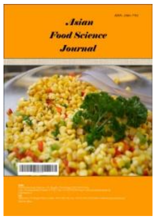

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Heavy Metals Health Risk Assessment through Consumption of Baobab Leaf Cultivated in Katsina State, North West Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author AIY designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors AJA, AN, KIM, AU and AI performed the statistical analysis and manage the analysis of the study. Authors IUM, LAS and MAD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Vegetables play important roles in human nutrition and health. They can also contain some undesirable components that can be harmful, e.g. Pesticides and heavy metals. The objectives of the study were mainly to detect the presence of heavy metals (Cr, Cd, Fe, Ni, Mn, Pb and Zn) in sampled Baobab leaf in Katsina state Nigeria and assessed the human health risks associated with the consumption of the Baobab leaves. The content of these metals was assayed by the AAS method. The health risk to the local inhabitants was evaluated by estimating daily heavy metal

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intake and computing the Incremental Lifetime Cancer Risk (ILCR) and the Target Hazard Quotient (THQ) for cancer and non-cancer risks. The results were compared with the safety standards established by the WHO/FAO and USEPA. With the exception of the heavy metal Pb (0.526-0.981) the mean concentration (mg/kg) range values of Cr (0.116-0.352), Cd (0.041-0.054), Fe (1.016-1.951) and Zn (0.940-1.229) in the samples were generally lower than the USEPA, WHO/FAO maximum permissive limits. The risk level of Target Hazard Quotient (THQ < 1) was observed for all the evaluated heavy metals for both adults and children. The THQ for the samples was in the decreasing order Zn>Fe>Pb>Cr>Cd, for all the baobab leaf samples respectively. All the studied samples showed the risk level (HI < 1). ILCR for Cd violated the threshold risk limit ($>10^{-4}$) and ILCR for Pb reached the moderate risk limit ($>10^{-3}$) for cancer in all the studied samples in adults, While in children ILCR for Pb in samples from Dabai and Daura have reached the moderate risk limit ($>10^{-3}$), while the ILCR for Pb in rest of the samples and ILCR for Cd of all the samples are beyond the moderate risk level ($>10^{-2}$). The consumption of the Baobab leaf sample may contribute to the population cancer burden.

Keywords: Baobab; heavy metals; Katsina; health risk index; cancer risk.

1. INTRODUCTION

Heavy metals are environmental contaminants capable of causing human health problems if excess amount is ingested through food. They are non-biodegradable and persistent, have long biological half-lives and can be bio-accumulated through biological chains [1]. Heavy metal toxicity may occur due to contamination of irrigation water, the application of fertilizer and metal-based pesticides, industrial emission, harvesting process, transportation, storage or sale. Crops and vegetables grown in soils contaminated with heavy metals have greater accumulation than those grown in uncontaminated soils [2]. The toxicity of heavy metals most commonly involves the brain and kidney but other manifestations can occur in some other parts of the body, for example, arsenic is clearly capable of causing cancer, hypertension can result in individuals exposed to lead and renal toxicity in individual exposed to cadmium [3]. The work of Oketayo et al. [4] also indicated that environmental impact assessment must be carried out periodically to monitor the levels of these heavy metals, not only in plant samples but also in the air, soil and water samples.

Apart from their rich contents of vitamin C and beta-carotene, leafy vegetables are an excellent source of mineral constituents whose importance in the human diet is undisputable [5]. Some of them, such as potassium, sodium, phosphorus, calcium, magnesium, or iron, are indispensable in the sustaining human health [6]. However, it is important to monitor the levels of toxic metals in leafy vegetables and fruits due to environmental concerns.

Katsina usually referred to as Katsina State to distinguish it from the city of Katsina, is a state in North West zone of Nigeria. In Katsina State Nigeria, there is limited information on the levels of heavy metals in locally cultivated leafy vegetables. This work therefore seeks to bridge that gap by providing information especially to the Katsina state populace on the levels of heavy metals of these most consumed vegetables. Information will further be provided on the heavy metals composition of the sources of these vegetables and the extent to which they are contaminated with these heavy metals for future studies and effective comparative analysis. The objective of this study, therefore, was to evaluate human exposure to some heavy metals through consumption of some locally cultivated leafy vegetables in Katsina State, Nigeria

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out during 2017 in Katsina State, Nigeria located between latitude 12°15’N and longitude of 7°30’E in the North West Zone of Nigeria, with an area of 24,192km2 (9,341 sq meters). Katsina State has two distinct seasons: rainy and dry. The rainy season begins in April and ends in October, while the dry season starts in November and ends in March. This study was undertaken during the dry season. The average annual rainfall, temperature and relative humidity of Katsina State are 1,312 mm, 27.3°C and 50.2%, respectively [7]. The study was conducted within some catchment areas located within the 3 senatorial zones that make up the state (Katsina senatorial zone: Birchi, Dutsinma and Katsina; Daura senatorial zone: Daura, Ingawa and Zango; Funtua senatorial zone: Dabai, Funtua, Kafur, Malunfashi and Matazu). Sampling for this work was carried out by dividing the catchment areas into five (5) locations. In each of the locations, the plot where the vegetables are cultivated was subdivided into twenty (20) sampling areas. Samples were collected from each of the areas and combined to form bulk sample, from which a representative sample was obtained. The samples were code-named and stored in glass bottles with tight covers to protect them from moisture and contamination. They were then stored in the refrigerator at 4°C until ready for use.

2.2 Identification of Sample

The samples were identified in the herbarium of the Department of Biology of Umaru Musa Yar'adua University Katsina.

2.3 Sample Preparation

Leafy vegetable samples were washed with tap water thoroughly to remove dust particles, soil, unicellular algae etc. The edible parts of the samples were further washed with distilled water and finally with deionized water. The washed vegetables were dried with blotting paper followed by filter paper at room temperature to remove surface water. The vegetables were immediately kept in desiccators to avoid further evaporation of moisture from the materials. The vegetables were then chopped into small pieces and oven dried at (55± 1)°C hours in a Gallenkamp hotbox oven (CHF097XX2.5) and then blended in an electric blender. The resulting powder was kept in airtight polythene packet at room temperature before digestion and metals analyses.

2.4 Heavy Metals Determination

Five (5) g of each Sample was dried at 80°C for 2 hours in a Gallenkamp hotbox oven (CHF097XX2.5) and then blended in an electric blender. 0.5 g of each sample was weighed and ashed at 550°C for 24 hours in an electric muffle furnace (Thermolyne FB131DM Fisher Scientific). The ash was diluted with 4.5 ml concentrated hydrochloric acid (HCl) and concentrated nitric acid ($HN0_3$) mixed at ratio 3:1 the diluent is left for some minutes for proper digestion in a beaker. 50 ml of distilled water was added to the diluents to make up to 100 ml in a volumetric flask. The levels of heavy metals (Pb, Zn, Ni, Cd, Cr, Mn and Fe) were determined using AA210RAP BUCK Atomic Absorption Spectrometer flame emission spectrometer filter GLA-4B Graphite furnace (East Norwalk USA), according to standard methods [8] and the results were given in (mg/kg).

2.5 Heavy Metal Health Risk Assessment

2.5.1 Daily Intake of Metals (DIM)

The daily intake of metals was calculated using the following equation:

$$\mathrm{DIM} = \frac{C_{metal} * C_{factor} * D_{intak}}{B_{weight}}$$

Where, C_{metal}, C_{factor}, D_{intake} and B_{weight} represent the heavy metal concentrations in the baobab leaf samples, the conversion factor, the daily intake of the samples and the average body weight, respectively. The conversion factor (CF) of 0.085 [9] was used for the conversion of the samples to dry weights. The average daily intake of the samples was 0.527 kg person^{-1} d^{-1} [10] and the average body weight for the adult and children population was 60 kg [11] and 24 kg [12] respectively; these values were used for the calculation of HRI as well.

2.5.2 Non-cancer risks

Non-carcinogenic risks for individual heavy metal for vegetable were evaluated by computing the target hazard quotient (THQ) using the following equation [13].

$$THQ=CDI/R_fD$$

CDI is the chronic daily heavy metal intake (mg/kg/day) obtained from the previous section and R_fD is the oral reference dose (mg/kg/day) which is an estimation of the maximum permissible risk on human population through daily exposure, taking into consideration a sensitive group during a lifetime (Li and Zhang, 2010) [14]. The following reference doses were used (Pb = 0.6, Cd = 0.5, Zn = 0.3, Fe = 0.7, Ni = 0.4, Mn = 0.014, Cr = 0.3) [15,16]. To evaluate the potential risk to human health through more than one heavy metal, chronic hazard index (HI) is obtained as the sum of all hazard quotients (THQ) calculated for individual heavy metals for a particular exposure pathway [17]. It is calculated as follows:

$$HI=THQ_1+THQ_2+\cdots+THQ_n$$

Where, 1, 2…, n are the individual heavy metals or vegetable and fruit species.

It is assumed that the magnitude of the effect is proportional to the sum of the multiple metal exposures and that similar working mechanism linearly affects the target organ [18]. The calculated HI is compared to standard levels: the population is assumed to be safe when HI < 1 and in a level of concern when 1 < HI < 5 [19].

2.5.3 Cancer risks

The possibility of cancer risks in the studied baobab leaf samples through the intake of carcinogenic heavy metals was estimated using the Incremental Lifetime Cancer Risk (ILCR) [20].

$$ILCR= CDI\times CSF$$

Where, CDI is chronic daily intake of chemical carcinogen, mg/kg BW/day which represents the lifetime average daily dose of exposure to the chemical carcinogen.

The US EPA ILCR is obtained using the cancer slope factor (CSF), which is the risk produced by a lifetime average dose of 1 mg/kg BW/day and is contaminant specific [13]. ILCR value in samples represents the probability of an individual's lifetime health risks from carcinogenic heavy metals' exposure [21]. The level of acceptable cancer risk (ILCR) for regulatory purposes is considered within the range of 10^{-6} to 10^{-4} [14]. The CDI value was calculated on the basis of the following equation and CSF values for carcinogenic heavy metals were used according to the literature [20].

$$CDI = (EDI \times EFr \times ED_{tot})/AT$$

where EDI is the estimated daily intake of metal via consumption of the samples; EFr is the exposure frequency (365 days/year); ED_{tot} is the exposure duration of 60 years, the average lifetime for Nigerians; AT is the period of exposure for non-carcinogenic effects (EFr × ED_{tot}), and 60 years lifetime for carcinogenic effect [13]. The cumulative cancer risk as a result of exposure to multiple carcinogenic heavy metals due to consumption of a particular type of food was assumed to be the sum of the individual heavy metal increment risks and calculated by the following equation [20].

$$\sum ILCR_n=ILCR_1+ILCR_2+\cdots+ILCR_n$$

Where, n = 1, 2…, n is the individual carcinogenic heavy metal.

3. RESULTS AND DISCUSSION

The present study investigated the presence of heavy metals in Baobab leaf which is a major component of the diet among the population in Katsina state, Nigeria. A total of 11 Baobab leaf samples were analyzed for the presence of heavy metals in this study. As shown in Table 1, among the heavy metals evaluated, the highest concentration (mg/kg) was observed for Fe (range: 1.016-1.951), followed by Zn (range: 1.064-1.852), Pb (range: 0.526-0.981) and Cr (range: 0.116-0.352). Cd has the lowest concentration (0.041-0.054) while heavy metals (Mn and Ni) were below detection level (BDL). The results for the heavy metals analysed in the sampled leaves is similar to that reported for heavy metals in beans and some beans products from some selected markets in Katsina state, Nigeria [22].

Lead was detected in all the samples, with 100% of samples seen to be higher than 0.01 mg/kg which is the maximum permissible limit set by WHO/FAO and also the maximum allowable concentration of 0.02 mg/kg by EU and 0.05 mg/kg limit set by USEPA [23]. The high percentage of samples which were in violation of the maximum permissible limits of Pb set by WHO, EU, and US EPA is a cause for public health concern considering the frequency of exposure. The Pb concentration range for the Baobab leaf samples in this study is lower than that reported for leafy vegetables from Kaduna state Nigeria [24] and that reported for beans samples from Italy, Mexico, India, Japan, Ghana and Ivory Coast with a Pb concentration range of 4.084- 14.475ppm [25] and the Pb result for homegrown vegetables near a former chemical manufacturing facility in Tarnaveni, Romania [26]. But the results are higher than that reported for the concentration of Pb from Kano and Kaduna states, Nigeria [27, 28]. The value was still higher than the range (0.116 to 0.390) reported by Ahmed and Mohammed in Egypt (0.116 to 0.390) in 2005 [29] and the range (0.007 to 0.032 mg/kg) reported by Okoye et al. [30] in a study conducted in South east of Nigeria in 2009.

The concentration of Cd (mg/kg) range from 0.041 to 0.054 in Baobab leaf, these values are higher than the range (0.002 to 0.004 mg/kg) reported by Edem et al. [31] in Wheat flours. The Cd concentration range for the samples in this study is lower than that reported for various beans samples from Europe, Asia and parts of West Africa [25]. But the results are similar to that reported in a study for the Cadmium concentration range for both unprocessed and processed bean samples from Katsina state Nigeria [22] and for locust beans from Odo-Ori market Iwo, Nigeria [32]. The reported Cd values are also lower than those obtained by Okoye et al. [30] in Cereals in Southeastern Nigeria (0.007 to 0.23 mg/kg) in 2009, that reported by Ahmed and Mohammed in Cereal products (0.091-0.143 mg/kg) in 2005 [29], Orisakwe et al. in Owerri (0.00 to 0.24 mg/kg) in 2012 [33] and Dahiru et al. in Kano (0.11 to 0.28 mg/kg) in 2013 [27].

The Fe values for the present study are higher than the range reported by Edem et al. in Calabar (0.002 to 0.004 mg/kg) in 2009 [31] but far below the joint FAO/WHO [34] permissible limit (40.7 mg/kg) for Fe in Cereals. These values are also too low to provide for the Recommended Daily allowance for Fe in both adult male (10mg/day) and female (15mg/day) from a nutritional point of view [28]. In the present study, the mean Fe concentration in the samples is higher than that reported in a study that evaluates heavy metals in millet from Kaduna, Nigeria [28]. The result is similar to that reported for market sold beans from Katsina, Nigeria [22], but is lower to that reported in a study in eastern Nigeria [30] and that recorded by Zahir et al. [35] in a study conducted in Pakistan and the results for the study conducted by Di Bella et al., [25].

The heavy metal Zn values obtained in this study is similar to that reported in some studies [27,36], but are higher than the range (0.04 to 0.19 mg/kg) reported by Edem et al. in 2009 [31] but far below the range reported by Ahmed and Mohammed [29] in 2005 (4.893 to 15.450 mg/kg) and that reported in a study conducted by Sulyman et al. [37]. These values also fall below the WHO permissible limit for Zn as reported by Umar et al. [38] and can also not provide for the required daily allowance for Zn which is 11 mg/day for men and 8mg/day for women [28].

Table 1. Heavy metal concentration (mg/kg) in baobab leaf samples from Katsina State

Location	Heavy metal						
	Mn	**Zn**	**Pb**	**Cd**	**Ni**	**Fe**	**Cr**
Birchi	BDL	1.325000 ±0.001600	0.981000 ±0.000300	0.052000 ±0.000200	BDL	1.951000 ±0.000300	0.247000 ±0.000200
Dabai	BDL	1.167000 ±0.000400	0.833000 ±0.000400	0.043000 ±0.000200	BDL	1.872000 ±0.000700	0.138000 ±0.000200
Daura	BDL	1.512000 ±0.000100	0.526000 ±0.000600	0.048000 ±0.000400	BDL	1.156000 ±0.000600	0.352000 ±0.000600
Dutsinma	BDL	1.386000 ±0,000600	0.917000 ±0.000400	0.046000 ±0.000200	BDL	1.155000 ±0.000200	0.116000 ±0.000400
Funtua	BDL	1.152000 ±0.000200	0.935000 ±0.000200	0.054000 ±0.000100	BDL	1.389000 ±0.000200	0.152000 ±0.000200
Ingawa	BDL	1.152000 ±0.000300	0.859000 ±0.000200	0.042000 ±0.000200	BDL	1.569000 ±0.000400	0.238000 ±0.000300
Kafur	BDL	1.094000 ±0.000300	0.931000 ±0.000300	0.047000 ±0.000300	BDL	1.437000 ±0.001100	0.157000 ±0.000200
Katsina	BDL	1.852000 ±0.000200	0.948000 ±0.000100	0.041000 ±0.000200	BDL	1.173000 ±0.000300	0.133000 ±0.000100
Malunfashi	BDL	1.132000 ±0.000400	0.972000 ±0.000200	0.045000 ±0.000600	BDL	1.826000 ±0.000200	0.251000 ±0.000100
Matazu	BDL	1.064000 ±0.000300	0.915000 ±0.000200	0.048000 ±0.000200	BDL	1.016000 ±0.001600	0.268000 ±0.000200
Zango	BDL	1.156000± 0.000200	0.975000± 0.000300	0.053000± 0.000100	BDL	1.928000± 0.000300	0.217000± 0.000200

Values are expressed as Mean ± Standard

The degree for heavy metal toxicity to humans depends on daily consumption rate [39]. The results for the estimated daily intake (EDI) of the heavy metals on consumption of the samples were given in Tables 2 and 3. From the tables, the estimated daily intake of the heavy metals (Pb, Zn, Cd, Cr and Fe) in both adults and children were lower than the tolerable daily intake limit set by the USEPA [40] in both samples.

The non-cancer risks (THQ) of the investigated heavy metals through the consumption of the samples for both adults and children inhabitants of the study area were determined and presented in Tables 2 and 3. The THQ has been recognized as a useful parameter for evaluating the risk associated with the consumption of metal-contaminated foods [41]. THQ is interpreted as either greater than 1 (>1) or less than 1 (<1), where THQ >1 shows human health risk concern [42]. Bhalkhair and Ashraf [10] in their study have put forward the suggestion that the ingested dose of heavy metals is not equal to the absorbed pollutant dose in reality because a fraction of the ingested heavy metals may be excreted, with the remainder being accumulated in body tissues where they can affect human health. The risk level of Target Hazard Quotient (THQ < 1) was observed for all the evaluated heavy metals for both adults and children. It indicates that the intake of these heavy metals through consumption of the baobab leaves does not pose a considerable non-cancer risk. The THQ for the samples was in the decreasing order Zn>Fe>Pb>Cr>Cd, for all the baobab leaf samples respectively. The sequence of risk was the same for both adults and children although the children had higher THQ values in all cases. Similar observations have been reported previously by Mahfuza et al., [43], Micheal et al. [13] and Liu et al. [20].

Table 2. Daily intake of heavy metal in adults from consuming cultivated baobab leaves from Katsina State

Location	Heavy metal				
	Zn	**Pb**	**Cd**	**Fe**	**Cr**
Birchi	0.000989	0.000732	0.000039	0.001457	0.000184
Dabai	0.000871	0.000622	0.000032	0.001398	0.000103
Daura	0.001128	0.000393	0.000036	0.008641	0.000263
Dutsinma	0.001035	0.000685	0.000034	0.008324	0.000866
Funtua	0.000860	0.000698	0.000040	0.001037	0.000114
Ingawa	0.000817	0.000641	0.000031	0.001171	0.000178
Kafur	0.001383	0.000695	0.000035	0.001068	0.000117
Katsina	0.001446	0.000708	0.000031	0.000874	0.000099
Malunfashi	0.000794	0.000726	0.000034	0.001364	0.000187
Matazu	0.000863	0.000683	0.000036	0.000759	0.000200
Zango	0.000771	0.000728	0.000040	0.001439	0.000162

Table 3. Daily intake of heavy metal in children from consuming cultivated baobab leaves from Katsina State

Location	Heavy metal				
	Zn	**Pb**	**Cd**	**Fe**	**Cr**
Birchi	0.002473	0.001831	0.000097	0.003643	0.000461
Dabai	0.002178	0.001555	0.000080	0.003494	0.000258
Daura	0.002822	0.000982	0.000090	0.002158	0.000657
Dutsinma	0.002587	0.001712	0.000086	0.002156	0.000217
Funtua	0.002150	0.001745	0.000101	0.002593	0.000284
Ingawa	0.002150	0.001603	0.000078	0.002929	0.000444
Kafur	0.002042	0.001738	0.000088	0.002682	0.000293
Katsina	0.003457	0.001769	0.000077	0.002189	0.000248
Malunfashi	0.002113	0.001824	0.000084	0.003408	0.000469
Matazu	0.001986	0.001713	0.000090	0.001896	0.000500
Zango	0.002158	0.001820	0.000100	0.003599	0.000405

Further, the non-cancer risks for each sample were expressed as the cumulative HI, which is the sum of individual metal THQ. All the studied samples showed the risk level (HI < 1) with the highest in the sample from Kafur and lowest in the sample from Funtua. It suggests that the inhabitants of Katsina state might not be exposed to non-carcinogenic health risk through the intake of heavy metals.

Cd and Pb are classified by the IARC as being carcinogenic agents [44]. Chronic exposure to low doses of Cd and Pb could, therefore, result in many types of cancers [45]. The computed ILCR and cumulative incremental lifetime cancer risk (∑ILCR) for Cd, and Pb through the cultivated millet samples are presented in Tables 6 and 7. US-EPA recommended the safe limit for cancer risk is below about 1 chance in 1,000,000 lifetime exposure (ILCR < 10^{-6}) and threshold risk limit (ILCR > 10^{-4}) for chance of cancer is above 1 in 10,000 exposure where remedial measures are considerable and moderate risk level (ILCR > 10^{-3}) is above 1 in 1,000 where public health safety consideration is more important [21,46]. ILCR for Cd violated the threshold risk limit (>10^{-4}) and ILCR for Pb reached the moderate risk limit (>10^{-3}) in all the studied samples in adults, While in children ILCR for Pb in samples from Dabai and Daura have reached the moderate risk limit (>10^{-3}), while the ILCR for Pb in rest of the samples and ILCR for Cd of all the samples are beyond the moderate risk level (>10^{-2}). The sampling area trend of risk for developing cancer as a result of consuming the studied baobab leaf samples showed: Birchi > Zango >Dabai > Malunfashi > Ingawa > Kafur > Funtua > Katsina > Dutsinma > Matazu > Daura for both adult and children (Tables 6 and 7).

Table 4. Heavy metal target hazard quotient and health risk index in adults from consuming cultivated baobab from Katsina State

Location	Target hazard quotient						Health Risk Index (HRIs)
	Heavy metal						
	Mn	Zn	Pb	Cd	Fe	Cr	
Birchi	BDL	0.003297	0.001221	0.000078	0.002081	0.000615	0.007291
Dabai	BDL	0.002904	0.001037	0.000064	0.001996	0.000343	0.006345
Daura	BDL	0.003763	0.000655	0.000072	0.001233	0.000876	0.006598
Dutsinma	BDL	0.003449	0.001141	0.000069	0.001892	0.000289	0.006137
Funtua	BDL	0.002867	0.001163	0.000081	0.001481	0.000378	0.005770
Ingawa	BDL	0.002723	0.001069	0.000063	0.001673	0.000592	0.006120
Kafur	BDL	0.002817	0.001159	0.000070	0.001526	0.000391	0.005963
Katsina	BDL	0.004609	0.001180	0.000061	0.001251	0.000331	0.007981
Malunfashi	BDL	0.002648	0.001210	0.000067	0.001948	0.000625	0.006497
Matazu	BDL	0.002877	0.001139	0.000072	0.001084	0.000667	0.005738
Zango	BDL	0.002568	0.001213	0.000079	0.002056	0.000540	0.006457

Table 5. Heavy metal target hazard quotient and health risk index in children from consuming cultivated baobab from Katsina State

Location	Target hazard quotient						Health Risk Index (HRIs)
	Heavy metal						
	Mn	Zn	Pb	Cd	Fe	Cr	
Birchi	BDL	0.008244	0.003052	0.000194	0.005202	0.001537	0.018228
Dabai	BDL	0.007261	0.002591	0.000161	0.004991	0.000859	0.011586
Daura	BDL	0.009407	0.001636	0.000179	0.003082	0.002190	0.016495
Dutsinma	BDL	0.008623	0.002853	0.000172	0.003080	0.007217	0.015449
Funtua	BDL	0.007167	0.002909	0.000202	0.003704	0.000946	0.014927
Ingawa	BDL	0.007167	0.002672	0.000157	0.004184	0.001481	0.015660
Kafur	BDL	0.006806	0.002896	0.000176	0.003832	0.000977	0.023477
Katsina	BDL	0.009852	0.002949	0.000153	0.003128	0.000825	0.018579
Malunfashi	BDL	0.007043	0.003039	0.000168	0.004869	0.001562	0.016513
Matazu	BDL	0.006620	0.002856	0.000179	0.002709	0.001667	0.014031
Zango	BDL	0.007192	0.003033	0.000198	0.005141	0.001350	0.016914

Table 6. Incremental life time cancer risk in adults from consuming baobab leaves from Katsina State

Location	ILCR		$\sum ILCR$
	Heavy metal		
	Pb	Cd	
Birchi	4.614107E-03	5.823300E-04	5.196437E-03
Dabai	3.917989E-03	4.815450E-04	4.399534E-03
Daura	2.474023E-03	5.375400E-04	3.011563E-03
Dutsinma	4.313081E-03	5.151300E-04	4.828211E-03
Funtua	4.397747E-03	6.047250E-04	5.002472E-03
Ingawa	4.040505E-03	4.703400E-04	4.510845E-03
Kafur	4.378872E-03	5.263350E-04	4.905207E-03
Katsina	4.445889E-03	4.591350E-04	4.905024E-03
Malunfashi	4.571777E-03	5.039400E-04	5.075717E-03
Matazu	4.303675E-03	5.375400E-04	4.841215E-03
Zango	4.585883E-03	5.935200E-04	5.179403E-03

Table 7. Incremental life time cancer risk in children from consuming baobab leaves from Katsina State

Location	Heavy metal		$\sum ILCR$
	Pb	Cd	
Birchi	1.153527E-02	5.463690E-02	6.617217E-02
Dabai	9.794981E-03	5.241015E-02	6.220513E-02
Daura	6.185069E-03	3.236433E-02	3.854944E-02
Dutsinma	1.078271E-02	3.233663E-02	4.311934E-02
Funtua	1.099437E-02	3.888765E-02	4.988202E-02
Ingawa	1.010071E-02	4.392720E-02	5.402780E-02
Kafur	1.094733E-02	4.023150E-02	5.117883E-02
Katsina	1.114723E-02	3.284033E-02	4.398756E-02
Malunfashi	1.148823E-02	5.112200E-02	5.600460E-02
Matazu	1.079447E-02	2.844815E-02	3.923929E-02
Zango	1.146471E-02	5.397797E-02	6.544268E-02

Moreover, cumulative cancer risk (∑ILCR) of all the studied samples have reached the moderate risk limit ($>10^{-3}$) in adult, while in children the ∑ILCR for all the samples were beyond the moderate cancer risk ($>10^{-2}$). Further, among all the studied samples, baobab leaf sample from Birchi has the highest chances of cancer risks (ILCR 5.196457×10^{-3} in adults; ILCR 6.6172168×10^{-2} in children) and baobab sample from Daura has the lowest chances of cancer risk (ILCR 3.011563×10^{-3} in adults; ILCR 3.854944×10^{-2} in children). These risk values indicate that consumption of the sample from Birchi would result in an excess of 52 cancer cases in adults per 10,000 people exposure and 66 cancer cases in children per 1,000 people exposure, while consumption of the sample from Daura would result in an excess of 30 cancer cases in adults per 10,000 people exposure and 39 cancer cases in children per 1,000 people exposure (US-EPA,). Prompt action should be needed to control the excessive use of heavy metal-based fertilizer and pesticides and also emission of heavy metal exhaust from automobiles should be checked to save the population from cancer risk.

4. CONCLUSION

This study determines the heavy metals concentration in baobab leaf samples from Katsina state Nigeria. Results from this study have shown that with the exception of the heavy metal Pb concentration values of Mn, Zn, Cd and Fe in the samples were generally lower than the USEPA, WHO/FAO maximum permissive limits. The results have indicated that the estimated daily intake of the heavy metals was lower than the tolerable daily intake limit set by the USEPA (2013) in both samples. The risk level of Target Hazard Quotient (THQ < 1) was observed for all the evaluated heavy metals for both adults and children. ILCR for Cd violated the threshold risk limit ($>10^{-4}$) and ILCR for Pb reached the moderate risk limit ($>10^{-3}$) in all the studied samples in adults, While in children ILCR for Pb in samples from Dabai and Daura have reached the moderate risk limit (>10^{-3}), while the ILCR for Pb in rest of the samples and ILCR for Cd of all the samples are beyond the moderate risk level (>10^{-2}). Cumulative cancer risk (∑ILCR) of all the studied samples have reached the moderate risk limit (>10^{-3}) in adult, while in children the ∑ILCR for all the samples were beyond the moderate cancer risk (>10^{-2}). The study suggests that consumption of the studied Baobab leaf samples in Katsina state is of public health concern as they may contribute to the population cancer burden.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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