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Comparative assessment of heavy metals in on farm paddy and parboiled rice in Gashua, Yobe state.

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Abstract
The study was carried out toassess the concentration of heavy metals in paddy rice grown at farms and parboiled rice sold at Gashua market. Samples were collected using Simple random sampling technique. A total of 120 samples 30 each from farms within Gashua town designated as Gashua North GN, Gashua South GS, Gashua Southeast SE, Gashua South west SW and 30 samples of parboiled rice from Gashua Market GMK were collected. The samples were digested and analyzed using Micro plasma atomic emission spectrometry (MP-AES). Data generated was subjected to one way analysis of variance.The result of the study revealed a significant (P<0.05) difference in heavy metals concentration across all samples. Despite the effect of parboiling; samples from GMK (0.383mg/kg) exhibited the highest Arsenic concentration greatly surpassing WHO/USEPA acceptable limits. Cadmium (0.0242mg/kg) also exceeded the acceptable limit of 0.001mg/kg. Lead concentration from all locations superseded the recommended limit especially from GMK at 0.102mg/kg exceeding the limit of 0.0035mg/kg alsoremarkable increases were seen in chromium. These however call for effective / stringent monitoring and regulation by regulatory authorities coupled with heightened public health awareness by sister agencies in other to curb the menace.

Keywords:*Parboiled rice, Heavy metals,MP-AES, regulatory agency*

Introduction

Toxic metals primarily arise either geogenic or anthropogenic which has become an issue of global concern(Naccarato*et al.*, 2020)**.** Heavy metals such as cadmium (Cd), manganese (Mn), lead (Pb), arsenic (As) and chromium (Cr) occur naturally in the earth and as a result have polluted water, air, soils, and food which in turn penetrated the food chains and have consequently inflicted adverse effects on human health (Zheng, 2020 and Ullah,2022).Despite the acceptance and consumption of rice worldwide due to its source of minerals, vitamins and essential elements,it still poses risk for contamination with heavy metals because rice can easily accumulate more metals than other grains/cereals. (Pateriya *et al.,* 2020 & Bhattacharya *et al.,*2012). Myriad report has shown the toxicity of rice with heavy metals (Song *et al.,* 2020 and Chen *et al.*, 2021).Myriad of research has shown processing methods and cooking can reduced the heavy metal content in rice(Huang *et al.*, 2021 andMohammadi *et al.,*2021**)**. Reports in other studies showed Increase in water during parboiling significantly help in reducing and removal of heavy metals by 15-63% (Raab *et al., 2009 and* Sengupta *et al.*, 2009**),** this can also cause loss of essential elements like iron by 40-75% base on the type of rice and the technique employed in cooking (Gray *et al*., 2016).Rice (*Oryza sativa* L.) is one of the most consumed food worldwide (Zohoum*et al.,*2018).The world demand for rice is estimated to reach 533 million tons in 2030 as compared to previous estimation of 472 million tons in 2015 (FAO, 2003). Rice is responsible for the supplies of up to 20% of the world's dietary energy and almostabout half of the world's population is heavily dependent on the cereal(FAO, 2006)**.** Rice consumption has increased considerably in sub-Sahara Africa as a result of lifestyle changesand urbanization(Zohoum*et al.*, 2018).

Parboiling is a hydrothermal treatment which is done by soaking the rice followed by heating and most recently advanced methods are carried out by high pressure steaming followed by drying (Behera andSutar, 2018). This process in turn increased the storage stability of the rice and maintained the nutritional quality. (Heinemann *et al*., 2006; Oli *et al*., 2014).

In Nigeriarice has become a staple food commonly consumed after boilingwith reports indicating that the average person consumes approximately 21 kg of the cereal per year(Odenigbo*et al***.**2014).While boiling and cooking are important methods for processing rice, numerous studies have shown that cooking changes some of the rice's harmful and nutritional components.(Otemuyiwa *et al.*2013). Boiling has been observed to reduce the essentials elements in rice (Goufo*et al*. 2014) consequently an increase in Fat, Vitamin B1, Protein and Ash contents were notably observedin other studies.(Alexandre *et al*. 2020)**.**

The study was therefore designed to assessthe concentration of some heavy metals (As, Cd, Pb, and Cr) innon-parboiled (paddy) and parboiled rice samplesinGashua, Bade LGA Yobe State and to compare with the threshold level of WHO.

Research question

- Does Parboiling have significant effect in reducing heavy metals in rice?

Hypothesis

1. H^1 o: Parboiling has less effect in reducing heavy metals in rice.
2. H^2 o: Parboiling can effectively reduce heavy metals in rice.

Materials and methods:

Brief description of the study area.

Gashua is located between latitude 120 52' 05 N and 120 87'11 N and longitude 110 57'26 E and 110 02'47 E. It is the largest community under Bade local government area. It has an area of 3,336 square kilometer and a population of 139,782 as at 2006 census. Gashua lies in the plain region of the savannah which supports the cultivation of Rice, Millet, Groundnut, Guinea corn, Sorghum and the vast land supports rearing of animals. Rice is one of the major grains cultivated because of the river that passes through the town (Oladimeji, 2001). The climate of Gashua is characterized by high amount of temperature and low annual rainfall towards the northern region. The rainfall ranges between 400 mm and 800 mm with an annual mean rainfall of 750 mm. The Mean annual temperature is usually around 39^{o}c and the mean monthly value range between 27^{o}c in the coolest month of December to January and 32^{o} C in the hottest month of April to May. The major river that flows in Gashua and the adjoining area is the River Komadugu Yobe (Kimmage, 2012).

Map of the Study area.

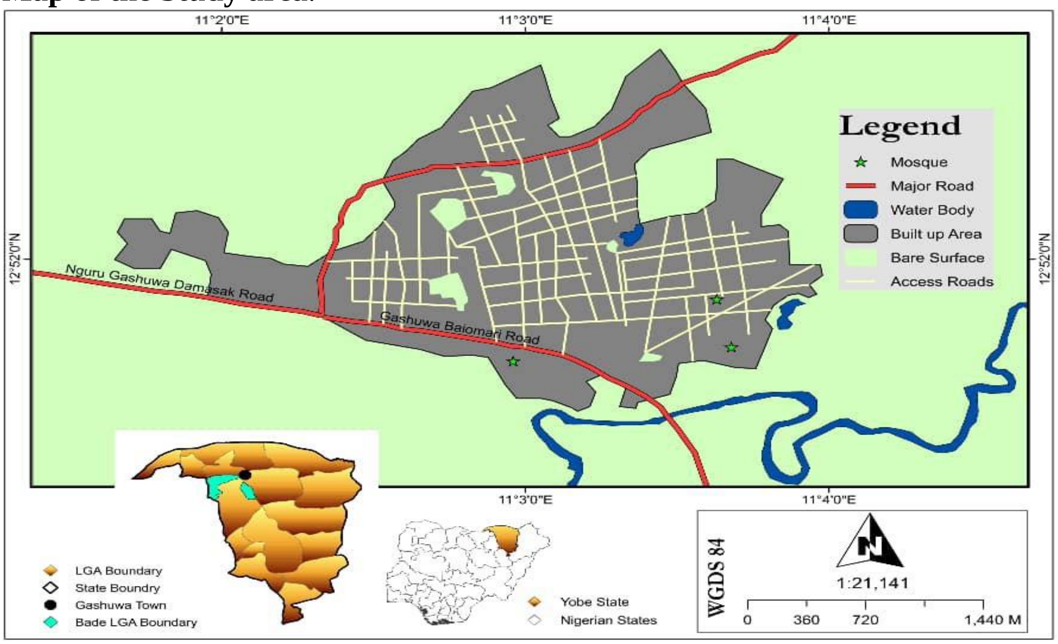

Figure 1: Map of the study area

(Source: Adopted and Modified from the Political Map of Yobe State, 2019)

Sample Size and Collection of Sample

Sampling paddy rice

All the samples were collected between 29th November, 2022 and 26th December, 2022. Simple random Sampling (Systematic sampling) was used in collecting rice samples at the farms. Aerial photographs of the farmlands were taken and the land mass subdivided into area sampling units with identifiable boundaries for enumeration. Maps were equally collected from Yobe Geographical Information Center (YOGIS) which aided in comparison with the taken photographs for accuracy.The sampling units were in a range of 20/20 ft to make at least 300 units. Numbers were assigned to all the elements within the population (1-300).

The sample size is 30, This will be divided by the population(300).

$S = n/N \qquad 30/300 = 6$

This is the “6th” sampling digit (i.e every 6th item was chosen). The random start was obtained by randomly selecting an integer. (Muhammad, 2017, Flatman and Yfantis, 1984; Mulla and Bhatti, 1997). Geographical positioning (Longitude & Latitude) of the sampling points was recorded using GPS (Lu *et al*. 2020***).***

Sampling parboiled rice

For the parboiled rice at the market, Simple random sampling wasused to collect the parboiled rice samples at the market. A list of 90 parboiled rice sellers from the market was collected and assigned numbers to each seller. A random number generator was use to generate a list of random numbers corresponding to the sample size (30). The random numbers were matched to the numbers on the sampling frame.(Muhammad, 2017 & Najib, 2015). Thirty (30) samples were then purchased, sealed in polyethylene sampling bags and taken to the laboratory.

Sample size

One hundred and twenty (120) samples of freshly harvested paddy rice samples(30 from each farm) and Thirty (30) samples of Parboiled rice from the market were sampled.

Chemical Analysis

Sample preparation(paddy rice)

The rice samples (Paddy rice) from the farm were rinsed with distilled water and deionized water to remove dust; the samples were then dried to constant weight in an oven at 60^{o} C. The Paddy ricewas then hulled using laboratory dehullerand pulverized into powder. The powders were sieve to less than 0.15mm, labeled and stored in plastic bags before analysis.

Sample preparation(parboiled rice)

The parboiled rice sampleswere rinsed with distilled water and deionized water to remove dust and they were dried to constant weight in an oven at 60^{o} C. The Sample were pulverized into powder and sieved to less than 0.15mm, labeled and stored in plastic bags before analysis.

Digestion

Two grams of samples was weighed into a crucible and incinerated at 600^{0}C in a Carbolite muffle furnace for three (3) hours. To the ash sampleexactly 10.0 ml of 6 N HCl was added and placed in a water bath and boiled for 10 minutes. The samplewas removed, filtered and transfer into 100 ml volumetric flask. The filter paper was washed down and the volume was made up to 100 ml using deionized water. Ten milliliter of the digested sample was transferred to the sample container and unto the MP-AES for analysis. Reading was recorded in ppm (AOAC, 2010)**.**

Analysis using MP-AES (Principles of MP-AES)

The principle of MP-AES (Microwave Plasma-Atomic Emission Spectrometry) is based on the excitation and emission of atoms in a high-temperature plasma generated by microwave energy.MP-AES takes advantage of the high-temperature plasma to atomize and excite the sample and then measures the resulting emissionwhere the emitted photons are collected and separated into their component wavelengths using a spectrometer. A diffraction grating or other dispersion element disperses the emitted light and a detector measures the intensity of each wavelength of light to determine the elemental composition of the sample. The method is known for its simplicity, speedand wide dynamic range providing accurate and precise elemental analysis for a variety of samples.

Operational procedure

The MP-AES instrument was set up and calibrated according to the manufacturer's guidelines. This includes ensuring that the correct plasma gas flow rates, sample introduction method and other parameters are optimized for the analysis.The prepared sample is introduced into the MP-AES instrument for analysis. This can be done using nebulization techniques. The plasma is then generated in the MP-AES instrument using microwave energy. This creates a high-temperatureionized gas phase where the sample is atomized and excited. An atomic emission from the excited sample is measured using a spectrometer. The emitted radiation will then be dispersed into its component wavelengths and detected by a detector. The intensities of the emitted wavelengths are recorded automatically. The recorded emission intensities are compared to calibration standards to determine the concentration of elements in the sample. Calibration curves or standard addition methods may be used for this quantification. The obtained analytical results are analyzed and processed to generate a report.

Data analysis

All data generated were subjected to analysis of variance (ANOVA) using Special package for social sciences 25.0 origin pro 8 and excel 2016 Where the analysis indicate significant difference mean which were separated using Duncan's multiple range test(DMRT).

Ethical consideration

The Chairman of Bade local government area, Emir of Bade LGA, Divisional police officer of Gashua town, Ward Head and the Rice farmers were met on 29th September and 30th September 2022 and the purpose of the study was explained to them. Each of them received a letter asking for their permission to do the research, and they all responded positively, granting permission for the study to proceed.

Results and discussion

TableI :-Mean and standard Deviation with minimum and maximum values of heavy metals concentrations measured in Rice samples from four (4) different sample site compared to Parboiled rice sample obtained from Gashua market with a statistical difference.

	HeavymetalsConcentrationsinppm)			
Locations	**As**	**Cd**	**Pb**	**Cr**
GMK	0.3830^{a} ±0.2451	0.0242^{b} ±0.0088	0.1020^{d} ±0.0467	0.2810^{c} ±0.2183
GN	0.0610^{b} ±0.0524	0.0283^{b} ±0.010	0.1877^{a} ±0.0634	0.3455^{a} ±0.3007
GS	0.0690^{b} ±0.0711	0.0330^{a} ±0.014	0.0907^{e} ±0.0415	0.2850^{b} ±0.2071
SE	0.0597^{b} ±0.0440	0.0262^{b} ±0.0133	0.1667^{b} ±0.0547	0.2815^{c} ±0.2462
SW	0.0697^{b} ±0.0422	0.0265^{b} ±0.0127	0.1533^{c} ±0.0585	0.2567^{d} ±0.2344
Minimumvalue	0.01	0.00	0.01	0.00
Maximumvalue	0.31	0.06	0.31	1.23
WHO/USEPA	0.003	0.001	0.0035	0.003

[a, b,]Means within each column with different superscripts are significantly different at $P \leq 0.05$

GMK= Gashua Market, GN= Gashua North, GS= Gashua South, SE= South East, SW= South West, WHO= World Health Organization, USEPA= United Nation Environmental protection Agency

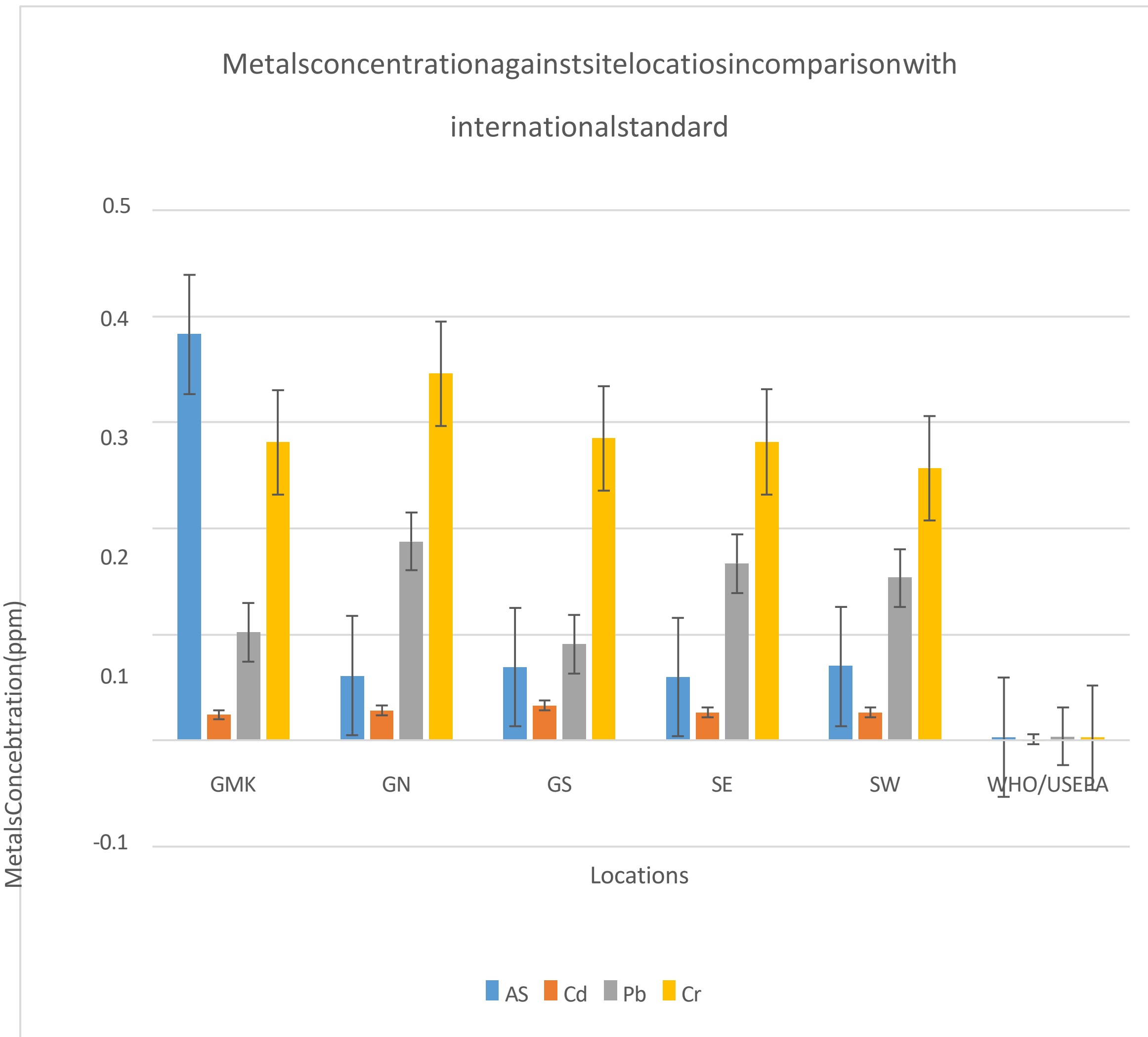

Figure 1 plot of variation in concentration ofvarious metals against sampling locations for rice within Gashua town, Bade Local Government, Yobe State.

Discussion

Assessment of metal level of contamination in rice sample wascarried out. Rice samplefromeachsitewereevaluatedfortheextent ofmetalpollution. The result from the Mean concentration and standard error of mean of Heavy metals in rice samples grown fromfour(4)locationswere compared with the parboiled rice sample obtained fromGashua market,Badelocal government AreaofYobeState which showed that the meanconcentrationsofArsenicinricesamplesvaryacross locations with GMK (parboiled rice) showing the highest concentration (0.3830 mg/kg) and SE having the lowest concentration (0.0597mg/kg)as shown in Table 1.

The standard deviationsindicatevariabilityinArseniclevelswithineachlocation. The high level ofarsenic in the parboiled rice sample (GMK) as shown in Figure I may be as a result of the usage of contaminated water, accumulation of Arsenic in the outer layers (Husk) or pesticide used which are usually reduced during cooking and helps to reduce the overall intake of Arsenic(Gunduz and Akman, 2013)**.**Countless studies within Gashua, Bade LGA Yobe state have shown that drinking water contains high levels of heavy metals above the WHO permissible limits (Amshi et al, 2019). According to Huang *et al*. (2013) Arsenic can easily be accumulated by almost all types of cereals largelybecauseofthehighbioavailabilityofArsenicunderreducedsoilconditions. Rice is much more efficient at assimilating Arsenic into its grain than other staple cereal crops. Long termexposure to high level of Arsenic has been linked to various health issuessuch as skin lesions, cancers, cardiovasculardiseasesanddevelopmental problems inchildren (Al-Saleh,and Abduljabbar, 2017**)**. The result agrees with the outcome of Watson &Gustavi (2022) on Arsenic concentration in the Bahamas where they showed 2% of unpolished rice samples had Arsenic concentration above WHO safety limit of 200µg/kg; they showed the range of contamination from 4.85- 269.4kg^{-1} with an average of 88.4µg/kg^{-1}. The results also agrees with the result of Yalwa *et al*. (2023) where they showed the level of Arsenic in rice from Damashewa, Jigawa state is above the acceptable level. In contrast however the result differs significantly from the outcomeof Jarjes andDarwesh (2023) where they showed Soaking is effective in reducing the concentration of heavy metals in rice. In their study they determined the concentration of As, Cd, Cr, Ni, & Pb. Their results showed the mean concentration before soaking where 0.655, 0.170, 0.160, 0.387 & 0.489 respectively and after soaking it was 0.421, 0.109, 0.115,0.124 and 0.336 respectively. In the current study the parboiling did not havesignificant effect on the level of Arsenic in the parboiled rice samples rather a significant increase was observed in Arsenic level most probably due to the use of contaminated water during parboiling as most local rice and advanced rice millers don’t take into cognizance the quality of water they use in parboiling and several studies showed the water within Gashua and environs are highly contaminated with heavy metals(Amshi et al, 2019). Elsewhere in the contrary Behrouzi*et al.* (2018) showed precooking/ soaking in acetic acid and citric acid at different time frame has considerable effect in reducing heavy metals. They equally showed soaking with citric acid and boiling with citric acid had the highest reducing effect on the content of lead in rice samples. They concluded household soaking and boiling of rice with vinegar (acetic acid) and lemon juice (citric acid) can be an effective means of decreasing heavy metals such as lead in rice. The present study also disagrees with the result of Hanan *et al*.(2023) where they showed washing, soaking and cooking reduces the percentage concentration level of elements in rice, they attributed it to the type of rice, resistance of the surface layers and ability of the organic compounds and proteins to form complexes with metals in rice grain. In the present study the parboiling did not show significant effect on the concentration of Arsenic especially in Parboiled samples from

GMK.The present study also disagrees with the study of Shahriar *et al*.(2022) where they showed rice after boiling with water in the ratio of 1:6 after five washing; As, Cd, and Pb were removed on an average of 33%, 35% and 27% respectively. The level of Arsenic (As) from Gashua main market sample GMK: 0.383 mg/kg is significantlyhigher thanthe WHO/USEPA limit of0.003 mg/kg and at same time higher thanthe other concentrationofArsenicfromall locationsGN,GS,SE,SWValues (0.061mg/kg, 0.0690mg/kg, 0.0597mg/kg, 0.0697mg/kg)all exceedingthelimit. The result agrees with the work of David et al. (2020) where Arsenic levels were however increased significantly after parboiling.Their results showed; Sample A parboiled 1.296 ± 0.08 Sample A unparboiled 0.00 ± 0.00,Sample B Parboiled 1.112 ± 0.04 Sample B unparboiled 0.02 ± 0.00, Sample C parboiled 1.340 ± 0.07 Sample C unparboiled 0.01 ± 0.00 respectively. The results also agrees with the work of Qadri,(2023) where they showed value of As (0.040mg/kg) from Kurdish rice cultivated in Iran where significantly higher. ThegeneraltrendforArsenic in the present study shows that all locations have concentrations that are substantially higher than the WHO/USEPA recommended limitespecially in Gashua Main market GMK sample which suggests a serious risk ofArsenic exposure through rice consumption. The constant fossils fuels burningaroundthe market canreleasesArseniccontentinto theatmospherewhichcaneasilygetin contact with the already parboiled rice or the presence of Agro-chemical shops that were sited near Gashuamarketcaneasilybe carriedawaythroughdustparticles and contaminate the rice.(Khan*etal*.,2018).Otheranthropogenicsourceswhichsignificantlycontributetoheavy metalcontaminationintheenvironment includeautomobileexhaust whichreleases lead, smeltingwhich releasesArsenicandinsecticideswhichalsoreleasesArsenicrespectively(Ugulu*etal*. 2021).According to Khan *et al.* (2021) the presence of heavy metals in the environment leads to a number of adverse impactsandriskelementpollutioninsoilhasbeenacauseforconcernbecauseriskelementsaredifficult to decompose and may be transported in to the human bodythroughthe food chainby eitherair and water. The result disagrees with the work of Wahyuningsih (2023) where they showed As values were within the recommended limit.

Cadmium (Cd) concentrations are relatively low across all locationswith GS showing the highest level (0.0330 mg/kg) and GMK having the lowest (0.0242mg/kg). Standard deviations are relatively small indicating more uniformity in cadmium levels within locations.The level of Cd in the parboiled rice is lower compared to the level of As. The results of Nader *et al.*(2016) and Ahmad and Qadir (2023) differ from the current study where they didn't detect cadmium in rice samples. Studies conducted by *Juliet &*Ndago (2023)at Wukari also didn't detect Cd in rice samples and Chalestori*et al.*(2016) showed contrary result to this study where they showed much higher concentrations of Cd, As, and Pb in Iranian rice. The results equally agrees with the work ofIjeoma *et al.*(2020)andIjeoma et al. (2021) where they showed lower concentration of Cd and other heavy metals in imported rice brands and indigenious rice brand in FCT Abuja , Nigeria. The work of Waribo *et al.*(2023)also agrees with the result of this study where they showed lower concentration which did not exceed WHO limit.Shahriar *et al.*(2023)showed contrary results where they showed higher values for Cd (1.13 mg/kg) which is greater than WHO acceptable limit. Cadmium (Cd) Concentration revealed as 0.0242mg/kg in GMK were very high exceeding the limit of 0.001mg/kgwhileGN,GS,SEandSWrangingfrom0.0262to0.033mg/kg wereallabovethepermissible limit.

Lead (Pb) concentrations showed more variationwith GN having the highest level

(0.1877mg/kg) and GS having the least value of (0.0907mg/kg). The standarddeviationvaluesaremoderatelyhighsuggestingsomevariabilitywithinlocations.The high variability in heavy metal concentrations across different locations suggests the influence of local environmental factors and agricultural practices (Huo *et al.,* 2016)**.** The result agrees with the work of Wahyuningsih (2023) where they analyzed local and imported rice samples in Semerang and showed Pb values ranging from 0.561-0.456 mg/kg in Indonesia sample and 0.307 mg/kg in United state sample which all exceeded Indonesia recommended level. Shahriar *et al.* (2023) showed higher value for Pb (6.87 mg/kg) which is greater than WHO acceptable limit. The result however agrees with the work *of* Juliet andNdago (2023)at Wukari where they detect Pb levels in rice samples ranging from 0.024mg/kg to 0.12mg/kg which they attributed to the residual effect of some agrochemicals. The results also agrees with the work of Yalwa *et al.* (2023) where they showed high level of Pb in rice from Damashewa , Jigawa state above the acceptable level. Chyad*et al.* (2022) equally showed higher levels of Pb with values ranging from 1.805-4.776 mg/kg.

It was vehemently clear that Lead(Pb)concentrationfromallthelocationssuperseded the recommended level most especiallyfor sample fromGashua market (GMK) forthe parboiled rice as 0.102mg/kg exceeding the limit of 0.0035mg/kg and the 0.1877mg/kg from Gashua North (GN) which were significantlyhigherthanrecommendedlimit. Leadlevelsareofparticularconcernespeciallyin GNwherethe concentration is markedlyhigh suggesting a potentialacute risk to public health. Notably Possible sources of Lead poisoning may originates from occupational setting such as batteryworkers,smelters, absorptionoflead (Pb) fromwaterorother environmental sources(Al- Saleh, and Abduljabbar,2017***;*** Khan *et al.,* 2021;Ugulu *et al.,* 2021**)**. The present outcome of this study is in line withthe workreportedbyHamid*etal.* (2020)andTariq*etal.* (2021)wherethey evaluated the role ofsewage sludge in increased concentrations oftrace metals (TMs) and showedthatwheatgrownonsoilamendedwithsludgehadhighconcentrationsoflead(Pb)andCd. Elevatedlevelsofmetals inthesoilcanheightenthesoil'sabilitytoamass these substances (Esmaili *et al.,* 2017 and Khan *et al.,* 2019)**.**Heavy metals possess a mobile nature enabling their movement fromthe soil to plants. These elements demonstratemobilitywithinplantstructuressuchasbetweenrootsandshootsandfromshootstograins. Crops tainted with these elements may pose health risks to individualspotentially leading to severe ailments (Saleem *et al.,* 2020)**.**Numerous studies support the carcinogenic properties of heavy metals contributing to conditions like blood, bone, heart and kidney diseases (Hashem *et al.,* 2020 *and* Javed*et al.,* 2020)**.**Even low concentrationsofheavymetalscanbeharmfultoorganisms for instance exposuretosmallamounts ofCdcanleadtoalveolitis,bronchitisandemphysema.InhalingCdcanresult inkidneyissueswhileits toxicityalso contributesto nerve and bone disordersin humans (Khan *et al.,* 2020 and Tariq *et al.,*2021)**.**

Chromium concentrations are highest in GN (0.3455 mg/kg) and lowest in SW (0.2567 mg/kg) all above the acceptable limit of 0.003mg/kg set by WHO/USEPA.This maybeas a result ofthe certainsoilstructurethat has long been contaminated withchromiumoveranextendedperiod. Theuseoffertilizerandsewage sludgeonfarmland can result in soil contamination and increased metal uptake by plantsespecially in low pH conditions thereby contributing to metalaccumulation in these areas. The Highest concentration recorded in GN (0.3455mg/kg) agrees with the result of Wahyuningsih (2023) where they recorded higher concentration ranging from 241-0.723mg/kg which are all higher. Shahriar *et al.*(2023) equally showed higher

value of Cr (0.43 mg/kg) which is greater than WHO acceptable limit of 0.003mg/kg .
The result however disagrees with the outcome of Ahmad and Qadir (2023) where they showed lower levels of Cr likewise the outcome of Waribo *et al.*(2023) and also Juliet andNdago (2023)in there research at Wukari didn't detect Cd in rice samples.
The surpassing of WHO/USEPA standards for heavy metalsinricesamplesfromtheseregionsraisessignificant public healthconcerns.Acomparisonagainst WHO/USEPA standards for heavy metals in food products (Arsenic: 0.003 mg/kg, Cadmium: 0.001 mg/kg, Lead: 0.0035 mg/kg, Chromium: 0.003 mg/kg) highlights that metal concentrations in most locations far exceed the recommended limits. This suggests potential health risks associated with consuming rice from these areas (Tariq *et al*., 2021).
Whiletheconcentrationofchromium(Cr)supersededtheadmissible limitrequiredbyregulatorybodymostespeciallyforsampleinvestigatedfromGashuaNorth(GN)having thehighestconcentrationof0.3455mg/kgamongallthelocations;Gashua south(GS),GashuaSouthEast(SE)andGashuaSouthWest(SW);GashuaMarket(GMK)forthisstudy all exceeded the permissible limit. GN has the highest Cr value(0.3455mg/kg) among the locations and wellabove the limit. Chromiumlevelsarealarminglyhighin alllocationsespeciallyinGN indicatingasignificant health hazard. Improper waste disposal and distinct metal deposition may be the cause of these metal pollution. These metals persist in the environment inducing severe health issues for both humans and animalprimarily because of their enduring presence and inherent toxicity (Zaheer *et al.,* 2020)**.**They induce various health issues such as cancer, mutations, teratogenicity, disruption of hormones, irritation of the skin and eyes, liver damage, tremors, decreased fertility, effects on the centralnervous system, kidneys, headaches, nausea, dizziness, poisoning leading to coma, endocrine disruption, respiratory illnesses, convulsions, abdominalpain, and loss ofmuscle coordination(Roya and Ali, 2017;Rehman *et al.,* 2019; Ugulu, *et al.,* 2019)

Conclusion

It may be concluded from the result of this study that heavy metals (Arsenic,Cadmium,Lead,andChromium) were found in paddy rice samples from farm and parboiled rice from Gashua Market. The concentration of heavy metals was not significantly affected by parboilingand higher levels of Arsenic were recorded from parboiled samples collected at Gashua market GMK.The findings highlighted significant variations in metal concentrations across locationsraising concerns about potential health risks associated with consuming rice from these areas.
From the result Parboiled samples from Gashua Main Market (GMK) exhibited the highest Arsenic concentrationgreatly surpassing WHO/USEPA limits.

Recommendations

Based on the result of this study the following recommendation was made:

1. Stringentmonitoring/regulation,heightenedpublichealth awarenessand robust environmental protection measures are required by the government.
2. Rice millers should regularly test for heavy metals in the source of water they use for parboiling/steaming of rice in both local and advance factories.
3. There is need for educating the public about health risks associated with consuming contaminated rice.
4. Authorities should regularly conduct thorough research to identify and address contamination sources and support affected communitiesespecially vulnerable groups

like children.

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Conflicts of Interest
There is no conflicts of interest.

Sample collection.
All samples were purchased based on mutual consent from the rice sellers at the market and from the farmers at the farm. Farmers just requested the need to incorporate them in any prospective intervention and they are open to contribute in future research.

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