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ORIGINAL ARTICLE

DETERMINATION OF HEAVY METAL LEVELS IN GREEN PEA (Pisum Sativum) A CASE STUDY OF SELECTED MARKETS IN ABUJA, FCT

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ABSTRACT

Background: Food safety is a major public concern worldwide. During the last decades, the increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and or toxins. **Materials and Methods:** In this study, selected heavy metals (Cd, Cr, Cu, Pb and Zn) in Green peas sold at Gwagwalada and Wuse markets in Abuja have been investigated. The samples were wet digested and the metals were analysed using Atomic Absoprtion Spectrophotometer (AAS). **Results:** The mean metal levels were found to be 0.75, 17.38, 0.75, 0.13, B.D.L, 34.50 µg/g for Cd, Cr, Cu Pb and Zn respectively. Zn was the highest metal found and Pb was below detection limit. The metal levels found in the study were compared with regional or international standards to determine whether these levels are within acceptable limits in foods. **Conclusion:** Notably, only Cd level was above the safe limits when compared with the National Agency for Food and Drug Administration and Control (NAFDAC) and World health Organization/ Food and Agriculture Organization (WHO/FAO) tolerable limits for metals in fresh vegetables.

Key words: *Androgenic factors, Phytonutrient, metals, pollution, atomic absorption spectrophotometry (ASS), NAFDAC.*

1. INTRODUCTION

Green Peas (*Pisum sativum*) are one of the few members of the legume family that are commonly sold and cooked as fresh vegetables, only about 5% of the peas grown are sold fresh; the rest are either frozen or canned [1,2]. There are generally three types of peas that are commonly eaten: garden or green peas (*Pisum sativum*), snow peas (*Pisum sativum var. macrocarpon*) and snap peas (*Pisum sativum var. macrocarpon ser. cv.*) [3]. Green Peas belong to the plant family known as the *Fabaceae*, which is also commonly called the bean family or the pulse family [4]. Its commercial production is commonly placed within the category of pulse production, and like its fellow legumes, peas are often referred to as "pulses" [4,3,5].

Green peas are an outstanding phytonutrient source supplying flavanols (including catechin and epicatechin), phenolic acids (including caffeic and ferulic acid), carotenoids (including alpha- and beta-carotene), lutein and zeaxanthin, which are known to promote vision and eye health. A Mexico City-based study has shown that daily consumption of green peas along with other legumes lowers risk of stomach cancer (type 2 diabetes-gastric cancer). Even more unique to it nutritional profile is its composition of saponins, pisumsaponins I and II and pisomosides A and B. The polyphenol coumestrol a stomach cancer protection is also provided in substantial amounts by this phytonutrient-rich food [6,7,8].

Green peas are a very good source of vitamin K, manganese, dietary fiber, vitamin B1, copper, vitamin C, phosphorus, and folate. They are also a good source of vitamin B6, niacin, vitamin B2, molybdenum, zinc, protein, magnesium, iron, potassium, and choline [9,10,11]. Even though green peas are an extremely low-fat food (with approximately one-third gram of total fat per cup) the type of fat and fat-soluble nutrients they contain is impressive. Recent research has shown that green peas are a reliable source of omega-3 fats in the form of alpha-linolenic acid (ALA). In one cup of green peas, you can expect to find about 30 milligrams of ALA. About 130 milligrams of the essential omega-6 fatty acid, linoleic acid, can also be found in a cup of green peas. This very small but high-quality fat content of green peas helps provide us with important fat-soluble nutrients from this legume, including sizable amounts of beta-carotene and small but valuable amounts of vitamin E. It is also noteworthy according to Agricultural research that pea crops can provide the soil with important benefits through its nitrogen fixation ability [3].

Despite the excellent socio-economic and health benefits of Green Peas, its consumption is counter-threatened by Heavy metals contaminations through environmental factors. Heavy or toxic metals are stable elements (they cannot be metabolized by the body) and bio-accumulative (passed up the food chain to humans). These include: mercury, nickel, lead, arsenic, cadmium, aluminium, platinum, copper, chromium and Zinc. If heavy metals enter and accumulate in body tissues faster than the body's detoxification process can handle, a gradual building up of these toxins will occur. Exposure to high concentrations will not therefore be necessary to produce a state of toxicity in the body, as heavy metals accumulate in body's tissues over time can reach toxic concentration [11]. The main sources of heavy metals to plants are the air or soil from which metals are taken up by the root or foliage. Some heavy metals are essential in plant nutrition, but plants growing in a polluted environment can accumulate these elements at high concentrations, causing a serious risk to human health [12,13,14,15,16,17].

The uptake of metal concentration by roots depends on speciation of metal and soil characteristics and type of plant species etc. Consequently, metal mobility and plant availability are very important when assessing the effect of soil contamination on plant metal uptake, as well as translocation and toxicity or ultra-structural alterations [18]. Atmospheric metals are deposited on plant surfaces by rain and dust. Several authors have shown a relationship between atmospheric element deposition and elevated element concentrations in plants and top soils, especially in cities and in the vicinity of emitting factories [19]. Airborne submicron particles are also filtered out on plant surfaces, constituting a substantial, but unknown, contribution to the atmospheric supply. Indirect effects of air pollutants through the soil are also great interference, because of the large – scale sustained exposure of soil to both wet and dry depositions of heavy elements [20].

Widespread interest in heavy metal accumulation in plant systems has emerged only over the last three decades, and several research articles reported concentrations of a number of heavy elements in the local crops and other plants as a consequence of anthropogenic emissions [21]. The present study was aimed to determine the levels of heavy metals in Green peas sold in selected markets in Federal Capital Territory, Abuja.

2. MATERIALS AND METHODS

2.1 Study site:

Abuja, the Federal Capital Territory of Nigeria has been selected for the research study. Gwagwalada and Wuse markets were selected for the case study. Abuja is the administrative seat of the nation, so no conscious farming activity take place there. Therefore most of the vegetables sold there were transported from neighbouring suburbs and states such as Plateau, Niger, Benue and Kogi states. Daily vehicular emissions in and out of the city poses a huge environmental concern to the quality of foods and consequently human lives. Therefore, the Green peas samples from the markets are analysed for heavy metals and to compare results obtained with one another and with those of National Agency for Food and Drugs Administration and Control (NAFDAC) safe limits. The metals of interest include cobalt (Co), chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn). The results obtained from this study will be useful for assessing the metals contamination, sources of the contaminations and as well as determining the need for remediation. The results would also provide information for background levels of metals in the vegetables in the study area.

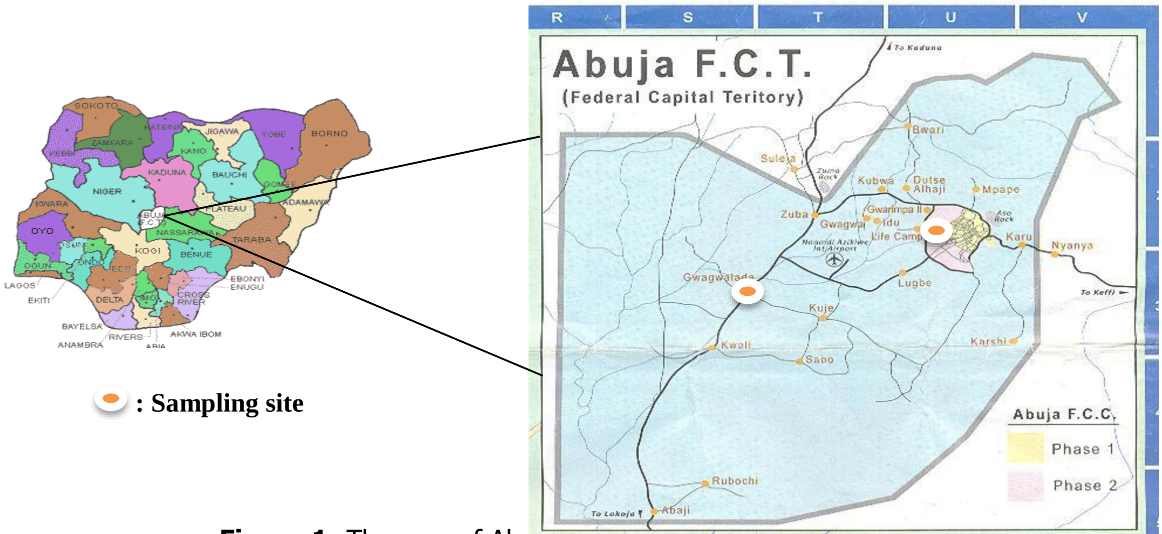

Figure 1: The map of Abuja showing the sampling site.

Analytical reagent (AnalaR) grade chemicals and distilled water were used throughout the study. All glassware and plastic containers used in this work were washed with detergent solution followed by 20% (v/v) nitric acid and then rinsed with tap water and finally with distilled water.

2.1 Sampling and Sample treatment

The Green pea samples were bought from Gwagwalada and Wuse markets. The samples were then placed into clean and well-labelled polythene containers and transported to the laboratory. At the laboratory, samples were thoroughly washed with ordinary water and then with doubly distilled water which were thereafter dried in an oven at 80°C [22]. At the end of the drying, the oven was turned off and left overnight to enable the sample cool to room temperature. Each sample was ground to fine powder, sieved and finally stored in a 250cm^3 screw caped plastic jar appropriately labelled.

2.2 Digestion Procedure

A 2.0 g of the sample was weighed out into a Kjaedahl flask mixed with 20 cm3 of concentrated sulphuric acid, concentrated perchloric acid and concentrated nitric acid in the ratio 1: 4: 40 by volume respectively and left to stand overnight. Thereafter, the flask was heated at 70°C for about 40 min and then, the heat was increased to 120°C. The mixture turned black after a while [23,24]. The digestion was complete when the solution became clear and white fumes appeared. The digest was diluted with 20 cm^3 of distilled water and boiled for 15 min. This was then allowed to cool, transferred into 100 cm^3 volumetric flasks and diluted to the mark with distilled water. The sample solution was then filtered through a filter paper into a screw capped polyethylene bottle.

2.3 Instrumental analysis

An Alpha 4 model atomic absorption spectrophotometer (Chemtec Analytical, UK) equipped with photomultiplier tube detector and hollow cathode lamps was used for the determination of metal concentrations. Working standards were also prepared by further dilution of 1000 ppm stock solution of each of the metals and a calibration curve was constructed by plotting absorbance versus concentration. By interpolation, the concentrations of the metals in sample digests were determined.

2.4 Statistical analysis

All analysis was performed in triplicates. Results were expressed by means of ±SD. Statistical significance was established using one way analysis of variance (ANOVA). Means were separated according to Duncan's multiple range analysis ($p < 0.05$) using software SPSS 16.0.

3. RESULTS

The mean concentrations of Co, Cr, Cu, Pb and Zn in Green Peas samples from the two markets are listed in Tables 1 below.

Table 1: Average levels of heavy metals (µg/Kg) in Green peas from Gwagwalada and Wuse Markets

	Concentrations (µg/g)	
Metal	**Gwagwalada**	**Wuse**
Cd	1.00±0	0.50±0
Cr	1.00±0	0.50±0
Cu	4.25±0.06	30.50±0.01
Ni	B.D.L	0.50±0.04
Pb	B.D.L	B.D.L
Zn	40.25±0.03	30.00±0.02

Values are mean ± SD of two samples of the Green peas, analyzed individually in triplicate. B.D.L: Below detection limit

The mean concentrations of heavy metals (Cd, Cr, Cu, Ni, Pb and Zn) found in the Green peas samples from Gwagwalada and Wuse markets are summarized in the Table 1. The data obtained indicates Zn with the highest concentration and Pb was below detection limit, 40.25±0.03µg/g and B.D.L respectively. The concentration of Zinc in Gwagwalada samples is higher than that of Wuse sample with the mean concentrations of 40.25±0.03µg/g and 30.00±0.02µg/g respectively. The concentrations of Cd and Cr in Gwagwalada samples are higher than that of Wuse with average concentrations of 1.00µg/g and 0.50µg/g respectively.

The Ni was below detection limit in Gwagwalada sample as compared with that of Wuse sample with an average concentration of 0.50µg/g while Pb was not detected in both samples. The results from the two sampling sites are favourably compared.

Table 2: comparison of present study levels with acceptable metal levels in foods by nafdac and WHO/FAO.

Metal	Concentrations (µg/g)			
	Gwagwalada	**Wuse**	**WHO/FAO** [25]	**NAFDAC** [26]
Cd	1.00±0	0.50±0	0.10	0.20
Cu	1.00±0	0.50±0	73.00	40.00
Cr	4.25±0.06	30.50±0.01	2.30	2.00
Ni	B.D.L	0.50±0.04	67.00	27.0
Pb	B.D.L	B.D.L	0.30	2.00
Zn	40.25±0.03	30.00±0.02	100.00	50.00

Table 2 shows the comparison of metals level in the present study with that of regulatory authorities' permissible limits, WHO/FAO and NAFDAC. It is however noteworthy that only Cd exceeded the permissible limit of WHO/FAO with mean concentrations of Gwagwalada and Wuse markets 1µg/g and 0.50µg/g respectively. The remaining metals fall below the maximum limits. The high level of Cd accumulation in the samples may be related to pollutants in irrigation water, farm soil or pollution from highway traffic, the amounts may be hazardous if the green peas are taken in large quantities.

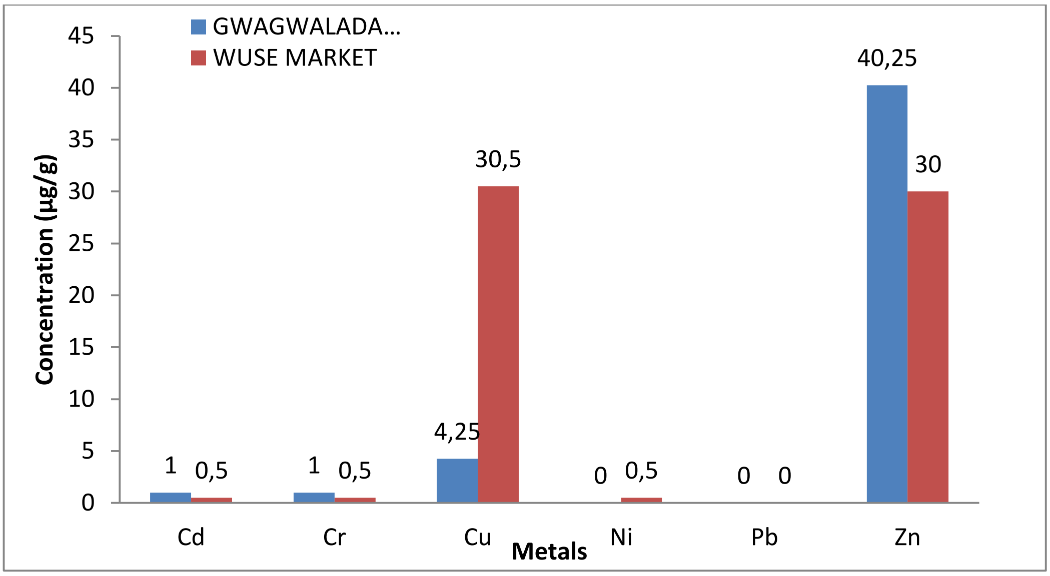

Figure 1: Average levels of heavy metals (µg/Kg) in Green peas from Gwagwalada and Wuse Markets.

4. DISCUSSION

Cadmium

From the results obtained, the mean concentration of Cd is 1.00µg/g and 0.50µg/g for Gwagwalada and Wuse markets samples respectively while the mean concentration of the study area is 0.75±0.29µg/g, these concentrations are high when compared with NAFDAC and WHO/FAO recommended maximum limit and thus posed a health hazard to the consumers. Results obtained by Ladipo et al (2011) indicated the concentration of cadmium in leafy vegetables to range from 0.028±0.003 to 0.091±0.103mg/kg dry weight; the data obtained are below the recommended maximum limit [27]. Cd with atomic number 48 has no known beneficial function in the human body it is transported in the blood bound to metallothionein and it is greatly accumulated in the kidneys and liver, urinary excretion is slow and the half-life may last 25-30 years. Cd exerts toxic effects on the kidney, the skeletal and the respiratory systems and is classified as a human carcinogen. Lower concentrations are found in vegetables, cereals and starch roots. Human exposure occurs mainly from consumption of contaminated food, active and passive inhalation of tobacco smoke and inhalation by workers in the non-ferrous metal industry. The high levels of Cadmium reported in these samples suggest that they (Green peas) might have been cultivated with phosphate fertilizers or sewage sludge. The contamination may also be associated with pollution by indiscriminate smoking in the markets (especially by the Mallams- Green peas sellers) or exhaust from vehicles during transportation or edaphic factors. Cadmium has also been reported to damage biomembranes and cause uncontrolled uptake or translocation of the metal in plants. The high level of cadmium reported in this study indicates that biomembranes may have been damaged in these crops [11].

Chromium

The results obtained from this study, shows that Cr detected in Green peas purchased from Gwagwalada and Wuse markets contain 1.00µg/g and 0.50µg/g respectively. The mean concentration of the present study is 0.13µg/g which falls below the maximum recommended limit of WHO/FAO of 2.31µg/kg. There is no significant difference between the level of Cr in the present study compared with literature data 1.68µg/g and 0.19µg/g for Spinach and Water leaf respectively [26,27,28].

Chromium have essential role for human health as it potentiates the action of insulin in patients with impaired glucose tolerance. The recommended intake of Cr is 50-200 mg/day. By this result, the level of Ni is of no health hazard to the consumers.

Copper (Cu)

The results obtained shows that the mean concentrations of Cu in Green peas purchased from Gwagwalada and Wuse markets, 4.25µg/g and 30.0µg/g respectively are below the maximum recommended limit of NAFDAC and WHO/FAO which is 73 and 40.0µg/g respectively. According to Abdulmojeeb (2011), mean concentrations of other vegetables such as Water cress and Spinach are 8.71 µg/g and 1.02 µg/g respectively, comparing this literature data with the concentration of this present study 0.75µg/g, the mean concentration is low [28].

Normal copper homeostasis is essential for human growth and development, a cofactor in enzymes.
Copper is an essential trace element required for proper health in an appropriate limit. Its high uptake in fruits and vegetables can be harmful for human health and in the same way the lower uptake in human consumption can cause a number of symptoms e.g. growth retardation, skin ailments, gastrointestinal disorders etc. Cu is required as cofactor in different oxidative and reductive enzymes. According to Nair et al.(1997), the recommended limit for dietary consumption is up to 10 ppm and average dietary daily requirement for copper is 1-3 mg [29]. Cu absorption in human body takes place from intestine and is reached to different other organs, where it is utilized in copper dependent enzyme, high intake can lead to gastrointestinal, respiratory, renal, hematological symptoms [30].

From the results obtained, the mean concentrations are within the normal range recommended by the FAO/WHO, large daily intake of these Green peas is not a health hazard to the consumer of Cu in the Green peas obtained from Gwagwalada and Wuse markets. It is noteworthy that the level of Cu in the present study is of no health hazard to the consumer.

Lead (Pb)

In the present study, Lead (Pb) was not detected in the Green peas purchased from Gwagwalada and Wuse markets. In General, Lead (Pb) concentrations in vegetation have increased in recent decades owing to pollution by human activities. The Pb content of edible parts of plants growing in uncontaminated areas generally range from 0.05 to 3.0 µg/g d.w [20]. It is clearly showing that the air or soil of the growing lands is free of Pb, this further buttress the safety of Green peas from Pb contamination. The permissible limit of lead in vegetables for human consumption is 2.0 – 2.5µg/g d.w [20-26].

Zinc (Zn)

Zn has the highest mean concentration in the Green Peas sample obtained from Gwagwalada and Wuse markets with 40.24µg/g and 30.00µg/g. However, this level is below that of NAFDAC and WHO/FAO, 50.00µg/g and 100.0µg/g respectively. Comparing the levels of mean concentrations of other vegetables such as Spinach, 10.81µg/g and Water leaf, 0.070µg/g obtained from literature data [28] is lower than the mean concentration obtained from the present study, 34.50µg/g.

Zinc is reported as a co-enzyme for over 200 enzymes involved in immunity, new cells growth, acid base regulation, etc. Lack of sufficient amount of Zn results in reduced activity of related enzymes e.g. carbonic anhydrase [30-20]. WHO has established the tolerance limit of fruits and vegetables as 100mg/kg and 50mg/kg respectively [26]. It is reported that Zn concentration in fruits and vegetables is as follows Green pepper >Spinach>Mint>Brinja etc. Zn is one of the less toxic metals and is essential for proper maintenance of body functions e.g. immune system, proper maintenance of body and is vital for the development of fetal growth. According to Agency for Toxic substances and Disease Registry (ATSDR), (2006), the daily intake limit is up to 15mg/day (ATSDR, while higher uptake of Zn can lead to muscle cramps, kidney damages and digestive problems. The reported limit of Zn for human uptake is up to 150ppm [32]. Since Zn is a micronutrient element, its level in the Green peas is of great health benefit to the consumers.

5. CONCLUSION

Among the six heavy metals discussed, the concentrations of Cr, Cu, Ni, Pb and Zn in vegetables purchased from Gwagwalada and Wuse markets were found relatively low and their concentrations are within the permissible limits for human consumption. The average Cd concentrations in Green peas grown in Gwagwalada and Wuse markets is reported to be higher levels and it is necessary to keep Cd levels in both air and soil environments as low as possible. This study shows that dietary intake of Green peas constitutes a source of accumulation of heavy metals in human body. The detrimental impacts of Cd become apparent after decades of exposure.

This study further confirms the increased danger of growing vegetables on soils irrigated with contaminated industrial and domestic wastewaters. However, the levels of other metals are currently within the NAFDAC safe limits guidelines. Therefore there is the need to continually monitor, control and take necessary policy decisions so as to limit and ultimately prevent these avoidable problems. It is hope that the result of this study would prompt further investigation of heavy metal contents of other vegetables widely sold in the Abuja markets.

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