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HEALTH AND CARCINOGENIC RISKS ASSOCIATED WITH HEAVY METAL CONCENTRATIONS FROM FOREIGN AND LOCAL TEA BRANDS SOLD IN RETAIL STORES WITHIN GOMBE METROPOLIS, NIGERIA

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Abstract

This study quantified and compared concentrations of seven heavy metals (cadmium [Cd], chromium [Cr], copper [Cu], iron [Fe], nickel [Ni], lead [Pb], and zinc [Zn]) in fourteen foreign and locally processed black and green tea brands sold in retail stores within Gombe Metropolis, Nigeria, and estimated the associated non-carcinogenic and carcinogenic health risks. Tea samples were acid-digested and analysed by atomic absorption spectrophotometer. Measured concentrations were compared with NAFDAC (2025) and Chinese National Food Safety Standard (2022) limits, and Welch's t-test was used to compare foreign and local tea groups. Non-carcinogenic risk was estimated using the Target Hazard Quotient (THQ) and Hazard Index (HI), while carcinogenic risk was estimated using the Incremental Lifetime Cancer Risk (ILCR) model. Cadmium concentrations (0.192-2.147 mg/kg)

Keywords: Heavy Metals; Tea; Carcinogenic; Health; Risks

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exceeded the NAFDAC maximum limit (0.1 mg/kg) in all sampled brands, with local black tea recording the highest group mean (0.589 mg/kg), driven by one local brand (GTL-B015-4; 2.147 mg/kg). Chromium and copper concentrations were within permissible limits, while lead exceeded the NAFDAC limit (0.5 mg/kg) in one foreign black tea brand. Welch's t-test showed no significant difference between foreign and local tea for most metals except nickel ($t = 2.46$, $p = 0.042$). Hazard Index values exceeded for all four tea groups, driven mainly by cadmium, indicating a potential non-carcinogenic health risk for habitual tea drinkers in Gombe. ILCR values indicated a potentially carcinogenic risk for all tea brands as all groups exceeded the tolerable threshold, indicating an unacceptable carcinogenic risk. The findings of the study suggest that there is heavy metal contaminations in the study area, particularly cadmium in local black tea, which poses a public health concern in Gombe Metropolis and highlight the need for stricter regulatory monitoring and enforcement of heavy metal limits in tea marketed in Nigeria.

Introduction

Tea (*Camellia sinensis)* is among the most widely consumed beverages globally, Hu et al. (2023). An estimated 5.5 million tonnes of tea is consumed annually, with consumption increasing by 4.5% annually (FAO 2018). Imitating this global trend, tea consumption in many parts of Nigeria in recent years has markedly increased, often taken alone or accompanied by other local delicacies as food in many households (Orimadegun et al., 2018; Ozukwe et al., 2023). This growing tea consumption rate explains its associated cultural and social roles, as well as its perceived health benefits such as its ability to lessen fatigue, stimulate mental alertness, relieve headache, boost energy level, and broader protection against diseases (Garba et al., 2015). However, as with other food undergoing industrial processing, tea production is increasingly scrutinized for risk of contamination by heavy metals, thus raising concerns about the health and carcinogenic risks associated with regular tea consumption.

Heavy metals such as cadmium, lead, copper, nickel, iron, zinc and chromium can enter tea by plant absorption and bioaccumulation from contaminated soils, fertilizer use, irrigation water, and underlying geology of tea-growing regions, as well as post-harvest contamination from factories during processing (Fagbohun et al 2026). Regardless of contamination pathway, several studies have indicated varying concentrations of these heavy metals in tea consumed in different geographic locations around the globe. For instance, Hu et al (2023) found carcinogenic risks associated with high cadmium concentration exceeding acceptable range from tea in Shaanxi Province, Anhui Province,

EDITOR-IN-CHIEF
Prof. E. Mclenna [Australia]

and southwest China. In the USA, Stoner et al (2025) discovered significant carcinogenic risk for heavy metals such as arsenic, cadmium and nickel in tea leaves. Although Cadmium, lead, nickel, and chromium are classified carcinogens; copper, iron, and zinc are essential trace elements but this empirical evidence on the international scene demonstrates the growing awareness of health and carcinogenicity associated with tea as a widely consumed beverage.

Heavy metals concentrations, their health and carcinogenic profile in tea leaves differ by region in Nigeria. Ozukwe et al. (2023) found that heavy metals in tea around the South-Eastern Nigeria pose no human health risk, while Garba et al. (2015), Fagbohun et al. (2026), as well as Rabiu and Abubakar (2025) reveal substantial heavy metal contamination and possible carcinogenic risk in tea consumed in the North-Central and North-Western Nigeria. However, there is a dearth of literature describing the current health and carcinogenicity status of heavy metals in teas consumed in the North-Eastern Nigeria, especially in a secondary city such as Gombe metropolis, the state capital of Gombe State. Given that tea is consumed daily and often over a lifetime, even modest contamination levels may translate into non-trivial long-term health risks for a Gombe population facing high poverty, illiteracy, and unemployment rates (NBS, 2022).

Local and foreign tea production techniques, agricultural practices, national regulatory oversight, and technologies may vary significantly, and these differences affect the extent to which heavy metals are introduced into branded tea products, resulting in diverse metal profiles. Despite this, empirical data directly comparing heavy metal concentrations between locally processed tea bags and their foreign counterparts, and associated health and carcinogenic risks in Nigeria remain scarce. Without such data, it remains unclear whether differences in regulatory frameworks, agricultural practices, or supply chain conditions translate into systematically different exposure risks for Nigerian consumers, and whether either category of product exceeds internationally recognized safety benchmarks. This gap is particularly urgent and significant in light of Nigeria's growing cancer burden. Chidebe et al. (2023) report approximately 124,815 cancer cases and 78,899 cancer-related deaths annually in Nigeria, underscoring the scale of the public health challenge.

This study, therefore quantified and compared the concentrations of heavy metals (cadmium, lead, nickel, iron, zinc, copper, and chromium) between foreign and locally processed tea brands, compared the measured concentrations against local and international benchmarks as well as estimate associated health and carcinogenic risks for each tea group as available in retail stores in Gombe Metropolis, Gombe State, Nigeria.

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Sampling

The study collected fourteen (seven locally produced and seven imported) tea brands available in major retails stores within Gombe Metropolis by convenience sampling and categorised them into four groups: 'Gombe Tea Foreign Black' (GTF-B007-1 to GTF-B011-5), 'Gombe Tea Foreign Green' (GTF-G002-1 to GTF-G003-2), 'Gombe Tea Local Black' (GTL-B012-1 to GTL-B017-5), and Locally processed Green Tea coded as 'Gombe Tea Local Green' (GTL-G001-1 to GTL-G016-2). Each sample code indicates the brand from which duplicate sample were prepared for analysis. The foreign tea brands were imported from regions such as South-East Asia, Central Asia and the Middle East, specific country of origin and brand name are withheld due to their commercial sensitivity.

Sample Preparation and Digestion

Digestion followed the procedure of Okalebo et al., (2002) and AOAC, (2000), with minor modifications as follows; collected tea sample from the stores were each emptied from their bags, dried and ground to fine powder using a clean mortar and pestle to ensure homogeneity. All reagents used were of analytical grade.

1.00 g of each powdered sample was accurately weighed into a 100 mL acid-washed glass beaker. To each beaker, 15 mL of 6 M nitric acid (HNO_3) was added. The mixture was allowed to stand at room temperature for about 30 minutes for pre-digestion, and then heated on a hot plate at 120–130 °C until near dryness

After cooling, 3 mL of 30% hydrogen peroxide (H_2O_2) was added dropwise to each semi-dried sample. The digestion was continued by heating at 130 °C for 1 hour to ensure complete mineralization. The digested samples were then cooled to room temperature, filtered through Whatman's No. 42 filter paper into acid-washed 100 mL volumetric flasks, and diluted to the mark with double-distilled water. The digested samples were then transferred into a 100 mL sample bottles, and stored at a temperature of 4 °C prior to the AAS analysis.

Blank samples were prepared in the same way, without tea leaf material, to monitor potential contamination during the digestion process, and adopted for method validation aspect of the AAS analysis (Okalebo et al., 2002; AOAC, 2000).

Laboratory Technique

The analysis of the concentrations of heavy metals in black tea and green tea from foreign and local sources was undertaken using PerkinElmer (PinAAcle 900H) atomic absorption spectrophotometry with an air-acetylene flame and Graphite furnace (GFASS) at Central Laboratory of Bayero University Kano.

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Statistical Analysis

Mean concentrations were used to describe the outcomes of laboratory analysis, while t-test was used to compare foreign and local tea brands for significant difference in concentration of heavy metals. Because the two groups are independent and sample sizes are small (n = 7 each) with unequal variances for several metals, Welch's t-test (unequal-variance t-test) was the inferential test employed. All statistical tests were carried-out on IBM SPSS (version 21) and Microsoft Excel (version 16).

Health and Carcinogenic Risk Assessment

Non-carcinogenic health risk was assessed using the Target Hazard Quotient (THQ) model following the methodology of Esfarjani et al. (2024) and Teng et al. (2023), as applied in comparable tea studies. The Estimated Daily Intake (EDI) was computed as:

EDI (mg/kg/day) = C (mg/kg) × IR (L/day) ÷ BW (kg) … Equation 1

Where;
C = Measured Metal Concentration;
IR = Ingestion Rate (0.25 L/day, equivalent to 1 cup × 250 mL, this is a conservative estimate for habitual tea drinkers);
BW = Average Adult Body weight (60 kg average Nigerian Adult).
While Target Hazard Quotient (THQ) was computed as

THQ = EDI ÷ RFD… Equation 2

Where;
EDI is Estimated Daily Intake
RfDs is Reference Dose
The Hazard Index (HI) = Σ THQ across all metals. HI > 1 indicates potential non-carcinogenic health risk; the higher the HI, the greater the probability and severity of adverse effects (Esfarjani et al. 2024; Teng et al. 2023).
The USEPA(1989) and Taylor et al. (2023) oral RfDs was adopted for this study as follows;
Cd = 1 × 10−3 mg/kg/day
Pb = 3.6 × 10−3 mg/kg/day
Cr = 3 × 10−3 mg/kg/day;
Cu = 4 × 10−2 mg/kg/day;
Fe = 7 × 10−1 mg/kg/day;
Ni = 2 × 10−2 mg/kg/day;

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Prof. E. Mclenna [Australia]

Zn = 3 × 10−1 mg/kg/day.

The assessment of potential carcinogenic health risk of lifetime of heavy metals on the other hand was calculated using the Incremental Lifetime Cancer Risk (ILCR) based on USEPA (2017).
$ILCR = EDI \times CSF \ldots$ equation 3
CSF: Cancer Slope Factor (CSF) (Pb-0.0085; Cd-0.38; Cr-0.5; and Ni-0.91 mg/kg/day respectively was adopted based on USEPA 2017 and Liu *et al.,* 2021)
EDI: Estimated Daily Intake for each element ($mgkg^{-1}day^{-1}$)

Results and Discussions

Heavy metal concentration in foreign and local tea brands compared to standards

Table 1 as follows describes the findings of the study on the concentration of heavy metals in tea brands sold within the study area as well as compares it to known standards related to tea.

Table 1. Heavy metals concentration in sample tea brands

SN	SAMPLE CODE	Heavy Metals (mg/kg)						
		Cd	Cr	Cu	Fe	Ni	Pb	Zn
1	GTF-B007-1	0.269	0.014	0.093	1.072	0.102	0.345	0.172
2	GTF-B008-2	0.228	0.007	0.162	0.750	0.095	0.613	0.217
3	GTF-B009-3	0.236	0.025	0.310	2.625	0.096	0.376	0.335
4	GTF-B010-4	0.195	0.076	0.233	10.240	0.096	0.400	0.363
5	GTF-B011-5	0.218	0.014	0.059	2.139	0.081	0.353	0.116
	Mean	***0.229***	***0.027***	***0.171***	***3.365***	***0.094***	***0.417***	***0.241***
6	GTF-G002-1	0.244	0.082	0.112	1.287	0.090	0.379	0.196
7	GTF-G003-2	0.210	0.047	0.130	1.380	0.098	0.333	0.258
	Mean	***0.23***	***0.06***	***0.12***	***1.33***	***0.090***	***0.36***	***0.23***
8	GTL-B012-1	0.192	0.105	0.089	9.816	0.103	0.411	0.224
9	GTL-B013-2	0.200	0.045	0.108	2.579	0.120	0.394	0.198
10	GTL-B014-3	0.204	0.182	0.096	12.610	0.130	0.390	0.166
11	GTL-B015-4	2.147	0.004	0.054	1.089	0.112	0.451	0.280
12	GTL-B017-5	0.200	0.270	0.116	17.550	0.138	0.447	0.258
	Mean	***0.589***	***0.121***	***0.093***	***8.729***	***0.121***	***0.419***	***0.225***
13	GTL-G001-1	0.216	0.096	0.065	0.951	0.076	0.326	0.099
14	GTL-G016-2	0.213	0.059	0.102	2.689	0.118	0.433	0.251
	Mean	***0.215***	***0.078***	***0.084***	***1.820***	***0.097***	***0.380***	***0.175***
	Maximum Limits (mg/Kg)	**0.1***	****5.0**	****6.0**	-	-	**0.5***	-

*NAFDAC Tea Regulation (2025), **China Health Commission (2022)

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Table 1 shows that there is variation in cadmium concentration among sample tea brands, cadmium concentration fall within the range 0.192 - 2.147 mg/kg among tea brand sampled. The Table 1 also reveals that, group mean cadmium concentration in tea brands is highest among local black tea brands (0.589 mg/kg), and lowest among local green tea (0.215 mg/kg). Compared to a standard on the other hand, cadmium concentrations in sample tea brands within the study area as shown in Table 1 fall above maximum limit set by NAFDAC in tea regulations. The presence of a single local brand (GTL-B015-4) with an extremely high Cd concentration (2.147 mg/kg) is a significant public health concern and warrants further investigation. The observed mean cadmium concentration in each black tea (foreign and local) in the study is higher than mean black tea cadmium concentration found in processed teas of Bangladesh by Rashid et al. (2016). Mean cadmium concentration for each tea group in this study is also higher than 0.18mg/kg recorded in north western Nigeria by Rabiu and Abubakar (2025) but contradicts 0.000mg/kg found in southern Nigeria by Ozukwe et al. (2023). Thus, suggest that heavy metal exposure through tea in Nigeria is markedly region- and product-dependent.

Chromium concentrations in sampled tea brands ranged between 0.007mg/kg and 0.270 mg/kg as shown in Table 1. The concentration of chromium in all samples fall below maximum permissible level set for tea as pegged by Chinese Health Commission (2022). The Table 1 also reveals that group-by-group comparison of mean concentration of chromium among tea group indicates higher mean concentration among local black tea brands while the lowest mean concentration of chromium was observed in foreign black teas. Chromium concentration in the study is similar to that found by Stoner et al. (2025) in the USA.

Table 1 still show distinguishing Nickel concentration distribution among sample tea in the Gombe Metropolis. Consequently, Table 1 reveals that nickel concentration in individual samples ranged between 0.0076 mg/kg and 0.138 mg/kg, within groups on the other hand, mean nickel concentration is highest in the local black teas (0.121 mg/kg) and lowest in the foreign green tea group (0.090 mg/kg). Although no set maximum limit is fixed for nickel in tea, the observed concentrations in the samples are higher than the range of nickel concentration found in tea in a study by Stoner et al. (2025). Higher nickel concentration in black tea compare to green tea follows a similar pattern as the one discovered in North-Western Nigeria. (Rabiu & Abubakar, 2025).

Lead concentration in sample tea brands according to Table 1 range between 0.326 mg/kg and 0.613 mg/kg. Furthermore, lead concentrations among sample tea all fall below maximum level (0.5mg/kg) except in GTF-B008-2 as set by NAFDAC tea regulations (2025). Although an outlier sample with the highest lead concentration fall among the foreign black tea, the mean concentration of lead is highest in local tea as revealed by 0.419 mg/kg

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Prof. E. Mclenna [Australia]

in Table 1. Observed range of lead concentration in this study differs greatly from 0.031-0.124mg/kg found in Ozukwe et al. (2023) study, but fall similar to global mean lead concentration in tea (0.55 mg/kg) discovered in a met-analysis by Mehri et al. (2020).

Table 1 also describe the concentration of essential trace metal such as copper, iron and zinc. It reveals that copper concentrations in sample tea brands range between 0.054mg/kg and 0.310 mg/kg, the concentration among tea brands analysed all fall below 0.6g/kg limit set for tea (China Health Commission, 2022). Iron and Zinc concentration in tea samples on the other hand as shown in Table 1 range between 0.750mg/kg to 17.550mg/kg and 0.099mg/kg to 0.363mg/kg respectively. Although no health based maximum limit is set for zinc, the observed concentration in this study is higher than concentrations found in Ozukwe et, al (2023), and Okunola et al. (2025). Furthermore, iron concentration indicates the highest mean concentration for each group with local black tea being the top followed by foreign black tea.

In order to investigate the degree of similarity in heavy metal concentrations among foreign and local tea, Table 2 shows the compared concentration for each metal between locally processed tea brands and their foreign counterparts;

Table 2. T-test comparing heavy metal concentration in foreign tea and local teas brands

Heavy Metal	Foreign Tea Mean ±SD	Local Tea Mean ±SD	Welch T test	p-value	Significance (α=0.05)
Cd	0.229±0.024	0.482±0.734	0.91	0.397	NO
Cr	0.038±0.031	0.109±0.090	1.96	0.088	NO
Cu	0.157±0.087	0.090±0.023	1.97	0.091	NO
Fe	2.785±3.350	6.755±6.582	1.42	0.189	NO
Ni	0.094±0.007	0.114±0.020	2.46	0.042	YES
Pb	0.400±0.097	0.407±0.043	0.19	0.855	NO
Zn	0.237±0.088	0.211±0.063	0.63	0.541	NO

Table 2 reveals that there is no significant statistical difference in virtually all heavy metals compared except nickel in this study. This lack of significant difference for most toxic metals suggests that despite potential differences in agricultural practices and regulatory oversight between Nigeria and the exporting regions (e.g., Asia), the heavy metal burden in the final packaged tea product available to consumers in Gombe may be similar. The exception, nickel, points to a source specific local processing or packaging contamination that merits targeted investigation. such contamination could be from contact with processing equipment, storage materials, or soil conditions at the point of local production

EDITOR-IN-CHIEF
Prof. E. Mclenna [Australia]

The associated health risk that comes with heavy metal concentration observed in the various tea groups examined in the study are presented in table 3 as follows;

Table 3. Health risk (Target Hazard Quotient and Hazard Index) of heavy metals in Tea Sample

		THQ of Heavy Metals							Σ THQ (HI)
S/N	SAMPLE CODE	Cd	Cr	Ni	Pb	Fe	Cu	Zn	
1	GTF-B007-1	1.1208	0.0194	0.0213	0.3993	0.0064	0.0097	0.0024	1.5793
2	GTF-B008-2	0.9500	0.0097	0.0198	0.7095	0.0045	0.0169	0.0030	1.7134
3	GTF-B009-3	0.9833	0.0347	0.0200	0.4352	0.0156	0.0323	0.0047	1.5258
4	GTF-B010-4	0.8125	0.1056	0.0200	0.4630	0.0610	0.0243	0.0050	1.4913
5	GTF-B011-5	0.9083	0.0194	0.0169	0.4086	0.0127	0.0061	0.0016	1.3737
	Mean	***0.9550***	***0.0378***	***0.0196***	***0.4831***	***0.0200***	***0.0179***	***0.0033***	***1.5367***
6	GTF-G002-1	1.0167	0.1139	0.0188	0.4387	0.0077	0.0117	0.0027	1.6100
7	GTF-G003-2	0.8750	0.0653	0.0204	0.3854	0.0082	0.0135	0.0036	1.3715
	Mean	***0.9458***	***0.0896***	***0.0196***	***0.4120***	***0.0079***	***0.0126***	***0.0032***	***1.4907***
8	GTL-B012-1	0.8000	0.1458	0.0215	0.4757	0.0584	0.0093	0.0031	1.5138
9	GTL-B013-2	0.8333	0.0625	0.0250	0.4560	0.0154	0.0113	0.0028	1.4062
10	GTL-B014-3	0.8500	0.2528	0.0271	0.4514	0.0751	0.0100	0.0023	1.6686
11	GTL-B015-4	8.9458	0.0056	0.0233	0.5220	0.0065	0.0056	0.0039	9.5127
12	GTL-B017-5	0.8333	0.3750	0.0288	0.5174	0.1045	0.0121	0.0036	1.8746
	Mean	***2.4525***	***0.1683***	***0.0251***	***0.4845***	***0.0520***	***0.0096***	***0.0031***	***3.1952***
13	GTL-G001-1	0.9000	0.1333	0.0158	0.3773	0.0057	0.0068	0.0014	1.4403
14	GTL-G016-2	0.8875	0.0819	0.0246	0.5012	0.0160	0.0106	0.0035	1.5253
	Mean	***0.8938***	***0.1076***	***0.0202***	***0.4392***	***0.0108***	***0.0087***	***0.0024***	***1.4828***

The USEPA (2017) HI > 1 is the threshold indicating a potential for non-carcinogenic health effects over a lifetime of exposure. Thus, since the individual samples and mean HI for all four-tea groups have exceeded the threshold of 1 as shown in Table 3, it suggests that there is a potential health risk for habitual adult tea drinkers in Gombe. Table 3 also shows that for all groups except Local Black tea, Cadmium (Cd) is the primary contributor to the HI. This aligns with the findings of Rabiu and Abubakar (2025) in Northwestern Nigeria, who reported HI > 1 for some green tea brands due to Cd but differ significantly from Ozukwe et al. (2023) who indicated insignificant contribution of cadmium to health risk. Compare to other beverages such zobo, kunu, palmwine and ogogoro, the HI determined for tea in this study is significantly higher than the non-carcinogenic health risk pose by other local beverages found by Ogidi et al. (2021).

The Incremental Lifetime Cancer Risk (ILCR) is assessed for the carcinogenic metals (Cd, Cr, Ni, Pb) in this study. The Table 4 shows the calculated carcinogenic risk for some of the heavy metals analysed in this study;

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Table 4. Carcinogenic Risks of some Heavy Metals in Foreign and local Tea

S/N	SAMPLE CODE	ILCR of Carcinogenic Heavy Metals				ΣILCR
		Cd	Cr	Ni	Pb	
1	GTF-B007-1	4.26E-04	2.92E-05	3.87E-04	1.22E-05	8.54E-04
2	GTF-B008-2	3.61E-04	1.46E-05	3.60E-04	2.17E-05	7.58E-04
3	GTF-B009-3	3.74E-04	5.21E-05	3.64E-04	1.33E-05	8.03E-04
4	GTF-B010-4	3.09E-04	1.58E-04	3.64E-04	1.42E-05	8.45E-04
5	GTF-B011-5	3.45E-04	2.92E-05	3.07E-04	1.25E-05	6.94E-04
	Mean	***3.63E-04***	***5.67E-05***	***3.56E-04***	***1.48E-05***	***7.91E-04***
6	GTF-G002-1	3.86E-04	1.71E-04	3.41E-04	1.34E-05	9.12E-04
7	GTF-G003-2	3.33E-04	9.79E-05	3.72E-04	1.18E-05	8.14E-04
	Mean	***3.59E-04***	***1.34E-04***	***3.56E-04***	***1.26E-05***	***8.63E-04***
8	GTL-B012-1	3.04E-04	2.19E-04	3.91E-04	1.46E-05	9.28E-04
9	GTL-B013-2	3.17E-04	9.38E-05	4.55E-04	1.40E-05	8.79E-04
10	GTL-B014-3	3.23E-04	3.79E-04	4.93E-04	1.38E-05	1.21E-03
11	GTL-B015-4	3.40E-03	8.33E-06	4.25E-04	1.60E-05	3.85E-03
12	GTL-B017-5	3.17E-04	5.63E-04	5.23E-04	1.58E-05	1.42E-03
	Mean	***9.32E-04***	***2.53E-04***	***4.57E-04***	***1.48E-05***	***1.66E-03***
13	GTL-G001-1	3.42E-04	2.00E-04	2.88E-04	1.15E-05	8.42E-04
14	GTL-G016-2	3.37E-04	1.23E-04	4.47E-04	1.53E-05	9.23E-04
	Mean	***3.40E-04***	***1.61E-04***	***3.68E-04***	***1.34E-05***	***8.82E-04***

The interpretation of the ILCR results in this study follows U.S. EPA (1989) ratings, that is, ILCR below 1×10^{-6} is considered negligible, and ILCR between 1×10^{-6} and 1×10^{-4} are considered potential but tolerable risk range. While, an ILCR above 1×10^{-4} indicates an unacceptable potential carcinogenic risk, denoting a significant public health hazard requiring immediate mitigation.

Thus, Table 4 indicates that, all sample tea brands analysed in the study fall within the unacceptable carcinogenic risks class. To be specific, Table 4 indicates that about 2 in 1,000 chronic consumers of locally processed black tea are at risk of developing cancer for ingesting at least 1 cup (0.25l) everyday, while roughly 9 in 10,000 chronic drinkers of locally processed green tea could develop cancer. Similarly, about 8 in 10,000 chronic consumers of foreign processed black tea are at risk of developing cancer for ingesting at least 1 cup (0.25l) everyday, roughly 8 in 10,000 persons who drink foreign processed green tea everyday could develop cancer. The observed probability of carcinogenicity in sample teas requires further studies to confirm the results as well as determine location-specific factors influencing these results

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Conclusion

The study provides a comparative assessment of heavy metal concentrations and associated health and carcinogenic risks in foreign and locally processed tea brands sold within Gombe Metropolis, North-Eastern Nigeria. Cadmium concentrations exceeded the NAFDAC maximum limit in all fourteen tea brands examined, with local black tea showing the highest mean concentration and the greatest sample-to-sample variability, including one brand with an extremely high value. Chromium and copper concentrations remained within permissible limits, while lead exceeded the NAFDAC limit in one foreign black tea brand. Foreign and local tea did not differ significantly in most metal concentrations, except nickel, suggesting a broadly comparable metal burden regardless of origin. Hazard Index values above 1 for all tea groups indicate a potential non-carcinogenic health risk for habitual adult tea drinkers in Gombe, driven mainly by cadmium, while Incremental Lifetime Cancer Risk values point to an unacceptable carcinogenic risk for all tea sampled. NAFDAC and other regulatory bodies should intensify heavy metal surveillance of tea, particularly locally processed black tea, sold within Gombe Metropolis and similar secondary Nigerian cities, and larger, method-validated follow-up studies are recommended to confirm the magnitude of risk identified here.

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