ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2021; 21(7): 18245-18260 https://doi.org/10.18697/ajfand.102.19700

CONTAMINATION AND HEALTH RISK ASSESSMENT OF INSTANT NOODLES BY HEAVY METALS FROM COMMERCIAL OUTLETS IN WINDHOEK, NAMIBIA

Kakoma FIS[1] and OR Awofolu[1]*

Omotayo Awofolu

*Corresponding author email: oawofolu@nust.na

[1]Department of Health Sciences, Namibia University of Science and Technology Private Bag 13388, Windhoek, Namibia

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

With growing international trade, food safety has emerged as an important global human health issue. One of the pathways by which extraneous contaminants such as toxic heavy metals access the human system is through food ingestion. At above permissible levels, these metals pose serious danger to human health. Cultivated farm produce on contaminated soil has the propensity to uptake and accumulate such contaminants. In this study, the prevalence and possible human health risks of toxic heavy metals such as Zinc, Cadmium, Copper, Lead, and Arsenic (Zn, Cd, Cu, Pb and As) in selected Instant Noodle Brands (INBs) from commercial outlets in Windhoek, Namibia was carried out. Different brands of instant noodle samples were purchased from four different commercial outlets for four periods with one-month interval. A total of 48 samples were collected and analysed for the level of heavy metals using mineral acid digestion method. Quantification of analysed metals in digested samples was done using Inductive Coupled Plasma -Optical Emission Spectrometer (ICP-OES). The mean concentration of heavy metals in the digested instant noodle samples across the sampling periods ranged from 13.1 – 17.9 mg/kg with overall mean concentration of 14.6mg/kg; 0.05 – 0.5mg/kg with overall mean level of 0.15 mg/kg; 1.5 – 2.4 mg/kg with overall mean concentration of 1.9 mg/kg; ND – 1.3 mg/kg with overall mean level of 0.4 mg/kg and 2.3 – 3.8 mg/kg with overall mean concentration of 1.4 mg/kg for Zn, Cd, Cu, Pb and As, respectively. A strong correlation ($r = 0.99$) was obtained between Zn and Cd levels but average correlation ($r = 0.56$) between Cd and Cu as well as between Cu and As ($r = 0.55$). Target Hazard Quotient (THQ) values greater than 1 (one) was obtained for Pb (1.7) and As (7.3). In addition, Carcinogenic Risk Index (CRI) values of 0.71 and 0.02 were also obtained for Pb and As, respectively. Of great concerns are the potential development of non-carcinogenic health effects and carcinogenic health risks with respect to these two toxic metals. Both metals are of no physiological benefits to the human system and very toxic at low levels. Hence, proper quality assurance protocol and monitoring of the level of toxic heavy metals in instant noodles products is recommended.

Key words: Noodles, Heavy metals, Health Risk, Toxicity, Food Safety, Contaminants, Food, Namibia

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

INTRODUCTION

Food is one of the fundamental requirements for human survival and is required to ensure proper growth and functioning of human system. These foods provide the necessary energy precursors for metabolic activities and sources of micro-elements such as Manganese, Cobalt, Selenium and Zinc (Mn, Co, Se and Zn) that are required for the maintenance of cells and regulation of human metabolism [1]. Increases in world population over past decades have exerted unprecedented pressure on the need for improved food production. Over decades, this pressure has led to unprecedented application of sludges and agro-chemicals such as inorganic fertilizers and pesticides to soils on a large scale in order to meet the demand of the growing world population.

However, many of these chemicals contain contaminants that are very toxic to human health. The use of arsenical herbicides for the eradication of pests has resulted in soil arsenic contamination. With the right soil-chemistry conditions such as pH and oxidation potential, these metals are available for uptake by plants. Uptake and accumulation of heavy metals by plants have been severally reported [2].

Instant Noodles is one of the food products that was produced in order to meet the increasing demand for food worldwide [3]. This product is very popular due to the relatively short period of time involved between preparation and consumption, usually between 2-5 minutes. They are particularly popular among school going children and workers that need to leave homes early in the morning. Another factor that is responsible for its wide consumption is the relative affordability. In fact, it is regarded as the second most popular and widely consumed food after bread [4].

Namibia is no exception to the wide consumption of Instant Noodles, which are commercially available to the public in several brands. However, these Instant Noodles brands (INBs) are mostly imported with the different brands reflecting countries of production and packaging. In recent times, several researchers have reported incidences of heavy metals contamination of agriculture farm produce [5]. Among such studies are investigation into possible contamination of Instant Noodle products by heavy metals [5, 6]. These studies recommended rigorous quality assurance protocols involving monitoring of the level of these toxic metals in food and allied products [7]. Other related studies carried out include heavy metals contamination of rice paddies, the precursor of the production of instant noodles [8, 9]. However, contaminants may also be introduced to the INBs from equipment used during the production cycle [10].

The presence of toxic heavy metals such as Cd, As and Pb in food products intended for human consumption usually elicit concerns due to their human health effects. Some essential micro-elements such as Zn and Cu, Se, Mo and Fe, though required by the human physiology as a result of their roles in metabolic reactions, have also been found to be toxic at elevated levels [1].

Lead (Pb), a heavy metal, has been implicated in the cancer of the stomach, ovaries, and delayed language development in children [11] as well as kidney damage [12].

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Cadmium (Cd) on the other hand has been classified as a human carcinogen [13] and also responsible for decalcification and deformation of bones [11].

Although several studies on incidences of toxic heavy metals in Instant Noodle products have been reported as mentioned earlier, there is no report of such study in Namibia and especially on noodle brands. This study is also important since all the noodle brands consumed in Namibia are imported.

MATERIALS AND METHOD

Samples and Sampling Protocol

Imported Instant Noodle samples were purchased from four commercial stores located in three different suburbs in the city of Windhoek. The suburbs covered were Khomasdal, Windhoek Central Business District (CBD), Katutura and Monte Christo. Purposive sampling technique was used in the selection of sampling sites. This method is widely used in quantitative research for the identification and selection of sampling sites based on specific points of interest [14]. These suburbs were selected to achieve wider geographical distribution among the sampling sites and also due to their high population densities. Seven different brands were identified and sampled in this study. Currently, noodles are not produced locally in Namibia, hence all sampled brands were imported into the country. The different brands and places where they were produced and packaged are presented in Table 1. Samples were purchased for analysis once a month for a period of four months. Hence, a total of 48 samples across sampling sites were collected and analysed for the level of heavy metals of interest. Samples were appropriately labelled and taken to the laboratory for further processing. Hence, quantitative data obtained are indicated as Periods I, II, III and IV in line with each month of sample collection. Since this investigation was purely for academic purpose, the names of commercial outlets, that is, the sampling sites were omitted.

Sample Treatment and Analysis

Small amounts of each noodle sample were cut from the package and placed in a clean acid washed mortar and pestle. This was then crushed, grinded into fine powder and sieved using a 0.2 mm mesh. All metal analyses were based on this fine powder of food samples. Mineral acid digestion of the powdery samples followed a previously described procedure [14]. Briefly, this involves digestion of about 1.0g of the fine powdery noodle samples with 4 ml of freshly prepared Aqua Regia (HNO_3:HCl 1:3) solution on a digester at low heat with period gentle swirling for about 10 min. Additional 2 ml portion Aqua Regia was added after the brown fume subsided and digestion continued slowly until the volume reduced to about 1.0 ml. The content was allowed to cool, rinsed with about 5ml of de-ionised water and filtered into 50 ml standard flask with Whatman Filter paper No 42 and content made to mark. The metallic content of interest was quantitatively determined using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES), 8000 Series.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7 August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Health Risk Assessment of Consumption of Instant Noodle Brands
Estimated Daily Intake (EDI)
Assessment of health risk that may occur due to the consumption of INBs in terms of the Estimated Daily Intake EDI) was determined through estimation of exposure doses of the metals. This was determined with the following previously used equation [15, 16].

EDI = C (metal conc. in food material) X D (food intake)/ B (average weight) .. (Eq. 1)

where EDI = Estimated daily intake; C = metal conc. in food material (mg/kg); D = average daily food intake (average *per capita* of cereal consumption in kg/person/day in Namibia is 0.094 kg [17], and B = average weight (average body weight of a Namibian is 59.58 kg) [18].

Non-carcinogenic Health Risks Index
The non-carcinogenic health risks that may occur as a result of consumption of the INBs was established through the Target Hazard Quotient (THQ). This is the ratio of EDI to that of R*f*D (Oral Reference Dose) and was estimated using previously applied equation [19, 20].

THQ = EDI/R*f*D .... (Eq. 2)

THQ >1 indicates an unacceptable risk of non-carcinogenic effects on health, while an HI <1 indicates no risk of non-carcinogenic effects on health.

Carcinogenic Health Risk Index (CRI)
This is employed to assess possible risk of development of cancer from the consumption of contaminated food. This was determined following a previously applied method [21].

CRI= EDI/CSF .... (Eq. 3)

where CSF is the oral carcinogenic slope factor of metals in (mg/kg/day). A limit of 1.0×10^{-6} – 1.0×10^{-4} was proposed [20] as the permissible range (1 in 10,000) for carcinogenic risk over a 70-year lifetime.

RESULTS AND DISCUSSION

Instant cereals including the noodles are very popular almost ready-to-eat sources of foods. The popularity is based on the relatively short time required for preparation, hence are consumed widely across ages including children. Table 1 shows the different places where the analysed INBs are produced and packaged. Products F, FM, M, S and R are produced and packaged in the same country while L* and L** were produced in a particular country but packaged in another. This implied that raw noodles are exported to another country for packaging. In this study, these are the commercial outlet that use their names as the INBs.

Heavy Metals in Instant Noodle Brands

Results of the analysis of Heavy Metals (HMs) in analysed INBs across the sampling points are presented in Tables 2-6. The concentration of HMs in analysed INBs during period I of sampling (Table 2) ranged from 7.6 mg/kg (S) – 21.0 mg/kg (M); ND (L*) – 0.05 mg/kg (other samples); 0.9 mg/kg (M) - 3.0 mg/kg (M, FM); 0.05 mg/kg (other samples) – 1.3 mg/kg (L*) and 0.3 mg/kg (FM) – 2.5 mg/kg (FM) for Zn, Cd, Cu, Pb and As, respectively. Hence, the highest level of each metal are the upper values in the range and the INB in which they are detected are in parentheses. The highest levels of Zn, Pb and As were higher than the prescribed limits with the exception of Cd and Cu. However, the mean values of each metal in the analysed food samples across this period were lower than the WHO limits [22] except for As. In a similar study [6], below permissible level of analysed heavy metals in noodles was reported with the exception for Pb.

Results of the analysis of HMs in INBs across sampling points during period II are presented in Table 3. Levels of HMs varied from 9.5 mg/kg (S) – 24.6 mg/kg (FM); 0.05 mg/kg (all samples); 1.8 mg/kg (FM) - 3.2 mg/kg (L*); 0.05 mg/kg (all samples) and 0.2 mg/kg (S) – 2.5 mg/kg (M) for Zn, Cd, Cu, Pb and As, respectively. Highest values obtained for each metal are indicated by the upper values in the ranges while the food samples in which they were detected are in parentheses. The highest values (Zn and As) were higher than the WHO prescribed limits [22], while others were lower. In comparison with the mean concentrations of analysed metals across the sampling points, all values were lower than the limits with the exception of As.

Findings from the analysis of HMs in INBs during period III are as presented in Table 4. The concentrations of HMs across the sampling points in the metallic order of Zn, Cd, Cu, Pb and As ranged from 8.5 mg/kg (F) – 34.6 mg/kg (FM); ND (M) – 1.2 mg/kg (S); 0.5 mg/kg (F) - 2.8 mg/kg (L**); ND (all samples) and 0.2 mg/kg (FM) – 1.5 mg/kg (FM, R). The highest metallic levels are expressed by the upper values in the respective INBs in parentheses. The highest individual metallic value as well as the mean values across sampling points obtained for Zn, Cd and As were higher than the prescribed limits [22]. Exceptions to these are the metallic concentrations obtained in Cu and Pb. Both highest individual values and the mean values across sampling points for these metals are lower than the prescribed limits.

The outcomes of the analyses of HMs in INBs during period IV are presented in Table 5. Metallic concentrations across sampling points varied from 7.5 mg/kg (M) – 20.9 mg/kg (FM); ND (varied) – 0.05 mg/kg (M); 0.3 mg/kg (L**) – 2.7 mg/kg (S); 0.2 mg/kg (FM) – 2.5 mg/kg (L**) and 0.2 mg/kg (M) – 2.5 mg/kg (FM). The upper values within the ranges represent the highest individual metallic level during this period. The obtained upper values for Zn, Pb and As are higher than the prescribed limits in cereals while those of Cd and Cu are lower. On the contrary, the mean values of Zn, Cd and Cu are lower than the limits [22] while those of Pb and As are quite higher (more than six folds).

In order to reveal the summative outlook of research findings, overall mean concentrations of analysed HMs in INBs were determined and utilised in the deduction

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

of health risk assessment that may be associated with consumption of the INBs. Results are as presented in Table 6. The overall mean levels of Cd, Pb and As are higher than the prescribed limits [22] while those of Zn and Cu are lower. However, the value obtained for Zn is of concern since it is quite close to the prescribed limits.

Health Risks of Consumption of INBs

Health risks that might be associated with the consumption of INBs in relation to HMs were assessed using hazard indices namely the EDI, THQ and CRI. Possible association between the analysed HMs were also evaluated through the correlation co-efficient (r) using MS Excel data analysis and presented in Table 7.

Although Zn is naturally present in the Earth's crust, elevated levels in the environment have been associated with anthropogenic activities [23]. Generally, plants and agricultural farm produce have been reported to accumulate heavy metals including Zn [16]. Hence, possible sources of Zn in the INBs include its raw material, rice paddy and contamination from equipment used during production process. High levels of Zn in rice paddy [24] and in Instant Noodles have been reported [6]. Relationship between the metals in food samples revealed a very strong correlation between Zn and Cd ($r = 0.99$) while other metals showed no correlation. This might be due to possible loss of the metal along the life-cycle processing of the INBs. The THQ of Zn (7.0×10^{-2}) is <1, hence there is non-carcinogenic risk to human health from consumption of the INBs.

Cadmium (Cd) is a toxic metal to human beings even at low levels with no physiological benefit. The metal is known to display carcinogenic and endocrine disrupting properties, hence its close monitoring in most human toxicological studies [25]. Possible contamination sources of Cd in INBs include uptake from cultivated rice paddies [24] and possible contamination from equipment use along the processing channels [26]. The metal is averagely correlated ($r = 0.6$) with Cu while it showed no correlation with other analysed metals. With THQ and CRI values of 0.24 and 0.007, respectively, there is no risk of non-carcinogenic and carcinogenic effects on human health from the consumption of the INBs since these values are <1.

Copper is one of the metals deemed to be essential due to positive role in human physiology. However, at high level, the metal has been linked to a genetic disorder known as Wilson disease [27]. Copper can be found naturally in the Earth's crust; however, anthropogenic activities have resulted in elevated concentrations which may become widely distributed into the aquatic and terrestrial ecosystems. As with other analysed metals, possible sources of Cu in the INBs include its raw-material (rice paddy) and possibly from equipment along the production cycle [26]. There was an average correlation ($r = 0.54$) of Cu with As but no correlation with the other analysed metals. The THQ value of Cu (0.08) obtained in this work is much lower than 1 (one) hence, there is non-carcinogenic risk with consumption of the INBs.

Lead (Pb) is also regarded as toxic, non-essential metals with deleterious health effects in human. Pb has been implicated in negative effects on the Central Nervous System (CNS), the cardiovascular system as well as on the immune system [28]. Possible contamination sources of the Pb in INBs are similar with those of Cu above and the

https://doi.org/10.18697/ajfand.102.19700

metal did not show any correlation with other analysed HMs. Sometimes, the chemistry of the metals such as oxidation state might be responsible for non-correlation or association. In terms of the human health risks associated with the consumption of the INBs, THQ of 1.7 as well as CRI of 0.71 indicate high probability of the development of non-carcinogenic and carcinogenic health effects with the consumption of the noodles.

Arsenic is also a toxic, non-essential metal with detrimental health effects in humans [29]. In terms of health risk, the THQ for As >1, therefore, the potential development of non-carcinogenic health effects is very high especially when the exceedance ratio is considered (1: 7.3). In addition, with the CRI value of 0.02, the probability of developing carcinogenic health effects associated with the consumption of the INBs is very high when compared with prescribed permissible range [20]. The metal has been implicated in disruptive functionality of enzymes in human body [30]. Although it exists naturally, industrial activities such as the production of pesticides, electronic components and others have resulted in elevated environmental levels [31].

CONCLUSION

Increases in the natural levels of heavy metals have been widely attributed to anthropogenic activities. These metals may find their way into the environment through erosional run-off, waste deposition and atmospheric dispersal. The uptake and accumulation of heavy metals by plants and agricultural farm produce may lead to water-soil-plant-human transfer chain of these metals. Although, the type or nature of equipment may also introduce these metals into the INBs. The investigation generally revealed contamination of the INBs by the HMs, however, the levels were mostly below permissible levels. Elevated levels above permissible limits by some metals (Zn, Pb and As) were obtained. Of concern are the THQ and CRI outlook for Pb and As with respect to non-carcinogenic and carcinogenic health effects that may develop from consumption of the INBs. The INBs are widely consumed globally due to the shortened preparation time. It is recommended that analysis of priority heavy metals in INBs should be included in the quality assurance and food safety protocols by both local and international manufacturers.

https://doi.org/10.18697/ajfand.102.19700

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Brands of analysed instant noodles from commercial outlets

Instant Noodle Brands	Place of Produce	Place of Package
F	Thailand	Thailand
L*	China	South Africa
L**	China	South Africa
FM	South Africa	South Africa
M	South Africa	South Africa
S	China	China
R	China	China

Table 2: Levels of Heavy Metals (mg/kg, dry wt., n=3) in Instant Noodle Brands (INBs) from Commercial Outlets in Windhoek During Period I

SP	INBs	Trace Metals				
		Zn	Cd	Cu	Pb	As
A	F	13.0 (2.8)	<0.05	2.1 (1.4)	<0.05	1.6 (1.5)
	L*	14.6 (5.6)	ND	1.9 (0.7)	1.3 (0.6)	0.5 (1.7)
	FM	15.7 (3.6)	<0.05	2.5 (0.4)	<0.05	2.5 (2.1)
	M	21.0 (4.2)	<0.05	1.5 (0.4)	<0.05	1.9 (0.7)
B	S	7.6 (1.4)	<0.05	1.8 (0.7)	<0.05	1.8 (1.4)
	FM	10.5 (3.3)	<0.05	1.5 (0.3)	<0.05	0.3 (1.4)
	M	18.0 (2.2)	<0.05	2.0 (1.5)	<0.05	1.3 (1.5)
	L**	7.8 (1.9)	<0.05	3.0 (1.5)	<0.05	2.5 (1.3)
C	R	12.0 (1.2)	<0.05	2.6 (0.9)	<0.05	1.8 (1.1)
	M	8.5 (2.5)	<0.05	2.0 (1.5)	<0.05	2.0 (0.6)
D	FM	16.2 (3.7)	<0.05	3.0 (0.8)	<0.05	1.2 (0.5)
	M	17.5 (4.6)	<0.05	0.9 (0.7)	<0.05	1.4 (1.6)
	X	13.5	0.05	2.1	0.15	1.7
	WHO Limit	15.0	0.05	10.0	0.2	0.2

SP = Sampling Points; **A** = Katutura; **B** = CBD; **C** = Monte Christo; **D** = Khomasdal**; INBs=** Instant Noodles Brands; **L*** = Commercial outlet Brand**; L** =** Second commercial outlet Brand; X= Mean Value; Values in Parenthesis = RSD; ND = Not Detected

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: Levels of Heavy Metals (mg/kg, dry wt., n=3) in Instant Noodle Brands (INBs) from Commercial Outlets in Windhoek During Period II

SP	INBs	Trace Metals				
		Zn	Cd	Cu	Pb	As
A	F	12.7 (1.8)	<0.05	2.4 (0.7)	<0.05	0.5 (1.3)
	L*	14.8 (5.3)	<0.05	3.2 (1.2)	<0.05	0.8 (1.5)
	FM	20.7 (9.2)	<0.05	2.1 (0.2)	<0.05	1.8 (0.7)
	M	11.5 (2.1)	<0.05	2.0 (0.5)	<0.05	1.9 (0.8)
B	S	9.5 (2.7)	<0.05	3.0 (0.5)	<0.05	0.2 (1.1)
	FM	24.6 (8.7)	<0.05	2.2 (0.4)	<0.05	1.7 (1.2)
	M	10.2 (1.3)	<0.05	1.9 (0.3)	<0.05	1.2 (0.9)
	L**	9.8 (4.2)	<0.05	2.5 (1.2)	<0.05	0.7 (1.3)
C	R	12.5 (3.2)	<0.05	2.5 (2.3)	<0.05	1.5 (1.2)
	M	10.5 (3.6)	<0.05	2.5 (0.6)	<0.05	1.0 (0.7)
D	FM	16.8 (1.9)	<0.05	1.8 (0.3)	<0.05	1.5 (0.4)
	M	13.0 (2.5)	<0.05	2.7 (1.1)	<0.05	2.5 (0.5)
	X	13.9	0.05	2.4	0.05	1.4
	WHO Limit	15.0	0.05	10	0.2	0.2

SP = Sampling Points; **A** = Katutura; **B** = CBD; **C** = Monte Christo; **D** = Khomasdal**; INBs=** Instant Noodles Brands; **L*** = Commercial outlet Brand**; L**** = Second commercial outlet Brand; X= Mean Value; Values in Parenthesis = RSD; ND = Not Detected

https://doi.org/10.18697/ajfand.102.19700

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Levels of Heavy Metals (mg/kg, dry wt., n=3) in Instant Noodle Brands (INBs) from Commercial Outlets in Windhoek During Period III

SP	INBs	Trace Metals				
		Zn	**Cd**	**Cu**	**Pb**	**As**
A	F	8.5 (1.3)	0.5 (0.04)	0.5 (1.5)	ND	1.4 (0.9)
	L*	27.2 (0.6)	0.5 (0.03)	1.0 (0.2)	ND	0.6 (1.3)
	FM	15.5 (0.7)	0.5 (0.02)	1.5 (0.4)	ND	0.8 (2.7)
	M	14.5 (1.0)	0.5 (0.05)	1.4 (0.6)	ND	0.4 (1.6)
B	S	18.2 (0.1)	1.2 (0.2)	1.9 (0.3)	ND	0.6 (1.8)
	FM	34.6 (1.6)	0.5 (0.04)	1.5 (0.1)	ND	1.5 (0.6)
	M	16.5 (1.1)	0.5 (0.11)	2.0 (0.5)	ND	0.5 (1.1)
	L**	22.5 (1.2)	0.6 (0.1)	2.8 (0.1)	ND	1.3 (1.6)
C	R	11.0 (1.6)	0.3 (0.02)	1.5 (1.6)	ND	1.5 (0.2)
	M	15.0 (0.8)	0.5 (0.03)	2.0 (0.7)	ND	0.3 (0.8)
D	FM	19.8 (0.4)	0.2 (0.01)	1.0 (0.7)	ND	0.2 (1.4)
	M	11.5 (1.7)	ND	0.9 (1.3)	ND	0.8 (1.9)
	X	17.9	0.5	1.5	ND	0.8
	WHO Limit	15.0	0.05	10	0.2	0.2

SP = Sampling Points; **A** = Katutura; **B** = CBD; **C** = Monte Christo; **D** = Khomasdal**; INBs=** Instant Noodles Brands; **L*** = Commercial outlet Brand**; L** =** Second commercial outlet Brand; X= Mean Value; Values in Parenthesis = RSD; ND = Not Detected

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 5: Levels of Heavy Metals (mg/kg, dry wt., n=3) in Instant Noodle Brands (INBs) from Commercial Outlets in Windhoek During Period IV

SP	INBs	Trace Metals				
		Zn	**Cd**	**Cu**	**Pb**	**As**
A	F	10.1 (1.5)	ND	1.5 (1.9)	1.4 (1.5)	2.4 (0.2)
	L*	18.5 (2.3)	ND	1.7 (0.6)	2.0 (1.0)	0.5 (1.2)
	FM	15.5 (1.3)	ND	1.4 (1.1)	1.8 (7.7)	2.1 (1.1)
	M	10.5 (0.7)	ND	1.9 (1.4)	1.5 (5.2)	1.5 (1.5)
B	S	12.0 (0.9)	0.04 (0.03)	2.7 (0.5)	0.5 (6.4)	0.5 (4.8)
	FM	20.9 (1.0)	ND	1.4 (1.2)	0.2 (1.7)	1.5 (1.2)
	M	7.5 (0.8)	ND	1.6 (0.5)	1.2 (8.2)	2.0 (0.8)
	L**	14.5 (1.1)	ND	0.3 (1.5)	2.5 (1.8)	0.5 (0.6)
C	R	9.8 (1.6)	ND	2.1 (0.4)	1.7 (0.4)	1.3 (1.2)
	M	9.0 (1.9)	ND	1.9 (0.3)	1.4 (1.2)	0.2 (1.5)
D	FM	19.0 (1.8)	ND	1.3 (1.7)	1.0 (3.0)	2.5 (0.9)
	M	10.0 (1.5)	0.05 (0.02)	1.8 (2.5)	0.4 (1.5)	2.2 (1.1)
X		13.1	0.004	1.6	1.3	1.5
WHO Limit		15.0	0.05	10.0	0.2	0.2

SP = Sampling Points; **A** = Katutura; **B** = CBD; **C** = Monte Christo; **D** = Khomasdal**; INBs**= Instant Noodles Brands; **L*** = Commercial outlet Brand**; L**** = Second commercial outlet Brand; X= Mean Value; Values in Parenthesis = RSD; ND = Not Detected

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 6: Overall mean concentration of Heavy Metals (mg/kg, dry wt., n=3), EDI, HRI and CRI in Instant Noodles from Commercial Outlets in Windhoek across the sampling periods

	Trace Metals				
	Zn	**Cd**	**Cu**	**Pb**	**As**
	13.5	0.05	2.1	0.15	2.3
	13.9	0.05	2.4	0.05	3.8
	17.9	0.5	1.5	ND	3.5
	13.1	0.004	1.6	1.3	2.3
Xo	**14.6**	**0.15**	**1.9**	**0.4**	**3.0**
WHO Limit	15.0	0.05	10.0	0.2	0.2
EDI	2.0×10^{-2}	2.4×10^{-4}	3.0×10^{-3}	6.0×10^{-4}	5.0×10^{-3}
THQ	7.0×10^{-2}	2.4×10^{-1}	8.0×10^{-2}	1.7	7.3
CRI	-	6.6×10^{-3}	-	7.1×10^{-1}	2.0×10^{-2}

Xo = Overall Mean

Table 7: Result of the correlation co-efficient of heavy metals in the food samples

	Zn	*Cd*	*Cu*	*Pb*	*As*
Zn	1				
Cd	0.996693	1			
Cu	-0.50868	0.55881	1		
Pb	-0.51988	-0.4863	-0.42465	1	
As	-0.95195	-0.937	0.547723	0.347147	1

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 7
August 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

REFERENCES

1. **Lokeshappa B, Shivpuri K, Tripath V and AK Dikshit** Assessment of toxic metals in agricultural product. *Food Pub Heat*. 2012; **2(1):**24–29.

2. **Yadav SK** Heavy metals toxicity in plants: An overview on the role of glutathione and phytochelatins in heavy metal stress tolerance of plants. *S Afr. J Bot.* 2010; **76**:16–179.

3. **WINA.** World Instant Noodles Association. Global demand of instant noodles: Top 15. https://instantnoodles.org/en/common_en/pdf/EN_market_volume_3lg_a4_2016.pd *Retrieved 05 December, 2020*

4. **Onyedikachi UB, Belonwu DC and MO Wegwu** Human health risk assessment of heavy metals in soils and commonly consumed food crops from quarry sites located at Isiagwu, Ebonyi State. *Ovidius University Annals of Chem*. 2018; **29 (1)**:8-24.

5. **Jothi JS and MB Uddin** Detection of Heavy Metals in Some Commercial Brands of Noodles. *European Acad. Res*. 2014; **8**:10667.

6. **Iniobong AC, Atieme O and UA Inimfon** Health risk assessment of instant noodles commonly consumed in Port Harcourt, Nigeria. *Environ Sci Pollut. Res.* 2018; **25**:2580–2587. https://doi.org/10.1007/s11356-017-0583-0

7. **Su C** A review on heavy metal contamination in the soil worldwide: situation, impact and remediation techniques. *Environmental Skeptics and Critics*. 2014; **3(2)**: 24.

8. **Liu JG, Li KQ, Xu JK, Liang JS, Lu XL and JL Yang** "Interaction of Cd and five mineral nutrients for uptake and accumulation in different rice cultivars and genotypes". *Field Crops Research.* 2003; **83(3)**:271–281.

9. **Reddy MV and SP Dhal** Risk Assessment of Heavy Metals Contamination in Paddy Soil, Plants, and Grains (*Oryza sativa* L.) at the East Coast of India. *BioMed Res Int.* https://doi.org/10.1155/2014/545473

10. **Lee JG, Hwang JY, Lee HE, Kim TH, Choi JD and GJ Gang** Effects of food processing methods on migration of heavy metals to food. *Appl Biol Chem.* 2019; ***62***:64.

11. **Filon J, Ustymowicz-Farbiszewska J, Górski J and J Karczewski** Contamination of cereal products with lead and cadmium as a risk factor to health of the population in the province of Podlasie (wojewodztwo podlaskie). *Journal of Elementology*. 2013; **18(3):** 318-390.

12. **Amour KO and NK Mohammed** Heavy Metal Concentrations in Soil and Green Vegetables (Vigna unguiculata) around Volcanic Mountain of Oldoinyo Lengai, Arusha, Tanzania. *Journal of Experimental Agriculture International*. 2015; **8(3):** 178-185.

13. **Shraim AM** Rice is a potential dietary source of not only arsenic but also other toxic elements like lead and chromium. *Arabian Journal of Chemistry*. 2017; **10**:S3434-S3443.

14. **Ehi-Eromosele CO, Adaramodu AA, Anake WU, Ajanaku CO and A Edobor-Osoh** Comparison of Three Methods of Digestion for Trace Metal Analysis in Surface Dust Collected from an E-waste Recycling Site. *Nature and Science.* 2012; **10(10)**:42-47.

15. **Adekunle IM and TY Lanre-Iyanda** Assessment of heavy metals and their estimated daily intakes from two commonly consumed foods (*Kulikuli and Robo*) found in Nigeria. Afr. *J of Food, Agr. Nutr. & Development.* 2012; **(12)3**: 6156-6169.

16. **Neeratanaphan L, Ruchuwararak P, Intamat S and B Tengjaroenkul** Bioaccumulation of heavy metals in local edible plants near a municipal landfill and the related human health risk assessment. *Int. J Human and Ecological Risk Assessment*. 2018. https://doi.org/10.1080/10807039.2018.1473755

17. **FAO.** Food Balance Sheets: Vegetables -Food supply quantity (kg/capita/yr) 2017; http:// www.fao.org/faostat/en/?#data/ *Retrieved 05 December, 2020*

18. **Walpole SC, Prieto-Merino D, Edwards P, Cleland J, Stevens G and I Roberts** The weight of nations: an estimation of adult human biomass. *BMC Public Health.* 2012; **(12):**439.

19. **Chien LC, Hung TC, Choang KY, Yeh CY, Meng PJ, Shieh MJ and BC Han** Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan. *Sci Total Environ.* 2002; **285(1)**:177–185.

20. **USEPA.** Exposure factors handbook 2011 edition (final report). U.S. Environmental Protection Agency. 2011; Washington, DC EPA/600/R-09/052F.

21. **Shaheen A and J Iqbal** Spatial Distribution and Mobility Assessment of Carcinogenic Heavy Metals in Soil Profiles Using Geostatistics and Random Forest, Boruta Algorithm. *Sustainability.* 2018;**(10):**799. https://doi.org/10.3390/su10030799

22. **CODEX Alimentarius Commission.** Food additives and contaminants. Joint FAO and WHO Food Standards Programme, *ALINORM*, 2001; **(1)**:1-289.

23. **Singh R, Gautam N, Mishra A and R Gupta** Heavy metals and living systems: An overview. *India J. Pharmacol*. 2011; **43(3)**:246-253.

24. **Zhao K, Liu X, Xu J and HM Selim** Heavy metal contaminations in a soil–rice system: Identification of spatial dependence in relation to soil properties of paddy fields. *J Hazard Mater*. 2010; **181**:77–87.

25. **Ali I, Damdimopoulou P, Stenius U, Adamsson A, Akesson A, Berglund M, Håkansson H and K Halldin** Cadmium-Induced Effects on Cellular Signaling Pathways in the Liver of Transgenic Estrogen Reporter Mice. *Toxicol. Sci.* 2012; **127(1):**66-75.

26. **Li Z, Feng X, Li G, Bi X, Sun G, Zhu J, Qin H and J Wang** Mercury and other metal and metalloid soil contamination near a Pb/Zn smelter in east Hunan province, China. *Appl. Geochem*. 2011; **26**:160-166. https://doi.org/10.1016/j.apgeochem.2010.11.014

27. **Brewer GJ and FK Askari** Wilson's disease: clinical management and therapy. *J. Hepathology*. 2005;**42**:S13-S21.

28. **Rossi E** Low level environmental lead exposure–a continuing challenge. *Clin Biochem. Rev.* 2008; **29(2):**63.

29. **Chung JY, Hong YS and KH Song** Health effects of chronic arsenic exposure. *J Prev Med Public Health.* 2014; **47(5)**:245-252. https://doi.org/10.3961/jpmph.14.035

30. **Le C, Chen B, Liu Q, Popowich A, Shen S, Yan X, Zhang Q, Li XF, Weinfeld M and WR Cullen** Therapeutic and analytical applications of arsenic binding to proteins. *Metallomics.* 2015; **7**:39-55. https://doi.org/10.1039/C4MT00222A

31. **Chen XG, Zhu XH, Zhang PP, Wu DD and Y Ye** Natural and anthropogenic influences on the arsenic geochemistry of lacustrine sediment from a typical fault-controlled highland lake: Yangzonghai Lake, Yunnan, China. *Environ. Earth Sci.* 2016; **75:217.** https://doi.org/10.1007/s12665-015-4924-3