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Article

Assessment of Some Heavy Metal Concentrations in Noodle Samples from Iraqi Markets and Study Probabilistic Health Risks Associated

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Abstract: Using the acid digestion method and flame atomic absorption spectrometry, the current study examined the amounts of heavy metals, lead (Pb), cadmium (Cd), chromium (Cr), and nickel (Ni), in popular instant noodles used in Iraq (imported or local). In addition, a non-carcinogenic risk assessment was also conducted by determining a target hazard quotient (THQ) for the heavy metal ingestion risk to children and adults. The results showed a large range in heavy metal concentrations among the brands with lead the range of 0.94- 1.7 mg/kg, which is higher than the amount refered by the WHO of 0.5 mg/kg, cadmium in the range of 0.064 mg/kg to 0.13 mg/kg, higher than the recommended level by the World Health Organisation of 0.03 mg/kg, chromium in the range of 0.19-0.41 mg/kg, higher than the recommended level by the WHO of 0.19 mg/kg, and nickel in the range of 0.008- 0.021mg/kg, greater than the 0.01 mg/kg WHO-recommended level. The Target Hazard Quotient (THQ), which is based on Monte Carlo simulations, was used to evaluate the health hazards. The results showed that all the elements' THQ values were below 1, meaning there was no immediate non-cancer threat to children and adults. Nickel and chromium were not found to have any effect, however, cadmium and lead were responsible for more than 99% of the total risk. Also, it was found that children were more susceptible to the negative effects than the adults. If cumulative health effects are possible with repeated exposures it means that continued monitoring programs of heavy metals in foods are needed and the quality of the raw materials and manufacturing process should be improved.

Keywords: Noodle, Heavy metals, THQ, TTHQ

Introduction

Food is necessary for life since it supplies energy for functions including breathing, digestion, growth, circulation, and development. With insufficient nutrients the body begins to break down and may lead to severe health issues [1]. Nowadays, instant noodles are gaining popularity in Iraq for a convenient food. They are readily available and can be consumed fresh, anytime as they are made from rice flour or wheat flour [2]. The instant noodles, an important component in the "convenience food" industry, were developed in North China but are also exported to other countries [3]. Noodles are a regular staple in the diets of billions of people globally, next to bread [4]. Because of lower price, the ease of preparation and instantness, instant noodles continue to grow rapidly in the market, and their shelf-life is also relatively long [3]. Noodles cook quickly and are a good choice for those that are busy. The fresh noodles can also be cooked a bit quicker than dried noodles, since the dried noodles will be required to boil in water for several minutes. Since the 20th century, the consumption of instant noodles has been steadily increasing, and is still on the rise [2]. Instant noodles are made with wheat flour; World Instant Noodles Association data from 2016 [5] indicates that this flour is low in fibre and protein and has little lysine, an essential amino acid. According to the data [6] Noodles are consumed in largest quantity in the world in China, followed by Indonesia, Japan and Vietnam. Eating of instant noodles is common in Iraq where there are concerns about the industrial production and potential health risks associated with them, particularly pollution with heavy metals. Soil, air and water pollution refres due to industrialization, farming practices, and human activities is causing contamination in food products [7]. The food supply, particularly instant noodles, is getting polluted with harmful metals such as Cadmium, Lead, Mercury and Arsenic [8]. Heavy metals can build up in soft tissues and have harmful effects, these metals have different effects [9]. For example, children exposed to high levels of lead might experience reduced intellectual development and behavioral problems, as well as learning disabilities [10]. Adults who are exposed to lead can develop dementia, migraines and memory loss [11]. Cadmium is a rare, but highly toxic element that is available in nature [12]. It is a health hazard because of its use in phosphate fertilizers to the cereal crops, like wheat, which is a vital component of noodles, and has been found to be a causative agent in several diseases [13]. As well as being dangerous, arsenic is another component of food [14]. Long-term exposure may result in such conditions as cirrhosis and in damage to the mucosa of the mouth or nose [15]. The soil contamination and uptake of arsenic by plants may make the use of these herbicides a serious threat of environment and human health [16,17]. It is the concern of the public with the accumulation of heavy metals (HM), also known as metals with significant health hazard, that has warranted studies on accumulation of these metals. Monitoring of heavy metals in food products is important for public health protection as it is subject to periodic monitoring. The present study is aimed to investigate the presence of five heavy metals such as cadmium (Cd), Nickle (Ni), lead (Pb), and chromium (Cr) in five randomly selected brands coming from Iraqi markets.

Materials and Methods

Chemicals and Materials

Chemicals of the highest purity from reliable producers were utilized. Merck KGaA, Germany, provided the Hydrogen peroxide (30%) and BDH Ltd., England, provided the nitric acid (65%). deionized water, were using for prepared samples. standard solutions of the measured heavy elements, which were also provided by BDH Ltd., England, were employed. These solutions had a concentration of 1000 mg/L after being diluted to reach the necessary concentrations for the calibration curve.

Sample Collection and Preparation

Twenty-five samples of noodles were collected randomly from local marketplaces in Kirkuk city, Iraq in 2026. These included one indigenous brand (coded E) and four commercially available brands (coded A, B, C and D). The samples were thoroughly dried for 24 hours in fan assisted oven at 80°C and ground properly in a ceramic mortar and pestle, mixed together and weighed. Following this, the samples stored in sterile plastic bags with the labeling of sample codes until further analysis.

Before the tests were to begin, the following breakdown was done on the dried materials:

After precisely weighing 1gm of homogenized pasta which put into a beaker. Then 2mL of hydrogen peroxide and 6mL of nitric acid were added to the beaker, and covered with a watch glass so that the entire contents would not evaporate. This mixture was then heated for 1 hour at 120ºC, filtered using a Wattman 42 filter papers. Sample volume increased to 10mL using deionized water for analysis.

Instrumentations

Lead, cadmium, nickel and chromium were detected by flame atomic absorption spectrophotometry (AA-7000 Shimadzu). The analytical lines for each metal were used for metallurgical analysis. [Pb-283.3 nm, Ni-232.0 nm, Cr-357.9 nm, and Cd-228.8 nm]. Four standard solutions were made for each metal with (0.01, 0.1, 1.0, and 5.0 ppm). The determination limits were 0.005, 0.002 and 0.001 mg/kg for Cr and Ni, Pb, and Cd, respectively.

Evaluation of health risk

The non-carcinogenic health risk of heavy metals in adults and children who consume instant noodles was calculated using the Monte Carlo Simulation (MCS) approach [18,19]. Equation 1 was used to assess the direct route of instant noodle consumption. The non-carcinogenic risk of heavy metals in direct eating of instant noodles is determined by Equation 1[20-22].

$$THQ = \frac{CDI}{RfD} \qquad (1)$$

Target hazard quotient (THQ), chronic daily intake (CDI) and reference dose of heavy metals through oral exposure (RfD). RfD is 0.0005, 0.02, 0.0085, and 1.5mg/kg/d for Cd, Ni, Pb, and Cr, respectively [23, 24]. Equation 2 was used to estimate the CDI [25, 26].

$$CDI = \frac{C \times IRi \times EFi \times EDi}{BWi \times ATn} \qquad (2)$$

All parts of the equation is defined in Table 1.

Potentially harmful health effects are likely if THQ is greater than 1, and unlikely if THQ is less than 1 [27][28]. Using Equation 3, The total THQ for each heavy metal was calculated to assess the health risks associated with various heavy metals in instant noodles [29,30].

$$TTHQ = \sum_{i=1}^{n} THQi \qquad (3)$$

The total target hazard quotient (TTHQ) is the aggregate of the target hazard quotients (THQi) for each specific heavy metal.

Table 1. Features of the factors used to estimate chronic daily consumption [23]

Variable	Definition	Unit	Value
C	Heavy metal content	$mg.kg^{-1}$	Section of 3.1–3.4
IRi	rate of ingestion	$kg.n\text{-}day^{-1}$	0.0027
EFi	Exposure frequency	$Days.year^{-1}$	350
EDi	Exposure duration	Years	30 Adults and 6 children
BWi	Body mass	kg	70 adults and 20 children
ATn	Exposure to time	Day	Children = 2100 and adults = 10550

Results and discussion

Other potential sources of heavy metals in instant noodles include water and spices, as well as wheat flour, which contains pesticides, fertilizers, and sewage sludge[19, 20]. Additionally, one of the potential causes could be the buildup of heavy metals in the soil and their subsequent penetration into wheat grain[31]. Furthermore, other sources of heavy metal pollution include the metal surfaces on the manufacturing line and the factory's contaminated air[32].

Lead in instant noodle samples

The concentration of lead in four brands of instant noodles from abroad (codes A, B, C and D) and in Iraqi instant noodles (code E) is presented in Figure 1. At 1.70 ± 0.120 mg/kg, the Iraqi brand (code E) had the greatest concentration of heavy metals. The lowest amount (0.94 ± 0.02 mg/kg) was for the imported brand (code C). The mean lead concentrations from all brands differed significantly ($p < 0.05$). The mean levels of lead in the samples of Iraqi and foreign instant noodles were significantly value at ($p < 0.05$). The results obtained from all the brands of instant noodles showed significantly higher levels of lead than the maximum limits guidelines set by the WHO and national standards.

A study of Iranian noodles, based on atomic absorption spectrometry and wet digestion method, revealed that the mean concentration of lead in the noodles was 2.797mg/kg[33]. In another study, using dry-burn atomic absorption spectrometry, lead concentration in the samples of Bangladeshi noodles has been found to range from 1.17- 1.67 mg/kg, which is lower than the permissible limit for lead in noodles according to the Bangladesh national standards [34]. Another study found that the amount of lead in instant noodles was 1.6473mg/kg, exceeding the acceptable limit set by the WHO [35]. The lead levels obtained ranged from 0.32- 2.88 mg/kg. Samples of pasta from Nigerian market had lead concentration of 0.025- 0.106mg/kg, which is lower than recommended limit by the WHO [36]. Furthermore, the samples of instant noodles from Nigeria, and Port Harcourt had a concentration from 0.043 ± 0.15 to 3.163 ± 0.21mg/kg[37] which is higher than the recorded by WHO (0.025mg/kg). The range of lead concentration for all the brands in our samples was 1.004 ± 0.62 to 1.57 ± 1.2 mg/kg.

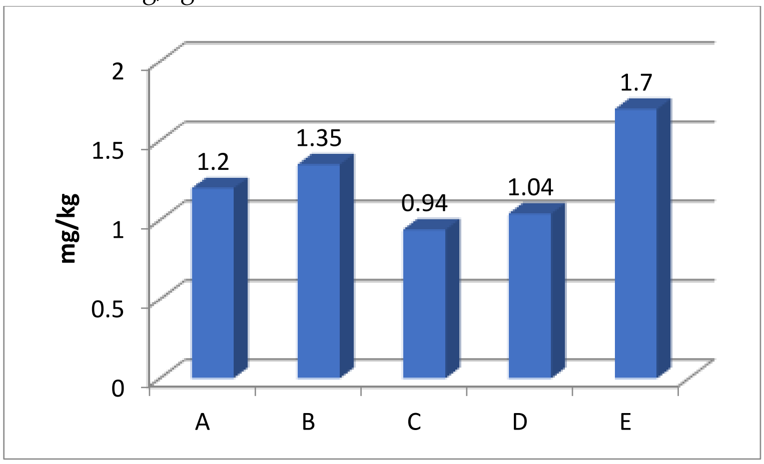

Figure 1. Comparison of Pb levels

Cadmium in samples

Taking into account the parameters for the technique validation, the LOD for cadmium Cd was 0.001 mg/kg. Figure 2 represents the concentration of Cad, which is present in instant noodles produced in Iraq (E) and four imported instant noodles: A, B, C and D. The highest concentration of heavy metals was found in the Iraqi brand (code E) with the value (0.13 ± 0.03mg/kg). The lowest amounts (0.064 ± 0.008 mg/kg) were found in the imported brand (code C). A significant value detected at ($p < 0.05$) in the mean cadmium levels among all brands. The cadmium concentration level was significantly higher than the permissible levels set by the national and World Health Organization.

Cd in the instant noodle samples were collected from Nigeria ranged from 0.001- 0.008mg/kg [36]. Three samples found to be above the recommended limit by WHO. The noodles of Bangladesh was been at 0.53-0.82mg/kg by Jothi and Uddin [34] and all samples protected according Bangladeshi law. It has not been found in the samples collected in other analysis, but it was observed that all of the samples in our analysis were polluted [37]. In another study, Cd in samples of Iranian flat breads was 0.35±0.12 in Tafton bread to 0.65±0.31 in Lavash bread (mg/kg dry weight) [38].

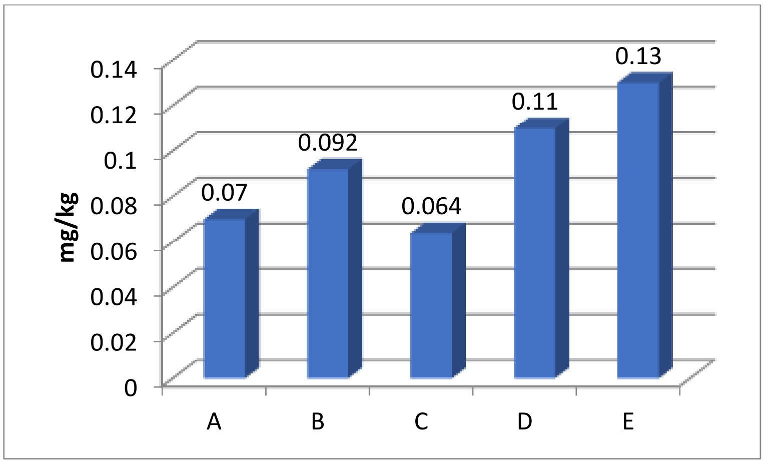

Figure 2. Comparison of Cd levels

Chromium in samples

The LOD that was reported was 0.005 mg/kg. The greatest level of Cr was found in commercial noodles (brand D) with 0.41 ±0.021 mg/kg). Another commercial noodle sample (brand C) had the lowest value (0.19 ±0.06 mg/kg), Figure 3. The levels of all the polluted brands of instant noodles, however, are greater than the recommended limit by WHO, 2011 [39]. The average levels of Cr was found to be significantly different (p value < 0.05) among all the brands.

The Cr concentrations in samples of instant noodles that were obtained from the markets of Nigeria ranged between 0.063 – 0.118 (mg/kg). The Cr concentrations in all noodle samples were above the limit recommended by WHO [36] suggesting high levels of Cr contents in the present study. Also, a study in Port Harcourt, Nigeria, showed that the Cr level between 0.041±0.11 to 2.421±0.71mg/kg [37]. They concluded that Cr was not recorded in 2 brands and levels of Cr were higher than the WHO permitted level for 3 brands, but lower than the WHO recommended level in 1 sample [37]. Bermudez [40] reported Cr concentration of wheat grain from different regions of Cordoba, varying from 0.22 to 1.00 mg/kg and an average of 0.54mg/kg.

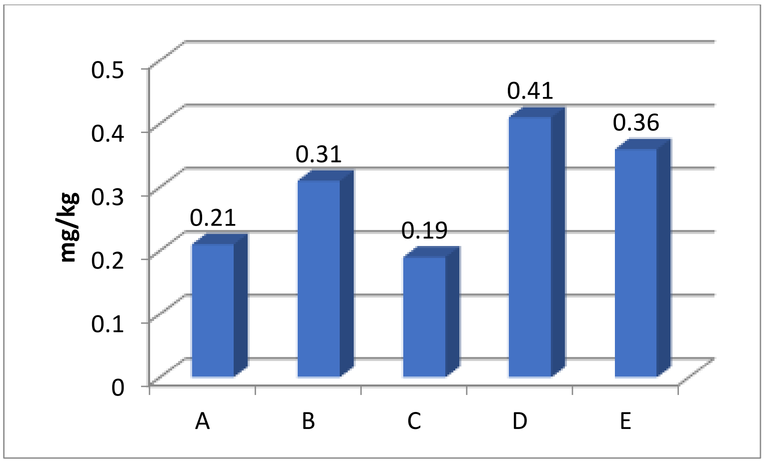

Figure 3. Comparison of Cr levels

Nickle in samples

The reported limit of detection LOD was 0.005 mg/kg. According to Figure 4, which displays the observed concentrations of nickel, Iraqi noodles (brand E) had the highest amount of nickel (0.021 ±0.0043mg/kg), while another commercial noodle sample (brand A) had the lowest value (0.008 ±0.001mg/kg). Nevertheless, all contaminated instant noodle brands have Ni levels over the WHO's suggested threshold (WHO 2011) [39]. Across all brands, the mean concentration of Ni varied considerably (p value < 0.05).

Nickel was absorbed from contaminated soil and water during wheat growth, which is why it is present in flour and noodle products [41]. Because nickel-bearing stainless steel equipment is used in production processes, it can also be transferred. Trace amounts can also be introduced by some food additives and packaging materials[42]. Although it is frequently found in trace amounts within allowable bounds, greater concentrations may be harmful to one's health.

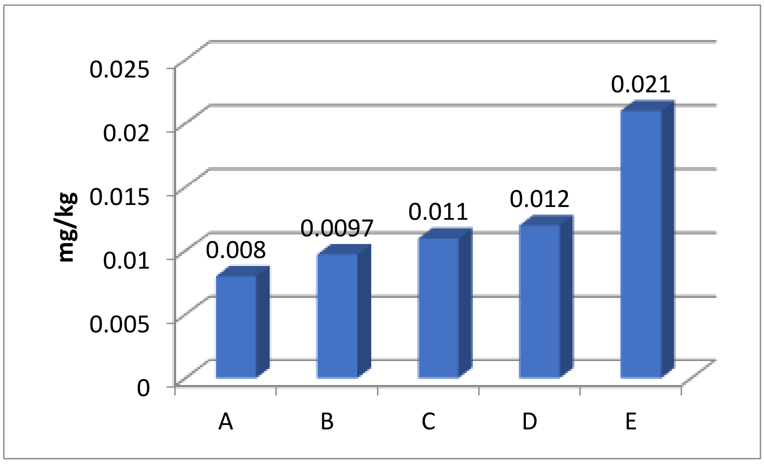

Figure 4. Comparison of Ni levels

Risk assessment for health

The Target Hazard Score (THQ) values for all examined elements (Cd, Pb, Ni, and Cr) in Iraqi children and adults were less than one (THQ < 1), according to the health risk evaluation results displayed in Table 2. These findings indicate that there are now no appreciable non-carcinogenic health concerns connected to eating instant noodles, according to US Environmental Protection Agency (EPA) regulations.

The threat level posed by each constituent varies significantly, nevertheless, according to statistical examination of the contributing percentages. At 55.84%, cadmium (Cd) contributed the most, followed by lead (Pb) at 43.91%. Due to their high toxicity and low Reference Intake (RfD) values, these two elements predominate and account for over 99% of the whole risk. As a result, continuous monitoring of the sources of contamination in these goods is required.

Additionally, children's THQ values are around three times greater than those of adults, according to the study. For instance, children's THQ value for cadmium was 0.025164, while adults' was 0.007155. Children's lower body mass, which raises the ingested dose per kilogram and increases their vulnerability to the cumulative toxic effects of heavy metals, is medically responsible for this discrepancy. Nickel (Ni) and chromium (Cr), on the other hand, contributed very little (less than 0.2%), suggesting that their influence in this investigation is minimal. Our results are agreed with consistent with the findings of researchers in Iran[23].

Table 2. THQ as instant noodle content of Cd, Pb, Ni, and Cr in the children consumers in Iraq

No.	Elements	THQ (Children)	THQ (Adult)	Contribution%
1	Cd	0.025164	0.00715564	55.84139174
2	Pb	0.0197894	0.005627321	43.91465167
3	Ni	0.00008329	0.0000236858	0.1848398
4	Cr	0.00002664	0.00000757536	0.059116781
	TTHQ	0.045063347	0.012814222	

The associated health risk for adult consumers of six instant noodle brands that were gathered from Nigeria was evaluated in a prior study[37]. Previous studies showed that the adult consumers' calculated THQ for Pb and Cr was greater than that of the current study. Because heavy metals naturally bioaccumulate, their combined bioaccumulation may have more detrimental impacts on health [43].

Although, it is important to evaluate the of heavy metals concentration in both raw material and the water used to prepare the noodles in order to reduce their conc. According to Haque and Suwannaporn [44,45], new rules for the raw materials and water in noodles should be established, along with additional changes to the equipment and processing.

Conclusion

The study's findings show that the noodle samples that are for sale are significantly contaminated with heavy metals (Cr, Pb, Ni, and Cd). Concentrations were higher than those allowed worldwide, and there were notable variations across brands. With comparatively high quantities, lead and cadmium were especially common, indicating the impact of contaminants associated with raw materials, the environment, and production processes.

Relative analysis showed that cadmium and lead contributed more than 99% of the overall risk because of their high toxicity and potential for bioaccumulation, even if the hazard ratio (THQ) for all elements was less than 1, indicating no immediate non-cancer-related health risk. The findings also demonstrated that children's increased absorption rate in relation to body weight makes them more vulnerable to these risks than adults.

In order to lower potential risks and safeguard public health, the study confirms that while the current situation may appear to be within relatively safe limits, prolonged exposure may result in cumulative health effects. This calls for tightening control over the quality of raw materials and manufacturing processes as well as strengthening periodic monitoring programs.

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