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Short Communication

An experimental study of arsenic and lead concentration in common food sources

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ABSTRACT

This study estimated the concentration of arsenic (As) and lead (Pb) in commonly used food items: chicken meat, potato and lentils. Furthermore, it also determined the contribution of As and Pb in food through leaching by different types of utensils. Samples of food were bought from open market of Karachi, Pakistan. Each food item was cooked under standardized condition for 20 minutes. The food samples were cooked in utensils made of four different types of materials which are commonly used for cooking. The As and Pb concentrations were determined by inductively coupled plasma mass spectrometry. None of the food items were free of As or Pb. Lentils cooked in aluminium and steel cookware had high concentration of Pb (55.1 and 34.6 ng/gm, respectively). The As concentration was higher in chicken meat (ranged from 41.3 to 47.7 ng/gm) compared to other food items. The chicken meat was uniformly contaminated with high As levels irrespective of the utensil material used for cooking. Thus, chicken meat could be potentially contaminated from external environment (mostly likely during raising). Aluminium or steel utensils have particular interaction with lentils and causes leaching of Pb during cooking. Exposure from As and Pb can be reduced by regulating food items and quality of cooking utensils.

Keywords: Arsenic, Lead, Chicken, Cooking utensils

INTRODUCTION

Chronic exposure to arsenic (As) increases the risk of cancer of skin, bladder, lung and kidney. It also leads to higher rates of cardiovascular diseases and impaired immunity. Furthermore As exposure decrease the intellectual quotient (IQ) among children.[1] The drinking water is the main source of exposure for As and an estimated 200 million people are at risk globally.[2,3] However, exposure of As from food is less commonly reported. For example, reports of crops cultivated in As-contaminated soil including rice and leafy vegetables had high As.[4,5] Furthermore, food items such as fish, dairy product and chicken meat were also sporadically reported for As contamination.[6-9]

Chronic exposures of lead (Pb) cause 0.6% of global burden of disease, mainly due to neurobehavioral disorders among children in developing countries. Despite the control of Pb in the primary sources (petroleum), exposure still occurs through secondary sources (mainly food) due to its widespread contamination of the general environment. [10] Thus, a shift in investigation has occurred to determine exposure of Pb through secondary sources.

The groundwater in river Indus is contaminated with As and approximately 13 million people are potentially exposed in Pakistan.[11-16] Also, several food items including vegetables, grains and fish have been reported to be contaminated with As, mainly by groundwater.[12] Also, despite control of Pb in petrol since 2001, studies

have reported high blood lead levels in Pakistan.[17,18] However, the sources of exposure to Pb are unclear.

This experiment was part of investigation of our recently published work to estimate the exposure of As and Pb among pregnant women, children and newborn in Pakistan.[18] The common food items including lentils, potato and chicken were analyzed for concentration of As and Pb. Furthermore, this investigation estimated the contribution of these metals from leaching during cooking process using commonly used cooking utensils.

METHODS

This experiment was a part of a larger cross-sectional study, which was aimed at identifying potential environmental sources of As and Pb exposure among pregnant women, newborn and young children. The details of the methodology were already published.[18]

Figure 1: Examples of types of utensils used in cooking food items. A) Alloy of aluminum, B) non-stick black-coated, c) stainless steel, d) iron.

In November 2015, we bought a market basket of random samples of three commonly consumed food items including chicken muscle meat, lentils and potato from Karachi city, Pakistan. Four samples of each food items were washed and cooked for 20 minutes in tap-water (only) in utensils made of aluminum, iron, stainless steel and black-coated non-stick cookware, separately (Figure 1). After cooking, each food item was homogenized adding 80 ml of deionized water (in Magimix® food processor). One uncooked sample of potato was also homogenized for comparison and sample of the tap-water used for washing and cooking the foods were also collected. Twenty-five (25) ml of each food sample and tap-water were packed into lead and arsenic free bottles and shipped by commercial carrier in ice-boxes to National Institute of Environmental Studies, Japan. Upon receipt, samples were stored at –20°C until sample preparation and analysis.

Instruments, analysis and quality control

The concentration of As and Pb was estimated by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) at National Institute for Environmental Studies (NIES) Japan.

The homogenized food samples (2 g) were digested with nitric acid (5 mL, Ultrapur-100) and hydrogen peroxide (1 mL) (Wako Pure Chemical Industries, Ltd., Osaka, Japan) using the microwave digestion system (TOPwave). ICP-MS analysis was conducted using Agilent 7500ce (Agilent Technologies Japan, Ltd., Tokyo, Japan) by Japan Food Research Laboratories (JFRL; Tokyo, Japan). JFRL is certified by ISO9001, ISO/IEC 17025 ISO9001, ISO/IEC 17025, and JAS.

Tap water samples were filtered with a 0.45 µm cellulose acetate disk filter MILLEX-HA 33mm diameter (Millipore Corporation, Billerica, MA, USA) and 1/100 volume of nitric acid was added to the filtered samples.

RESULTS

None of the water, food (uncooked or cooked) samples were free from Pb or As. The Pb and As concentration in tap water was 1.3 ng/g and 2.5 ng/g, respectively. Uncooked potato had 10.3 ng/g of Pb and 3.5 ng/g As. The concentration of Pb in chicken and potato cooked in iron cookware was 23 ng/g and 13.4 ng/g, respectively. Concentration of Pb was high in lentils cooked in aluminum and steel cookware, 55.1 ng/g and 34.6 ng/g, respectively. The As level was high in cooked chicken muscle meat regardless of type of cooking utensils and ranged from 41.3 to 47.7 ng/g (Table 1).

Table 1: Lead and arsenic concentration in uncooked and cooked staple food items boiled in different types of cooking utensils (ng/g).

Chemical	Food item	Uncooked concentration of food items and water	Cooked food item concentration			
			Types of utensils used for cooking			
			Steel	Aluminium	Iron	Non-stick
Pb	Chicken	-	13.0	19.3	23.0	13.3
	Lentils (Daal)	-	34.6	55.1	8.6	9.1
	Potato	10.3	9.4	8.9	13.4	10.1
	Tap-water	1.3				
As	Chicken	-	45.0	47.5	47.7	41.3
	Lentils (Daal)	-	3.6	6.2	7.2	8.0
	Potato	3.5	1.4	1.1	1.7	2.7
	Tap-water	2.5				

DISCUSSION

This experiment was a part of larger observational study conducted in urban and rural Sindh, Pakistan, which was conducted to determine the total exposure of pregnant women, newborn and children from three-day food from As and Pb. In the previous study, the weekly As intake of young children through food was high (188 µg/kg bw) and around 14% of the children's weekly As intake was exceeding the provisional tolerable weekly intake (PTWI) level of 15 µg/kg bw.[18,19] The logical next step was to identify the main sources of food commonly contributing to high level of exposure among the vulnerable population. This study confirms that the common food items consumed by the population including lentils, potato and chicken were contaminated with As and Pb in the city of Karachi, Pakistan.

Furthermore, the PTWI standard used for above assessment for As was withdrawn by Joint Food and Agricultural Organization/World Health Organization's (FAO/WHO) Expert Committee on Food Additives (JECFA) in 2011 because of the uncertainty regarding its safety for human health. Reports suggest that lower levels of As below PTWI levels were also associated with lung cancers.[20] Exposure to 0.01–0.04 mg/kg/day As reported to increase the risk for several internal cancers and adverse health outcomes.[21-24]

Few other studies have also reported high levels of As in chicken meat. For example in United States Roxarsone fed chickens had high As (30 to 86 ppb), and the sample of chicken from Canada also has high As (29 ppb).[6,25] Therefore, further investigation and monitoring is required regarding poultry feed and vaccination in Pakistan. The chicken meat makes a large share of meat consumed because of lowest price and it is one of the main sources of protein for the population.[26] Studies have also shown that, arsenic is excreted by chickens in their manures and remain in the environment for longer time, these excretory products are used as fertilizers in agricultural fields, elevating soil arsenic loads and leading to expanded chain of human arsenical exposure.[27] A study conducted in Pakistan reported that chicken feeds in poultry farms may contain as high As as 43.7 µg/g (43700 ppb).[28] In Pakistan, chicken feeds are mostly prepared from small sized sea and fresh water fish, waste materials of animals (blood and non-consumable parts) and low quality grains. This pattern of chicken raising supports the claim for this vicious circle runs to sufficiently maintain the chain, from chicken feeds to chicken and their excretions and finally entering into crops and feeds. Findings also showed direct strong relationship of the accumulation of arsenic in different tissues of broiler chicken and amount of As in feeds.[28]

In our study we used cooked food samples to determine the contribution of different types of utensil in contaminating it. There was apparently no significant difference in concentration of both As and Pb across all types of utensils. However, estimated concentration of Pb was high in lentils which were cooked in steel and aluminum types of cooking utensils. A possible explanation of this higher concentration in lentils could be due to the larger surface area which comes into contact with type of cooking utensils. However, it needs to be further investigated.

The As contribution of water used for cleaning and boiling of food items was negligible. Our study was limited to few food items therefore in future studies we recommend including variety of food items and particularly for children, the junk foods which are being frequently consumed, for analyzing concentration of arsenic and lead. Exclusion of spices, condiments and other food additives used while cooking is another limitation of our study as higher concentrations of such metals have been identifies in spices in Pakistan.[29] We have not used the spices while cooking to determine contamination from raw food items instead.

CONCLUSION

The food items including lentils, potato and chicken meat which were commonly taken by the population in Pakistan was contaminated with As and Pb. In the wake of endeavor of lowering the standards of exposure As and Pb and uncertainty around its safe level in food, a significant proportion of vulnerable population in Pakistan should be considered at risk. Chronic exposure of As and Pb have potential for increasing the risk for cancerous and non-cancerous disease burden. Therefore, strict enforcement of regulation regarding prevention of contamination during raising of chickens, processing and packaging of food items are required. Furthermore, investigation should be expanded for other food items and regular monitoring is warranted.

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REFERENCES

1. Hong Y-S, Song K-H, Chung J-Y. Health effects of chronic arsenic exposure. J Prev Med Public Health. 2014;47(5):245.

2. World Health Organization. Guidelines for Drinking-water Quality [electronic resource]: incorporating 1st and 2nd addenda, Vol. 1, Recommendations. 2008.
3. Naujokas MF, Anderson B, Ahsan H, Aposhian HV, Graziano JH, Thompson C, et al. The broad scope of health effects from chronic arsenic exposure: update on a worldwide public health problem. Environ Health Perspect. 2013;121(3):295-302.
4. Sharifi R, Moore F, Keshavarzi B, Badiei S. Assessment of health risks of arsenic exposure via consumption of crops. Exposure Health. 2017:1-15.
5. Ma L, Wang L, Jia Y, Yang Z. Accumulation, translocation and conversion of six arsenic species in rice plants grown near a mine impacted city. Chemosphere. 2017;183:44-52.
6. Dabeka RW, McKenzie AD, Lacroix GM, Cleroux C, Bowe S, Graham RA, et al. Survey of arsenic in total diet food composites and estimation of the dietary intake of arsenic by Canadian adults and children. J AOAC Int. 1993;76(1):14-25.
7. Schoof RA, Yost LJ, Eickhoff J, Crecelius EA, Cragin DW, Meacher DM, et al. A market basket survey of inorganic arsenic in food. Food Chem Toxicol. 1999;37(8):839-46.
8. Yost LJ, Tao SH, Egan SK, Barraj LM, Smith KM, Tsuji JS, et al. Estimation of Dietary Intake of Inorganic Arsenic in U.S. Children. Hum Ecol Risk Assess. 2004;10(3):473-83.
9. Silbergeld EK, Nachman K. The environmental and public health risks associated with arsenical use in animal feeds. Ann N Y Acad Sci. 2008;1140(1):346-57.
10. Fillion M, Blais JM, Yumvihoze E, Nakajima M, Workman P, Osborne G, et al. Identification of environmental sources of lead exposure in Nunavut (Canada) using stable isotope analyses. Environ Int. 2014;71:63-73.
11. Fatmi Z, Azam I, Ahmed F, Kazi A, Gill AB, Kadir MM, et al. Health burden of skin lesions at low arsenic exposure through groundwater in Pakistan. Is river the source? Environ Res. 2009;109(5):575-81.
12. Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Shah AQ, et al. Determination of arsenic levels in lake water, sediment, and foodstuff from selected area of Sindh, Pakistan: Estimation of daily dietary intake. Food Chem Toxicol. 2009;47(1):242-8.
13. Nickson RT, McArthur JM, Shrestha B, Kyaw-Myint TO, Lowry D. Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan. Applied Geochemistry. 2005;20(1):55-68.
14. Farooqi A, Masuda H, Firdous N. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environ Pollut. 2007;145(3):839-49.
15. Arain M, Kazi T, Baig J, Jamali M, Afridi H, Shah A, et al. Determination of arsenic levels in lake water, sediment, and foodstuff from selected area of Sindh, Pakistan: estimation of daily dietary intake. Food Chem Toxicol. 2009;47(1):242-8.
16. Rabbani U, Mahar G, Siddique A, Fatmi Z. Risk assessment for arsenic-contaminated groundwater along River Indus in Pakistan. Environmental Geochemistry Health. 2017;39(1):179-90.
17. Kadir MM, Janjua NZ, Kristensen S, Fatmi Z, Sathiakumar N. Status of children's blood lead levels in Pakistan: implications for research and policy. Public Health. 2008;122(7):708-15.
18. Fatmi Z, Sahito A, Ikegami A, Mizuno A, Cui X, Mise N, et al. Lead Exposure Assessment among Pregnant Women, Newborns, and Children: Case Study from Karachi, Pakistan. International J Environmental Res Public Health. 2017;14(4):413.
19. Kayama F, Fatmi Z, Ikegami A, Mizuno A, Ohtsu M, Mise N, et al. Exposure assessment of lead from food and airborne dusts and biomonitoring in pregnant mothers, their fetus and siblings in Karachi, Pakistan and Shimotsuke, Japan. Rev Environ Health. 2016;31(1):33-5.
20. Putila JJ, Guo NL. Association of arsenic exposure with lung cancer incidence rates in the United States. PloS One. 2011;6(10):e25886.
21. Hsueh YM, Cheng GS, Wu MM, Yu HS, Kuo TL, Chen CJ. Multiple risk factors associated with arsenic-induced skin cancer: effects of chronic liver disease and malnutritional status. Br J Cancer. 1995;71(1):109-14.
22. Lubin JH, Pottern LM, Stone BJ, Fraumeni JJF. Respiratory cancer in a cohort of copper smelter workers: results from more than 50 years of follow-up. Am J Epidemiol. 2000;151(6):554-65.
23. Kurttio P, Pukkala E, Kahelin H, Auvinen A, Pekkanen J. Arsenic concentrations in well water and risk of bladder and kidney cancer in Finland. Environ Health Perspect. 1999;107(9):705-10.
24. Chiou HY, Hsueh YM, Liaw KF, Horng SF, Chiang MH, Pu YS, et al. Incidence of internal cancers and ingested inorganic arsenic: a seven-year follow-up study in Taiwan. Cancer Res. 1995;55(6):1296-300.
25. Tao SSH, Michael Bolger P. Dietary arsenic intakes in the United States: FDA total diet study, September 1991-December 1996. Food Addit Contam. 1999;16(11):465-72.
26. Hussain J, Rabbani I, Aslam S, Ahmad H. An overview of poultry industry in Pakistan. Worlds Poult Sci J. 2015;71(4):689-700.
27. Arai Y, Lanzirotti A, Sutton S, Davis JA, Sparks DL. Arsenic speciation and reactivity in poultry litter. Environ Sci Technol. 2003;37(18):4083-90.
28. Kazi TG, Shah AQ, Afridi HI, Shah NA, Arain MB. Hazardous impact of organic arsenical compounds in chicken feed on different tissues of broiler chicken and manure. Ecotoxicol Environ Saf. 2013;87:120-3.

29. Nordin N, Selamat J. Heavy metals in spices and herbs from wholesale markets in Malaysia. Food Addit Contam Part B Surveill. 2013;6(1):36-41.

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