricultural substances such as fertilizers, pesticides and industrial activities constitute the anthropogenic sources [3, 8, 9]. Like in other parts of the world, mining, agriculture and industrial activities that happen in Nigeria increase and distribute heavy metals in the environment [3, 10]. The effects of heavy metals include the disruption of anabolic and catabolic processes and the human genome; they may also affect the proper development of the embryo or fetus.

These resultant effects of heavy metals are seen as cancer, changes in the neural processes and behaviours, or developmental disorders especially in the young [3, 11]. Although there are policies in place to protect the public from such pollution and food contamination, the enforcement has been poor in Nigeria- a country with a large population and very high poverty level – this could imply that the contamination of crops might be a continuous occurrence with no foreseeable end [3, 12, 13]. Therefore, research is needed and should be promoted to inform agricultural, environmental and political decisions towards ensuring the safety of public health and its sustenance in Nigerians [3, 13]. This study focuses on the harmful effects of heavy metals and metalloids on Spring onions grown around industrial areas and sold as food in Bukuru market of Jos South Local Government Area of Plateau State, Nigeria.

Materials and Methods

Collection and Identification of vegetable sample

Spring onions (*Allium fistulosum* L.; Family: Amaryllidaceae) were collected in July 2022 from Bukuru Market in Jos South Local Government Area of Plateau State, Nigeria and authenticated by the Department of Horticulture and Landscape Technology, Federal College of Forestry, Jos, Nigeria and assigned a Voucher Number: FHJ 161 which was deposited in the herbarium of the Department of Pharmacognosy & Traditional Medicine, University of Jos. The leaves were washed with tap water to remove any dust, and sand particles and then dried under shade for twenty-one days. The leaves were ground into fine powder by a grinder and sieved with a mesh of size-20 then stored in a plastic bag labeled sample S until when needed.

Chemicals and reagents

65% Nitric acid (HNO_3), 30% Hydrogen peroxide (H_2O_2), and 70% Perchloric acid ($HClO_4$) of analytical grade from Sigma-Aldrich Company and multi-element standard solution (reference material) were used.

Digestion of samples

The method described by Olotu *et al*. [14] was adopted. Nitric acid (10 ml) and Perchloric acid (5 ml) were added to a portion of the sample (0.2 g). To dilute the solution, 19 ml of distilled water was added to 1 ml of the solution. To determine the amount of metals in the dilute solution, the atomic absorption spectrophotometer was employed. The results were reported in mg/kg.

Statistical analysis

The data is represented diagrammatically in a bar chart.

Results

Table 1: Amount of elements in spring onion sample

Metals	Zn	Fe	Ni	Cu	Pb	Cd	Na	K	Ca
Amount of metals (mg/kg)	18.30	24.25	8.30	16.50	ND	ND	6500.32	1300.12	290.78

ND = Non-Detectable

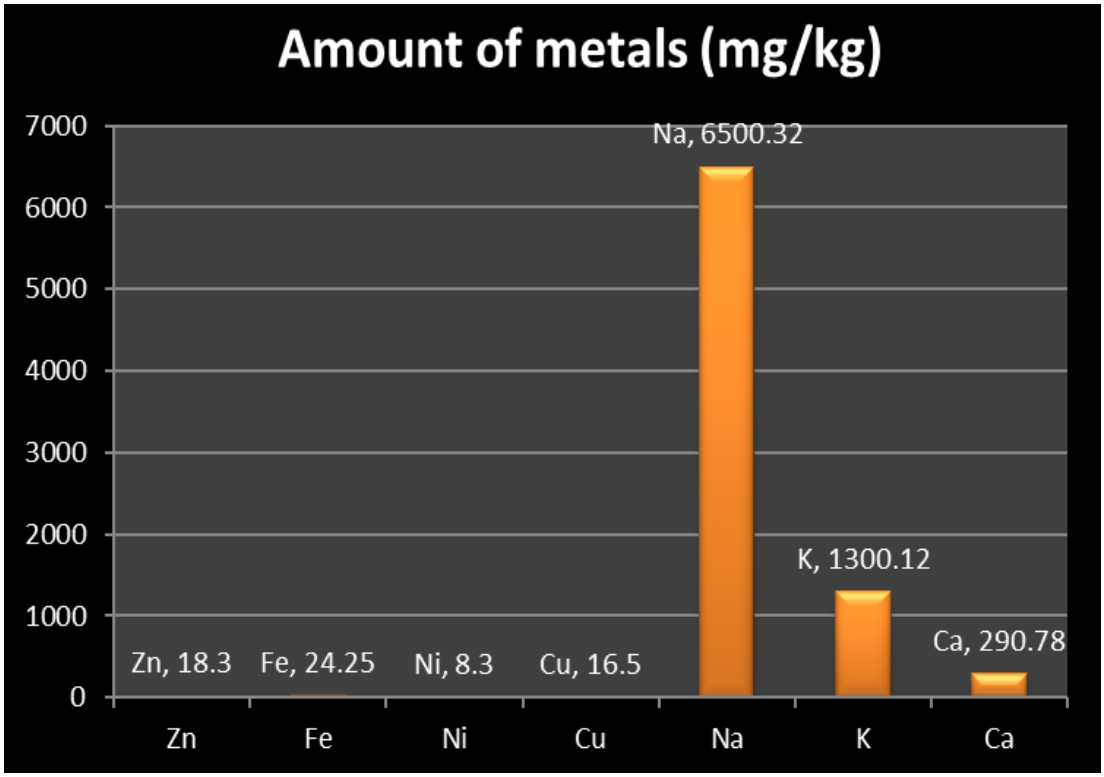

Fig 1: Bar Chart showing the amount of metals in spring onions

Discussion

The recommended daily intake of zinc (Zn) by the United States Food and Nutrition Board is 11 mg and 8 mg for adult males and females respectively [15]. Zinc is a metal element that gives immunity to the body [16, 17]. Deficiency of zinc results in immunodeficiency [18]. Toxicity occurs when zinc greater than 50 mg is ingested into the body. This can lead to the suppression of copper and iron absorption which could result in anaemia, abdominal pain, nausea, vomiting, lethargy and dizziness and even death could occur [15]. The daily recommended dose of iron intake by the Institute of Medicine, Food and Nutrition Board is 8.7 mg and 14.8 mg for adult

males and females [19]. A deficiency of iron in the body results in anaemia [20, 21]. Toxicity of daily intake of iron in the body between 10-20 mg could be severe and an overdose of up to 40 mg per day increases the level of free iron in the body which are pro-oxidants- that is, they act opposite the activity of anti-oxidants and as such could cause severe damage to the cells [20, 21]. Death could occur in children younger than six years and in sickle cell anaemia disease, patients could develop thalassemia and haematological myelodysplastic syndrome that could lead to death [19-21]. The human body needs nickel but in a very small amount of 1 mg daily to prevent nickel deficiency [22, 23]. It is also used in treating low levels of red blood cells (anaemia) due to iron deficiency and in treating weak and feeble bones (osteoporosis) [22, 23]. The toxicity of Nickel in the body could result in respiratory problems, cardiovascular diseases, contact dermatitis, lung cancer, headaches, lung fibrosis, nasal cancer or epigenetic effects [22, 23]. The recommended daily allowance for copper in the body is about 0.9 mg for adolescents and adults [22, 23]. The maximum level for adults of 19 years and above is 10 mg a day [22, 23]. An intake above this maximum level could be toxic [22, 23]. Copper deficiency has been identified in infants who were fed cow's milk instead of breast milk or formula [22, 23] as cow's milk has low levels of copper [22, 23]. It is therefore recommended that infants under 1 year should be breastfed and if not possible, they should be fed with manufactured formula since cow milk does not contain the needed nutrients for a human infant. Low levels of copper can result in anaemia, bone fracture, low body temperature, loss of skin pigmentation, osteoporosis, thyroid problem, and Menkes disease in infants between 6 to 8 weeks of age which makes it hard for them to survive for 3-year-old toddlers [22, 23]. Toxicity of copper in the blood could lead to Wilson disease where copper collects in vital organs like the brain and liver [22, 23]. Wilson disease is diagnosed before the ages of 5 and 35 but can affect individuals of all age ranges. The disease can cause jaundice, fatigue, oedema, lack of appetite, muscle stiffness, abdominal pain, etc. [22, 23]. It is estimated that 0.114 mg and 0.05 mg be the average daily intake of lead for adults and children respectively; the tolerable limit is at 0.25 mg for adults and 0.09 mg for children [24, 25]. Elevated levels of lead in the body can cause weakness, anaemia, brain or kidney damage. Extremely elevated levels may lead to death and because lead is capable of passing through the placenta in pregnant women, unborn babies can be exposed to it with its damaging effect on fetal neural development [26]. Cadmium is obtained primarily from food [27-29] and the recommended daily oral intake level lies between 0.01-0.35 mg. Cadmium metal collects mainly in the kidney where it exerts its toxicity and its half-life in the human body is between 10-35 years which is a long time [27-29]. Findings show that when cadmium is inhaled, it could be carcinogenic and the International Agency for Research on Cancer (IARC) categorized it as a group 1 carcinogen [40] but when taken in orally, there is no report of its carcinogenicity or genotoxicity [27-29]. The recommended maximum level of cadmium for public health was 0.01 mg/litre in 1963 by the International Standards and the same level was maintained in 1971 [27-29]. In drinking water, the recommended cadmium level was 0.005 mg/litre in 1984 by the Guidelines for drinking-water Quality but the level was reduced to 0.003 mg/litre in the 1993 Guidelines based on the Provisional Tolerable Weekly Intake (PTWL) as advised by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) [27-29]. Despite the standards, extended environmental exposures through the soil, water, food or air could have toxic effects on several organ systems or result in cancer [27-29]. Sodium is a metal, mineral, element and electrolyte. It plays the homeostatic role of maintaining electrolyte and water balance in the body. It is also essential in signal transmission in the nervous system and muscle contraction. Sodium in the body is predominantly in the lymph fluid and blood [30-34]. Deficiency of sodium or low levels of blood sodium has many implications like malnutrition, heart failure, diarrhoea, etc. [30-34]. The recommended dietary Guidelines for Americans on sodium intake are < 2,300 mg for a day which is equivalent to a teaspoon of salt [30-34]. With high sodium levels in the blood, water moves into the bloodstream through the process of osmosis raising the volume of blood and blood pressure eventually [30-34]. Elevated blood pressure (hypertension) causes the heart to work harder, and the enhanced pressure of blood flow can harm body tissues or organs and the blood vessel - arteries [30-34]. Blindness, stroke, heart failure or heart attacks are possible consequences of unmanaged elevated blood pressure levels [30-34]. Potassium metal is a required nutrient for public health; it has a low level of intake and a high risk of deficiency [32-34]. A rise in potassium intake can lower the risk of developing cardiovascular diseases by reducing blood pressure [32-34]. On the other hand, low levels of potassium intake can raise blood pressure and may lead to death [32-34]. It is advised that a healthy adult consumes between 3,500 -4,700 mg daily of potassium from food [32-34]. The recommended daily intake of calcium in adults between the ages of 19-50 years is 1000 mg; for adult males of 51-70 years, it is1000 mg; for adult females of 51-70 years it is 1200 mg and for adults of 71 years and above, it is 1200 mg [35-39]. Calcium is dominant in the teeth and bones where it functions in the maintenance of strong and healthy bones and teeth and reinforces their strength and structure [35-39]. Calcium is also required in muscle contraction, the proper functioning of the nervous, circulatory and endocrine systems and enzymatic activities [35-39]. The effects of low levels of intake of calcium are not immediate because the body keeps calcium levels from bones [35-39]. The effects of low levels of calcium over extended periods have health implications that include osteopenia, high risks of osteoporosis, and bone fracture; other health implications include weight loss, cancer, high blood pressure, cardiovascular diseases, preeclampsia, etc. [35-39]. Extended low levels of calcium in the body can cause convulsions, numbness, tingling in the fingers, and or abnormal heart rhythms that can result in death where the condition is not remedied [35-39]. The intake of calcium and vitamin D lowers the tendency of bone damage and reduces incidents of falling in frail adults but elevated levels of calcium can give rise to constipation or interfere with the absorption of zinc and iron in the body which in turn can lead to anaemia, immunodeficiency; increasing the risk of kidney stones, prostate cancer and heart diseases [35-39].

Conclusion

Vegetables grown around industrial areas stand a high risk of heavy metal poisoning. The presence of these metals in high concentration in plant tissues reduces the amount of essential elements like potassium and increases the toxicity levels of others such as zinc, iron, sodium, calcium, etc., which at normal levels, are useful to the body when these plants are eaten. Awareness should be created on the danger of consuming plants around the industrial areas as they adversely affect the health of humans.

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