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Original Article

Effect of Environmental Exposure of Arsenic on Cattle and Poultry in Nadia District, West Bengal, India

Bakul Kumar Datta, Moloy Kumar Bhar, Pabitra Hriday Patra, Debasish Majumdar[1], Radha Raman Dey[3], Samar Sarkar[2], Tapan Kumar Mandal, Animesh Kumar Chakraborty

Department of Pharmacology and Toxicology, [2]Veterinary Medicine and Jurisprudence, West Bengal University of Animal and Fishery Sciences, 37, K.B. Sarani, Kolkata, [1]Department of Agricultural Statistics, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, [3]Calcutta National Medical College, Kolkata, India

ABSTRACT

A study was undertaken to evaluate an alternative source of arsenicosis in human food chain through livestock. Thirty milch cattle and 20 poultry birds along with their eggs were selected randomly from two endemic villages of Nadia district and one nonendemic villages of Hooghly district in West Bengal, India. Milk, feces, urine, and hair samples of cattle and feed materials, such as water and straw, were collected to analyze arsenic status. Arsenic concentration in egg yolk and albumen from poultry eggs and different poultry organs after culling was estimated. Distribution of arsenic in animal body indicates that major portion of arsenic was eliminated through feces, urine, and milk. Poultry egg yolk, albumen, and poultry products retain arsenic in all organs. Cows and poultry birds reared in endemic zone retain significantly higher concentration of arsenic. Consumption of egg, agricultural produces grown in contaminated soil, and milk might have produced arsenicosis and may be considered as alternative source of arsenic contamination.

Key words: Arsenic, cattle, poultry, residue

INTRODUCTION

Several regions of south and East Asia, including West Bengal, have naturally occurring arsenic in ground water. In West Bengal alone one million people are at risk due to consumption of water having arsenic concentration 10- to 20-fold higher than the maximum permissible limit of 0.05 mg/L.[1] Due to irrational and unplanned withdrawal of water for irrigational purpose from shallow and/or deep tubewell, water level is reduced. It is suspected that arseno-pyryte-rich sediment is solubilized because of increased oxygen availability leading to more availability of arsenic in water.[1] Large number of cattle and poultry reared in this area consumed their drinking water from arsenic-affected tube well. It was observed that the people of arsenic endemic region suffer from arsenicosis although they are supplied with arsenic-free drinking water for more than 12 years.[2,3] Therefore, it is expected that arsenic from other sources except water may enter the food chain through agricultural produces, fishes, and animal products, such as meat, milk, egg, and so on. It is also reported that arsenic excretes through milk.[3] Therefore, consumption of agricultural produces, fish, meat, milk, milk products, and eggs may cause arsenicosis in human being.

In Nadia district village Mandal-Hat under Chakda block and another village named Mitrapur under Haringhata block were badly affected with arsenic poisoning, and were selected as our experimental villages. Akna village of Hooghly district under Polba block was selected as

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Address for correspondence: Dr. Tapan Kumar Mandal, Department of Veterinary Pharmacology and Toxicology, West Bengal University of Animal and Fishery Sciences, 37 K.B.Sarani, Kolkata - 700 037, India. E-mail: drtkm48@yahoo.co.in

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control.[3] Since arsenic concentration in different substrates were found to be below permissible limit.

Available literature does not indicate that any work on residue of arsenic in poultry egg, meat, and cattle milk were carried out in these areas. Considering the above, the present work was undertaken to study residue of arsenic in livestock produces.

MATERIALS AND METHODS

Selection of animals

Thirty milch animals from each village of Akna (control), Mandal-Hat and Mitrapur rearing for more than 2 years were selected for this study. Arsenic concentration of different substrate like hair, feces, urine, and milk were collected from experimental as well as control animals. Water and straw samples fed to those animals were also collected. Twenty healthy laying poultry birds weighing between 1.5 and 2 kg reared for at least one year in those villages were considered and their eggs were selected for estimation of arsenic residue in different organs and eggs.

Chemicals

All chemicals were of analytical grade and purchased from Rankem Pvt Ltd, E-Merck (India), and Sigma–Aldrich (USA).

Collection of samples

Milk samples after manual milching from all 4 teats were mixed and pooled samples placed in a dry plastic container prewashed with nitric acid (20%). Feces samples were taken from rectum manually and kept in plastic zipper bag. Hair samples were collected from tail. Straw and water samples were collected directly from manger of respective cow. Urine sample was collected by gently stroking a cow just under her vulva.[4] Egg samples were kept in freeze at 4°C and poultry birds were slaughtered to collect various organs and kept in plastic zipper. All samples except straw and hair stored in −20°C until processed.

Estimation of total arsenic

Total arsenic was analyzed in all samples by wet ashing procedure in hot plate. Milk, water, feces, urine, straw, hair, poultry organs, such as intestine, muscle, brain, lung, liver, kidney, feather, ovary, stomach, heart, crushed bone of poultry birds, and egg yolk and albumen, were digested by tri-acid mixture (nitric, perchloric, and sulfuric acid in the ratio 10:4:1).[3] Digested samples were diluted with Millipore water and filtered through Whatman filter paper no. 1 and made it to 10 mL. Five milliliters of concentrated hydrochloric acid and 1 mL of potassium iodide (5%) and ascorbic acid (5%) mixture was added. The aliquots were kept for 45 min for transformation of arsenate to arsenite. Millipore water was added thereafter to make the final volume 50 mL. All the samples were analyzed in hydride generation technique in Atomic Absorption Spectrometer (AAS). A Varian AA240 model AAS with vapor generation accessories (model no VGA77) was used for total arsenic estimation. Reducing agent (aqueous solution of 0.6% sodium boro-hydride in 0.5% sodium hydroxide) and acid (40% HCl) were prepared freshly before use. Working standard solutions were prepared by dilution of stock solution. The working standards of 2.5, 5, 10, 15, and 20 µg/L were prepared from stock solution for preparation of standard curve. The calibration is periodically checked at the frequency of 20 readings.

Validation of total arsenic estimation

For validation of total arsenic analysis, substrates, such as milk, feces, and hair, were collected from animals of control zone. Likewise water, straw, poultry organs, and egg albumen and yolk were collected from specified zone. Arsenic content of each substrate was then assayed and considered for validation. The natural arsenic content of each substrate was deducted from the fortified result and expressed in percentage. Known quantity of arsenic AAS grade standard solution was spiked in different concentrations in a single and combined manner in different concentrations in water, milk, feces, urine, straw, hair, poultry substrates, and egg yolk and albumen so that the final total arsenic concentration would be 1, 2, 4, 8, and 16 µg/L. Then the acid digestion procedure was carried out and total arsenic concentration was estimated by hydride generation technique. It was observed that total recovery varied from 89% to 96% and limit of detection for each substrate was 1 µg/L.

This project was approved by the Institutional Animal Ethics Committee.

Statistical analysis

Data obtained were analyzed in SPSS (version 10.0) by one-way ANOVA for more than 2 groups of observations. Multiple comparisons were made by Duncan's multiple range tests. The significance in differences was accepted at $P<0.05$.

RESULTS

Residue of total arsenic in milk, feces, urine, hair, straw, and water samples were significantly higher in all experimental village samples compared with control values [Table 1]. Likewise, concentration of arsenic in milk, feces, urine, hair, straw, and water collected from Mitrapur village were found to be significantly ($P<0.05$) higher than those of

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Mandal-Hat [Table 1]. Total arsenic concentration in egg albumen as well as egg yolk of Mandal-Hat was higher ($P<0.05$) compared to control village Akna, whereas arsenic concentration of egg yolk samples of Mitrapur showed significant difference with control village. Arsenic concentration of both egg albumen and egg yolk of Mitrapur was significantly lower than that of values of Mandal-Hat [Table 2]. Residue study showed that all organs of poultry birds of Akna village (control group) retained the arsenic of which feather retained the highest quantity followed by ovary and bone in sequence. All the organs of poultry birds of Mitrapur retained increased quantity ($P<0.05$) of arsenic residue from that of control values. All the organs of poultry birds except lung, liver, stomach, bone, and heart of experimental village Mandal-Hat retained significant increase of arsenic residue compared to control values. Feather retained the highest residue of arsenic in poultry birds of Mitrapur and Mandal-Hat village [Table 3].

Table 1: Residue of arsenic in different substrates in arsenic nonendemic and endemic villages

Substrate	Concentration of arsenic (ppm)		
	Control (Akna)	Mitrapur	Mandal–Hat
Water	$0.015^{a} \pm 0.002$	$0.057^{b} \pm 0.010$	$0.034^{c} \pm 0.009$
Milk	$0.013^{a} \pm 0.002$	$0.072^{b} \pm 0.012$	$0.047^{c} \pm 0.004$
Feces	$0.143^{a} \pm 0.016$	$0.580^{b} \pm 0.045$	$0.259^{c} \pm 0.027$
Urine	$0.038^{a} \pm 0.008$	$0.098^{b} \pm 0.014$	$0.061^{c} \pm 0.010$
Hair	$0.425^{a} \pm 0.050$	$4.065^{b} \pm 0.547$	$1.628^{c} \pm 0.256$
Straw	$0.276^{a} \pm 0.022$	$2.748^{b} \pm 0.275$	$0.772^{c} \pm 0.063$

Dissimilar superscript varied significantly in between rows ($P<0.05$). Mean ± SE, n = 30

Table 2: Residue of arsenic in poultry egg albumen and yolk

Substrates	Concentration of arsenic (mg/kg) in poultry eggs of different villages		
	Control (Akna)	Mitrapur	Mandal Hat
Egg albumen	$0.029^{a} \pm 0.006$	$0.028^{a} \pm 0.008$	$0.062^{b} \pm 0.014$
Egg yolk	$0.048^{a} \pm 0.011$	$0.071^{b} \pm 0.019$	$0.111^{c} \pm 0.027$

Dissimilar superscript varied significantly in between rows. ($P<0.05$). Mean ± SE, n = 20

Table 3: Residue of arsenic in different poultry organs

Organ	Concentration of arsenic (mg/kg) in poultry organs of different villages		
	Control (Polba)	Mitrapur	Mandal Hat
Intestine	$0.052^{a} \pm 0.012$	$0.087^{b} \pm 0.031$	$0.074^{b} \pm 0.033$
Muscle	$0.019^{a} \pm 0.006$	$0.029^{b} \pm 0.007$	$0.030^{b} \pm 0.007$
Brain	$0.016^{a} \pm 0.004$	$0.029^{b} \pm 0.006$	$0.020^{b} \pm 0.005$
Lung	$0.024^{a} \pm 0.007$	$0.040^{b} \pm 0.009$	$0.023^{a} \pm 0.006$
Liver	$0.021^{a} \pm 0.005$	$0.072^{b} \pm 0.016$	$0.020^{a} \pm 0.006$
Kidney	$0.031^{a} \pm 0.007$	$0.098^{b} \pm 0.019$	$0.053^{c} \pm 0.010$
Feather	$0.208^{a} \pm 0.043$	$0.485^{b} \pm 0.097$	$0.346^{c} \pm 0.083$
Ovary	$0.055^{a} \pm 0.009$	$0.099^{b} \pm 0.014$	$0.096^{b} \pm 0.015$
Stomach	$0.044^{a} \pm 0.008$	$0.112^{b} \pm 0.035$	$0.047^{a} \pm 0.012$
Bone	$0.049^{a} \pm 0.012$	$0.074^{b} \pm 0.019$	$0.063^{a}b \pm 0.021$
Heart	$0.018^{a} \pm 0.005$	$0.071^{b} \pm 0.018$	$0.019^{a} \pm 0.006$

(Mean ± SE, n = 20). Dissimilar superscript varied significantly in between rows. ($P<0.05$)

DISCUSSION

A lactating cow on an average drinks 55 L of water per day.[5] Based on the above references a lactating cow of Akna (control), and Mitrapur and Mandal-Hat (experimental) consumes, respectively, 0.825, 3.135, and 1.87 µg arsenic per day. Likewise, a cow consumes on an average 13.5 kg straw per day[6] and if it is calculated on the basis of present findings, then a cow of Akna (control) and Mitrapur and Mandal-Hat (experimental) villages intake 3.675, 37.09, and 10.42 µg of arsenic per day, respectively. Therefore, a cow consumes more amount of arsenic through straw than that of water. The data suggest that arsenic predominantly enters the body of cow through straw followed by drinking water. Distribution of arsenic in the body indicates that hair retained the maximum concentration followed by excretion through feces, urine, and milk in sequence. Hair is not normally consumed by human beings, but excretion of arsenic through feces and urine of cow contaminates the surrounding and milk or milk products are consumed by human beings. If human beings of three villages are supplied by arsenic-free water (below permissible limit),[3] then consumption of foods growing in contaminated soils and milk or milk products might be one of the possible alternative sources of arsenicosis in human beings.

Analysis of egg yolk and albumen and different substrates of poultry showed that arsenic concentration is retained in all the organs, including meat. Besides, the concentration of arsenic in egg yolk and albumen and poultry products reared in arsenic endemic zone (Mitrapur and Mandal-Hat) is significantly higher than those in the birds reared in the nonendemic zone (Akna). Therefore, the concentration of arsenic present in egg, poultry products coupled with contaminated foods and milk of cow may constrain a food chain, which on consumption might produce arsenicosis in human beings.

CONCLUSION

Consumption of cow milk, poultry egg, poultry products, and agricultural produces grown on contaminated soil from arsenic endemic area may cause public health hazards.

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