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Research paper

Analysis of cu and NI concentrations in some commonly consumed spices sold in Kaduna metropolis, Kaduna state, Nigeria

Omenesa J [1] *, Mohammed Y. [1], Babatunde A. O. [1], Salawu S. J. [2]

[1] Department of Chemistry, Nigerian Defence Academy, PMB. 2109 Kaduna, Nigeria
**Corresponding author E-mail: omenesajafaru@gmail.com*

Abstract

This research was conducted with a view to determine the risks associated with Cu, and Ni through the consumption of spices viz; curry leaves, ginger, turmeric, garlic and cloves) sold within Kaduna Metropolis. The samples were analyzed for Cu and Ni using Atomic Absorption Spectrophotometer (AAS). The mean concentrations of the metals in the samples are curry leaves: - Cu (0.123 mg/kg); Ni (0.029 mg/kg). Ginger:- Cu (0.063 mg/kg); Ni (0.046 mg/kg). Garlic: - Cu (0.064 mg/kg); Ni (0.034 mg/kg). Cloves: - Cu (0.056 mg/kg); Ni (0.024 mg/kg). Turmeric: - Cu (0.052 mg/kg); Ni (0.022 mg/kg). The concentration of Cu and Ni analyzed in all the samples are within the safety limits set by FAO/WHO while the Target Hazard Quotient (THQ) evaluated for all the samples were less than one (1). Hence, the selected spices sold within Kaduna Metropolis are safe for human consumption.

Keywords: *Target Hazard Quotient (THQ); Toxic Reference Value (TRV); Spices; Atomic Absorption Spectroscopy (AAS); and Kaduna Metropolis.*

1. Introduction

Spices are the leaves, flowers or stems of plants used in flavoring or garnishing of food. They are sometimes used in medicine; cosmetics and production of perfume. Dietary specialists have reported importance of food to human. For example, when used in larger quantity, spices can contribute a substantial amount of minerals and other micronutrient. They stimulate the secretion, prevent body from cold and influenza, and reduce nausea and vomiting (Ravindran, 2002; Sultan et al., 2010). Recent studies highlighted other biological functions of spices, which include antimicrobial, antioxidant and anti-inflammatory (Tajkarimi et al., 2010). Some of these metals Mg, Zn, Fe, are needed at a moderated concentration. While others such as Ni, Cd, Cu, Cr and Pb are harmful to the body even at lower concentrations (Muyidat et al., 2013).

These metals get into the human population through ingestion; plants are exposed to heavy metals through uptake of water and nutrients; animals eat these plants and human consumes both plant and animals (Dupler, 2001). Consumption of these heavy metals through food intake can be very toxic.

Heavy metal toxicity is the degree at which heavy metals can affect human or animals. Acute toxicity involves harmful effects through short-term exposure while chronic toxicity involves harmful effects over an extended period of time (Garba et al., 2013). Ingestion of heavy metals causes numerous health problems.

For example, Nickel compounds are classified as human carcinogens based on increased respiratory cancer risks observed in epidemiological studies of sulfidic ore refinery workers (Muhammad et al., 2011). Gram quantities of various copper salts have been taken in suicide attempts and produced acute copper toxicity in humans, possibly due to redox cycling and the generation of reactive oxygen species that damage DNA. Corresponding amounts of copper salts (30 mg/kg) are toxic in animals (Bonham et al., 2002). Researches on concentration of metals present in foods is not enough as it does not give a clear account of how long it could accumulate in the body before it can be harmful. Hence, the need for risk assessment.

Risk assessment refer to the process that evaluates the potential health effects of dietary exposure to a contaminant through one or more exposure pathways such as oral, nasal and dermal exposure pathways (USEPA, 2002). Risk assessment helps scientists and regulators to identify serious health hazards and derive adequate measure against such exposure such that there is no significant threat to public health (Davis et al., 2001).

Several methods have been proposed to estimate the potential health risk of metal pollutants, which are mainly divided into carcinogenic and non-carcinogenic. For carcinogenic metal contaminants, probability risk assessment technique has been used by a number of researchers to utilize fully, the available exposure and toxicity data (Solomon et al., 1996; Sajjad et al., 2009; Okunola., 2011). The observed or predicted exposure concentrations are compared with thresholds for adverse effect or the toxic reference value (TRV) as determined by dose-effect relations (Solomon et al., 1996). These methods are only applied to quantify the magnitude of health risks of carcinogenic pollutants and not for non-cancer risks. The non-carcinogenic risk assessment methods do not provide quantitative estimates on the probability of experiencing non-cancer effects from contaminant exposures. These are based on the target hazard quotient (THQ). The increasing concern on the quality of food has prompted research regarding the risk associated with food contaminated by heavy metals (Mansour et al., 2009).

2. Materials and methods

2.1. Reagents and solutions

All reagents used were of analytical grade. Distilled water was used for the preparation of all solutions.

2.2. Sampling

Fresh samples of ginger, turmeric, clove, garlic and curry leaf were procured from three selling points in each of the market (Sabo Market, Monday Market, Central Market and Kawo Market) in Kaduna Metropolis. The samples were labeled appropriately according to their names, date of sampling and point of collection and were identified by a botanist to be; ginger (Zingiberofficinale) family Zingiberaceae, voucher number 2210; turmeric (Curcuma domestica) family; Zingiberaceae voucher number 3309; cloves (Eugenia Catyophyllata), family; Myrtaceae and voucher number 3451; garlic (Allium sativum), belongs to the family, amaryllidaceae, and voucher number 0013; curry leaves (murrayaKoenigii), family; Sapindaceae. voucher number 6792.

2.3. Preparation of samples

The samples were thoroughly washed with deionized water, cut into pieces with the help of a stainless metal knife and oven dried at 100°C for 24 hrs. The dried samples were reduced to powdered form using mortar and pestle. The ground samples were stored in an appropriate sample bottles and labeled.
Composite sample of each spice were made by thoroughly mixing equal portions of the samples collected from different sampling points. After which they were labeled and kept for the next stage of analysis.

2.3.1. Digestion of samples

Exactly 1.0 g of a composite sample was weighed into a cleaned dried 250 mL beaker. Then 5.0 mL of concentrated HNO_3 and 1.0 mL of H_2O_2 were added into the beaker and heated in a hotplate in a fume cupboard. This was followed by gradual addition of 25.0 mL deionized water, until the yellow fume turns colourless and the solution was allowed to cool and then filtered into 250 mL conical flask using whatsman filter paper no. 11. The filtrate was quantitatively transferred into a 100 mL volumetric flask and made up to the mark with the deionized water. The sample was stored in 100 mL plastic container and labeled. This process was repeated for all the samples (Taghipour and Aziz, 2011).

3. Determination of Cu and Ni levels in the sample

Atomic Absorption Spectrophotometer was used for heavy metal determinations which involved the use of Hallow Cathode Lamp (HML) for Cu and Ni. The analysis was carried out in triplicates to produce data between experimental variables that could be computed using statistics. The mean standard deviation concentration of each sorted triplicate was obtained by taking the average metal concentration between individual element using excel Microsoft packages.
Target Hazard Quotient for Cu and Ni in the Samples:
Target Hazard Quotient (THQ) for Cu and Ni in spice samples were evaluated according to USEPA 2015, using equations 1 and 2.

$$\text{EDI} = \frac{\text{FIR x Cm}}{\text{WAB}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..1$$

Where: EDI = Estimated Daily Intake

FIR = Food ingestion rate (2.9 mg/kg)

Cm = Mean concentration of metal analyzed in spices (mg/kg,)

WAB = Average body weight (72 kg for Men and 70 kg for Women)

$$\text{THQ} = \frac{\text{EDI}}{\text{RfD}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.2$$

THQ = Target Hazard Quotient

RfD = Oral reference dose (which will be based on 4.0 x 10^{-2}, 1.4 x 10^{-1} mg/kg/day for Cu and Ni) (USEPA, 1997; USEPA - IRIS, 2007).
If THQ is above 1, it indicates that the consumer of such food is bound to experience adverse heath effect and if below 1, the food is considered safe from the effect of the metals concern.

4. Results and discussions

The concentrations of Cu and Ni in the spice samples are presented in table 1, target hazard quotient for male and female in tables 2 and 3 respectively. Comparison of THQ for male and female are presented graphically in figures 1 and 2.

Table 1: Mean Concentrations (Mg/Kg) and Standard Deviation of Cu and Ni n Some Commonly Consumed Spices

Heavy Metals	Samples	SB	Sampling KK	Area CM	KW
Cu	CL	0.102±0.01	0.139 ±0.09	0.148±0.02	0.103±0.11
	Gg	0.049±0.05	0.038±0.07	0.047±0.01	0.116±0.04
	Gl	0.048±0.09	0.051±0.12	0.054±0.06	0.051±0.14
	Cv	0.042±0.08	0.033±0.11	0,031±0.02	0.116±0.20
	Tm	0.083±0.03	0.059±0.09	0.034±0.11	0.031±0.03
Ni	CL	0.036±0.16	0.330±0.19	0.028±0.03	0.017±0.04
	Gg	0.050±0.07	0.042±0.14	0.064±0.18	0.028±0.01
	Gl	0.022±0.01	0.039±0.10	0.045±0.11	0.020±0.15
	Cv	0.050±0.07	0.020±0.13	0.019±0.10	0.006±0.11
	Tm	0.034±0.18	0.039±0.16	0.008±0.08	0.008±0.10

Key: CL = Curry leaves, Gg = Ginger, Gl = Garlic, Cv = Clove, Tm = Turmeric, SB = Sabo, KK = Kakuri, CM = Central Market, KW = Kawo

Table 2: Target Hazard Quotient of Cu and Ni (Mgkg^{-2}) in Some Commonly Consumed Spices for Women

		Sampling Area			
Heavy Metals	Sample	SB	KK	CM	KW
Cu	CL	0.105	0.143	0.153	0.106
	Gg	0.051	0.039	0.048	0.120
	Gl	0.049	0.052	0.055	0.052
	Cv	0.043	0.034	0.032	0.020
	Tm	0.085	0.061	0.035	0.032
Ni	CL	0.075	0.684	0.058	0.035
	Gg	0.104	0.087	0.133	0.058
	Gl	0.046	0.081	0.093	0.041
	Cv	0.104	0.041	0.038	0.012
	Tm	0.070	0.081	0.017	0.017

Key: CL = Curry leaves, Gg = Ginger, Gl = Garlic, Cv = Clove, Tm = Turmeric, SB = Sabo, KK = Kakuri, CM = Central Market, KW = Kawo

Table 3: Target Hazard Quotient of Cu and Ni (Mgkg^{-2}) in Some Commonly Consumed Spices for Men

		Sampling Area			
Heavy Metals	Sample	SB	KK	CM	KW
Cu	CL	0.103	0.139	0.149	0.103
	Gg	0.049	0.038	0.047	0.117
	Gl	0.048	0.051	0.054	0.051
	Cv	0.043	0.033	0.031	0.011
	Tm	0.083	0.060	0.034	0.031
Ni	CL	0.073	0.665	0.056	0.034
	Gg	0.101	0.085	0.130	0.051
	Gl	0.045	0.079	0.084	0.039
	Cv	0.101	0.040	0.040	0.011
	Tm	0.068	0.079	0.017	0.016

Key: CL = Curry leaves, Gg = Ginger, Gl = Garlic, Cv = Clove, Tm = Turmeric, SB = Sabo, KK = Kakuri, CM = Central Market, KW = Kawo

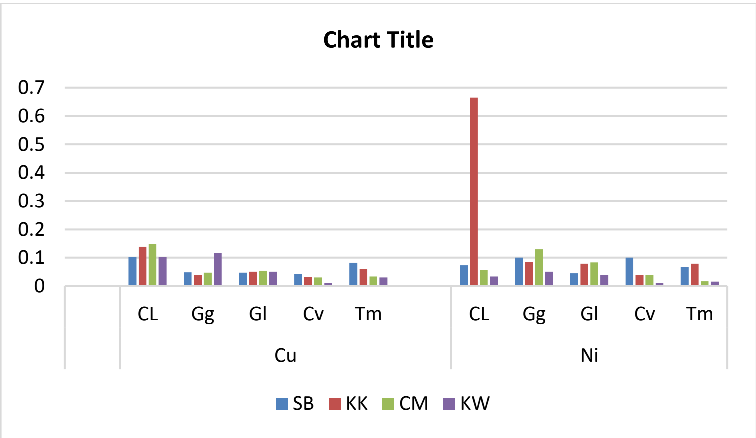

Fig. 1: Comparative of THQ for Women.

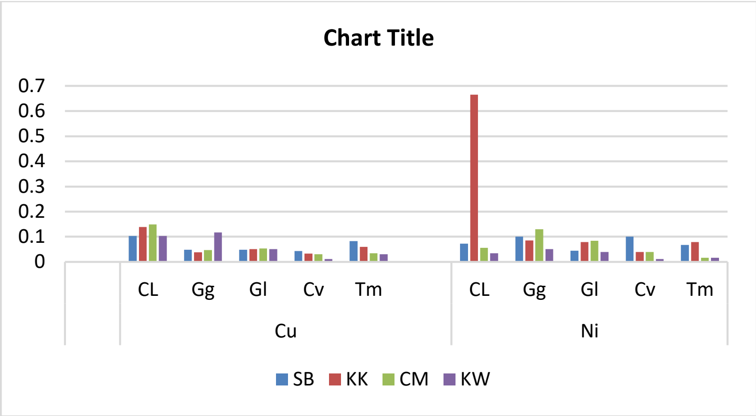

Fig. 2: Comparative of THQ for Men.

Discussion:

In this research, the concentrations obtained for Cu, ranged from 0.031 mg/kg for cloves and turmeric in Kawo and Central Market to 0.148 mg/kg for curry leaves in Central Market. Which is in conformity with those reported by Marian and Cosmos (2010), where ginger and garlic both recorded lowest concentration range of 0.089- 0.09 mg/kg, while Krejpcio et al in 2007 recorded higher level of Cu in garlic, ginger and cloves.

However, the Cu levels detected in all the samples are below the maximum allowable limits of 0.4 mg/kg set by FAO/ WHO (2006) and 40.00 mg/kg by WHO/NAFDAC, 2001.

Copper is necessary in the life of both plants and animal as it is an essential component of various enzymes and plays a vital role in skeletal mineralization; bone formation and maintaining the connective tissues at low intake levels. It plays a role in oxidative defense system.

Copper at levels above the tolerable limit can cause liver and kidney damage and its toxicity can results in severe poisoning (Uriu and Keen, 2005).

The concentration of Ni ranged from 0.006 mg/kg for cloves in Kawo Market to 0.330 mg/kg for curry leaves in Kakuri Market.

In contrast to our results, Ikechukwu and Gaya (2016), reported high concentrations of Ni for cloves, garlic, curry leaves and ginger respectively. The concentrations obtained for Ni in this research were lower when compared with the ones recorded by Onyema et al., (2015). Except for curry leaves (0.330 mg/kg) collected from Kakuri Market, the levels of Ni recorded in this research work were below the permissible limit of 5.0 mg/kg (W.H.O 1999) and 27.00 mg/kg by WHO/NAFDAC, 2001. Therefore, the health risk posed by the metals at these concentrations could be insignificant.

Nickel is a necessary element for iron absorption and preventing anemia in the body. It also plays a major role in the absorption of calcium in the bones. Nickel concentration above threshold levels could lead to chronic bronchitis, reduced lung function and cancer (Behnaz and Muhammad, 2017).

Target Hazard Quotient of Cu and Ni for Women

The target hazard quotients (THQ) of toxic metals for women through consumption of spices are presented in Table4.2

The results of THQ of Cu in the samples of curry leaves ranged (0.105 – 0.153mgkg); ginger (0.039 – 0.120 mgkg^{-2}); garlic (0.049-0.055 mgkg^{-2}); cloves (0.032-0.125 mgkg^{-2}); and turmeric (0.032 – 0.085 mgkg^{-2}) with the highest THQ of Cu (0.153 mgkg^{-2}) for curry leaves from Central Market and the lowest (0.032 mgkg^{-2}) was recorded for cloves in Kawo and Central Market.

In line with the THQ analyzed for Cu in these spices, Sylvester et al., 2018 reported THQ of less than 1 for Cu in onions and seasonings. All the THQ recorded for Cu were less than one. Hence, safe for consumption.

The results of Target Hazard Quotient of Ni for the spices in the four Markets ranged from curry leaves (0.035-0.684 mgkg^{-2}); ginger (0.058-0.133 mgkg^{-2}); garlic (0.041-0.093 mgkg^{-2}); cloves (0.012-0.104 mgkg^{-2}) and turmeric (0.017-0.081 mgkg^{-2}).The highest THQ recorded for Ni (0.684 mgkg^{-2}) was for curry leaves from Kakuri Market and the lowest (0.012 mgkg^{-2}) was for cloves from Kawo Market. Monica et al., 2011 recorded similar THQ of less than 1 for Ni in cucumber, green beans and lettuce. The values recorded were less than one. THQ < 1 indicates that there is no risk from the consumption of these spices.

Graphical representations of THQ in various samples of spice (garlic, ginger, curry leaves, turmeric and cloves) for women are presented in Figure 1. The graph revealed a comparable level of accumulation across the spices. The highest accumulation of Cu was seen in curry leaves and Ni (curry leaves). Therefore, the pattern of THQ accumulation in the various spices are presented as follows; Cu>Ni

Target Hazard Quotient of Cu and Ni for Men

The results of Target Hazard Quotients (THQ) of toxic metals for men through the consumption of spices are presented in Table 4.3.

The Target Hazard Quotient for Cu across the Markets ranged: curry leaves (0.103-0.149 mgkg^{-2}), ginger (0.038-0.117 mgkg^{-2}); garlic (0.048-0.054 mgkg^{-2}); cloves (0.011-0.043 mgkg^{-2}) and turmeric (0.031-0.083 mgkg^{-2}). The highest THQ recorded for Cu (0.149 mgkg^{-2}) was for curry leaves from Central Market and the lowest (0.011 mgkg^{-2}) for cloves from Kawo Market.

The THQ values obtained for Cu samples are below one.

Results of Target Hazard Quotients for Ni ranged: curry leaves (0.034-0.665 mgkg^{-2}); ginger (0.051-0.130 mgkg^{-2}); garlic (0.037-0.084 mgkg^{-2}); cloves (0.012-0.101 mgkg^{-2}) and turmeric (0.016-0.079 mgkg^{-2}).

The highest THQ value of Ni was recorded for curry leaves (0.665 mgkg^{-2}) from Kakuri Market and the lowest was for turmeric (0.011 mgkg^{-2}) from Kawo Market. Monica et al., 2011 recorded similar THQ of less than 1 for Ni in cucumber, green beans and lettuce. The THQ of Ni in the entire samples was less than one. THQ < 1 indicates that there is no risk from the consumption of these spices.

The results of graphical representation for heavy metals (Cu and Ni) in various spice samples for men are presented in Figure 2 The graph revealed a comparable level of accumulation across the spices (curry leaves, ginger, garlic, turmeric and cloves). In Figure 2, the highest accumulation of Cu was seen in Curry leaves and Ni (curry leaves). Therefore, the pattern of THQ accumulation in the various spices are presented as follows; Cu>Ni.

5. Conclusion

The concentrations of Cu and Ni in all the spices analyzed were below the maximum permissible limits of FAO/WHO. The Target Hazard Quotient evaluated for both men and women were below the limit set by USEPA. Therefore, the spices (curry leaves, ginger, garlic, cloves and turmeric) sold within Kaduna Metropolis are safe for consumption with respect to Cu and Ni for both men and women.

Conflicts of Interest

The authors declare no conflicts of interest.

Authors' contribution statement

Conceptualization and supervision: Mohammed, Y., and Babatunde, O.A.: Experiment and Manuscript writing: Omenesa, J., and Salawu, S. J.; Project design and supervision: Omenesa, J., Mohammed, Y., and Babatunde, O.A.; Manuscript review: Omenesa, J., and Salawu, S.J.; Manuscript writing and editing: Omenesa, J., and Salawu, S.J.

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