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Assessment of the Proximate and Heavy Metals Composition of Some Street-Vended Foods Sold in Ado/Iworoko Ekiti, and their Health Implications

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ABSTRACT

Street foods are very popular among general population due to its price affordability and convenience. This reasonable price turns out to be the main reason for most of low-income family in hunting everyday meals. This study is designed to assess the basic nutritional composition, levels of heavy metals and health risks associated with their consumption. Five common street-vended foods (Dokua, Fried plantain, Roasted maize, Moimoi, Roasted plantain) consumed in Ado and Iworoko-Ekiti, of Ekiti State, Nigeria were examined using standard analytical techniques. The results showed that the samples, in terms of proximate composition (%), had values ranged as follows: crude fat (1.56 - 10.4), crude protein (7.20- 12.6), ash content (1.93 – 4.71), fibre (1.35 – 12.4), moisture (2.99 – 14.1), CHO (60.3 – 77.8), proportion of energy due to fat (PEF) (4.20 – 24.2), due to protein (PEP) (8.66 – 13.1), due to carbohydrate (62.7 – 88.1), Utilizable energy due to protein (UEDP) (5.20 – 7.86), gross energy (kJ/100g)(1412 - 1635). Concentrations (mg/kg) of heavy metals: Co, Ni, Pb, Cd, Cr all ranged between 0.00015 – 0.255), Zn, Mn (1.48 – 6.12). Generally for all the heavy metals analyzed, estimated daily intakes (EDI and EDI/Df) were far below the maximum tolerable daily intakes and Target hazard quotient (THQ) and Hazard Index (HI) were all lower than 1.0 across all the selected street-vended food for both adults and children set by FAO, WHO and USEPA. However, the calculated Target cancer risks (TCR) values for both adults and children categories indicated low to moderately high carcinogenic risks. Statistical analysis (correlation) indicated that there exists significant difference between the results for the analyzed street vended foods in terms of nutritional and heavy metals composition.

Keywords: Street-vended foods, heavy metals, health implications

INTRODUCTION

Today, the majority of the food energy required by the ever-increasing population of the world is supplied by the industrial food industry, which produces food with intensive agriculture and distributes it through complex food processing and food distribution systems. The food system has significant impacts on a wide range of other social and political issues including: sustainability, biological diversity, economics, population growth, water supply, and access to food. The right to food is a human right derived from the International Covenant on Economic, Social and Cultural Rights (ICESCR), recognizing the "right to an adequate standard of living, including adequate food", as well as the "fundamental right to be free from hunger". Because of these fundamental rights, food security is often a priority international policy activity; for example, Sustainable Development Goal 2 "Zero hunger" is meant to eliminate hunger by 2030. Food safety and food security are monitored by international agencies like the International Association for Food Protection, World Resources Institute, World Food Programme, Food and Agriculture Organization, and International Food Information Council, and are often subject to national regulation by institutions, like the Food and Drug Administration in the United States. [1].

Street Vended food are defined as foods and beverages prepared and/or sold by vendors in streets and other public places for immediate consumption or consumption at a later time without further processing or preparation. This definition includes fresh fruits and vegetables which are sold outside authorized market areas

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for immediate consumption [2]. Because of socioeconomic changes in many countries, this sector has experienced significant growth during the past few decades. Urbanization and population growth, especially in developing countries, are expected to continue into the next century and street-vended foods, which are largely but not exclusively an urban phenomenon, will expand accordingly.

While street-vended foods are appreciated for their unique flavours as well as their convenience, they are also often essential for maintaining the nutritional status of the population. Street food vending assures food security for low-income urban populations and provides a livelihood for a large number of workers who would otherwise be unable to establish a business for want of capital. Street food vending also offers business opportunities for developing entrepreneurs. In contrast to these potential benefits, it is also recognized that street-food vendors are often poor and uneducated and lack appreciation for safe food handling. Consequently, street foods are perceived to be a major public health risk. If a community is to have the full benefits of street-vended foods with minimal risk of food borne disease, government intervention is required to ensure that the standard of safety for such foods is the best attainable in the context of the prevailing local situation [3].

Food safety is used as a scientific method/discipline describing handling, preparation, and storage of food in ways that prevent food-borne illness. The occurrence of two or more cases of a similar illnesses resulting from the ingestion of a common food is known as a food-borne disease outbreak [4]. This includes a number of routines that should be followed to avoid potential health hazards. In this way, food safety often overlaps with food defense to prevent harm to consumers. The tracks within this line of thought are safety between industry and the market and then between the market and the consumer. In considering industry to market practices, food safety considerations include the origins of food including the practices relating to food labeling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food and guidelines for the management of governmental import and export inspection and certification systems for foods. In considering market to consumer practices, the usual thought is that food ought to be safe in the market and the concern is safe delivery and preparation of the food for the consumer.

Food can transmit pathogens which can result in the illness or death of the person or other animals. The main types of pathogens are bacteria, viruses, mold, and fungus. Food can also serve as a growth and reproductive medium for pathogens. In developed countries there are intricate standards for food preparation, whereas in lesser developed countries there are fewer standards and less enforcement of those standards. Another main issue is simply the availability of adequate safe water, which is usually a critical item in the spreading of diseases. [5].

Street foods are very popular among general population due to its price affordability and convenience [6]. This reasonable price turns out to be the main reason for most of low-income family in hunting everyday meals. It also provides business opportunity with minimum costs capital [7]. Often, street food is perceived as major public health risk due to reasons such as poor vendors, inadequate education and lack of knowledge plus appreciation of basic food safety [8]. Street food are only considered as contaminated with heavy metals if it is greater than 5 mg/cm^3 as a result of exposure to the open air and other sources. Aluminum (Al), Cobalt (Co), lead (Pb), cadmium (Cd), chromium (Cr), Nickel (Ni), Arsenic (As), Manganese (Mn) and other rare metals are examples of heavy metals exposed [9].

There is increasing recognition that street food vending plays an important socio-economic role in terms of employment potential, providing special income particularly for women and provision of food at affordable costs to mainly the lower income groups in the cities [10]. Because of socioeconomic changes in many countries, this sector has experienced significant growth during the past few decades [3]. Increased industrialization and civilization in the general populace has made these vended food sources a popular menu even among the elites here are varieties of street vended foods/snacks consumed in Nigeria.

As human activities increase, especially with the application of modern technologies, pollution and contamination of human food chain has become inevitable. In particular, human exposure to heavy metals has risen dramatically in the last 50 years as a result of an exponential increase in the use of heavy metals in industrial processes and products. Heavy metals have been reported to have positive and negative roles in human life [11,12,13,14]. Cadmium, lead and mercury are major contaminants of food supply and may be considered the most important problem to our environment while others like iron, zinc and copper are essential

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for biochemical reactions in the body [15]. The main possible issue with foods sold on streets that can impose health hazards for consumers is their contamination. The contamination of street foods with chemical, and metallic agents causes a huge disease burden and a major public concern [46].

The presence of heavy metal at an unacceptable level in food will contribute to negative effects to human health [7]. Foods that are being sold near roads especially are the one easily exposed to these heavy metals. High concentration of heavy metal in human body will possibly damage several biochemical processes, leading to kidney, bones, liver, brain, nervous system and cardiovascular problems [8]. Nuapia *et al*. [8] also stated that the major source of heavy metal contamination in food is not only from vehicle emission and atmospheric deposition but also from exposure to the chemicals and microbes. Not just sold near roads, but overcrowded areas such as taxi ranks and busy street pavements is also the reason why these street foods are easily contaminated with heavy metals. According to Asiegbu *et al*.[16], people who consume street food may be potentially exposed to the foodborne hazard such as salmonellosis, listeriosis, typhoid fever, cholera and nausea. High concentration of heavy metal in the human body can lead to damage for several biochemical processes, leading to kidney, bones, liver, brain, nervous system and cardiovascular problems [8]. Street vended foods are increasingly consumed in educational institutions, markets, auto stations, and industrial areas in mainly developing countries without the safety of these foods being guaranteed. Therefore, this study was conducted to analyze the basic nutritional contents and heavy metals contamination in Five common street-vended foods (Dokua, Fried plantain, Roasted maize, Moimoi, Roasted plantain) consumed in Ado and Iworoko-Ekiti, of Ekiti State, Nigeria.

MATERIALS AND METHODS

Collection and treatment of samples

The selected street vended food (Dokua, Fried plantain, Roasted maize, Moimoi, Roasted plantain) samples were randomly purchased from different vendors, both in Iworoko and Ado-Ekiti streets, Ekiti State, Nigeria in the month of December, 2024. The food samples were oven dried after which they were grounded into fine powder using Excella mixer grinder II (3 Jars) and stored in a screw capped containers prior to analysis

Proximate Determination

Micro-Kjedahl method [17] was followed to determine the crude protein. The crude fat was extracted with a chloroform/methanol (2:1 v/v) mixture using Soxhlet extraction apparatus method while carbohydrate was determined by difference. The calorific value in kilojoule (kJ) was calculated by multiplying the crude fat, protein and carbohydrate by Atwater factors of (kJ) 37, 17 and 17 respectively. All determinations were in duplicate.

Heavy metal determination

The metals were analyzed from the solution obtained by initially dry ashing the samples at 550 ^{o}C. Filtered solutions were used to determine Zn, Fe, Mn, Cu, Pb and Cd by means of atomic absorption spectrophotometer (Buck Scientific Model- 200A/210, Norwalk, Connecticut 06855). All chemicals used were of British Drug House (BDH, London, UK) analytical grade. Earlier, the detection limits for the metals in aqueous solution had been determined using the methods of Varian Techtron, Varian [45]. The optimal analytical range was 0.1-0.5 absorbance units with coefficients of variation from 0.9% to 2.21%. From the mineral elements determined, further calculations were made.

Other calculations

Other calculations made include, the estimated daily intake (EDI), target hazard quotient (THQ), chronic hazard index (HI), EDI/D_f ratio and target cancer risk (TCR)

Estimated daily intake (EDI)

Daily intake of contaminated vegetables is a general pathway of heavy metal exposure to human. EDI of heavy metals from these foods was calculated using the equation [18,19]:

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$$EDI = \frac{Cm \times Df}{Bw} \qquad (1)$$

where C_m is the concentration of heavy metals ($m_g\ k_g^{-1}$ dry weight), D_f denotes the daily intake of food in k_g per person per day and B_w is the average body weight in kg (70 for adults, 24 for children).

Non-carcinogenic risk

Target hazard quotient (THQ)

THQ was calculated by the following formula [18]:

$$THQ = \frac{EDI \times Ef \times De}{Df \times Tavncar} \qquad (2)$$

where, THQ represents non-cancer risks, Ef denotes the exposure frequency (365 days $year^{-1}$), and De denotes exposure duration (56 years) [19, 20]. Reference doses (D_f) of Fe, Mn, Cu, Zn, Pb, and Cd are 0.7, 0.14, 0.04, 0.03, 0.0035 and 0.003 (mg, kg^{-1} day^{-1}) respectively [18,21] and Tavncar represents average time for non-carcinogens (365days $year^{-1}$ x De) [19].

Chronic hazard index (HI)

Chronic hazard index (HI) is the sum of more than one hazard quotient for multiple toxicants or multiple exposure pathways [18,19]. This was calculated using the equation:

$$HI = \sum THQ \qquad (3)$$

Carcinogenic risk

Target cancer risk (TCR)

TCR was estimated by using the formula:

$$TCR = THQ \times S_{epo} \qquad (4)$$

S_{epo} (carcinogenic potency slope), the reference values for Pb and Cd are 0.0085 and 6.1 mg kg^{-1} body weight $days^{-1}$ respectively [21].

Statistical Analysis

The statistical analysis of the results of nutritional and heavy metals compositions were evaluated using IBM SPSS Statistics Vs21.

RESULTS AND DISCUSSION

The proximate composition of selected street vended foods (SVF) as well as other calculated parameters (energy contributions) were shown in Table 1. Moisture content (%) ranged between 2.99 and 14.1. The values were generally Lowe except for Moimoi (MM) which could affect its keeping quality. Ash content of a food is an indication of inorganic or mineral level. In all the five samples analyzed, the ash content ranged from 1.93 - 4.71%. These values suggest that the SVF could be rich minerals [22,23]. Foods high in dietary fibres have been reported to facilitate feacal elimination, lower the risk of coronary heart diseases, constipation, diabetes, hypertension and colon cancer [24]. The results of fibre in the present report for all the five samples of SVF (1.35 - 12.4 %) especially in fried plantain dodo (FPD) and roasted maize (RM) (9.54 and 12. 4 %, respectively) favour the above representation and benefits. The results for these samples compared favourably with reports from literatures both for foods from animal origin [19,24] and plant origin [22]. The low levels of fat in the samples would improve the health of consumers [24]. The range (1.56 - 4.69 %), with the highest value occurred in Dokua (DK) were in agreement with values reported in the literatures for eight organs of

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Guinea fowl [7,24] and vegetables of *Corchorus olitorious* family [22].

The levels of protein in the samples of SVF ranged from 7.20 - 12.6 g/100g with highest concentration in roasted plantain (RP)(12.6g/100g), closely followed by MM (10.4g/100g). Protein is highly important in foods as it forms basis for nutrition and functional ingredients [25]. It plays a very important role in texture determination in foods. All the samples of SVF showed adequate concentrations that compared favourably with literature reported values for some vegetables: 12.66 g/100g for *A. cruethus*, 9.35 g/100g [26]; *C. olitorious* [22]. Pearson [27] in his earlier report stated that any food that can provide more than 12.0 % of its caloric value from, protein is considered a good protein source. It is therefore good to note that three out of the five SVF samples (DK, RP and MM) would meet this requirement. However, according to NRC [28], more of her samples would need to be consumed in order to meet the recommended 23- 56 g/100g human daily protein requirements.

Proportion of energy contributions by macromolecules (protein, fat and carbohydrate: PEP %, PEF %, PEC %) and utilizable energy due protein (UEDP %) occurred in the following ranges: PEP (8.66 -13.1), PEF (4.20 - 24.2), PEC (62.7 - 88.1) and UEDP (5.20 - 7.86). From the results, the major energy contributions was from carbohydrate and this is likely due to the fact that the SVF samples were mostly from carbohydrate sources. The UEDP % in all the samples were lower than the recommended safe level of 8.0% for an adult man who requires 55 g of protein per day with 60% utilization [24].

Table 1. Proximate composition (%), gross energy (kJ/100g) and various percentage energy contributions of the selected street vended foods

Parameters	DK	RM	FPD	MM	RP	Mean	SD	CV (%)
Crude Fat (%)	4.69	1.56	3.85	2.75	10.4	4.65	3.42	73.6
Crude Protein (%)	7.66	9.45	7.20	10.4	12.6	9.46	2.18	23.1
Carbohydrate (%)	77.8	70.1	65.6	67.3	60.3	68.2	32.5	47.6
Ash (%)	2.03	4.71	2.40	3.10	1.93	2.83	1.14	40.4
Crude Fibre (%)	4.74	9.54	12.4	1.35	4.75	6.56	4.38	66.8
Moisture (%)	2.99	4.63	8.60	14.1	10.1	11.6	7.60	65.5
PEF (%)	11.9	4.20	10.6	7.33	24.2	17.1	14.6	85.0
PEP (%)	8.66	11.4	8.84	12.4	13.1	10.9	2.89	2.65
PEC (%)	88.1	84.4	80.6	80.3	62.7	79.2	21.8	27.5
UEDP (%)	5.20	6.83	5.31	7.44	7.86	6.52	2.74	42.0
Gross Energy (kJ/100g)	1500	1412	1384	1425	1635	1471	540	36.7

DK= Dokua, RM= Roasted Maize, FPD= Fried Plantain (Dodo), MM= Moi Moi, RP= Roasted Plantain, PEF = Proportion of total Energy due to Fat, PEC = Proportion of total Energy due to Carbohydrate, PEP = Proportion of total Energy due to Protein, UEDP = Utilizable Energy due to protein, SD = Standard Deviation, CV = Coefficient of Variation

Table 2. Heavy Metals concentrations (mg/kg) of the selected street vended foods

Heavy Metals	DK	RM	FPD	MM	RP	Mean	SD	CV (%)
Co	0.001	0.0008	0.00063	0.00015	0.0005	0.000516	0.000239	46.3
Mn	1.48	4.96	2.78	1.78	2.11	2.62	1.39	53.1
Ni	0.013	0.01	0.011	0.0015	0.014	0.0099	0.004955	50.0

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Zn	3.57	6.12	4.29	1.60	3.67	3.85	1.62	42.1
Pb	0.111	0.2011	0.022	0.201	0.255	0.158	0.092	58.2
Cd	0.112	0.0231	0.2115	0.115	0.0012	0.093	0.084	90.71
Al	0.017	0.015	0.016	0.001	0.017	0.013	0.0069	52.0
As	ND	ND	ND	ND	ND	Na	Na	Na
Hg	ND	ND	ND	ND	ND	Na	Na	Na
Cr	0.045	0.071	0.053	0.026	0.046	0.048	0.026	54.2

ND = Not determined, Na = Not applicable

Concentrations (mg/kg) of heavy metals in the samples are depicted in Table 2. Heavy metals have been widely reported to adversely affect the nutritional values of agricultural produce leading to their deleterious effects on humans [29,30]. Exposures to heavy metals by humans have been the main focus of attention among researchers and health, and nutrition experts due to their public health implications [31]. The present report had the following concentration (mg/kg) ranges across the SVF samples analyzed: Co (0.00015 - 0.001), Mn (1.48 - 4.96), Ni (0.0015 - 0.014), Zn (1.60 - 6.12),

Pb (0.022 - 0.255), Cd (0.0012 - 0.231), Al (0.001 - 0.017) and Cr(2.60 - 7.12). From the results, RM had the highest concentration of the following metals: Co, Mn, Zn, CD and Cr. This could be due to the processing methods used (open tray roasting and display during sale). As and Hg were not detected in any of the samples analyzed. These are highly toxic metals, their presence in foods is undesirable and should very negligible or trace amounts [30]. According to Iweala *et al*. [32], generally in areas with high anthropogenic pressure, heavy metals concentration is widespread and it is the major determinant of food quality. The concentration of Pb in the samples were all found to lower than the permissible levels of 0.3 mg/kg set by FAO/WHO [33]. The levels of Lead in the present report compares favourably with previous reports on metals on ready to eat foods [34] and street vended fruits and vegetables [30]. The presence of lead in the street vended foods may be as a result of processing, ingredients handling and preparation methods which usually involve roasting and burning of woods. It could also be due to open display of the foods on public places such as road sides, allowing deposition and accumulation of heavy metals [20]. Health issues associated with lead according to Adefemi *et al.* [35] was reported to include abdominal pains, renal diseases, interference with peripheral nervous system in children and cardiovascular diseases. Nevertheless, the low levels of Pb recorded in the SVF may not pose any immediate health threat to consumers.

The level (mg/kg) of Cd in the samples were comparably lower than the 0.3mg/kg maximum permissible limit set by WHO [36]. The highest level was found in RM (roasted maize). Cadmium presence in the samples, even at trace concentration is undesirable and may have resulted from certain processes such as roasting and mode of sale. Literatures have shown Cd to be carcinogenic at high concentration and it's accumulation in the kidney can cause renal track impairment, weak bones and lung problem [37].

The concentration of Zn in the analyzed samples of SVF (1.60 - 6.12) mg/kg were lower than the 50.0 mg/kg and 60 mg/kg maximum permissible limits provided by Chinese Department of Preventive Medicine (CDPM) [38] and FAO/WHO [2] respectively. Human body regimes Zn at low level as an essential trace element. It performs several positive function which include: metabolism of cholesterol and carbohydrates [20]. It is therefore worthy of note that presence of Zn at these level in the samples would be beneficial in human nutrition [20, 22]. As given by WHO [3], the maximum permissible limit for Ni is 10.0mg/kg. In the present report, levels of Ni in the samples were comparably lower than the set maximum limit. Through Ni in trace amount may be beneficial biochemically for activation of some enzymes in the body. However, toxicity at reflectively high concentration in more pronounced especially consumption over a long period of time [20,22].

It is important to note that the presence of Cr, Al and Co in the selected street vended foods at high concentration were not desirable [39] and can result from several factors including environmental concentration cooking methods and mode of display at the point of sale [20,22]. However, as shown in the

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present result, the levels of Cr, Al and Co were comparably low compared to the set maximum levels (mg/kg) [Cr = 0.2, Co = 0.03 Al = 1.0] [18,19,39].

The Estimated Daily Intake (EDI) for the selected street vended foods is shown in Table 3.

Table 3. Estimated Daily Intake in the selected street vended foods for Adult (70kg body weight) and Children (24kg body weight)

HM	Adult (70 kg body weight)					Children (24 kg body weight)				
	DK	RM	FPD	MM	RP	DK	RM	FPD	MM	RP
Co	1.43E-07	2.29E-07	1.8E-07	4.29E-08	1.43E-07	4.17E-07	6.67E-07	5.25E-07	1.25E-07	4.17E-07
Mn	0.00296	0.00992	0.00556	0.00356	0.00422	0.008633	0.028933	0.016217	0.010383	0.012308
Ni	3.71E-06	2.86E-06	3.14E-06	4.29E-07	0.000004	1.08E-05	8.33E-06	9.17E-06	1.25E-06	1.17E-05
Zn	0.00153	0.002623	0.001839	0.000686	0.001573	0.004463	0.00765	0.005363	0.002	0.004588
Pb	5.55E-06	1.01E-05	1.1E-06	1.01E-05	1.28E-05	1.62E-05	2.93E-05	3.21E-06	2.93E-05	3.72E-05
Cd	4.8E-06	9.9E-07	9.06E-06	4.93E-06	5.14E-08	0.000014	2.89E-06	2.64E-05	1.44E-05	1.5E-07
Al	9.71E-08	8.57E-08	9.14E-08	5.71E-09	9.71E-08	2.83E-07	2.5E-07	2.67E-07	1.67E-08	2.83E-07
As	Na	Na	Na	Na	Na	Na	Na	Na	na	na
Hg	Na	Na	Na	Na	Na	Na	Na	Na	na	na
Cr	0.0765	0.131143	0.091929	0.034286	0.078643	0.223125	0.3825	0.268125	0.100	0.229375

The estimated daily intake for the heavy metal content of the selected street vended foods for adults (70kg, bw) and children (24kg, bw) are shown in Table 3 above. To access the risk of heavy metal exposure to human health in the exposed population, information about the dietary intake is necessary. Generally, for all the heavy metals analyzed, estimated daily intakes were far below the maximum tolerable daily intake for both adults and children set by FAO, WHO and USEPA [3,21, 40].

The EDI/Df ratios of the analyzed heavy metals are also presented above. The comparison of EDI values and of heavy metals with the respective reference dose (Df) revealed that the EDI value of all heavy metals were lower than the Df for all the heavy metals. In this regard, the New York State Department of Health (NYSDOH)[41] suggested that if the ratio of EDI/Df is less than or equal to the Df. the risk will be minimal. In the present report, the ratios are all less than the Df, indicating that the risk will be minimal [18,19,20].

The Target Hazard Quotient (THQ), Hazard Index (HI) and Target Cancer Risk (TCR) of the selected street vended foods is shown in Table 4 (for Adult (70kg average body weight) and Children (24kg average body weight).

Table 4. Target Hazard Quotient (THQ), Hazard Index (HI) and Target Cancer Risk (TCR) of the selected street vended foods

HM	Adult (70 kg body weight)					Children (24 kg body weight)				
	DK	RM	FPD	MM	RP	DK	RM	FPD	MM	RP
Co	7.14E-06	1.14E-05	0.000009	2.14E-06	7.14E-06	2.08E-05	3.33E-05	2.63E-05	6.25E-06	2.08E-05
Mn	0.021143	0.070857	0.039714	0.025429	0.030143	0.061667	0.206667	0.115833	0.074167	0.087917
Ni	0.000186	0.000143	0.000157	2.14E-05	0.0002	0.000542	0.000417	0.000458	6.25E-05	0.000583
Zn	0.051	0.087429	0.061286	0.022857	0.052429	0.14875	0.255	0.17875	0.066667	0.152917
Pb	0.001586	0.002873	0.000314	0.002871	0.003643	0.004625	0.008379	0.000917	0.008375	0.010625
Cd	0.0016	0.00033	0.003021	0.001643	1.71E-05	0.004667	0.000963	0.008813	0.004792	0.00005
Al	0.000243	0.000214	0.000229	1.43E-05	0.000243	0.000708	0.000625	0.000667	4.17E-05	0.000708

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As	Na	Na	Na	Na	Na	Na	Na	Na	na	na
Hg	Na	Na	Na	Na	Na	Na	Na	Na	na	na
Cr	0.051	0.087429	0.061286	0.022857	0.052429	0.14875	0.255	0.17875	0.066667	0.152917
HI	0.126764	0.249286	0.166016	0.075695	0.13911	0.369729	0.727083	0.484214	0.220777	0.405738
TCR	0.009773	0.002037	0.018433	0.010046	0.000136	0.028506	0.005942	0.053764	0.0293	0.000395

The THQ results for the adult category ranged as follows Cd (2.14e-06 to 1.14e-05), Mn (0.021143 to 0.070857), Ni (0.0000214 to 0.0002), Pb (0.000314 to 0.002873), Cd (1.7e-05 to 0.003021), and Cr (0.022857 to 0.087429).

For adults, as shown above, no THQ value was greater than 1.0 for any of the metals across all the street vended foods. THQ is the measure of the possibility of developing non-carcinogenic health problems and the acceptable limit is ≤ 1.0. If the THQ value obtained for individual heavy metal is greater than the tolerable limit, it might pose non-carcinogenic health risks to human.

In this study, the THQ value across the entire street vended for all metals were less than 1.0 for both adult and children. Hazard index, which is calculated to assess the combined risk of heavy metal toxicity, is the sum total of all the THQ values in a food sample and a value greater than 1.0 is an indication that the probability of an adverse health effect associated with such exposure is high [18,19,21]. In adults, the values of HI ranged from 0.075695 to 0.249286. These values were comparably lower than the tolerable limit of 1.0 and same in children and so the consumption of these foods may not increase the exposure risk and possibility of metal toxicity [44].

Carcinogenic risk is estimated and expressed as a probability of contracting cancer over a lifetime of 70 years. In the present study, the possibility of development cancer was calculated based on the USEPA approach. Prolonged exposure to a specific carcinogen may develop cancer and the probability increases with contact time [21, 42, 43].

According to New York State Department of Health [41], the TCR categories are described as follows: Low risk, if the TCR value is $\leq 10^{-6}$, moderate risk if the TCR value is between 10^{-5} and 10^{-3}, high risk, if the TCR value is 10^{-3} to 10^{-1}, and very high risk if the TCR value is 10^{-1}. In this study, the TCR value in Table 4 for Pb (adult: 0.000314 - 0.002873), Cd (adult: 1.71E-05 - 0.003021) revealed moderate to high carcinogenic risk, whereas for children, the TCR values for Pb (0.000917 - 0.010625) and Cd (0.00005 - 0.008813) showed moderate to high carcinogenic risks from the consumption of these street vended foods

Table 5. Statistical analysis (correlation) of results from Table 1.

	Co	Mn	Ni	Zn	Pb	Cd	Al	Cr
Co	1							
Mn	.249	1						
Ni	.733	.067	1					
Zn	.666	.850	.560	1				
Pb	-.367	.092	-.140	-.106	1			
Cd	-.033	-.295	-.228	-.266	-.906*	1		
Al	.802	.226	.978**	.696	-.252	-.147	1	
Cr	.655	.858	.545	1.000**	-.115	-.252	.684	1

**. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed)

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Table 6. Statistical analysis (correlation) of results from Table 2.

	DK	RM	FPD	MM	RP
DK	1				
RM	1.000**	1			
FPD	1.000**	1.000**	1		
MM	1.000**	1.000**	1.000**	1	
RP	1.000**	1.000**	1.000**	1.000**	1
**. Correlation is significant at the 0.01 level (2-tailed).					

Results of statistical analysis (correlation, $r_{=0.01, 0.05}$) are shown in Tables 5 and 6 for results from Tables 1 and 2 respectively. The results indicated that there were significant difference between the parameters at $r_{=0.01}$ and $_{0.05}$.

CONCLUSION

Street-vended foods form an important part of human diets and also represent an important route through which contaminants especially heavy metals get into human body. From this study, generally low level of heavy metal concentrations were observed in all the samples of street-vended foods analyzed when compared with the permissible limits set by FAO/WHO. However, the results of this study revealed that the level of contamination with respect and calculated THQ, HI and Target cancer risks of heavy metals were between low to moderately high carcinogenic risks. Nonetheless, adequate regular monitoring and proper hygiene are highly recommended especially at the points processing and sale.

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