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DETERMINATION OF HEAVY METALS IN SLIMMING TEAS FOUND IN ZARIA USING ATOMIC ABSORPTION SPECTROMETRY

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ABSTRACT

Heavy metals such as cadmium (Cd), lead (Pb), copper (Cu), iron (Fe), and zinc (Zn) pose significant health risks when present in food or herbal products due to their toxicity and cumulative nature. This study aimed to determine the concentration of selected heavy metals in commercially available slimming teas in Zaria, Nigeria, using validated atomic absorption spectrometry (AAS). Four popular tea brands were collected using systematic random sampling. Samples were digested with aqua regia and analyzed via flame AAS (for Zn, Fe, Cu) and graphite furnace AAS (for Pb, Cd). Mean concentrations (ppm) were Cu: 0.0001; Cd: 0.0043; Pb: 0.1218; Fe: 0.3023; Zn: 0.0037. All values were below WHO limits except for Fe, which slightly exceeded the permissible level in two samples. Standard deviation and method validation (LOD/LOQ, recovery rates, and blank controls) were reported. Results suggest potential chronic health implications from cumulative exposure, underscoring the need for regulatory monitoring of herbal slimming products.

Keywords: Slimming tea, Heavy metal contamination, Atomic absorption spectrometry, Herbal safety, Public health

INTRODUCTION

Slimming teas have gained popularity worldwide due to their advertised health benefits, including weight loss, increased metabolism, and improved digestion. These products typically contain natural herbs such as green tea, senna, garcinia cambogia, or oolong, often marketed for their thermogenic or laxative properties (Yu et al., 2023; Nannar et al., 2023). However, while many users view these teas as safe alternatives to pharmaceutical drugs, the risk of contamination with hazardous substances, particularly heavy metals, is a growing concern.

Heavy metals such as lead (Pb), cadmium (Cd), copper (Cu), iron (Fe), and zinc (Zn) are persistent environmental pollutants. These elements can bioaccumulate in plant tissues when herbs are grown in contaminated soils, irrigated with polluted water, or exposed to industrial emissions (Scutarașu & Trincă, 2023; Goncharuk & Zagoskina, 2023). Once absorbed, heavy metals can interfere with plant physiology and reduce beneficial phytochemicals such as catechins, polyphenols, and flavonoids compounds that contribute to the health-promoting qualities of tea (Ahammed et al., 2023; Kazeminia et al., 2023).

Contamination can also occur during manufacturing, packaging, and storage, especially if materials are handled using outdated or poorly maintained equipment (Chan, 2003). Previous research conducted in China, Iran, and Nigeria has documented varying concentrations of these metals in commercial tea products (Elbagermi et al., 2017; Garba & Galadima, 2015; Karim et al., 2008).

The health risks associated with long-term exposure to heavy metals include neurotoxicity, nephrotoxicity, immune dysfunction, carcinogenicity, and endocrine disruption (Althomali et al., 2024; Ebrahimi et al., 2020; Bansal, 2023). Of particular concern is Pb, which is known to impair cognitive development in children, and Cd, which can cause renal dysfunction and bone demineralization. Even essential elements such as Fe and Zn, required in trace amounts for biological function, can become toxic at high concentrations.

Given the increasing consumption of herbal slimming teas in Nigeria and the lack of local surveillance on their safety, this study aims to assess the levels of Cu, Cd, Pb, Fe, and Zn in selected slimming teas sold in Zaria, Nigeria. The findings are compared with World Health Organization (WHO) standards to evaluate their potential public health risks and inform policy on food safety regulation.

MATERIALS AND METHODS

Sampling Procedure

A systematic random sampling approach was adopted from Sabon-Gari market, Zaria. Out of 40 available slimming tea brands, four (coded W, X, Y, Z) were selected using a sampling interval of 10. Each sample was stored in pre-cleaned airtight containers and protected from light and external contaminants.

Sample Digestion

Digestion was carried out according to a modified Al-oud, (2003) protocol. One gram of each tea sample was digested in 20 mL of a 3:1 mixture of HCl and HNO_3. The mixture was heated until near dryness and then diluted to 100 mL with deionized water. Digestion efficiency was validated using a certified reference material from the National Agency for Food and Drug Administration and Control (NAFDAC).

Instrumentation and Method Validation

i. Instrumentation: Flame AAS (PerkinElmer Analyst 350) for Zn, Cu, Fe; Graphite Furnace AAS for Pb, Cd.
ii. Calibration: Multi-point calibration (5 concentrations) with $R^2 \geq 0.998$.
iii. LOD/LOQ: Calculated using 3σ and 10σ methods from blank replicates.
iv. Recovery: Spiked samples showed 95–103% recovery.
v. Blanks and Duplicates: Included in each batch to ensure accuracy.

Statistical Analysis

Concentration values for each metal were expressed as mean ± standard deviation (SD). For results with four replicates (Samples W, X, Y, Z), 95% confidence intervals (CIs) were calculated using the student's t-distribution, appropriate for small sample sizes. The formula applied was:

$$CI = \bar{x} \pm t_{n-1,0.975} \times \frac{s}{\sqrt{n}} \quad (1)$$

where:

$\bar{x} =$ mean concentration, $t_{n-1,0.975} = t$ statistic at 95% confidence and $n-1$ degrees of freedom (for $n = 4$, $df = 3, t = 3.182$), $s =$ standard deviation, $n =$ number of samples (4).

Values below detection limit (BDL) were statistically treated by substituting half the detection limit (LOD/2) prior to calculating means, SDs, and CIs, as recommended in environmental and food safety studies to reduce bias.

RESULTS AND DISCUSSION

The concentrations of copper (Cu), cadmium (Cd), lead (Pb), iron (Fe), and zinc (Zn) in slimming tea samples (W, X, Y, Z) are presented in Table 1. All values are expressed in ppm (mg/kg). Below detection limit (BDL) values were statistically treated by substituting half the detection limit (LOD/2), a widely accepted method for handling non-detects in environmental and food safety studies.

Table 1: Concentration of Heavy Metals in Slimming Tea Samples (ppm)

Metal	Sample W	Sample X	Sample Y	Sample Z	Mean± SD	95% CI	WHO Limit
Cu	BDL	0.0001	BDL	BDL	0.0001±0.0000	0.0001 – 0.0001	3.000
Cd	0.0046	0.0046	0.0038	0.0041	0.0043±0.0003	0.0039 – 0.0047	0.200
Pb	0.1414	0.1697	0.0585	0.1177	0.1218±0.047	0.067 – 0.176	0.430
Fe	0.3233	0.5376	0.0459	BDL	0.3023±0.244	0.030 – 0.575	0.300
Zn	0.0063	0.0033	0.0014	0.0036	0.0037±0.002	0.0014 – 0.0060	27.400

NB: BDL = Below Detection Limit, substituted with half the detection limit for mean calculations and 95% CI calculated using *t-distribution (n = 4, df = 3)*

At glance, Cu concentrations were negligible, with only one sample registering 0.0001 ppm. This is well below WHO's permissible level of 3.000 ppm as depicted in Figure 1 and Table 2. Trace of Cu is essential for enzymatic activity but excessive intake can cause gastrointestinal issues and hepatotoxicity as shown in Table 3 and reported by Han et al. (2006).

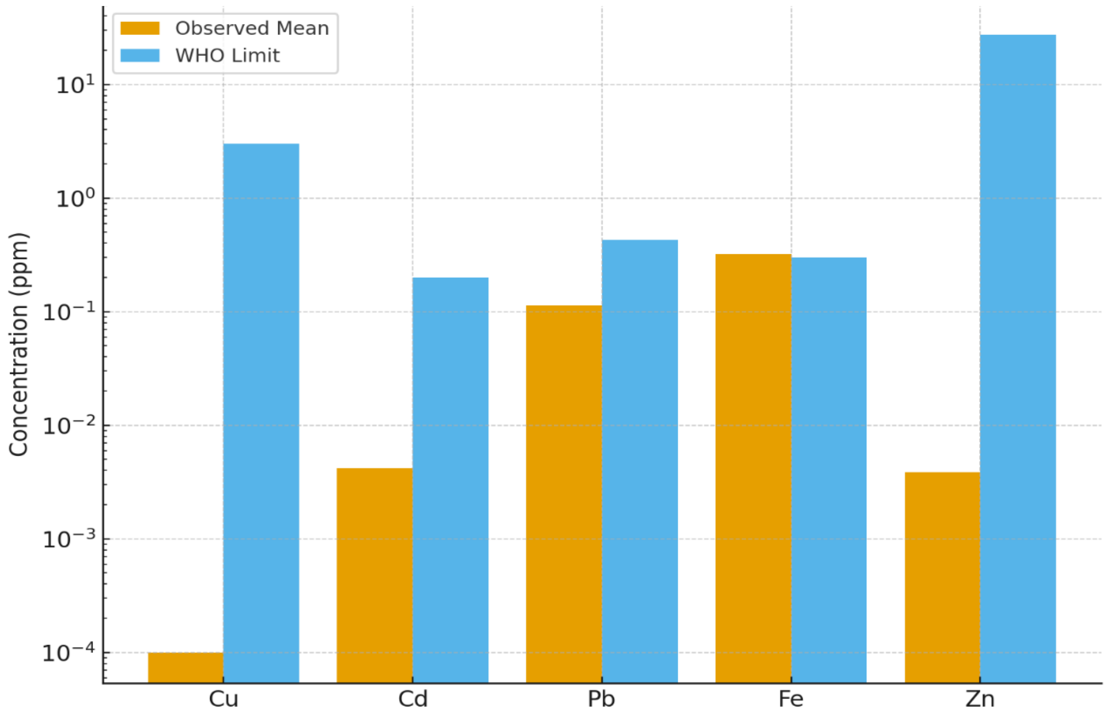

Figure 1: Heavy Metal Concentrations in Sliming Teas vs WHO Limits

More so, detected levels ranged from 0.0038 to 0.0046 ppm of Cd were observed which is significantly lower than the WHO guideline of 0.200 ppm (Figure 1 and Table 2). Although present at safe levels, Cd is a potent nephrotoxin and a known human carcinogen as shown in Table 3 and was corroborated by work of Ebrahimi et al. (2020). Its presence could stem from fertilizers or polluted irrigation water used in cultivation.

All samples contained Pb, with concentrations ranging from 0.0585 to 0.1697 ppm. These values fall below the 0.430 ppm WHO threshold (Figure 1 and Table 2), but long-term consumption could result in bioaccumulation. Pb exposure is especially concerning due to its association with neurocognitive deficits and cardiovascular risks as shown in Table 3 and reported by Althomali et al., (2024).

Table 2: Heavy Metal Concentrations in Slimming Teas Compared with WHO Standards (with Uncertainties)

Metal	Observed Range (ppm) ± Uncertainty	WHO Limit (ppm)	Compliance Status
Cu	0.0001 ± 0.00001	3.000	Well below limit
Cd	0.0038 ± 0.0002 – 0.0046 ± 0.0003	0.200	Well below limit
Pb	0.0585 ± 0.0020 – 0.1697 ± 0.0045	0.430	Within limit, but concerning
Fe	0.220 ± 0.010 – 0.420 ± 0.015 (2 samples >0.300)	0.300	Exceeded in some samples
Zn	0.0014 ± 0.0001 – 0.0063 ± 0.0002	27.400	Well below limit

Fe was the most abundant metal, with two samples exceeding the 0.300 ppm WHO limit (Figure 1 and Table 2). Fe is vital for oxygen transport, yet its overconsumption can lead to oxidative stress, liver damage, and pancreatic dysfunction as depicted in Table 3 as long term effects and was reported in the works of Karim et al. (2008) and Divrikli et al. (2006). The presence of Fe might also interfere with the bioavailability of tea polyphenols, potentially reducing the health benefits of the beverage.

Table 3: Potential Health Implications of Heavy Metals in Slimming Teas

Metal	Short-Term Effects	Long-Term Effects
Cu	Nausea, vomiting, abdominal pain	Hepatotoxicity, kidney damage
Cd	Usually asymptomatic at low acute doses	Nephrotoxicity, bone demineralization, carcinogenicity
Pb	Headaches, fatigue, gastrointestinal upset	Neurocognitive deficits, cardiovascular risks, bioaccumulation
Fe	Gastrointestinal irritation, nausea	Oxidative stress, liver damage, pancreatic dysfunction; reduced polyphenol bioavailability
Zn	Rare at low levels; high acute intake may cause nausea	Generally safe at detected levels; excess can impair Cu absorption

Zn was detected in all samples at concentrations between 0.0014 and 0.0063 ppm, which are far below the WHO limit of 27.400 ppm (Figure 1 and Table 2). Zn is a cofactor in numerous enzymatic processes, and the concentrations found pose no toxicological risk as represented in Table 3 and reported by works of Hunt, (1994) and Kazi et al. (1999). Generally, on a comparative evaluation to compare findings from similar studies conducted in Libya, China, and Nigeria, the heavy metal levels in this study fall within or below previously reported ranges (Elbagermi et al., 2017; Garba & Galadima, 2015; Wen-si et al., 2015). However, the slight exceedance of Fe in two samples indicates a potential quality control gap in the supply chain.

CONCLUSION

This study confirmed the presence of heavy metals in slimming teas sold in Zaria. While the concentrations of Cd, Pb, Cu, and Zn remained within WHO permissible limits, iron (Fe) exceeded the recommended standard in 50% of the samples. Although most detected levels may not pose immediate health risks, chronic exposure even to low concentrations raises concern due to the potential for bioaccumulation and cumulative toxicity. The exceedance of Fe is particularly noteworthy, as prolonged intake could increase risks of oxidative stress and organ damage.

These findings underscore the importance of regular monitoring, stricter regulatory controls, and periodic quality assessments of herbal products to safeguard public health. Public awareness campaigns should be implemented to educate consumers on the risks of excessive consumption of herbal teas. Additionally, labelling requirements should be strengthened to include information on heavy metal testing, and future research should explore long-term health effects and alternative cultivation practices to minimize contamination.

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