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Heavy Metals Content in Cloves Spices (*Syzygium aromaticum*) Cultivated in Zanzibar

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Abstract

The concentration of selected heavy metals (Chromium-Cr, Cadmium-Cd and Lead-Pb) collected from different sites of Unguja and Pemba were determined using Energy Dispersive X-Ray Fluorescence (EDXRF). The findings showed that Cr ranged from 10.3 to 16.25 ppm, Cd from 3.39 to 8.00 ppm and Pb from 0.35 to1.18 ppm for Pemba Island. For Unguja Island Cr ranged from (6.65 to 12.3 ppm, Cd ranged from (2.61 to 6.00) ppm and Pb ranged from (0.52 to 0.80 ppm). Significant elemental correlation ($p \geq 0.05$) for all three metals detected from Unguja sites. The metal levels found from both sides of Islands were above standard limits set by FAO and WHO. The results of this study suggest that the levels of toxic metals detected from Zanzibar spices have potential risk to public health.

Subject Areas

Applied Physics

Keywords

Heavy Metals, Zanzibar, Clove, Spice,
Energy Dispersive X-Ray Fluorescence Spectrometer

1. Introduction

Clove is among the most popular spice plant grown in some parts of east Africa, Asia and South America. In Tanzania, cloves *syzygium aromaticum* are primarily produced in Zanzibar. Clove and its byproduct clove oil have been widely used in a variety of health therapies such as parasitic infections, cosmetics toothaches etc. More commonly, cloves are used as food spices, aroma or flavor and

cosmetics. Inspite of importance of cloves there is increasing concern over the safety and toxicity due to contamination of various hazardous substances including heavy metals ([1] [2]).

In recent years, there is an increasing involvement in observance heavy metals contamination in various spices which are commonly consumed by people including cloves. These toxic levels on human wellness and the environment have attracted considerable attention in recent years [3]. The toxic metals concentration level is due to their long persistence and accumulation behavior in the environment and ecosystem [4]. Heavy metals contaminate clove trees through soils and atmospheric deposition.

Existence of heavy metals concentration in spices including cloves and their toxicity has been widely reported ([1] [2] [5] [6] [7]). However, there is no published data on heavy metals in clove in Zanzibar. The aim of this study therefore was to determine levels of heavy metal in clove collected from Zanzibar. The analyzed heavy metals were (Lead (Pb), Cadmium (Cd), and Chromium (Cr).

2. Materials and Methods

Materials

A bench top energy dispersive X-ray spectrometer of TAEC in Arusha is the machine used to conduct elemental analyses of samples. The machine is operated by automatic turbo-quant X-lab ProTM software at a rate of 50W power and 50 kV voltage. The florescent X-rays were collected by a Si(Li) detector having a resolution (FWHM) at MnKα ≤ 160 eV. A good immovability information and resolution of the peaks obtained by a spectrum which is runs for 15 minutes. The concentration of each elements were determined by using basic parameter method intrinsic in X-lab Pro computer software in which matrix effects was reckoning for.

Quality control was carried out using IAEA reference material Trace and Minor Elements in Cabbage (IAEA 359) analyzed with the samples and another reference standard from TAEC results expressed in ppm of dry weight and evaluated by comparing with MPL of the basis of FAO/WHO.

3. Methods

Samples of cloves buds were collected from two regions, North Unguja (Chaani and Mahonda) and South Pemba (Chokocho, Kinyasini, and Ziwani). The sites labelled by letter A, B, C, D and E as representative for Kinyasini, Ziwani, Chokochoko, Chaani and Mahonda respectively. The samples were purchased from sites which are among high clove yield areas in Unguja and Pemba. (15 samples of cloves, purchased from farmers, chopped, separated from bud, stem and leaves, to facilitate drying) the clove were taken from five area in same sites and processed separately. The results were then taken by averaged them to have one result for statistical analysis.

The samples then sun and oven dried at 80˚C for 6 h. The dried samples were then ground in a motor with pestle till a fine powder was obtained. The powder then sieved to obtain a less than 0.07 mm size before put in to clean polyethylene bags and send to (TAEC) laboratory for analysis by using (EDXRF) equipment. A sample of 5 g of mixed sieved powder mixed carefully, uniformity and be compressed into pellets of diameter of 32 mm to give reproducible irradiation and counting geometry.

4. Statistical Analysis of Data

The accuracy and precision of the EDXRF method was assured by simultaneous analysis of the reference material (Spinach vegetable sample) provided by the IAEA. The results were expressed in ppm of dry weight. The evaluation is done by comparison with the maximum allowable Limits (mPL) on the ground of FAO/WHO. Descriptive statistical parameters (Mean, Range and Standards deviation) calculated using the statistical Package for ANOVA and Sigma Plot of version-12. F-and Tukey HSD testing of ANOVA was employed to detect significant differences among means. Data are presented as Mean ± standard deviation where a statistically significant level was considered, using probability coefficient correlation $p < 0.05$. A probability level of $p < 0.05$ was considered statistically significant, reported values obtained through calculation. As Table 1 shown, the experimental values were all in good accord with the recommended values within 13% accuracy.

5. Results

The level of Cr, Cd and Pb in clove buds and their descriptive parameters in statistics are shown in Table 2. For all sites in Unguja and Pemba while, Table 3 and Table 4 for Pemba and Unguja pooled values.

Table 1. Maximum allowable limits of heavy metals (Cr, Cd and Pb) in plants set by FAO/WHO.

Elements	Symbol	Maximum permissible limit (MPL)
Chromium	Cr	2.00 mg/kg
Cadmium	Cd	3 ppm
Lead	Pb	1 ppm

Table 2. Shows the representative control measured values for accuracy of sample.

Name of elements	Measured value (ppm)	Standard dev. (ppm)	Actual value (ppm)
Chromium	18.25	18.25	0.5
Cadmium Cd	4.5	0.9	3.98
Lead Pb	0.7	0.1	0.9

Table 3. Average concentration of Cr, Cd and Pb for clove buds cultivated in Zanzibar from each site with its standard deviation and ranges.

Elements	Cr ± SD (ppm)	Cd ± SD (ppm)	Pb ± SD (ppm)
Sites			
A	12.26 ± 0.52 range (10.35 - 13.35)	6.17 ± 1.0 range (3.48 - 8.00)	0.74 ± 0.08 range (0.59 - 1.18)
B	18.62 ± 0.9 range (15.8 - 21.3)	4.28 ± 0.71 range (3.39 - 5.3)	0.4 ± 0.06 range (0.35 - 0.47)
C	6.13 ± 0.6 range (5.2 - 7.45)	5.45 ± 0.6 range (3.39 - 7.13)	0.36 ± 0.08 range (0.29 - 0.41)
D	7.27 ± 0.9 range (5.85 - 9.3)	4.49 ± 0.48 range (2.6 - 6.00)	0.84 ± 0.08 range (0.65 - 0.89)
E	10.5 ± 0.8 range (9.3 - 11.65)	5.03 ± 0.38 range (2.78 - 6.9)	0.52 ± 0.08 range (0.47 - 0.59)

Table 4. Average concentration of metals from Unguja and Pemba sites only with their descriptive statistics (mean, SD and Range).

Region	Chromium	Cadmium	Lead
Pemba	13.52 ± 0.4 (10.3 - 16.25)	4.84 ± 0.3 (3.9 - 8.00)	0.7 ± 0.6 (0.35 - 1.18)
Unguja	10.43 ± 0.5 (6.65 - 12.3)	4.76 ± 0.4 (2.61 - 6.00)	0.68 ± 0.2 (0.4 - 0.97)

Average concentration of metals from Unguja and Pemba sites only with their descriptive statistics (mean, Standard deviation and Range).

The pooled content of Cr, Cd and Pb Table 4, in clove buds from Unguja and Pemba were measured, compared with maximum permissible limit of FAO/WHO in Table 2 & Table 3 above, the level of content also compared with other studies value as determined by other suitable standards applied to other spices and condiments from various places.

The results revealed the concentration of metals from Pemba varies from (10.3 - 16.25) ppm, (3.39 - 8.00) ppm and (0.35 - 1.18) ppm for Cr, Cd and Pb respectively, while chromium Cr, Cadmium (Cd) and Pb ranged (6.65 - 15.5) ppm, 2.61 - 6.96 and (0.47 - 0.97) in Unguja sites which are higher than the maximum permissible limit in all sites from unguja and Pemba.

The average concentration variation of metal in Figure 1, show that as all elements increases at site number five to other sites.

5.1. Chromium Cr

Food is a major source of exposure of chromium to human [8], but excessive intake particularly of more oxidizing Cr(VI) can harm biological system [9]. The knowledge of Cr has recently received much attention to its importance as an essential element in human body metabolic process and improvement of glucose tolerance special Cr(III), [10] and its carcinogenic effects in case of excessive

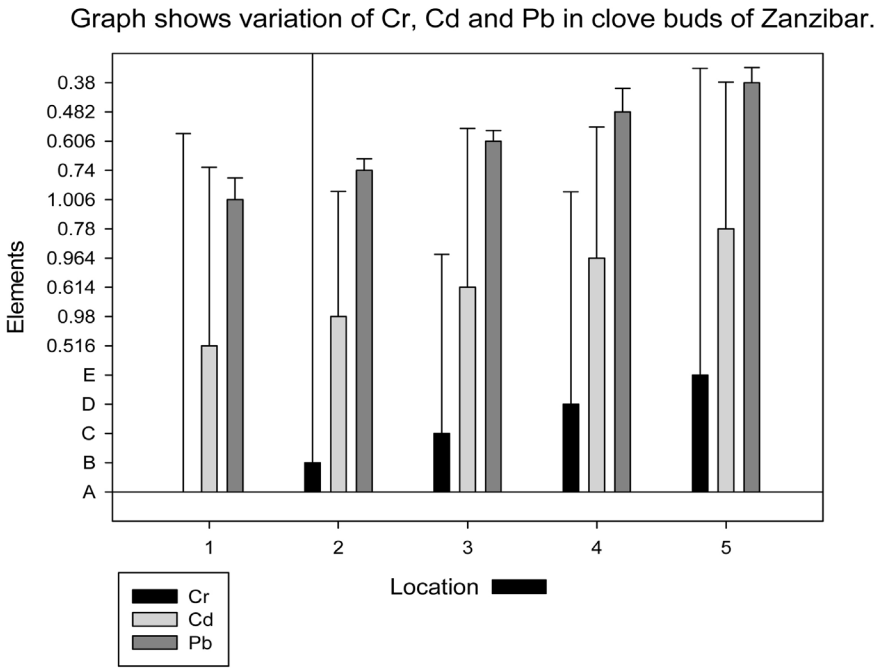

Figure 1. Variation of Cr, Cd and Pb in clove.

uptake, particularly Cr(VI). Maximum concentration of Cr was found to be higher in all five sites from Unguja and Pemba. The result show that, the accumulation of Cr from all locations was well above permissible limits recommended by FAO/WHO. The average concentration of Chromium Cr in clove buds from Pemba ranged from (5.2 ± 0.6 ppm site C to 21.3 ± 0.9 ppm site B, even the lower limit of range is above the value set by spice regulatory bodies such as FAO/WHO, a maximum permissible limit of 2.00 mm/kg for spice, while at Unguja sites ranged from 585 ± 0.9 pmm site D to 11.65 ± 0.8 ppm site E the results shows that evidently all Cr value were above FAO/WHO limits. Maximum concentration of chromium was found at site B 18.62 ± 0.9 ppm where minimum concentration of Cr was observed 6.13 ± 0.6 ppm at site C. The level recorded in this study is generally higher than the level recorded in the literatures. The study by [11] shows value of chromium in spices as 115 to 368 mg/kg which is above permissible level of WHO of 100 mg/kg of spices.

5.2. Lead Pb

As revealed by data concentration of Pb varied from 0.35 - 1.18 ppm from Pemba Island and 0.4 - 0.97 ppm Unguja Island. Maximum value of Pb found at site D which varied 0.65 - 1.18 with average concentration of 0.84 ± 0.08 ppm while the lowest concentration detected from site C as 0.29 - 0.41 with average concentration of 0.36 ± 0.08 ppm. All the samples from five locations recorded less than half of 1 mg/kg the WHO standard limit for Pb in the clove spice. Hence the Pb levels of the clove bud samples are relatively very tolerable that consumer are safe from exposure resulted from consuming such spices. The study of [12] reported a concentration of 5.1 ppm of (Pb) which is much higher than allowed

limits in spices amount to 1 ppm according to the World Health Organization (WHO) [13]. Accumulative impacts of (Pb) can cause kidney damage, reduce fertility, and increase the chance of occurrence of the failure of the pregnancy or the occurrence of congenital malformations, anemia, colic, headache, brain damage and central nervous system disorder [14], In addition, Pb can affect human body and can cause nausea anemia, abdominal pain, vomiting and paralysis in the joints. High-level exposure in men can damage the organs responsible for sperm production [15].

5.3. Cadmium Cd

Cadmium is well thought out as one of the most toxic metal that exhibit highly adverse effect on human health. The main toxicity of Cadmium mostly effect kidney, it also connected with lung damage and bony changes in people worked in affected areas. In safe soil Cd is governed by soil texture 0.2 - 0.8 loamy soil and 0.02 - 0.3 sandy soil. Since cadmium get into plant from air or soil source, its availability to plant depend on the polluted site. In this study Cd ranged from 3.9 - 8.00 ppm for Pemba Island with average concentration 4.84 ± 0.3 ppm and 2.61 - 6.00 ppm from Unguja Island. The highest was 8.00 ppm at Site A Pemba and the lowest 2.9 at site D Unguja Island. Compare to other studies on heavy metals in spices, Cd in this study was higher than the range 0.011 - 1.389 mmg/kg by [16] in spices at Iraq. Study by [1] reported a range of 0.04 ppm - 0.4 ppm amount for Cd level in spices while [17], recorded value of Cd ranged 0.03 - 0.31 ppm, [12] report Cd in spices varied from (0.71 - 1.89) ppm which are within permissible limits, of 3 ppm, according the [13].

6. Conclusion

This study presents the toxic metal level in spices collected from Zanzibar. Most of the levels have exceeded the permissible level of international standards *i.e.* FAO/WHO. The study suggests that there is a necessity of monitoring the levels of heavy metals in spices commodities for the purpose of safeguarding both environmental and public health.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

Disclosure Statement

The Authors declare that there are no conflicts of interest regarding the paper, it

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