Original research article.

POTENTIAL HEALTH RISK EVALUATION OF HEAVY METAL EXPOSURE FROM CONSUMING BRANDED SEASONINGS IN ENUGU, NIGERIA

Abstract

Heavy metals are inherently non-biodegradable elements of the earth's crust that collect and remain in the ecosystem in perpetuity due to both human and natural activity. Their contamination of seasonings remains a public health concern because of the frequency of use. Prolonged exposure to these heavy metals is a severe health risk worldwide. This study evaluated the potential health risk of heavy metal exposure from consuming branded seasonings in Enugu, Nigeria. Thirty (30) branded seasonings were selected by simple random sampling and grouped into five (6) according to their batches. Atomic absorption spectroscopy was used to analyze arsenic, cadmium, lead and nickel. The level of arsenic in group S_A(1.28±0.21mg/kg), S_B(1.73±0.31mg/kg), S_C(1.13±0.17mg/kg), S_D(2.11±0.20mg/kg) were observed to be above (1.00mg/kg), the WHO maximum permissible limit. Cadmium levels in S_A(0.36±0.01mg/kg) were observed to be above(0.30 mg/kg), the WHO maximum permissible limit. The estimated daily intake, hazard quotient and hazard index of the metals were within the normal range. The presence of heavy metals above WHO permissible limits in branded seasonings should be a public health concern. To protect the population's health, producers, retailers, and vendors of branded seasonings should be informed of the hazards of exposing their products to heavy metal contamination. Continuous surveillance of branded seasonings for heavy metal contamination is recommended.

1. INTRODUCTION

Seasonings are a group of diversely composed and functioning edible products. Numerous definitions of seasonings can be found in the literature. Codex Alimentarius lists salts, seasonings, spices, soups, sauces, salads, and protein supplements among the ingredients added to food to improve scent and flavor [1]. Most scientists classify seasonings as products of plant origin, albeit with a more complex composition than seasoning mixtures [2]. They are composed of dried seed, fruit, root, bark, or other plant parts mainly used as aromatic additives enhancing the sensory values of food or keeping food fresh [3]. In addition to plant-based constituents, seasonings may also contain salt, monosodium glutamate, and citric acid [2].

Despite all the benefits of these products, it is believed that seasonings harm the biological system, probably due to contamination. Contamination may arise from several different factors, including alterations in the amount and quality of components, the use of a raw material lacking a bioactive substance, biogenic or chemical environmental contaminants, Pesticide residues, mycotoxins, and heavy metals, as well as unintentional contaminants including floral debris, ashes and others [4, 5, 6].

The toxicity of heavy metals to human health and the environment has received much attention. Plants are the primary conduit for heavy metals from polluted soil to people. Metals can easily contaminate plants because they can emanate from the type of soil used for cultivation, the fertilizers applied, and the source of irrigation water [7]. Heavy metals in extremely low quantities may be hazardous due to their poor excretion rates via the kidneys [8]. Heavy metals enter our food chains through soils [9, 10]. Heavy metals have piqued the attention of researchers owing to their persistent, bio accumulating, and biomagnifying properties [11, 12]. Heavy metals cause oxidative stress in aerobic cells by increasing reactive oxygen species (ROS). It has been linked to changes in the nervous system, cognitive impairment, infertility, foetal harm, preterm birth, cardiovascular disease, bronchitis, and coughing [13]. Cancers of the lung and bladder are the most common sites where it’s carcinogenic effects manifest [14, 15]. Due to excessive levels of lead, the Food and Drug Administration of the United States (US FDA) reported in September 2013 that distributors of turmeric powder, including a business based in Bangladesh, were voluntarily recalling their products [16].

Commercially produced branded food seasoning are preferred currently for convenience; it is easy to use. Information regarding the raw material used in the production of seasonings is supposed to be made available in the containers or packs of such seasonings. Regrettably, this information is sometimes not present on the containers of such seasonings. It may be quite challenging to spot adulterations in this all-important and every day-use product, which calls for sophisticated analytical techniques [17].

Due to a paucity of such information and because most research focused on natural food spices, it is critical to examine the heavy metal contents, estimated daily intake, total hazard quotients and hazard index in commercially produced branded food seasonings sold in Enugu markets. This study assesses the possible health risk of heavy metal exposure from consuming branded seasonings in Enugu, Nigeria.

2. MATERIALS AND METHODS

2.1Subject area

The study was conducted in Enugu State, situated in the Southeastern region of Nigeria. Enugu is a metropolitan city notable for its coal extraction, with few industrial sites and numerous markets. This city has a population of approximately 722,664; a total area of 556 km^2; latitudes of 6.4584°N and 7.5464°E; and a warm climate with an annual average temperature of 26.3°C and an average yearly rainfall of 1,730$_{mm}$. Enugu State residents work in various sectors, including government, business, the arts, and agriculture. The map in Figure 1 [18] presents where the branded seasonings were purchased.

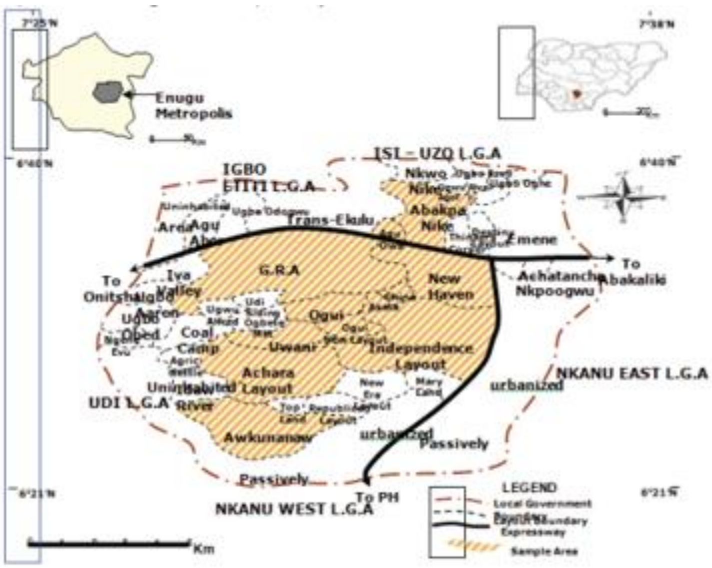

Fig. 1. Map of Enugu Municipality

2.1.1 Sample selection and analysis

The branded seasonings were selected by simple random sampling. Every fourth seasoning as was placed on the table was selected, as all the branded seasonings were placed on a table. The selected seasonings were then bought from the vendors at the different markets in Enugu municipality. A total of thirty (30) commercially produced branded seasonings were purchased from four different markets in Enugu municipality. The selected seasonings were grouped into seven (6). Each group constituted five (5) batches as followed:

Group A- This consisted of five different batches of stew seasoning (SA).

Group B- This consisted of five different batches of local soup seasoning (SB)

Group C- This consisted of five different batches of Beef seasoning (SC)

Group D- This consisted of five different batches of Chicken seasoning (SD)

Group E- This consisted of five different batches of Jollof rice seasoning (SE)

Group F- This consisted of five different batches of fried rice seasoning (SF)

Their expiry dates were used in place of the batch numbers as some of the batch numbers were blurred.

The selected seasonings were used for the analysis of heavy metals (arsenic, cadmium, lead and nickel) using flame atomic absorption spectroscopy as described[19] at the National Centre for Energy Research and Development, University of Nigeria Nsukka.

2.1.2.Determination of Hazard quotient and Hazard index of the selected seasonings

$$DIM\ (mgkg^{-1}\ Day^{-1}) = \frac{X\ (mgkg^{-1}) \times Y\ (kg)}{Z\ (kg)} \quad (1)\ [20]$$

where DIM refers to the Dietary intake of metal, X is the level of heavy metal contained in the seasoning as determined by atomic absorption in this study Y (0.01)is the ingestion rate while Z (24 for child and 60 for adult)[21].

The hazard quotient (HQ) was calculated using the ratio of the daily intake of metal (DIM) to the reference dose for heavy metals.

$$Hazard\ quotient = \frac{Daily\ intake\ of\ metal}{R_fD} \quad (2)\ [22]$$

Where: R_fD is the oral reference for each heavy metal investigated.

The hazard index (HI) was expressed as the total sum of the hazard quotients (HQs) of the heavy metals.

$$Hazard\ index = HQ1+HQ2+HQ3+HQ4 \ldots\ldots\ldots\ldots\ldots\ldots HQ_n \quad (3)\ [23]$$

2.2 Statistical data analysis

The statistical analysis software, Graph Pad prism version7 (Graph Pad Software Inc., USA) was used to analyse the data from this study. Values were expressed as Mean ± Standard deviation. Student's t-test was used to compare continuous variables such as concentration of heavy metals in the seasonings and WHO permissible limits [24]. P-value of <0.05 was considered statistically significant.

3.0 RESULTS AND DISCUSSION

The levels of heavy metals in seasonings consumed by Enugu metropolis residents as sold in their markets have been brought to focus. The findings of this study showed an increase level of arsenic in SA(1.28±0.21)mg/kg, SB (1.73±0.31)mg/Kg, SD(1.13±0.17)mg/kg and SE (2.11±0.20)mg/kg in comparison with the WHO maximum permissible limit (1.00) mg/kg [24] (Table1). The beauty of this study is that it is the first to report the level of arsenic in seasonings in Nigeria. This study's results agree with the observation of Pakistan and Bangladesh studies that revealed the presence of arsenic in food spices [6, 25,]. The level of arsenic found in both studies was higher than the findings in this current study. The finding of their study could be because they worked on natural spices, technological conditions or environmental contamination. Arsenic ingestion, even though at low-level may cause non carcinogenic effects, such as sore pharynx and irritated airways, vertigo, vomiting, and discolouration of skin lesions and tumours [26]. In addition, chronic consumption may result in neurobehavioral and neuropathic changes, memory loss, a decrease in intellectual level, infertility disorder, foetal injury, premature delivery, cardiovascular diseases, chronic cough, and chronic bronchitis [13]. In most cases, its carcinogenic effects manifest as lung and bladder cancer [14, 27].

The findings of this study showed an increased cadmium level in SA (0.36±0.01)mg/kg in comparison with the WHO maximum permissible limit (Table 1). These findings are lower than those of [6,24,28] and are higher than that observed in the work of Nnorom et al [29]. Variability in outcomes may be attributable to variations in raw materials used in manufacturing, technological processes, and distribution networks. Colourants may also contribute to cadmium contamination of spices. Cadmium (Cd) causes chronic human diseases. It predominantly affects the liver, kidneys, testicles, pancreas, and bones [30]. Cd^{2+} may also inhibit the liver enzymes catalase, glutathione peroxidase, and superoxide dismutase [28]. In addition to damaging the skeletal system by interfering with the metabolism of Ca, Zn, Cu, Fe and Mg [31]. Cd may also play an initial role in the development of cancer in the breasts, pancreas, lungs, prostate, kidneys, nasopharynx, and genitalia [32]. Cadmium levels in SA, SC, SD, SE, and SF were below the WHO maximum permissible limit[24] (Table 1).

The levels of other heavy metals such as Lead (Pb) and Nickel assayed in this study were all within the WHO maximum permissible limit as observed in this study.Pb primarily affects the brain, the kidneys, the liver, and the reproductive system [33]. It may induce a decline in IQ and perceptual ability. It may also increase nervous system hyperactivity [30]. Moreover, the presence of Pb in the blood causes bladder cancer [35]. Nickel can induce a variety of pathological effects in humans. The chronic accumulation of nickel and nickel compounds in the human body may be responsible for a variety of adverse health effects, including pulmonary fibrosis, renal and cardiovascular diseases, and respiratory cancer [32].

A health risk assessment was conducted to determine if there may be a link between the intake of branded seasoning and the overall well-being of the study population. The EDIs of the heavy metals as a consequence of seasoning intake are shown in Table 2. The EDI ranged from 1.03E-05 to 9.17E-06 in adults and 1.00E-05 to 8.33E-07 in juveniles. All EDIs were lower than the TDIs [35], indicating that the individual consumption of branded seasonings sold in Enugu metropolis markets may not pose any health hazards to the population.

The Hazard quotient(HQ) of all the heavy metals in this study were less than 1 (HQ<1) as shown in Table 3 in this study. HQ values less than 1 (HQ<1) indicate that the cumulative consumption of that substance will not induce an adverse effect but with the tendency of adverse effect when it is above 1 (HQ>1); the same applies also to HI. The HI of all spices were less than 1.

The HI of the heavy metals, the source of contamination and methods to eradicate them have been described as a constant focus of research [36]. It is necessary to periodically check the branded seasonings for these heavy metals contamination in order to rule out any potential chronic heavy metal toxicity in the population.

4.0 CONCLUSION

This study revealed an arsenic level above the WHO maximum permissible limit in SA, SB, SDand SE. The cadmium levels in S_A was above the WHO maximum permissible limit.

However, the Nickel and Lead levels in the selected branded seasonings were below the WHO permissible limits. The risk assessment indicates that there is little cause for concern. The presence of these contaminants in branded seasonings should be a public health concern. To protect the population's health, producers, retailers, and vendors of branded seasonings should be informed of the hazards of exposing their products to heavy metal contamination. Continuous surveillance on branded seasonings for heavy metal contamination is recommended.

Conflict of interest- None

Table 1. Analytical result of the heavy metals(mg/kg) in branded seasonings in Enugu, Nigeria

Samples		Pb	As	Ni	Cd
WHOMPL		10.00	1.00	1.50	0.30
SA	Mean±SD	0.15±0.04	1.28±0.21	0.62±0.13	0.36±0.01
SB	Mean±SD	0.18±0.02	1.73±0.31	0.38±0.12	0.24±0.01
SC	Mean±SD	0.17±0.03	0.98±0.08	0.07±0.02	0.08±0.01
SD	Mean±SD	0.10±0.02	1.13±0.17	0.79±0.12	0.02±0.01
SE	Mean±SD	0.10±0.02	2.11±0.20	0.55±0.02	0.12±0.03
SF	Mean±SD	0.15±0.07	0.75±0.16	0.62±0.80	0.05±0.01

*WHO MPL=World Health Organization Maximum Permissible Limit

SA= Stew seasoning

SB=Local soup seasoning

	Pb		As		Ni		Cd	
Samples	Adults	Children	Adult	Children	adult	Children	Adult	Children
SA	2.50E-06	6.20E-05	2.13E-05	5.33E-05	1.03E-05	2.58E-05	6.00E-06	1.50E-05
SB	3.00E-06	7.50E-06	2.88E-05	7.20E-05	6.33E-06	1.58E-05	4.00E-06	1.00E-05
SC	2.80E-06	7.00E-06	1.63E-05	4.08E-05	1.17E-06	2.92E-06	1.33E-06	3.33E-06
SD	1.67E-06	4.17E-06	1.88E-05	4.71E-05	1.32E-05	3.29E+05	3.33E-07	8.33E-07
SE	1.67E-06	4.17E-06	3.52E-05	8.79E-05	9.17E-06	2.29E-05	2.00E-05	5.00E-06
SF	2.50E-06	6.25E-06	1.25E-05	3.13E-05	1.03E--05	2.58E-05	8.33E-07	2.08E-06

SC=Beef seasoning

SD=Chicken seasoning

SE=Jollof rice seasoning

SF=Fried rice seasoning

Pb=Lead

As= Arsenic

Ni=Nickel

Cd=Cadmium

Table 2. Estimated daily intake (EDI) (mg/kg^{-1}) of the branded seasonings in Enugu, Nigeria

SA= Stew seasoning

SB=Local soup seasoning

SC=Beef seasoning

SD=Chicken seasoning

SE=Jollof rice seasoning

SF=Fried rice seasoning

Pb=Lead

As= Arsenic

Ni=Nickel

Cd=Cadmium

Table 3. Hazard quotient (HQ) and (HI) of the branded seasonings in Enugu, Nigeria

		SA		SB		SC		SD		SE		SF	
Metals	RfD	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children
Nickel	0.02	5.15E-04	1.29E-04	3.16E-04	7.90E-04	5.85E-05	1.46E-04	6.60E-04	1.60E-03	4.85E-04	1.14E-03	5.15E-04	1.29E-03
Cadmium	0.001	6.00E-03	1.50E-02	4.00E-03	1.00E-02	1.30E-03	3.30E-03	3.33E-04	8.33E-04	2.00E-04	5.00E-03	8.33E-04	2.08E-03
Lead	0.0035	7.14E-04	1.70E-02	8.57E-04	2.10E-03	8.09E-04	2.00E-03	4.77E-04	2.00E-03	4.77E-04	1.00E-03	7.14E-04	1.70E-02
Arsenic	0.0003	7.10E-02	2.10E-02	9.60E-02	2.00E-03	5.40E-02	3.60E-02	6.20E-03	1.57E-02	3.50E-02	2.93E-02	1.25E-02	1'04E-01
HI		7.80E-02	5.30E-02	1.00E-01	4.50E-02	5.62E-02	4.14E-02	7.67E-03	2.00E-02	7.20E-02	3.64E-02	1.40E-02	1.24E-01

SA= Stew seasoning

SB=Local soup seasoning

SC=Beef seasoning

SD=Chicken seasoning

SE=Jollof rice seasoning

SF=Fried rice seasoning

HI=Hazard Index

RfD=Oral Reference Dose

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