Journal of Environment, Earth Sciences and Ecology
Vol.06, No.03; July –September-2024
p –ISSN (7304–490X);
ISSN (2202–3011)

HEALTH RISK ASSESSMENT OF CD, CR AND PB LEVELS IN ARTIFICIAL COLOURS, FOODS AND DRINKS CONSUMED IN JALINGO, TARABA STATE

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Abstract: Street-vended foods are classified as those foods cooked, prepared and served by vendors in streets and/or other public places and are directly consumed without further preparation. Although street foods offer a great deal of advantages to food security, concerns about their health risk effects on humans are far too great to be ignored. Triplicate samples of four food colours namely Yellow, Orange, Red and White; four cooked foods – jellof rice, Okpa, moi-moi and Spaghetti and local drinks colours Yellow, Orange, White and Caramel were randomly collected from the surroundings of the Jalingo Main Market where food vendors hawked, and was taken to the Central laboratory of the Federal University Wukari for analysis. Cd, Cr and Pb levels was determined using the Atomic Absorption Spectrophotometry to evaluate the concentrations in each of the samples and to predict the potential health risk on the exposed population using the estimated daily intake (EDI), target hazard quotient (THQ) and health index (HI). Results reveal that Pb was above the WHO/FAO (2016) permissible limit in the artificial colours and cooked food only and below in local drinks, except for Colour Caramel in local drinks and Okpa or Moi-moi. Cd and Cr was generally below in cooked food, artificial colours and local drinks. The high levels of Pb reflect the handling, storage, processing, cooking and preparation of the Bambara nut pudding and spaghetti, local drinks yellow, orange and red colours. The EDI was less than one for all samples, THQ was greater one in cooked foods and local drinks but higher for Pb in artificial colours. The HI for Cd, Cr and Pb recorded very high values reflecting synergistic health risk effects of more than one contaminants on the exposed population.

Keywords: Artificial Colours, Cadmium, Chromium, Estimated Daily Intake, Health Index, Lead, Street-vended foods, Target Hazard Quotient.

INTRODUCTION

Food manufacturers and street food vendors commonly use food additives in different foods and beverages to increase taste, appearance, and flavour (Lok *et al*., 2011; Dilrukshi *et al*., 2019). However, Street-vended foods are ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers in the streets and other public places for immediate consumption or later without further processing or preparation. Street foods provide essential nutrients and are a source of energy for millions of consumers worldwide. They are also a means of income for many low-income earners around the world (Ekhator *et al*., 2017). These foods are inexpensive and readily accessible and as a result, street-vended foods have experienced an economic boom in the past few years (Rakha *et al*., 2022). In the Asian countries like Kolkata, Bangladesh, India, Sri Lanka, many varieties of street vended foods are available and known for their unique flavour, appearance, variety and availability at a low cost (Dilrukshi *et al*., 2019). These street foods are very popular to a large number of people as a source of inexpensive, convenient and more-or less nutritious food. They are a source of attraction and novelty to tourists and economically advantaged individuals and also provides business opportunities at very low capital. Street food vending plays an important role in assuring food security for low income urban populations. The vividly coloured appearance of these street foods is due to the presence of artificial colours which are a source of a variety of health hazards (Dilrukshi *et al*., 2019) .

There are many food colouring agents both permitted and non-permitted found in many countries worldwide. Natural food colours are mostly derived from plants including vegetables and fruit, such as beet juice (red or pink) and turmeric (yellow). Nine synthetic dyes have been approved for use in food by FDA but Red 40, Yellow 5 and Yellow 6 are the ones seen on most labels. Red 40, Yellow 5 and Yellow 6 are most likely to cause systemic allergic reactions. These same dyes also contain the cancer-causing contaminants Benzidine, 4-aminobiphenyl and 4-aminoazobenzene. Red 40 is linked to certain ADHD symptons such as hyperactivity and may cause behavioural effects in Children. Red 3 has been found to increase the risk of thyroid tumors in rat studies. After 3 hours of exposure, Red 5 caused damage to human white blood cells in every concentration tested. Synthetic food colour dyes can destroy the nutrients in the food because of the chemical composition. They can also cause skin irritation and eczema, intestinal upset and breathing problems. Several researches have focused mainly on reviews of previous works with scanty reports on health risks implications of specific metals as investigated in this research.

In the Jalingo, four commonly used artificial drink colours are yellow, orange, white and caramel and also Red, Yellow, Orange in jellof rice, okpa (Bambara nut pudding) and spaghetti, the commonly consumed food. However, the possibility of the presence of toxic heavy metals in street foods at an unacceptable level is one aspect of the health hazards that has not been widely explored. This study intends to evaluate the health risk potentials of Cd, Cr and Pb levels present in the commonly street vended foods and its effects on the health of regular consumers of such food over a long period of time. Goswami and Mazumdar, 2016 reported high Pb levels in street- vended food due to exposure to air pollution and artificial food colourant containing high level of Pb. However the specific artificial food colour containing such high amount of Pb has not reported.

MATERIALS AND METHOD

Study area

Jalingo is the capital of Taraba state which is situated in the Northcentral geopolitical zone of Nigeria. Jalingo lies approximately between longitudes 11° 09'E to 11° 30'E and latitude 8° 47'N to 9° 01'N. The Local government lies in the north of Taraba state and is bounded to the north by Lau L.G.A, to the east by Yorro L.G.A, and to the south and west by Ardo-Kola L.G.A. and with a total land mass of about 195.071 km^2. The estimated population of Jalingo is 241,590 inhabitants with the most prominent tribes being the Fulani and the Mumuye. Jalingo has a tropical savannah climate marked by wet and dry seasons. The wet season begins in April and ends in October while the dry season which is characterized by the prevalence of the north-east trade wind from the sahara desert begins in November and ends in March. Jalingo has a mean annual rainfall of about 1200 mm and mean temperature of about 29°C. Jalingo also has an average humidity level of 49%. Jalingo LGA is an urban and cosmopolitan area and has a lot of hotels, banks, restaurants, industries and both government and privately owned institutions. Farming is also very popular amongst the people of Jalingo especially at the outskirts of Jalingo, crops such as rice, melon and millet are usually grown in large quantities. (https://www.manpower.com.ng>places>lga>jalingo).
The map of the Study area is shown in Fig 1.

Sample collection and Analysis

The samples which include four (4) cooked foods - jellof rice, moi-moi, Okpa and spaghetti were collected from randomly selected local food vendors from Jalingo main market. A total number of four (4) different colours used in local drinks and three (3) most commonly used artificial colours used in food were bought in the month

Journal of Environment, Earth Sciences and Ecology
Vol.06, No.03; July –September-2024
p –ISSN (7304–490X);
ISSN (2202–3011)

of June, 2023 from randomly selected shops in Jalingo main market for analysis. These colours are commonly used in foods and drinks to make them more appealing to the consumers since the eyes eats before the mouth and consequently enhance the sales of their products. All the samples were transported to Central Laboratory Federal University Wukari for metal (Cd, Cr and Pb) analysis using the atomic absorption spectrophotometry (AAS) following standard procedures of sample preparation.

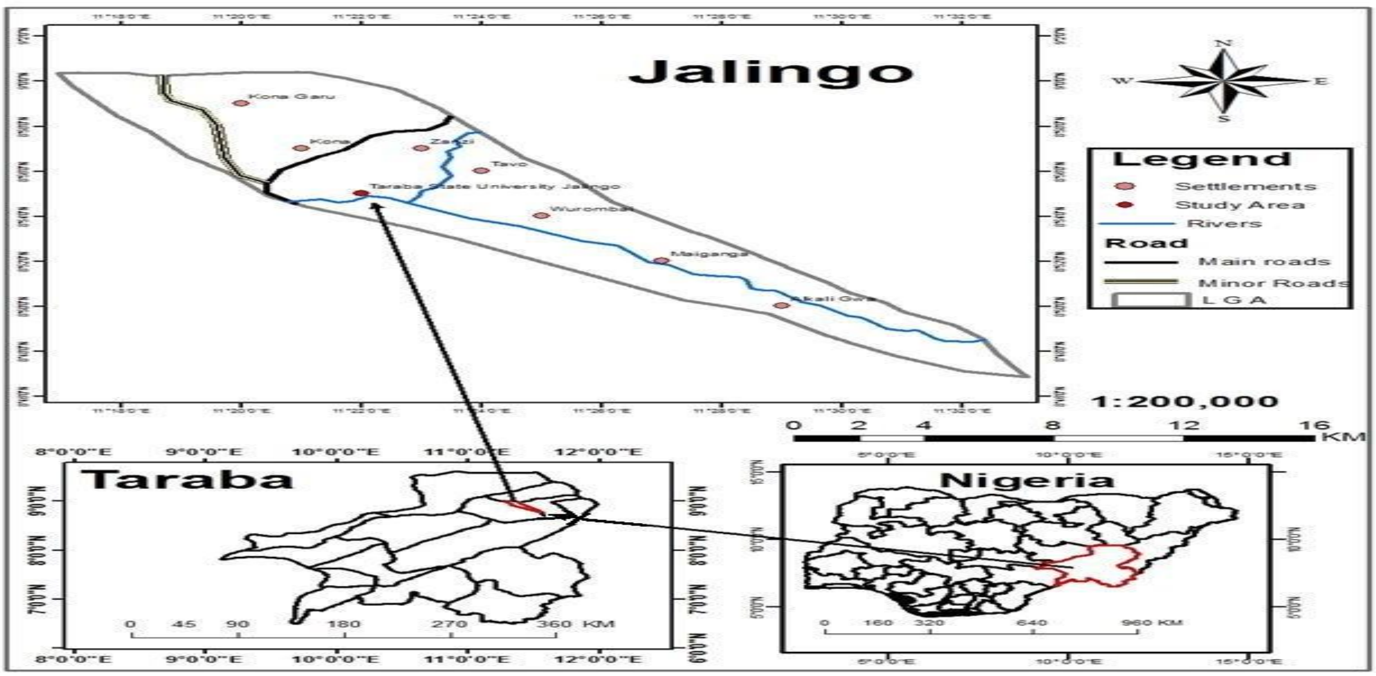

Figure **Fig 1: A map showing the study area. Source: (Vincent *et al.*, 2020)**

Sample Preparation of Cooked Food Samples

The food samples were air dried, ground with a porcelain mortar and pestle and stored in a cellophane bag ready for digestion. 2g of each sample was weighed using analytical weighing balance and placed into large test tubes. 6ml of 65% HNO_3 and 4ml HCL was added into each of the test tubes and stirred thoroughly to combine. The test tubes were placed in a micro digestor (FOSS Tecator Digestor 2520) at a temperature of 150°C for three hours until the contents of the test tubes were completely dissolved and a clear solution was formed. The solution was allowed to cool and then filtered using Whatman filter paper No. 41. The filtered solution was diluted and made up to 100ml mark of volumetric flask with deionized water, the solutions were turned into sample bottles and were ready for AAS analysis. Four replicates of each of the samples were used to determine the concentrations of cadmium (Cd), chromium (Cr) and lead (Pb using atomic absorption spectrophotometer (AAS).

Quality Control

The quality of the analytical data was ensured by implementing laboratory quality assurance and laboratory methods, including the use of standard operating procedures, calibration with standards, analysis of reagent blanks and analysis of replicates of the samples. Wavelength (nm) Calibration curves were optimized by the application of quality control standards at every step of sample measurement. All chemicals and reagents used in the study were of analytical grade and all glassware used were washed with deionized water, dipped in 10% NHO_3 overnight, rinsed with deionized water and finally dried in an oven. The sample bottles were tightly capped before proceeding to AAS analysis.

Table 1: Wavelength and Method of Validation Parameters Obtained by AAS Analysis in Artificial Colours used in Local Foods and Drinks.

Element	Wavelenght (nm)	R^2 Value	Calibration Range	Slit Setting	Max current	P/N
Cd	228.8nm	0.9975	1-1200	7	10mA	4108
Cr	357.9nm	0.9980	1-1200	7	20mA	4112
Pb	217.0nm	0.9935	1-1200	7	15mA	4129

Health Risk Assessment

Risk assessment is the method of evaluating the probability of occurrence of any given probable amount of the harmful health impacts over a determined period of time, (Bempah and Ewusi, 2016). The health risk assessment of each contaminant is normally based on the estimation of the risk level and is classified as carcinogenic or non-carcinogenic health hazards (Wongsasuluk *et al.*, 2014). The potential health risks of heavy metal consumption were assessed using the estimated daily intake (EDI), target hazard quotient (THQ), and Hazard Index (HI). The EDI value is determined by the heavy metal concentrations in the samples, the amount consumed daily and body weight. EDI values of the analyzed metals were estimated based on Eq. (1). (Tefera and Teklewold, 2021)

EDI= (C metal × IR) / BW……………………….(1)

Where:

EDI is the estimated daily intake of metal, C is the metal(mg/kg) is the mean concentration of heavy metal in the samples, IR, which is the ingestion rate is the average daily consumption of the colour additives(gram/day/person), BW is the average body weight (Kg) (Amer, 2019). The ingestion rate of colour additives in food is assumed to be 2g/day/person. The average body weight for adult was 60.0 kg (Meseret, 2020).

THQ: (target hazard quotient) is used to assess the non-carcinogenic risks of long-term exposure to contaminants and the calculations were done using Eq (2).

THQ = EDI / RfD……………………(2)

Where:

RfD is reference dose values of the heavy metals under investigation (mg/kg/day). The RfD values for Pb. Cd and Cr are 0.004, 0.001 and 0.003mg/kg/day, respectively (USEPA 2011; Gebeyehu and Bayissa, 2020). THQ $\geq$ 1 indicates a non-carcinogenic health risk effect on the exposed population while a THQ $<$ 1 shows that the consumers are safe.

HI (health index): The HI is used to estimate the overall non-carcinogenic risk to human health through exposure of more than one contaminant. As shown in Eq. (3), HI is the sum of the total hazard quotients of all heavy metals in the samples.

HI= THQ(Cd) + THQ(Cr) + THQ(Pb) ………………..……. eq(3)

If the values of HI $\geq$1, it indicates that the population will be exposed to adverse health effects while HI $<$ 1 means

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Vol.06, No.03; July –September-2024
p –ISSN (7304–490X);
ISSN (2202–3011)

the population is unlikely to experience adverse health effect (Ghasemidehkordi, 2018; Mohammadi, 2019).

Statistical analysis

The statistical analysis was conducted with SPSS v.27 using a one-way analysis of variance (ANOVA). The toxic metal concentration is represented as the mean of four independent experiments (four replicates). Data are presented as mean ± SE value and the considered significant level is $p < 0.01$.

RESULTS AND DISCUSSION

The mean levels of Cd, Cr and Pb in the four cooked foods are presented in Table 2. Among the four cooked foods, FSO (okpa) had the highest mean Pb levels followed by FSM (moi-moi) and FSS (spaghetti) while Cd and Cr were lower in all the cooked foods. In comparison with the WHO/FAO (2016) permissible limits, Pb was above the permissible limits for all the four cooked food samples and below for Cd and Cr.

Table 2: Mean ± S.E of cooked food containing artificial food colours commonly consumed in Jalingo

Sample	**Heavy Metal Concentrations (mg/kg)**		
Cooked Food	**Cd**	**Cr**	**Pb**
FSS	0.00 ±0.00	0.00±0.02	0.14±0.02
FSM	0.01±0.00	0.02±0.07	0.42±0.04
FSR	0.00±0.00	0.01 ±0.02	0.07±0.02
FSO	0.003±0.001	0.002±0.001	0.645±0.232
Mean of Means	0.003	0.008	0.216
WHO/FAO(2016)	0.1	0.25	0.3

Key: FSS = food sample spaghetti; FSM = food sample moi-moi; FSR = food sample rice; FSO = food sample Okpa

The artificial food colours (red, yellow and orange) used in local food had a negligible value for Cd and Cr when compared to Pb according to WHO/FAO (2016) as shown in Table 3. Pb (0.696) was higher than the WHO permissible limit of 0.3mg/kg. The reason for the similar findings by Ekhator *et al*., (2017), Ojimoto *et al*., (2019) and Nowreen, (2019) could be from the synthesis of the colours, the raw materials used for the synthesis, the equipment used, the level of hygiene employed throughout the process of the synthesis and also during the packaging, storage and transportation of the artificial colours.

Table 3: Mean ± S.E of artificial colour additives used in local food commonly consumed in Jalingo

Sample	**Heavy Metal Concentrations (mg/kg)**		
Food Colours	**Cd**	**Cr**	**Pb**
FCR	0.02 ±0.00	0.00±0.00	0.94±0.03
FCY	0.01±0.00	0.01±0.00	0.60±0.01
FCO	0.01±0.00	0.01 ±0.00	0.55±0.05
Mean of Means	0.01	0.004	0.696
WHO/FAO(2016)	0.1	0.25	0.3

Key: FCR = food colour red; FCY= food colour yellow; FCO= food colour orange.

Among the three heavy metals investigated in this research on artificial colours used in local drinks commonly consumed in Jalingo, Pb concentration was very high in four of the colours analyzed as shown in Table 4. Pb levels in all the artificial food colours were above the permissible limit while a negligible levels of Cd and Cr were below the WHO/FAO (2016) limits. The WHO/FAO (2016) permissible limits for Cd, Cr and Pb levels showed that Pb was above the limit in the artificial colours and cooked food only and below in local drinks, except for DCC (local drinks) and FSR (cooked food). Cd and Cr were generally below in cooked food, artificial colours and local drinks. The high levels of Pb reflect the handling, storage, processing, local cookwares, cooking

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Vol.06, No.03; July –September-2024
p –ISSN (7304–490X);
ISSN (2202–3011)

and preparation of the Bambara nut pudding and spaghetti, local drinks yellow, orange and red colours. This agrees with Letuka *et al*., 2023, that heavy metal contamination in street-vended foods sometimes occurs as a result of leaching from poorly designed or old and inadequately cleaned utensils.

Table 4: Mean ± S.E of artificial colours used in local drinks commonly consumed in Jalingo

Sample Local Drinks	Heavy Metal Concentrations (mg/kg) Cd	Cr	Pb
DCY	0.02 ±0.00	0.00±0.00	0.29±0.06
DCO	0.01±0.00	0.01±0.00	0.26±0.01
DCW	0.01±0.00	0.00±0.00	0.27±0.05
DCC	0.01±0.02	0.01±0.00	0.12±0.04
Mean of Means	0.01	0.007	0.241
WHO/FAO(2016)	0.1	0.25	0.3

DCY = Drink colour yellow; DCO = drink colour orange; DCW = Drink colour white; DCC = Drink colour caramel

Non-Carcinogenic Health Risk Assessment Factors

The health risk assessment factors (EDI, THQ and HI) for Cd, Cr and Pb levels in the artificial colours, cooked food and local drinks obtained from Jalingo food vendors are shown in Table 5.

Table 5: Non-carcinogenic health risk assessment using EDI, THQ and HI

	Expected Daily Intake			Target Hazard Quotient			Hazard Index
Samples	**Cd**	**Cr**	**Pb**	**Cd**	**Cr**	**Pb**	
Articicial colours in drinks							
DCY	0.013	0.001	0.183	13*	0.33	47.75*	61.08*
DCO	0.005	0.008	0.164	5*	2.66*	41*	48.66*
DCW	0.003	0.002	0.169	3*	0.66	42.25*	45.91*
DCWred	0.003	0.004	0.076	3*	1.33*	19*	23.33*
Artificial colours used in local foods							
FCR	0.002	0.0002	0.109	0.002	0.06	27.25*	29.31*
FCY	0.0007	0.0008	0.060	0.7	0.26	15*	15.96*
FCO	0.001	0.0005	0.064	1	0.16	16*	17.16*
Colour additives in cooked food							
FSS	0.006	0.006	0.241	6*	2*	60.25*	68.25*
FSM	0.004	0.013	0.357	4*	4.33*	89.25*	97.58*
FSR	0.009	0.015	0.234	9*	5*	58.5*	72.5*
FSO	0.0001	0.000	0.021	0.1	0.00	5.35	5.45*

S1-10 = sample 1 – 10; Provisional tolerable daily intake (PTDI) Cd = 0.0002mg/kg (JECFA, 2004); and Cr =0.3mg/kg (EFSA, 2014); Pb = 0.00357mg/kg (JECFA, 2004). * = Significant

The expected daily intake (EDI) of the health risk assessment for the artificial colours, cooked food and local drinks were less than one shows that the consumers are safe reflecting that these street-vended foods are not consumed on a daily basis by consumers. This could also reflect the high metabolic rates of the consumers that are mostly truck or wheelbarrow pushers, tricyclers, ware house loaders etc and subsequent excretion from the body systems. Therefore, metal contamination in other researches arose due to air pollution and agrees with the findings of Goswami and Muzamdar (2016). The target hazard quotient (THQ) of Cd, Cr and Pb in the cooked foods and drinks were greater than one for cooked foods and local drinks indicating health risk potentials on the exposed population. Pb was greater than one too in the artificial colours indicating the insolubility nature of Pb at slightly acidic to alkaline pH. Leaching of PB from environmental media usually occurs at very low pH. However, the less than one value for Cd and Cr in the artificial colours reflect that the consumers are safe. The health Index (HI) which estimates the overall human health effects of more than one contaminant shows very high values for all the samples analysed (artificial colours, cooked foods and local drinks). The synergistic, antagonistic and additives effects of more than one contaminants is greater than for their individual effects reflecting this high values of HI in this present study. This agrees with the findings of Yoo *et al*., 2021.

Carcinogens such as Pb and Arsenic are often present in high levels in some vended foodstuffs and their prolonged ingestion could have injurious effects on consumer health (Letuka *et al*., 2023).

CONCLUSION

The WHO/FAO (2016) permissible limits for Cd, Cr and Pb levels showed that Pb was above the limit in the artificial colours and cooked food only and below in local drinks, except for DCC (local drinks) and FSR (cooked food). Cd and Cr were generally below in cooked food, artificial colours and local drinks. The high levels of Pb reflect the handling, storage, processing, local cookwares, cooking and preparation of the Bambara nut pudding and spaghetti, local drinks yellow, orange and red colours. The daily consumption of local foods and drinks containing artificial colours poses a threat to food safety of the consumers in Jalingo because of its high concentration of Pb.

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