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Analysis and Health Risk Assessment of Heavy Metals in Bakery Products Sold in the Local Market of Rajshahi City, Bangladesh

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ABSTRACT

All age groups are fond of bakery items, although middle-class and lower-class people in Bangladesh are especially prominent. However, this food product's ingredients, manufacturing process, and packaging all have the potential for heavy metal contamination. As a result, the mean concentrations of Cr, Mn, Cu, Ni, Cd and Pb in 18 different brands of local bakery items, while others were from well-known brands readily available in Rajshahi City, were evaluated using an atomic absorption spectrometer. The concentrations of Cr, Mn, Cu, Ni, Cd, and Pb were 0.34–1.66, 0.29–1.70, 0.19–1.27, ND–7.04, ND–0.38, and ND–1.33 mg/kg, respectively. The order of the metal content was Ni> Mn> Cr> Pb> Cu> Cd, with their polluted values. According to the results, some cereals and cereal-based food product samples included levels of Ni, Pb, & Cd that were greater than the permissible range recommended by the World Health Organization. Fewer samples typically exceed the acceptable limit than all of them. The metals' estimated daily intake levels did not exceed the permitted intake thresholds. On the other hand, the amounts of healthy nutritive metals like Mn and Cu that were ingested from that foodstuff were relatively small and barely met the daily demands for these nutrients. As a whole, the heavy metals' estimated target hazard quotients were < 1, indicating that people who regularly use these goods on a daily basis shouldn't have any health concerns.

1. Introduction

In the modern world, making breakfast takes up very little time. It was the bread, buns, or biscuits that had occurred as compared to other types of items. In contrast, the components, manufacturing process, and packaging of this food product all have the potential to be contaminated with heavy metals. Bakery products are mainly cereal-based products. Wheat flour is a main and irreplaceable ingredient for all kinds of bakery products. Heavy metal can enter the wheat flour and then into the bakery products which is harmful to the people who consumed it. Around the world, there are significant nutritional challenges with diets focused on cereal, particularly vitamin and mineral deficiencies in vulnerable populations including children under five and women of reproductive age. For everyday nutritional demands, mineral compounds are crucial. As a result of its widespread use in a variety of nutritional products, wheat is thought to be a substantial source of mineral compounds [1]. Due to their lack of biodegradability and potential for unintended consequences, heavy metals are the most toxic elements. Environmental parameters, production processes, and processing methods are some of the elements that affect the percentage of heavy metals in food [2]. Food contamination and food safety are important global issues that are exacerbated by environmental pollution. There have been numerous reports looking into the concentrations of heavy metals in food [3].

Akpambang and Onifade A (2020) also studied that in Nigerian bakeries, there is some trace metal contamination in the bread components [4]. The acquired results showed that no samples contained any harmful trace elements, such as Pb, Cr, as well as Cd. This investigation found that both the bread components and the sampled bread loaves included vital trace metals, but in too low a concentration to endanger human health when consumed regularly over an extended period. Arigbede et al. (2019) conduct study on the dietary intake and risk assessment of heavy metals from a few brands of Nigerian biscuits [5]. They observed mean concentrations of trace metals were ND-46.4 mg/kg Cr, ND-12.5 mg/kg Mn, 99.4-296 mg/kg Fe, 5.64-157 mg/kg Zn, 3.11-92.0 mg/kg Pb. Food security must be a significant human health issue, along with consumption of foods polluted with heavy metals has gained relevance across the globe [6]. Unsafe food intake is an utmost concern due to the heavy metal pollution caused by various anthropogenic activities [7]. WHO shared its worry about the public health effect of food safety in Bangladesh on its website. Most of the food that is harvested, processed, or refined in Bangladesh is unfit for human consumption or contains various levels of adulteration. Bangladesh's rapid urbanization along with industrialization has led to the exit of metal-contaminated fumes, soil contamination, and heavy metal deposits on fruits and vegetables throughout the time of their cultivation, transportation, as well as retailing, resulting in unfit food for human consumption and adulteration [8]. There are few published studies on the percentages of heavy metals and the dietary consumption of the contaminants in the produced foods in Bangladesh's industrial regions. Routine sampling and evaluation of the concentrations of harmful metals in food crops have been conducted in some developing and industrialised countries near industrial and mining areas [9].

For many years, customers have been provided with health advantages by adding micronutrients, which include vitamins and minerals, to bakery goods, particularly bread and biscuits, through wheat enrichment. For this reason, it is very necessary to know the amount of heavy metal in bakery products consumed by people.

This study will be carried out to determine levels of six heavy metals, including Cr, Mn, Cu, Ni, Cd, and Pb, in some bakery products available in the market of Rajshahi City. In addition, some factors, such as estimated daily intake (EDI), target hazard quotient (THQ), total target hazard quotient (TTHQ) and Incremental lifetime carcinogenic risk (ILCR) were also studied for assessing the risk of carcinogenic and non-carcinogenic effects on human health.

2. Materials and methods

2.1. Study area and sample collection

Bangladesh is a South Asian country surrounded by India, Myanmar, and the Bay of Bengal, with Rajshahi serving as its vital commercial, urban, and educational centre and known for its cleanliness and greenery. Eighteen different samples of bakery products commercially accessible were collected from different retail shops and also grocery shops from seven different locations in Rajshahi City (**Fig. 1**). Bread, biscuits, and cakes are the three main categories of bakery goods from which the various brands of samples were gathered (**Table 1**).

2.2. Sample digestion

The sample was digested by the wet digestion method by following the method described in the literature [3-5]. 2 g of the 18 samples, solid crushed and powdered, was transferred into a 100 ml volumetric flask. The mixture was mixed carefully with 10 ml of concentrated HNO_3. After that 5ml of $HClO_4$ of 70% was added into the mixture. The mixture was kept overnight for the digestion of the sample into the solution. After overnight the samples are totally dissolved into the solution. A thermo-stated hot plate maintained at 100-120°C was used to heat the mixture to remove the brown fume. To prevent the drying up of the sample 1 ml of HNO_3 was added in the liquor at certain time intervals. The solution was heated until the solution became transparent.

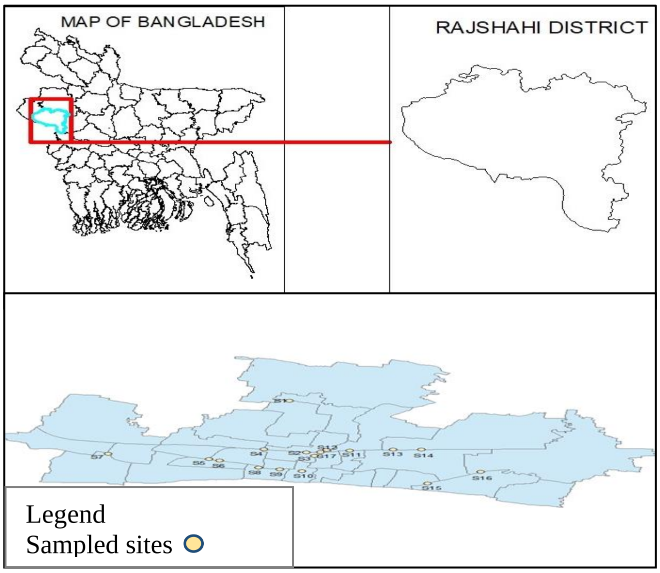

Figure 1. Samples collection area.

2.3. Analysis of elements

The concentrations of Cr, Cu, Mn, Ni, Pb and Cd in digested sample solution were determined using Flame Atomic Absorption Spectrophotometer (Shimadzu AA-6800, Shimadzu Europe, Kyoto, Japan) of Rajshahi University Central Laboratory, Bangladesh. The comparable values in mg/kg of analytical blanks and standard solutions were calculated based on the identical evaluation procedures used with the samples. The AAS was calibrated using manually made standard solutions of the relevant heavy metals and drift blanks. Standard stock solutions of 1000 mg/l for all the metals were purchased from Kanto Chemical Co. Inc, Tokyo, Japan and diluted to the desired concentrations to calibrate the instrument. Data were analyzed by IBM® SPSS® Statistics of version 17.0 for Windows®. Results are presented as mean± Standard Deviations (SD). The operating conditions and limit of detection (LOD) of Shimadzu AA-6800 AAS are given in **Table 2**.

3. Analysis of health risk assessment

The potential carcinogenic and non-carcinogenic threads of exposure of humans to these heavy metals through consumption of those contaminated bakery products will be analyzed by measuring some factors, including estimated daily intake (EDI), target hazard quotient (THQ), total target hazard quotient (TTHQ) and Incremental lifetime carcinogenic risk (ILCR).

3.1. Estimated daily intake (EDI)

The quantity of metals in the diet and the amount of food consumed daily both have an impact on the amount of metals ingested daily. How well a person may withstand pollutants might also depend on their body weight. The EDI can be estimated as follows [10].

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$$EDI = \frac{C \times FIR}{Bw} \quad (1)$$

Here, C stands for concentration of heavy metals in contaminated rice, FIR refers to the rice ingestion rate (g/person/day) in the investigation region and Bw represents the body weight.

Table 1. Details on the brands and locations of the samples analyzed

Sample Id.	Name of the Brand	Net Weight (gm)	Price(Tk)	Sample location
S-1	Bishal Special School Bun	80	13	Talaimari
S-2	Aroma Milk Bun	90	15	Kajla
S-3	Quality Bun	70	16	Residual area, Rajshahi University Campus
S-4	Sotota Bakery	80	12	University Main Gate
S-5	Star Foods Special Bun and Bread	70	15	University Main Gate
S-6	Bishal Mini Cake	20	5	Binodpur
S-7	Shohag Mini Cake	25	5	Railgate
S-8	Tripti Bakery	70	13	Vodra
S-9	National Food Plain Cake	18	6	ShahebBajar
S-10	National Food Plain Cake	18	6	Academic area, Rajshahi University Campus
S-11	Messrs Biscuit Biponi Slice Cake	20	7	Laxmipur
S-12	All Time Premium Bun White Bread	80	12	ShahebBajar
S-13	Fu wang Bun	50	10	Kajla
S-14	DAN Cake Chocolate Plain Cake	25	10	Binodpur
S-15	Bisk Club Dry Cake	20	10	Talamari
S-16	All Time Soft Cake Chocolate	90	40	CNB
S-17	Bisk Club Fruit Fun Biscuit	20	5	Academic area, Rajshahi University Campus
S-18	Gold Mark Poops	27	5	RUET Campus

Table 2. Shimadzu AA-6800 AAS operational conditions and LOD

Element	Wave length (nm)	Slit width (nm)	Lamp current (mA)	Atomizer	LOD (mg/l)
Cr	357.9	0.5	10	Flame	0.01
Mn	285.2	0.5	08	Flame	0.02
Cu	324.8	0.5	10	Flame	0.04
Ni	232.0	0.5	10	Flame	0.02
Cd	228.8	0.5	08	Flame	0.01
Pb	283.3	0.5	10	Flame	0.04

3.2. Target hazard quotient (THQ)

The ratio of the hazardous element exposure to the reference dosage is known as the THQ. In this study, the health risks connected to local individuals' food consumption were determined as follows [10, 11].

$$THQ = \frac{EFr \times ED \times FIR \times C}{RfD \times Bw \times AT} \quad (2)$$

Here, EFr is the exposure frequency (365 days per year), and ED is the duration of exposure (73 years), which is equal to the typical human lifetime, FIR stands for the rice ingestion rate (g/person/day) in the study area, C for the metal concentration in food (mg/kg-fw), RfD for the oral reference dosage (mg/kg/day), and Bw for the average body weight. The average time for non-carcinogens is AT (365 days per year x number of exposure years, assuming 73 years). The oral reference doses were 1.5, 0.004, 0.14, .04, 0.02 and 0.001 mg/kg/day for Cr, Pb, Mn, Cu, Ni as well as Cd, respectively [5, 12]. If the value of THQ is less than 1 i. e. THQ is < 1, The exposed community is unlikely to suffer immediate negative consequences, and when the value is greater or equal to 1 i. e. THQ ≥ 1, potential health concern occurs, and related interventions as well as protective measurements should be taken [10].

3. 3. Total target hazard quotient (TTHQ)

The total heavy metals' THQs are added to form TTHQ. The total of THQ was used to determine TTHQ [13].

$$TTHQ = THQ_{Pb} + THQ_{Cr} + THQ_{Mn} + THQ_{Cd} + THQ_{Cu} + THQ_{Ni} \quad (3)$$

When TTHQ < 1.0, harmful consequences are less likely to occur, but when TTHQ ≥ 1.0, demonstrates the likelihood of negative impacts when TTHQ > 10, the possibility of long-term or even short-term negative health effects is high [14].

3.4. Daily intake of metals (DIM)

The DIM could be calculated by the following equation:

$$DIM = \frac{C_{metal} \times C_{factor} \times C_{food\ intake}}{B_{avarage\ weight}} \quad (4)$$

Here, C_{metal}, $B_{avarage\ weight}$, C_{factor}, and $C_{food\ intake}$ represent the heavy metal concentrations in plants (mg/kg), average body weight, conversion factor, and daily intake of vegetables respectively. Fresh weight was converted to dry weight by employing the conversion factor (0.085) [15].

3.5. Health Risk Index (HRI)

According to the food chain, the HRI for locals who ingested bakery products was evaluated, and the reference oral dosage (RfD) for each metal was evaluated using the equation below:

$$HRI = \frac{DIM}{RfD} \quad (5)$$

Where, DIM and RfD refer to a daily intake of metal and reference dose of metal, respectively. The oral reference doses for Pb, Cr, Mn, Cu, Ni and Cd were 0.004, 1.5, 0.14,

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.04, 0.02 and 0.001 mg/kg/, respectively. The HRI<1 means the exposed population is assumed to be safe **[16]**.

3.6. Total health risk index (THRI)

Using the following equation, the total HRI (THRI) of heavy metals in the fruit was determined by adding the HRI values of each individual metal. **[17]**.

$$THRI = HRI(toxicant_1) + HRI(toxicant_2) + \cdots\cdots + HRI(toxicant_n) \quad \textbf{(6)}$$

3.7. Incremental lifetime carcinogenic risk (ILCR)

The term "carcinogenic risk" (CR) refers to the likelihood of a person getting cancer because of a possible carcinogen exposure over one's lifetime. The ILCR has been used to calculate the prospective cancer risks developed by consuming carcinogenic heavy metals in the studied biscuit samples. ILCR to each metal has been calculated utilizing the cancer slope factor (CSF) that measures the thread brought on by lifespan exposure to 1 mg/kg bw/day of a given contaminant [18]. The following formula was used to determine the carcinogenic risk of Cr and Pb [19].

$$ILCR = CSF \times EDI \quad \textbf{(7)}$$

Where, CSF is the carcinogenic slope factor for Cr and Pb, which are 0.5 mg/kg/day and 0.0085 mg/kg/day, respectively, and EDI is the estimated daily intake of each of the metals (µg/kg/day), and ILCR is the incremental lifelong cancer risk (limitless). Carcinogens have permissible risk ranges between 10^{-4} and 10^{-6}. As a result, contaminants with risk factors lesser than 10^{-6} might not be considered contaminants worthy of another attention. According to the following equation, the cumulative cancer risk carried on by consuming a specific brand of biscuit and being exposed to several carcinogenic trace metals was supposed to be equal to the total of the individual hazards carried on by each trace metal increase and can be estimated through the following equation [19].

$$\sum_{i=1}^{n} = ILCR_1 + ILCR_2 + \cdots\cdots + ILCR_n \quad \textbf{(8)}$$

Where, the value of n can be 1, 2,…n, which is the specific heavy metal that causes cancer found in samples of biscuits.

4. Result and discussion

4.1. Level of heavy metals

Table 3 consists of metal concentration in different bakery product available in Rajshahi City and also give the value of Min, Max, Standard Deviation, and Relative Standard Deviation of Ni, Mn, Cu, Cd, Cr and aiso Pb in bakery product samples. The quantity of the heavy metals (Cr, Mn, Cd, Ni, Cu and Pb) in bakery product samples compared with the different studies in different countries and permissible limit approved by FAO/WHO.

Chromium (Cr): The analysis found that the range of Cr in bakery products is from 0.34 to 1.66 mg/kg, along with the highest concentration in S-1 and lowest in S-5. These results did not exceed the FAO/WHO 2001 maximum allowable level of 2.3 mg/kg. The levels were lower and higher than reported by Naghipour et al., 2014 where the concentration of Cr ranging between 0.34 to 2.7 mg/kg in different breads sample from Iran [20] and Arigbede (2019) who reported the concentration of Cr in six distinct cookie varieties offered in Ibadan varied from 0.12 mg/kg to 0.25 mg/kg, and also the concentration of Cr from some biscuits sample from Nigeria ranged between below detection level to 46.4 mg/kg which exceed the permissible limit [5].

Manganese (Mn): The investigation discovered that the range of manganese concentrations in different meal samples was 0.29 to 1.7 mg/kg, with Bisk Club Dry Cake having the highest concentration. The FAO/WHO's (2001) maximum permissible limit of Mn in food is 500 mg/kg, but the results were lower than this limit [21]. Manganese concentrations in bakery products from Chittagong, Bangladesh ranged from not detected to 2.99 mg/kg [22]. The amounts detected in gofret waf sold in Konya markets ranged from 4.64 mg/kg to 13.50 mg/kg, which was lower than those reported by Harmankaya et al. (2012) [23]. Mn is frequently used in alloys and steel cleaning chemicals, so the potential for Mn contamination in biscuit goods might arise from the manufacturing of containers [24].

Copper (Cu): The sample's average copper content in this investigation was 0.51 mg/kg, with a range of 0.19 to 2.75 mg/kg. These amounts are far less than the 10 mg/kg of copper that is allowed in food [25]. A study in Iran about heavy metal contamination in different types of bread. They found the concentration of Cu in the samples ranged from 1.975-3.250 mg/kg which is also higher than this study [13]. Upon comparing the result of our study it was found that heavy metal concentration in our sample was higher than the study about heavy metal concentration in bread from Chittagong, Bangladesh ranging between (0.10-1.15) [22] and also Okoye and Ulasi (2009) reported the content of Cu levels in different bread brands ranged from 0.03 to 0.08 mg/kg [26].

Nickel (Ni): The Ni concentration in the sample ranged from 1.004 mg/kg to 7.04 mg/kg, with the highest concentration found in S-8 bread from Tripti Bakery. Ni concentration was not detected in almost 50% of the sample. The permissible limit of Ni in foodstuff is < 0.5 mg/kg approved by FAO/WHO (2001) [21]. In our study 25.77% sample have higher Ni concentration than permissible limit which are from some local bakery of Rajshahi. A study from Iran reported higher Ni concentration in bread sample ranged from 0.24 to 2.8 mg/kg [20]. Okoye and Ulasi (2009) found the highest concentration of Ni in bread sample is 8.84 a study from Nigeria. Higher amount of Ni in food staffs have some adverse effect [26].

Cadmium (Cd): The study found that the concentration of cadmium in bakery products ranged from below detection level to 0.385 mg/kg, exceeding the permissible limit set by the Codex Committee on Food Additives and Contamination (CCFAC,2001)0.05 mg/kg [27] and 0.2 mg/kg set by FAO/WHO(2001) [21]. The highest concentration was found inlocal bakery bread, Aroma Milk Bun. The study also found that the concentration of cadmium in ready-to-eat foods from Nigeria [12] and Milk Marie Biscuit [22] was also higher than the permissible limit. Hence, in this study the concentration of Cd in bakery product sample are not detected in ppm level in 72.22% sample.

Table 3. Heavy metal concentration (mg/kg) in different bakery product sample collected from Rajshahi City

Sample Id.	Concentration of Heavy metal in different sample (mg/kg)					
	Cr	Mn	Cu	Ni	Cd	Pb
S-1	1.66 ± 0.025	0.29 ± 0.170	0.235 ± 0.098	ND	ND	1.335± 0.291
S-2	0.78 ± 0.002	0.105 ± 0.039	0.52 ± 0.395	ND	0.385± 0.102	ND
S-3	1.025 ± 0.03	0.4 ± 0.251	0.235 ± 0.123	ND	ND	ND
S-4	0.73 ± 0.0125	0.37 ± 0.0251	0.565 ± 0.073	ND	ND	ND
S-5	0.34 ± 0.0416	0.265 ± 0.036	0.19 ± 0.0252	0.335± 0.240	ND	ND
S-6	0.83 ± 0.055	1.01 ± 0.0152	0.9 ± 0.157	0.855 ± 0.016	0.105 ± 0.012	ND
S-7	1.27 ± 0.0360	0.48 ± 0.388	0.66 ± 0.0531	2.57 ± 0.140	ND	0.935 ± 0.065
S-8	0.83 ± 0.0152	0.135 ± 0.095	0.285 ± 0.281	7.04 ± 1.04	ND	ND
S-9	0.685 ± 0.052	0.955 ± 0.308	0.755 ± 0.627	6.04 ± 0.360	ND	ND
S-10	0.685 ± 0.120	0.875 ± 0.210	1.04 ± 0.042	0.525 ± 0.084	ND	ND
S-11	1.025 ± 0.037	0.635 ± 0.023	0.14 ± 0.175	ND	ND	0.445 ± 0.215
S-12	0.535 ± 0.022	0.32 ± 0.0742	0.19 ± 0.0387	0.095 ± 0.013	ND	ND
S-13	0.975 ± 0.021	0.48 ± 0.126	0.045 ± 0.015	0.335 ± 0.861	0.015 ± 0.326	ND
S-14	0.635 ± 0.031	0.955 ± 0.247	0.71 ± 0.056	ND	ND	ND
S-15	0.39 ± 0.371	1.7 ± 0.061	0.945 ± 0.034	ND	ND	ND
S-16	0.44 ± 0.020	0.715 ± 0.381	1.275 ± 0.383	0.285 ± 0.092	0.245 ± 0.047	ND
S-17	0.46 ± 0.107	0.36 ± 0.172	0.29 ± 0.371	ND	0.025 ± 0.036	ND
S-18	0.6 ± 0.274	0.345 ± 0.094	0.24 ± 0.0749	ND	0.26 ± 0.024	ND
Min	0.34	0.29	0.19	ND	ND	ND
Max	1.66	1.7	1.275	7.04	0.385	1.335
Average	0.7719	0.5775	0.5122	1.0044	0.0575	0.905
SD	0.3320	0.3987	0.3608	2.1117	0.1158	0.4457
%RSD	43.01	69.05	70.46	210.2	201.5	49.26
MPL (WHO/FAO)	2.3	500	10	0.5	0.2	0.3

Results are expressed as mean±SD, ND= Not Detected, Min= maximum value, Max= maximum value, SD= Standard Deviation, RSD=Relative Standard Deviation, MPL = maximum permissible level.

Lead (Pb): Lead (Pb) is a hazardous element that may be harmful even at concentrations of 10 μg/kg and has no recognised biological purpose. The present study's Pb content in biscuits surpasses the acceptable limit of 0.3 mg/kg established by FAO/WHO (2001), suggesting a possible health risk to consumers [21]. The concentration of Pb in bakery products is higher than those reported in some literature, such as those from Lagos universities [28] and Nigeria [12]. These biscuit samples' primary Pb source could have been contamination during handling and manufacture, and it is not ruled out that Pb contamination from automobile emissions is present.

4.2 Health risk assessment

A bread or cake which is known a as bakery product was eaten by almost all classes people in Bangladesh. **Table 4** displays the EDI of several metals from a 60 kg weighted adult consuming 70 g of different brands of bread products. In this investigation, the EDIs for chromium ranged from 0.000397 to 0.001937 mg/kg/day for an adult consuming 70g of biscuits per day. Trivalent chromium has a safe upper limit of 0.15 mg/kg/day by the WHO Expert Group on Minerals and Vitamins (EVM), however, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) recommends 0.2 mg/day of Cr daily intake [29]. The EDI for Cr were below the recommended daily intake. The National Research Council of Canada (NRC) recommended safe and tolerated daily intake amounts of Mn for persons aged 19 to 70, ranging from 2 to 11 mg/day (Institute of Medicine, 2003) [30]. Adults were expected to consume between 0.000123 to 0.001983 mg/kg/day of manganese [31].

In this study the EDI of Cadmium for an adult 0 to 0.00049 mg/kg/day. The tolerable daily intakes of Cadmium for an adult is 0.001 mg/kg/day [32]. All of samples in this study have lower daily intake value than daily intake limit. In this study EDI of nickel ranged from 0 to 0.008213 mg/kg/day. Nickel exposure can occur to the general public through oral, cutaneous, and inhalation routes.

In our study, EDI of Cu for an adult ranging between less than 0 to 0.001488 mg/day/kg. Hence Cu is an essential mineral so we can see from this study all sample have lower value than daily intake of Cu. The EDI of Pb in this study ranged from 0 to 0.001558 mg/kg/bw/day an adult. The results for the adult instance were below the 0.24 mg/day WHO acceptable daily intake for individuals with a body weight of 68 kg [33].

The estimated THQ of selected trace metals through the consumption of 70 g of bakery product for 60 kg weighted adults in Rajshahi City is presented in **Table 5.** For all categories sample heavy metals had THQ < 1. The values of THQ for individual metals for all scenarios follow the order: Cr>Pb>Cd>Ni>Cu>Mn.

Table 4. EDI based on consumption of 70 g bread/cake for average 60 kg weighted people in Bangladesh

Sample Id.	Estimated Daily Intake (EDI) (mg/kg/day)					
	Cr	Mn	Cu	Ni	Cd	Pb
S-1	0.001937	0.000338	0.000274	0	0	0.001558
S-2	0.000910	0.000123	0.000607	0	0.000449	0
S-3	0.001196	0.000467	0.000274	0	0	0
S-4	0.000852	0.000432	0.000659	0	0	0
S-5	0.000397	0.000309	0.000222	0.000391	0	0
S-6	0.000968	0.001178	0.001050	0.000998	0.000123	0
S-7	0.001482	0.000560	0.000770	0.002998	0	0.001091
S-8	0.000968	0.000158	0.000333	0.008213	0	0
S-9	0.000799	0.001114	0.000881	0.007047	0	0
S-10	0.000799	0.001021	0.001213	0.000613	0	0
S-11	0.001196	0.000741	0.000163	0	0	0.000519
S-12	0.000624	0.000373	0.000222	0.000111	0	0
S-13	0.001138	0.000560	5.25×10-05	0.000391	1.75×10-05	0
S-14	0.000741	0.001114	0.000828	0	0	0
S-15	0.000455	0.001983	0.001103	0	0	0
S-16	0.000513	0.000834	0.001488	0.000333	0.000286	0
S-17	0.000537	0.000420	0.000338	0	2.92×10-05	0
S-18	0.00070	0.000403	0.000280	0	0.000303	0

It was observed that the primary contributors of ΣTHQ levels more than 1 were cadmium, nickel, and cobalt [34]. The study found that Pb and Cr were the main risk factors, followed by Cd, Cu, Ni, and Mn. The formula used to convert fresh weight to dry weight was 0.085. With an average body weight of 60 kg, individuals consume 0.07 kg of bakery items each day on average.

Table 5. THQ based on consumption of 70 g bread/cake for average 60 kg weighted people in Bangladesh

Sample Id.	THQ						TTHQ
	Cr	Mn	Cu	Ni	Cd	Pb	
S-1	0.000646	2.42×10-06	6.85×10-06	0	0	0.000389	1.04×10-03
S-2	0.000303	8.75×10-07	1.52×10-05	0	0.000449	0	7.68×10-04
S-3	0.000399	3.33×10-06	6.85E-06	0	0	0	4.09×10-04
S-4	0.000284	3.08×10-06	1.65×10-05	0	0	0	3.04×10-04
S-5	0.000132	2.21×10-06	5.54×10-06	1.95×10-05	0	0	1.59×10-04
S-6	0.000323	8.42×10-06	2.63×10-05	4.99×10-05	0.000123	0	5.31×10-04
S-7	0.000494	0.000004	1.93×10-05	0.00015	0	0.000273	9.40×10-04
S-8	0.000323	1.13×10-06	8.31×10-06	0.000411	0	0	7.43×10-04
S-9	0.000266	7.96×10-06	2.2×10-05	0.000352	0	0	6.48×10-04
S-10	0.000266	7.29×10-06	3.03×10-05	3.06×10-05	0	0	3.34×10-04
S-11	0.000399	5.29×10-06	4.08×10-06	0	0	0.00013	5.38×10-04
S-12	0.000208	2.67×10-06	5.54×10-06	5.54×10-06	0	0	2.22×10-04
S-13	0.000379	0.000004	1.31×10-06	1.95×10-05	1.75×10-05	0	4.21×10-04
S-14	0.000247	7.96×10-06	2.07×10-05	0	0	0	2.76×10-04
S-15	0.000152	1.42×10-05	2.76×10-05	0	0	0	1.94×10-04
S-16	0.000171	5.96×10-06	3.72×10-05	1.66×10-05	0.000286	0	5.17×10-04
S-17	0.000179	0.000003	8.46×10-06	0	2.92×10-05	0	2.20×10-04
S-18	0.000233	2.88×10-06	0.000007	0	0.000303	0	5.46×10-04

Daily intake of metal from this study showed in following **Table 6.** DIM and RfD, which stand for daily intake of metal and reference dosage of metal, respectively, were used to determine the health risk index (HRI) for the local population associated with food consumption. Oral reference doses of 0.001, 0.14, 0.004, 0.02 and 0.003mg/kg/day, respectively, were used as reference doses for Cd, Mn, Pb, Ni, Cu and Cr. An HRI < 1 means the exposed population is assumed to be safe [14]. The study found that the Health Risk Index (HRI) values were <1, demonstrating the widespread notion that exposure to heavy metals through the food chain is safe. The HRI of all metal is represented in **Table 7.**

The mathematical sum of the HRI values for each individual metal was used to determine the total HRI (THRI) for heavy metals. All of the estimated heavy metal THRI values fell below the safe range (THRI < 1). Therefore, we can conclude that consuming exclusively bakery products from Rajshahi City carries no significant threat to people's health.

Table 6. DIM based on consumption of 70g bread/cake for average 60kg weighted people in Bangladesh

Sample Id.	DIM					
	Cr	Mn	Cu	Ni	Cd	Pb
S-1	0.000165	2.88×10-05	2.33×10-05	0	0	0.000132
S-2	7.74×10-05	1.04×10-05	5.16×10-05	0	3.82×10-05	0
S-3	0.000102	3.97×10-05	2.33×10-05	0	0	0
S-4	7.24×10-05	3.67×10-05	5.6×10-05	0	0	0
S-5	3.37×10-05	2.63×10-05	1.88×10-05	3.32×10-05	0	0
S-6	8.23×10-05	0.0001	8.93×10-05	8.48×10-05	1.04×10-05	0
S-7	0.000126	4.76×10-05	6.55×10-05	0.000255	0	9.27×10-05
S-8	8.23×10-05	1.34×10-05	2.83×10-05	0.000698	0	0
S-9	6.79×10-05	9.47×10-05	7.49×10-05	0.000599	0	0
S-10	6.79×10-05	8.68×10-05	0.000103	5.21×10-05	0	0
S-11	0.000102	6.3×10-05	1.39×10-05	0	0	4.41×10-05
S-12	5.31×10-05	3.17×10-05	1.88×10-05	9.42×10-06	0	0
S-13	9.67×10-05	4.76×10-05	4.46×10-06	3.32×10-05	1.49×10-05	0
S-14	6.3×10-05	9.47×10-05	7.04×10-05	0	0	0
S-15	3.87×10-05	0.000169	9.37×10-05	0	0	0
S-16	4.36×10-05	7.09×10-05	0.000126	2.83×10-05	2.43×10-05	0
S-17	4.56×10-05	3.57×10-05	2.88×10-05	0	2.48×10-05	0
S-18	5.95×10-05	3.42×10-05	2.38×10-05	0	2.58×10-05	0

Table 7. HRI based on consumption of 70g bread/cake for average 60kg weighted people in Bangladesh

Sample Id.	HRI						THRI
	Cr	Mn	Cu	Ni	Cd	Pb	
S-1	0.054872	0.000205	0.000583	0	0	0.033097	8.88×10-02
S-2	0.025783	7.44×10-05	0.001289	0	0.038179	0	6.53×10-02
S-3	0.033882	0.000283	0.000583	0	0	0	3.47×10-02
S-4	0.024131	0.000262	0.001401	0	0	0	2.58×10-02
S-5	0.011239	0.000188	0.000471	0.001661	0	0	1.36×10-02
S-6	0.027436	0.000715	0.002231	0.004239	0.010413	0	4.50×10-02
S-7	0.041981	0.000340	0.001636	0.012743	0	0.02318	7.99×10-02
S-8	0.027436	9.56×10-05	0.000707	0.034907	0	0	6.31×10-02
S-9	0.022643	0.000676	0.001872	0.029948	0	0	5.51×10-02
S-10	0.022643	0.00062	0.002578	0.002603	0	0	2.84×10-02
S-11	0.033882	0.00045	0.000347	0	0	0.011032	4.57×10-02
S-12	0.017685	0.000227	0.000471	0.000471	0	0	1.89×10-02
S-13	0.032229	0.00034	0.000112	0.001661	0.001488	0	3.58×10-02
S-14	0.02099	0.000676	0.00176	0	0	0	2.34×10-02
S-15	0.012892	0.001204	0.002343	0	0	0	1.64×10-02
S-16	0.014544	0.000506	0.003161	0.001413	0.024296	0	4.39×10-02
S-17	0.015206	0.000255	0.000719	0	0.002479	0	1.87×10-02
S-18	0.019833	0.000244	0.000595	0	0.025783	0	4.65×10-02

The computed values for ILCR and ΣILCR for Pb alongside Cr due to the exposure from the ingestion of 70 g of bakery products are presented in **Table 8.** While the ILCR values for Pb were between 10-6 and 10-5, with a range between 1.32388×10-5 and 9.27208×10-6, the values for Cr in this study were practically within the permitted range of (>10-4) in all investigated samples of biscuits with a range of 1.98×10^{-4} to 9.69×10^{-4}. Nevertheless, the Pb values for all categories and samples have been considered acceptable. Consuming the sample bakery product is therefore less dangerous in this investigation and less susceptible to cancer risk. Finally, the cumulative cancer risk (ΣILCR) of all bakery product samples studied are breached in the recommended threshold risk limit (>10-4) ranging between 1.98×10-4 to 9.82×10-4.

Table 8. ILCR based on consumption of 70g bread/cake for average 60kg weighted people in Bangladesh

Sample Id.	ILCR						ΣILCR
	Cr	Mn	Cu	Ni	Cd	Pb	
S-1	0.000968333	-	-	-	-	1.32388×10-05	9.82×10-04
S-2	0.000455	-	-	-	-	0	4.55×10-04
S-3	0.000597917	-	-	-	-	0	5.98×10-04
S-4	0.000425833	-	-	-	-	0	4.26×10-04
S-5	0.000198333	-	-	-	-	0	1.98×10-04
S-6	0.000484167	-	-	-	-	0	4.84×10-04
S-7	0.000740833	-	-	-	-	9.27208×10-06	7.50×10-04
S-8	0.000484167	-	-	-	-	0	4.84×10-04
S-9	0.000399583	-	-	-	-	0	4.00×10-04
S-10	0.000399583	-	-	-	-	0	4.00×10-04
S-11	0.000597917	-	-	-	-	4.41292×10-06	6.02×10-04
S-12	0.000312083	-	-	-	-	0	3.12×10-04
S-13	0.000568750	-	-	-	-	0	5.69×10-04
S-14	0.000370417	-	-	-	-	0	3.70×10-04
S-15	0.000227500	-	-	-	-	0	2.28×10-04
S-16	0.000256667	-	-	-	-	0	2.57×10-04
S-17	0.000268333	-	-	-	-	0	2.68×10-04
S-18	0.000350000	-	-	-	-	0	3.50×10-04

5. Conclusions

The study finds that customers are exposed to higher levels of heavy metals when they consume local bakery S-1, S-7, S-8, and S-11 brands. S-1, S-7, S-8, and S-11 brands are more concentrated with heavy metal than other brands. The concentrations of Ni, Pb, and Cd in some samples were higher than permissible limits, causing health risks such as allergic reactions, hyperglycemia, and reproductive problems. Most samples had lower values than permissible limits, and Ni, Pb, and Cd were not detected in some samples. All other metals were at concentrations below permissible limits, indicating that Mn, Ni, and Cu are necessary for human health.

The EDI values represented that the metal ingestion from consuming these products was within the tolerable limit of daily intake for the potentially toxic metals and the recommended limit of daily intake for the essential metals. These goods only slightly increased dietary intakes of healthy metals like Mn and Cu, but they nevertheless made a considerable contribution to these nutrients' needs. However, this suggests that overindulging in these goods can lead to elevated metal concentrations. In general, the predicted THQ and HRI values for metals from consuming various brands of biscuits were lower than the potential risk condition. ILCR value for Cr and Pb also ranged between permissible conditions which indicate there’s no cancer risk from this sample. But it also mentioned that some caution should be maintained for some samples which have close ILCR value for Cr.

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