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Simultaneous Determination of Accumulated Hazardous Metals in Hen's Egg by Atomic Absorption Spectroscopy

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Abstract: The present study was conducted to investigate the quality of hen's egg and to elaborate the contamination of toxic metals and their distribution between feed and egg. For this purpose, Toxic elements (Pb, Cd, Zn, Cu, Co, Ni, Cr and Fe) have been investigated their quality, quantity, suitability and possible health hazards. Lead, chromium and cadmium were found higher concentration and cobalt was detected below the detection limit. Atomic absorption spectroscopy technique was used for performing these tests and data of different local batches in Pakistan were compared.

Key words: Toxic metals, atomic absorption spectroscopy, egg contamination

INTRODUCTION

The presence of toxic metals in food of animal origin has received considerable attention during recent years. Most of us ingest heavy metals (lead, cadmium, chromium, zinc, iron, copper and cobalt) via food in our daily diet, although the quantity of heavy metals varies from place to place depending on dietary habits, levels of environmental pollution and recycling of poultry food. The egg is one of the most common sources of protein in the diet of the population of Pakistan. Per capita egg consumption increased significantly during the past few years' even egg is a source of metal exposure. Commercial poultry farmers now use inorganic materials in poultry feed for augmentation of health and production. The metals examined in the research paper include lead, cadmium, chromium, iron, cobalt copper, chromium and zinc. In some cases, heavy metals attack nervous tissues by enzymatic blocking of biochemical reactions. More frequently, they destroy excretory organs, such as the liver and kidneys. Lead and cadmium do not have any significant or useful nutritional value[1]. High amount of trace elements, like Cu, Pb, Zn, Cd and Hg is responsible for several diseases[2]. Cadmium is suspected for renal arterial hypertension, cancer and bone weakness[3]. Chronic Lead toxicity produces anemia, paralysis and mental retard ness. Mercury hazards are characterized by kidney damage, vomiting, inflammation of mouth and gums and muscle tremors[4]. The uptake of Pb from eggs in children is approximately 40%[5]. The rate of egg consumption depends on socioeconomic status, age group and place of residence either urban or rural. The rate of egg consumption among lower class individuals and those residing in rural areas is very low. Boiling and frying are the predominant ways of egg preparation among lower-class individuals and their average intake is 6 eggs/week (egg per capita: 3.7 kg; i.e., the total weight of eggs consumed in a year calculated by multiplying the average weight of eggs taken per day by 365). The upper class, the rich and the affluent consume more eggs prepared in several ways, in addition to the normal boiled and fried eggs. These individuals eat more egg containing cakes, homemade biscuits, drinks (eggovin) and salad than poor individuals; such behaviours could amount to an average intake of 3 eggs per day (egg per capita: 18.6 kg). On average, a middle-class individual (i.e., healthy urban inhabitant) consumes an average of 2 eggs per day, for an egg per capita of 12.4 kg.

In this study the contributions of heavy metals from other sources did not completely rule out, such as direct inhalation by chickens of particulate metals in air, ingestion of metals in drinking water and atmospheric deposition of particulate metals on eggs from industry. The concentrations of lead and cadmium in eggs were reported in India (i.e., both in third-world countries) slightly greater than the concentrations reported in eggs in many of the advanced countries, where the quality of animal feed and food items is monitored strictly[6].

MATERIALS AND METHODS

This study was conducted during May 2003 to August 2004. A total of 150 hen's eggs were obtained from local market in different batches. Each egg was

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broken individually and the yolk and egg white were mixed. Two grams of emulsified samples were taken in duplicate. The samples were digested in a double-acid mixture (4 parts nitric acid and 1 part perchloric acid), in accordance with the official methods of analysis[7].

Estimation of toxic (heavy) elements was made by using atomic absorption spectrophotometer (Perkin Elmer, Model 3030B) with air acetylene as combustion gas in PCSIR, Labs. Complex, Lahore, Pakistan. The detection limits Cd and Pb were 0.001 and 0.02 μg g^{-1}, respectively. The results were expressed in micro gram/gram and proceeded the data statistically with standard methods.

RESULTS AND DISCUSSION

The present studies were conducted to investigate the quality of the hen's egg. For this purpose the identification and analysis of hazardous metals (Pb, Cd, Cr, Zn, Cu, Co, Ni, Cr and Fe) were performed (Table 1). The average content of metals in the various feeds was correlated strongly with the corresponding overall average concentrations of the metals in eggs. Considering the high correlation between the metal content in feeds and the corresponding amounts of metals in eggs but apparently little or no variation in the metal content of eggs bought at different locations, feed seemed to be the major contributor to the amount of metals in eggs. Intrusion of metals during the grinding or milling process might contribute to the high concentration of Cd in feed. The high Pb content of 0.66 g L^{-1} in Pakistani petrol could result in Pb contamination of feed from the emission of Pb particulate matter.

The overall average concentration of Pb was 0.59 mg kg^{-1} in eggs (Table 3) and it was greater then the averages of 0.048 and 0.489 mg kg^{-1} reported in eggs in china and India, respectively[8,9]. Similarly, the average concentration of Cd found in eggs (0.07 mg kg^{-1}) was slightly higher than (Table 3) the 0.01, 0.004 and 0.005 mg kg^{-1} reported in eggs in Canada, Finland and China, respectively[10-12] but was comparable with the concentration of 0.072 mg kg^{-1} reported for Cd in hen's eggs in India[13]. The average values of 0.78 mg kg^{-1} for Cu and 23.20 mg kg^{-1} for Fe, was similar to the average values found in eggs in Finland: 0.70 mg kg^{-1} for Cu and 25 mg kg^{-1} for Fe[14]. The average concentrations of Ni, Zn and Co was 0.03, 13.75 and 0.01 mg kg^{-1} did not differ significantly (Table 2) from previously reported concentrations of 0.01, 14 and 0.005 mg kg^{-1}, respectively, in eggs[15].

The average estimated daily intake of Pb and Cd from eggs in Pakistan was 19.5 and 2.4 μg (Table 3) significantly more than the daily intake of Pb from eggs of 0.3, 5.1 and 6.1 μg and Cd from egg of 0.1, 0.6 and 0.5 μg which was about four times as reported in Finland, Germany and Japan, respectively[16]. The difference in the daily intake of Pb and Cd in Pakistan and the reported daily intake in those countries may be traceable to differences in the eating habits of individuals from the different countries. People consume the whole egg in Pakistan, whereas in many developed countries the yolk is generally avoided because it contains high concentrations of cholesterol and high heavy metal content. From (Table 3) estimated average daily intake of Cu from eggs (25.6 μg) was less than the daily reported intake of 40 μg of Cu from eggs in Taiwan[12]. Estimated daily intakes of Fe and Ni were 762.3 and 0.9 μg, respectively (Table 3), whereas the estimated daily intakes of Zn and Co were 452.1 and 0.2 μg, respectively. The estimated daily intakes for Fe, Zn, Co and Ni were comparable with the estimated daily intake reported from chicken eggs in Canada for Fe (821.3 μg), Zn (557.7 μg), Co (1.1 μg) and Ni (1.5 μg).

Table 1: The toxic metals level in poultry feed samples (mg kg^{-1})

Feed code*	Lead	Cd	Cu	Iron	Ni	Zinc	Co	Cr
A	2.84	0.37	4.70	109.00	0.11	79.75	0.05	3.42
B	2.79	0.41	5.20	111.10	0.11	80.21	0.03	4.45
C	2.80	0.33	5.70	106.80	0.11	79.32	0.04	3.85
D	3.01	0.36	5.50	108.20	0.10	79.40	0.04	3.95
E	3.15	0.38	4.80	111.80	0.10	80.8	0.05	4.20
Average	2.86	0.37	5.28	108.78	0.11	79.67	0.04	3.97

Cd: Cadmium; Cu: Copper; Cr: Chromium; Co: Cobalt; Ni: Nickel

Table 2: The toxic metals level in poultry egg samples (mg kg^{-1})

Egg source	No. of batches	No. of samples	Pb	Cd	Cu	Fe	Ni	Zn	Co	Cr
Farm 1	10	26	0.52	0.07	0.81	23.20	0.02	13.70	0.01	0.70
Market a	5	11	0.60	0.07	0.78	22.30	0.02	13.80	0.01	0.85
Farm 2	10	23	0.61	0.08	0.78	24.10	0.03	13.80	0.01	0.69
Market (b)	5	22	0.58	0.08	0.80	23.60	0.03	13.90	0.01	0.58
Farm 3	10	15	0.62	0.08	0.79	23.50	0.03	13.90	0.01	0.75
Market (c)	5	25	0.59	0.07	0.77	21.80	0.03	13.70	0.01	0.81
Farm 4	10	14	0.60	0.07	0.75	22.90	0.03	13.60	0.01	0.68
Market (d)	5	13	0.61	0.07	0.74	23.80	0.03	13.60	0.01	0.70
Farm 5	10	24	0.57	0.07	0.77	22.56	0.03	13.56	0.01	0.76
Market (e)	5	15	0.63	0.07	0.82	24.00	0.03	13.88	0.01	0.80

(Market) Set of egg samples were collected from different markets. (Farm) Set of egg samples were collected from poultry farms. 1,2,3,4, 5 and a, b, c, d, e are main big cities of Pakistan

Table 3: Statistical views of toxic metals and average estimated daily intake of trace metals

Metal	Average	Range	SD	Average estimated daily intake (μg person^{-1})
Pb	0.59	0.52-0.62	0.03	19.5
Cd	0.07	0.07-0.08	0.00	2.4
Cu	0.78	0.74-0.81	0.02	25.6
Fe	23.20	21.80-24.10	0.80	762.3
Ni	0.03	0.02-0.03	0.01	0.9
Zn	13.75	12.90-14.50	0.22	452.1
Co	0.01	0.01-0.01	0.00	0.2
Cr	0.732	0.68-0.78	0.074	24.8

Grains, such as maize, soybeans and wheat, which are the major components of feed, could also have picked up or bioaccumulated Pb, Cr and Cd directly from contaminated soil, depending on the location in which they were grown and the chemical nature of the soil there. Excessive and improper use of inorganic or organic fertilizer could lead to the accumulation of metals in the soil (particularly Cd, Cr and Pb), which would be biomagnified by plants and eventually end up in animal feed[17], Close proximity of farms and crop plantations to industry could also result in crop contamination by metals. Increased concentrations of lead, chromium and other metals have been reported in Pakistan in soils and vegetation around a lead battery and particularly at Kasur Leather factories.

Other dietary constituents or food matrices may interact with the metals through formation of complexes or oxidation-reduction activity, all of which may strongly influence the absorption of the metal in the alimentary canal. High amount of trace elements, like Cu, Pb, Zn, Cd and Hg is responsible for several diseases[17]. Cadmium is suspected for renal arterial hypertension, kidney damage and cancer and bone weakness. Chronic Lead toxicity produces anemia, paralysis and mental retard ness. Mercury hazards are characterized by, blindness, deafness vomiting, inflammation of mouth and gums and muscle tremors[18].

The daily intake of metals from eggs among the poor people in Pakistan is less than the estimated average daily intake from other classes, but we expect that their daily intake of metals from eggs will approach the estimated average value in the near future. The present estimated daily intake is also expected to increase when the economic status of the general population is improved. Although the amounts of some metals in eggs are not at the level that can cause health hazards to the population, the amounts of Pb and Cd in particular call for serious attention. Considering the gravity and intensity of danger that Pb, Cr and Cd could cause to public health and safety.

CONCLUSIONS

A little variation of toxic metals in hen's egg was observed even egg samples were collected in different locations of Pakistan. Grains, such as maize, soybeans and wheat, which are the major components of feed, could also have picked up or bioaccumulated heavy metals directly from contaminated soil, depending on the location in which they were grown and the chemical nature of the soil there. Pb, Cr and Cd were present in higher level and could cause many diseases like Kidney damages, behavior changes, blood pressure and hearty diseases.

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