BCSIR

Available online at www.banglajol.info

Bangladesh J. Sci. Ind. Res. **44(1)**, 11-30, 2009

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

E-mail: bjsir07@gmail.com

Assessment of Tannery Based Chromium Eco-toxicity through Investigating Regional Bio-concentration in Commercially Produced Chicken Eggs and their Physical Properties

A. M. M. Maruf Hossain*[a], M. Shahidul Islam[b], M. Moklesur Rahman[a], M. Mustafa Mamun[a], M. Azizul Islam Kazi[b], and Syed Fazle Elahi[a]

[a]Department of Soil, Water and Environment, Faculty of Biological Sciences, University of Dhaka; [b]Analytical Research Division, BCSIR Laboratories, Dhaka, Bangladesh.

Abstract

In Bangladesh, among the routes of chromium eco-toxicity, feeds and fertilizer production from tanned skin-cut wastes is the most direct one leading to food chain contamination. The tanning industries of Hazaribagh are processing some 220 metric tons of hide a day with an associated release of 600 - 1000 Kg of tanned skin-cut waste (SCW) resulting from per ton processed hide. The SCW are protein-rich and are unscientifically used to produce protein-concentrates for poultry and fish feeds, and organic fertilizer. In view of the facts, a huge migration of chromium can happen into poultry products, fish and vegetables, and further bio-magnify into food chain. The target population of this phenomenon is also huge. Regional bio-concentration of chromium was investigated in commercially produced chicken eggs. Though the routes of distribution of this hugely produced protein-concentrates from SCW are unknown, eggs were sampled from Dhaka and its nearby other seven districts covering the central region of Bangladesh. Twelve eggs were randomly sampled from each district's egg stock market while albumen and yolk in each egg were studied separately for all studies. Out of the 192 samples from 96 eggs, dry weight basis mean chromium concentration was found to be 1.9016 ppm with a sample standard deviation of 0.1502. The concentration levels were ranged from maximum of 19.8051 ppm to undetectable levels. Single poultry egg was found to contain a mean chromium content of 23.3809 µg, which exceeds adequate daily dietary intake of children up to 8 years of age as well as corresponds to major part for other age groups. The region-wise physical properties of the eggs were also studied which included USDA size grading by whole weight at raw condition, whole weight ratio of raw condition to complete boiled condition, weight ratio of boiled shell-albumen-yolk, moisture content of albumen of boiled eggs, and moisture content of yolk of boiled eggs. The mean whole weights of eggs at raw condition were within the range of 39.9568 g ('peewee' as per USDA size grading) to 62.4047 g ('large' as per USDA size grading), the mean whole weight ratio of raw condition to complete boiled

* Corresponding author, E- mail: *Email: mueed_abd@yahoo.com

condition ranged between "1 : 0.9704" to "1 : 0.9782", the minimum weight ratio of boiled shell-albumen-yolk for all sample classes were ranged from "1 : 2.0714 : 1.1549" to "1 : 4.8810 : 2.0677" whereas the maximum weight ratio ranged from "1 : 3.1933 : 1.4557" to "1 : 7.8084 : 3.3818", the mean moisture content of albumen of boiled eggs varied within the range of 82.8876% to 84.7636%, and the mean moisture content of yolk of boiled eggs were between 50.6563% to 52.5124%. These properties are of importance for local-level as well as basic researches on poultry.

Key words: Heavy metal bio-concentration, Ecotoxicology, Egg science

Introduction

Leather, a traditional export item in Bangladesh, enjoys a good reputation worldwide for their quality. This sector plays a significant role in the economy of Bangladesh in terms of its contribution to export and domestic market. In south-west part of Dhaka city, there is a tannery area occupying 25 hectares of land at Hazaribagh, where about 90% of tannery industries of Bangladesh are located. The tanning industries of Hazaribagh are processing some 220 metric tons of hide a day with an associated release of 600 - 1000 Kg of tanned skin-cut waste (SCW) resulting from production of each ton processed rawhide or skin (Zahid, *et al*., 2004). The SCW are sliced cut pieces of hides produced at the end of some tanning processes to maintain a definite thickness. Being protein origin, these wastes are converted to protein-concentrate to be used as poultry feed, fish feed, and in production of organic fertilizers with some treatment. One of the major concerns of these activities is the heavy metals, especially chromium, used in the tanning processes. Large amounts of chrome powder and chrome liquor are used during tanning process. Some 47 % collagen and 85 % chemicals enter the waste streams as effluent (UNIDO, 2000). This means that some 53 % of the collagen and 15 % of the chemicals used are retained in the leather. Hossain, *et al.*, (2007) reported that protein-concentrates produced from SCW were found to contain chromium at levels as high as 2.49%. This suggests that a huge migration of chromium can take place into poultry products, fish and vegetables through use of the protein-concentrates as feed ingredient, and further bio-magnify into food chain. The present study is performed to assess the nature and extent of the suspected ecotoxicity through investigating regional bioconcentration in poultry eggs.

Poultry plays a vital role in the economy of Bangladesh in recent years. The contribution by livestock is 3% of the total GDP (BBS, 2004) and nearly 10% of the agricultural GDP (Poultry Business Directory, 2007). As food poultry provides meat and egg. An egg is a good source of energy, protein, and fat. A 50 g weighing grade A chicken egg provides estimated values of 297 KJ energy, 6g

protein, 5g fat (1.5g saturated, 2.0g monounsaturated, and 0.8g polyunsaturated), and 190mg cholesterol (FAO, 2007b). Chicken eggs are the most commonly eaten eggs, and are highly nutritious (FAO, 2007a). They supply a large amount of complete, high-quality proteins (which contains all essential amino acids for humans), and provide significant amounts of several vitamins and minerals, including vitamin A, riboflavin, folic acid, vitamin B6, vitamin B12, choline, iron, calcium, phosphorus and potassium.

Status of commercial poultry egg production and its relation with SCW produced protein-concentrates

From the beginning of early 1990's, production of layer and broiler has taken the shape of an industry. Government of Bangladesh has declared poultry as a thrust sector and classified it as agro-based industry. By 2005, about 110,800 different sized farms have been established in the country (BRAC, 2005). At present a total of 6 million people are working in poultry sector (Rahman, 2007). About 130 breeding farms are producing 6 million broiler Day Old Chicks and 0.2 million layer Day Old Chicks per week from 3 million broiler Parent Stock and 0.5 million layer Parent Stock (Poultry Business Directory, 2007).

As per FAO's statistics, between 1961 and 2000, annual world egg production rose by more than 3.5 times to reach about 55 million tons (all eggs, not just hen eggs); about 6 % are hatching eggs. This large, linear increase was due to the rapid expansion in egg production of developing countries. Starting from a low base of 3.8 million tons in 1961, developing countries achieved an increase of egg production almost 10-fold, with growth mainly in Asia (Gillin, 2003).

In the year 2000, Asian countries alone contributed 81% of total egg production of developing countries. In fact, egg production of Asian developing countries (36261 thousand MT) was double that produced in developed countries in 2000 (Gillin, 2003).

The total requirement for poultry feed in the years 1995 and 2000 were 0.528 and 1.055 million tons, respectively which increased enormously in 2006 as 22.756 million tons. There are 54 large and medium industrial type feed mills in Bangladesh of which 9 feed mills produce more than 50% of total feed, and about 50% of the feedstuffs are being imported (Poultry Business Directory, 2007). In 2005, about 52% of poultry feed were produced by feed mills and the rests by the farmers themselves. In that year about 90% broiler feeds were produced by the feed mills, whereas only 18% layer feeds were produced by feed mills (Poultry Business Directory, 2007). This means, most of layer farmers have used hand mixed feeds which can certainly incorporate the large distribution of protein-concentrates produced from SCW.

Materials and Methods

Study area and sampling

The study area constituted eight districts including capital Dhaka and covered the central portion of Bangladesh. Dhaka, Narsingdi, Kishoreganj, Mymensingh, Tangail, Gazipur, Narayanganj, and Munshigonj were selected for the study. Commercially produced poultry eggs were randomly sampled from each district's egg stock market. Twelve eggs were sampled from each district. In Dhaka, Gazipur, and Tangail's egg stock market both brown and white colored eggs were found. Six eggs from each type were sampled from these three districts. In the rest five districts only brown colored eggs could be found. The collected samples are classified district-wise, which are shown in Table I.

Table I. District-wise classification of collected samples

Sampling districts	ID for brown colored egg samples	ID for white colored egg samples
Dhaka	Dhaka - Brown	Dhaka - White
Narsingdi	Narsingdi - Brown	-
Kishoreganj	Kishoreganj - Brown	-
Mymensingh	Mymensingh - Brown	-
Tangail	Tangail - Brown	Tangail - White
Gazipur	Gazipur - Brown	Gazipur - White
Narayanganj	Narayanganj - Brown	-
Munshigonj	Munshigonj - Brown	-

Sample preparation

The egg samples were boiled in deionized water and after complete boiling albumen and yolk were separately oven-dried at 80^{O}C to remove all moisture. The samples were oven-dried unless the difference between two readings of weight was found negligible. Each of oven-died albumen and yolk were treated and analyzed separately.

The samples were prepared by using HNO_3 - $HClO_4$ digestion (Kebbekus and Mitra, 1998). Since the samples were of organic origin with a very high organic content, HNO_3 - $HClO_4$ digestion was preferred over the more common HNO_3 extraction for the determination of heavy metals. This strongly oxidizing digestion decomposes organics quickly and efficiently.

Sample analysis

Analysis of all prepared samples was performed through atomic absorption spectrophotometry (AAS). BDH standard solution was used for preparation of chromium

standard curve. Chromium determination was done in air-acetylene flame.

Study of physical properties

A total of five following physical properties were studied for the samples, which are listed in Table II.

Property 1: USDA size grading by whole weight at raw condition

Property 2: Whole weight ratio of raw condition to complete boiled condition

Property 3: Weight ratio of boiled shell-albumen-yolk

Property 4: Moisture content of albumen of boiled eggs

Property 5: Moisture content of yolk of boiled eggs

All of these properties could not have studied for all samples due to practical inconveniences.

Whole weight at raw condition was measured after cleaning and subsequent air-drying of external surface of the eggs. Then the eggs were boiled in beaker containing distilled water in controlled temperature using hot plate. The eggs were boiled in 100^{O}C for 30 minutes. After complete boiling these were air-dried before taking another weight. Albumen and yolk were separated and weighed twice, first to determine the weight ratio of boiled shell-albumen-yolk, and again after slicing them separately for oven drying. The later measurement was used to determine the moisture contents of albumens and yolks as during slicing slight sample loss can occur. Samples were dried in 100^{O}C in oven until significant variation in their weight detected.

Table II. Physical properties studied for classification of samples

Sampling districts	Sample ID	Physical properties studied				
		Property 1	Property 2	Property 3	Property 4	Property 5
Dhaka	Dhaka - Brown	3	3	3	3	3
	Dhaka - White	3	3	3	3	3
Narsingdi	Narsingdi - Brown	3	3	3	3	3
Kishoreganj	Kishoreganj - Brown	3	3	3	3	3
Mymensingh	Mymensingh - Brown	3	3	3	3	3
Tangail	Tangail - Brown	3	3	3		
	Tangail - White	3	3	3		
Gazipur	Gazipur - Brown	3	3	3		
	Gazipur - White	3	3	3		
Narayanganj	Narayanganj - Brown	3	3			
Munshigonj	Munshigonj - Brown	3	3			

Table III. Average physical parameters for comparative regional bio-concentration

Physical parameter	Average values	Standard error
Whole weight of eggs, (g)	55.5098	0.7590
Shell: albumen: yolk ratio	1: 4.8672: 1.9775	NA
Albumen raw weight, (g)	34.4401	-
Albumen moisture content, (%)	84.0603	0.1512
Albumen dry weight, (g)	5.4900	-
Yolk raw weight, (g)	13.9930	-
Yolk moisture content,(%)	51.3656	0.1616
Yolk dry weight, (g)	6.8054	-

Table IV. Calculation of regional chromium bio-concentration

Sample class	Sample size and standard error	Cr in egg albumen, µg/g (dry weight)	Cr in total egg albumen µg	Cr in egg yolk, µg/g (dry weight)	Cr in total egg yolk, µg	Total Cr in each egg (albumen +yolk), µg	Concentration in total edible egg (albumen +yolk), µg/g
Brown Egg (Dhaka)	6	1.5621	8.5759	1.1354	7.7269	16.3028	1.3259
	Std.Error	0.1950	-	0.2149	-	-	-
White Egg (Dhaka)	6	2.0858	11.4510	1.3410	9.1260	20.5771	1.6736
	Std.Error	0.6073	-	0.4133	-	-	-
Brown Egg (Narsingdi)	12	1.0671	5.8584	1.0383	7.0660	12.9244	1.0512
	Std.Error	0.2070	-	0.2597	-	-	-
Brown Egg (Kishoreganj)	12	2.1827	11.9830	1.2334	8.3938	20.3764	1.6573
	Std.Error	0.3379	-	0.1995	-	-	-
Brown Egg (Mymensingh)	12	2.9545	16.2202	1.9318	13.1467	29.3669	2.3884
	Std.Error	0.3636	-	0.3741	-	-	-
Brown Egg (Tangail)	6	1.9104	10.4881	1.7997	12.2477	22.7358	1.8491
	Std.Error	0.3401	-	0.3797	-	-	-
White Egg (Tangail)	6	1.7281	9.4873	0.6670	4.5392	14.0265	1.1408
	Std.Error	0.2592	-	0.2476	-	-	-
Brown Egg (Gazipur)	6	2.3930	13.1376	1.5584	10.6055	23.7431	1.9311
	Std.Error	0.4060	-	0.4111	-	-	-
White Egg (Gazipur)	6	1.4699	8.0698	1.9289	13.1269	21.1967	1.7240
	Std.Error	0.1971	-	0.4274	-	-	-
Brown Egg (Narayanganj)	12	3.3685	18.4931	2.2028	14.9909	33.4840	2.7233
	Std.Error	1.4602	-	0.2418	-	-	-
Brown Egg (Munshigonj)	12	3.3878	18.5990	1.2682	8.6306	27.2296	2.2146
	Std.Error	1.5026	-	0.2536	-	-	-

Results and Discussion

Regional bio-concentration of chromium

Some average physical parameters were estimated from all samples so that the regional bio-concentration of chromium can be determined in a comparative way. The results obtained from these investigation are given in Table III.

On the basis of the average dry weight, calculation of regional chromium bio-concentration is shown in Table IV.

The average statistics for all egg samples, irrespective of albumen and yolk separately counted are presented in Table V.

Table V. Statistics of all egg samples

Total sample number	192
Mean concentration, µg/g	1.9016
Std. error of mean	0.1502
Minimum, µg/g	ND*
Maximum, µg/g	19.8051
Average total content in single egg, µg	23.3809

* = Not detected

The comparison between albumen and yolk for their likelihood to contain chromium is shown in Fig. 1.

Region-wise physical properties of the eggs

The "United States Department of Agriculture" grades chicken eggs by weight per dozen (USDA, 2000). Egg masses in Table 6 have been calculated on the basis of the USDA size grades.

Table VI. USDA size grades on basis of mass per egg

Modern sizes (USA)	
Size	Mass per egg
Jumbo	Greater than 2.5 oz. or 71g
Extra Large (XL)	Greater than 2.55 oz. or 64g
Large (L)	Greater than 2 oz. or 57g
Medium (M)	Greater than 1.75 oz. or 50g
Small (S)	Greater than 1.5 oz. or 43g
Peewee	Greater than 1.25 oz. or 35g

The physical properties with their respective statistics for individual sample classes are presented in Tables VII to XVII.

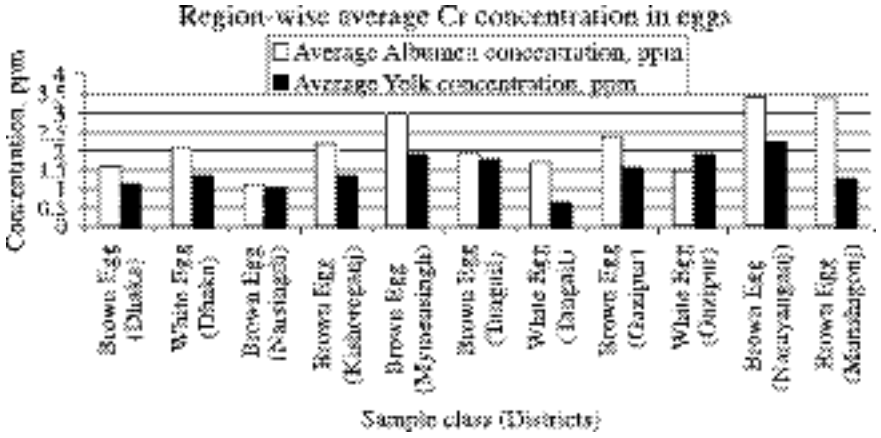

Fig. 1. Comparative chromium concentration in egg albumen and yolk

Table VII. Physical properties of ``Dhaka- Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio	Property 4: boiled albumen moisture content (%)	Property 5: boiled yolk moisture content (%)
R - 1	53.1718	Medium	1 : 0.9678	1 : 6.0982 : 2.2182	82.0594	51.0165
R - 2	56.1305	Medium	1 : 0.9692	1: 5.8644 : 1.9270	84.0761	51.1205
R - 3	63.7801	Large	1 : 0.9770	1: 7.1942 : 2.5219	84.2837	50.6038
R - 4	54.421	Medium	1 : 0.9722	1 : 4.5313 : 1.6597	84.4730	50.8725
R - 5	57.3433	Large	1 : 0.9680	1 : 6.7456 : 2.5732	84.0844	50.5400
R - 6	61.2825	Large	1 : 0.9681	1 :7.4093 : 2.4944	84.5091	50.5520
Minimum value	53.1718	Medium	1 : 0.9678	1 : 4.5313 : 1.6597	82.0594	50.5400
Maximum value	63.7801	Large	1 : 0.9770	1 : 7.4093 : 2.4944	84.5091	51.1205
Mean	57.6892	Large	1 : 0.9704	NA*	83.9143	50.7842
Standard error	1.6694	NA*	0.0015	NA	0.3785	0.1034

NA* = Not Applicable]

Table VIII. Physical properties of ``Dhaka- Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio	Property 4: boiled albumen moisture content (%)	Property 5: boiled yolk moisture content (%)
R - 1	60.7885	Large	1 : 0.9688	1 : 5.6699 : 2.0344	83.6506	50.9005
R - 2	54.4185	Medium	1 : 0.9714	1: 5.9534 : 2.8246	85.4504	50.7258
R - 3	50.4281	Medium	1 : 0.9762	1: 6.0450 : 2.3445	84.8282	51.4818
R - 4	55.2353	Medium	1 : 0.9710	1 : 4.5166 : 1.5527	83.1184	50.2009
R - 5	57.3005	Large	1 : 0.9694	1 : 5.8753 : 2.0129	85.2394	51.0053
R - 6	48.896	Small	1 : 0.9702	1 :5.5100 : 1.9517	84.8956	51.7757
Minimum value	48.8960	Small	1 : 0.9688	1 : 4.5166 : 1.5527	83.1184	50.2009
Maximum value	60.7885	Large	1 : 0.9762	1 : 6.0450 : 2.3445	85.4504	51.7757
Mean	54.5112	Medium	1 : 0.9716	NA	84.5304	51.0150
Standard error	1.7881	NA	0.0012	NA	0.3803	0.2278

Table IX. Physical properties of "Narsingdi - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio	Property 4: boiled albumen moisture content (%)	Property 5: boiled yolk moisture content (%)
R - 1	63.8716	Large	1 : 0.9745	1 : 5.1597 : 2.1951	85.8635	49.9375
R - 2	57.7092	Large	1 : 0.9810	1 : 6.0377 : 2.6406	84.9249	50.4956
R - 3	57.8982	Large	1 : 0.9710	1 : 4.8810 : 2.0677	84.6685	51.0261
R - 4	62.5003	Large	1 : 0.9689	1 : 7.8084 : 3.3818	83.2821	50.3619
R - 5	56.3723	Medium	1 : 0.9681	1 : 5.7656 : 2.3415	84.9491	50.9399
R - 6	67.6032	Extra large	1 : 0.9702	1 : 5.5249 : 2.1302	85.3564	49.4025
R - 7	60.3247	Large	1 : 0.9706	1 : 5.9178 : 2.3761	85.2470	51.1561
R - 8	61.9726	Large	1 : 0.9726	1 : 6.7795 : 2.6738	85.3712	51.8413
R - 9	60.6593	Large	1 : 0.9699	1 : 6.2042 : 2.7171	84.5736	50.8230
R - 10	62.4194	Large	1 : 0.9730	1 : 5.8561 : 2.1160	84.4279	50.4320
R - 11	60.2693	Large	1 : 0.9705	1 : 7.5778 : 2.8549	83.9024	50.5394
R - 12	58.7996	Large	1 : 0.9680	1 : 7.6807 : 2.9395	84.5966	50.9208
Minimum value	56.3723	Medium	1 : 0.9680	1 : 4.8810 : 2.0677	83.2821	49.4025
Maximum value	67.6032	Extra Large	1 : 0.9810	1 : 7.8084 : 3.3818	85.8635	51.8413
Mean	60.8666	Large	1 : 0.9715	NA	84.7636	50.6563
Standard error	0.8904	NA	0.0010	NA	0.2013	0.1791

Mean physical properties of all samples

The mean values for physical properties of all sample classes are presented in Table XVIII.

Essentiality and toxicity of chromium

Chromium is a mineral that humans require in trace amounts, although its mechanisms of action in the body and the amounts needed for optimal health are not well defined. Chromium as heavy metal has no adverse effect. The trivalent form of chromium is considered as essential for normal carbohydrate and lipid metabolism (NRC, 1980). Chromium is known to enhance the action of insulin (Mertz, 1998) a hormone critical to the metabolism and storage of carbohydrate, fat, and protein in the body. Little toxic effect is attributed to trivalent chromium when present in large concentrations. However, Cr(III) is ubiquitous in nature, occurring in air, water, soil, and biological materials. Cr(VI) has much higher toxicity in comparison to Cr(III), and the most important toxic

Table X. Physical properties of "Kishoreganj - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio	Property 4: boiled albumen moisture content (%)	Property 5: boiled yolk moisture content (%)
R - 1	60.4331	Large	1 : 0.9692	1 : 4.0141 : 2.0398	84.7147	52.9912
R - 2	54.1158	Medium	1 : 0.9711	1 : 2.9015 : 1.3200	83.6934	48.9653
R - 3	50.543	Medium	1 : 0.9735	1 : 3.6885 : 1.6984	85.0742	53.6001
R - 4	59.4774	Large	1 : 0.9685	1 : 2.4464 : 1.4271	84.2902	51.1880
R - 5	53.8434	Medium	1 : 0.9711	1 : 4.1202 : 1.6948	84.1460	53.2331
R - 6	63.82	Large	1 : 0.9775	1 : 3.7207 : 1.6230	84.6314	52.6694
R - 7	53.0333	Medium	1 : 0.9707	1 : 4.4679 : 1.8607	85.6527	52.8032
R - 8	59.7496	Large	1 : 0.9809	1 : 3.7479 : 1.8190	84.5351	53.5434
R - 9	48.493	Small	1 : 0.9744	1 : 4.0969 : 1.5061	83.8783	54.1786
R - 10	67.388	Extra large	1 : 0.9889	1 : 3.0995 : 1.4257	83.6152	51.1574
R - 11	66.9525	Extra Large	1 : 0.9778	1 : 3.5853 : 2.0774	84.3932	53.2080
R - 12	49.3147	Small	1 : 0.9744	1 : 4.1113 : 2.0180	83.7893	52.6114
Minimum value	48.4930	Small	1 : 0.9685	1 : 2.4464 : 1.4271	83.6152	48.9653
Maximum value	67.3880	Extra Large	1 : 0.9889	1 : 4.4679 : 1.8607	85.6527	54.1786
Mean	57.2637	Large	1 : 0.9748	NA	84.3678	52.5124
Standard error	1.9174	NA	0.0017	NA	0.1745	0.4133

effects, after contact, inhalation, or ingestion of hexavalent chromium compounds include dermatitis, allergic and eczematous skin reactions, skin and mucous ulcerations, perforation of the nasal septum, allergic asthmatic reactions, bronchial carcinomas, gastro-enteritis, hepatocellular deficiency, and renal oligo-anuric deficiency (Baruthio, 1992).

In vivo carcinogenicity of chromium

Chromium occurs most commonly in valance states of 3+ and 6+. Cr^{3+} is the most stable oxidation state (Greenwood and Earnshaw, 1997) and presumably is the form in the food supply due to the presence of reducing substances in foods. Even a bolus dose of 5 mg Cr^{6+} was reduced to Cr^{3+} in 0.5 L of orange juice (Kuykendall *et al.*, 1996), and endogenous reducing agents within the

Table XI. Physical properties of "Mymensingh - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio	Property 4: boiled albumen moisture content (%)	Property 5: boiled yolk moisture content (%)
R - 1	54.2869	Medium	1 : 0.9705	1 : 3.1665 : 1.4392	82.4655	50.9407
R - 2	49.2058	Small	1 : 0.9726	1 : 2.0714 : 1.1549	83.3195	52.8795
R - 3	54.7403	Medium	1 : 0.9721	1 : 3.7493 : 1.2290	83.8288	52.4243
R - 4	56.5528	Medium	1 : 0.9726	1 : 3.3299 : 1.4300	84.0992	51.7156
R - 5	54.3853	Medium	1 : 0.9734	1 : 2.9382 : 1.3823	80.7665	50.4200
R - 6	60.5077	Large	1 : 0.9711	1 : 3.2820 : 1.1829	82.1882	51.1330
R - 7	55.6505	Medium	1 : 0.9711	1 : 2.8930 : 1.4356	83.0736	50.7611
R - 8	55.1685	Medium	1 : 0.9789	1 : 3.1411 : 1.2366	82.5688	51.0391
R - 9	52.1831	Medium	1 : 0.9706	1 : 3.1602 : 1.4058	83.0579	51.3165
R - 10	55.0537	Medium	1 : 0.9720	1 : 3.3626 : 1.5647	82.6263	50.9080
R - 11	52.7628	Medium	1 : 0.9721	1 : 3.2657 : 1.4021	82.9843	51.2608
R - 12	58.1148	Large	1 : 0.9717	1 : 2.8655 : 1.2724	83.6721	51.9305
Minimum value	49.2058	Small	1 : 0.9705	1 : 2.0714 : 1.1549	80.7665	50.4200
Maximum value	60.5077	Large	1 : 0.9789	1 : 3.7493 : 1.2290	84.0992	52.8795
Mean	54.8844	Medium	1 : 0.9724	NA	82.8876	51.3941
Standard error	0.8267	NA	0.0006	NA	0.2547	0.2072

upper gastrointestinal tract and the blood also serve to prevent systemic uptake of Cr^{6+} (Kerger *et al*., 1997). But in their in vivo toxicity the intermediates of Cr^{5+} and Cr^{4+}, or indirectly the reduced Cr^{3+} can be ultimately responsible.

In the carcinogenic behavior of chromium, chromate (CrO_4^{2-}) (which is a strong oxidizing agent) is reduced intracellularly to Cr^{5+} inside biological system and reacts with nucleic acids and other cell components to produce mutagenic and carcinogenic effects on biological systems (Clark, 1994; McLean and Beveridge, 2001).

But Cohen and Costa (2000) mentioned about derived trivalent form of chromium to be ultimately responsible for the carcinogenic effect. The Cr (VI) ion is readily taken up into eukaryotic cells by anion-carrying proteins, after which it is reduced to Cr (III)

Table XII. Physical properties of "Tangail - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio
R - 1	54.6955	Medium	1 : 0.9747	1 : 3.0487 : 1.2567
R - 2	51.7022	Medium	1 : 0.9739	1 : 3.0213 : 1.2868
R - 3	54.6834	Medium	1 : 0.9743	1 : 2.8551 : 1.1622
R - 4	49.9917	Small	1 : 0.9729	1 : 3.1933 : 1.4557
R - 5	54.6611	Medium	1 : 0.9722	1 : 3.1671 : 1.4640
R - 6	51.0989	Medium	1 : 0.9760	1 : 2.9715 : 1.3273
Minimum value	49.9917	Small	1 : 0.9722	1 : 2.8551 : 1.1622
Maximum value	54.6955	Medium	1 : 0.9760	1 : 3.1933 : 1.4557
Mean	52.8055	Medium	1 : 0.9740	NA
Standard error	0.8677	NA	0.0005	NA

Table XIII. Physical properties of "Tangail - White" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio
R - 1	63.6611	Large	1 : 0.9741	1 : 3.6539 : 1.8125
R - 2	55.8108	Medium	1 : 0.9768	1 : 3.3684 : 2.0007
R - 3	57.7141	Large	1 : 0.9761	1 : 3.3576 : 1.9475
R - 4	60.7531	Large	1 : 0.9760	1 : 3.5093 : 1.7176
R - 5	57.3988	Large	1 : 0.9746	1 : 2.9558 : 1.5224
R - 6	55.2091	Medium	1 : 0.9745	1 : 2.9529 : 1.7272
Minimum value	55.2091	Medium	1 : 0.9741	1 : 2.9529 : 1.7272
Maximum value	63.6611	Large	1 : 0.9768	1 : 3.6539 : 1.8125
Mean	58.4245	Large	1 : 0.9754	NA
Standard error	1.3111	NA	0.0004	NA

Table XIV. Physical properties of "Gazipur - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDAsize grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3:boiled shell albumen-yolk weight ratio
R - 1	66.5640	Extra large	1 : 0.9720	1 : 4.9691 : 1.8388
R - 2	53.5825	Medium	1 : 0.9745	1 : 3.9039 : 1.7491
R - 3	64.4329	Extra large	1 : 0.9732	1 : 4.9209 : 1.6355
R - 4	65.5652	Extra large	1 : 0.9730	1 : 5.2128 : 1.8541
R - 5	64.9578	Extra large	1 : 0.9728	1 : 4.4783 : 1.7152
R - 6	59.3256	Large	1 : 0.9712	1 : 5.3726 : 1.8557
Minimum value	53.5825	Medium	1 : 0.9712	1 : 3.9039 : 1.7491
Maximum value	66.5640	Extra large	1 : 0.9745	1 : 5.3726 : 1.8557
Mean	62.4047	Large	1 : 0.9728	NA
Standard error	2.0431	NA	0.0005	NA

Table XV. Physical properties of "Gazipur - White" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition	Property 3: boiled shell albumen-yolk weight ratio
R - 1	58.4650	Large	1 : 0.9706	1 : 5.0276 : 2.1221
R - 2	58.4632	Large	1 : 0.9715	1 : 4.5553 : 1.9581
R - 3	57.8559	Large	1 : 0.9718	1 : 4.9392 : 1.9775
R - 4	57.7793	Large	1 : 0.9735	1 : 3.6139 : 1.5480
R - 5	63.6566	Large	1 : 0.9695	1 : 3.9911 : 1.6162
R - 6	62.8208	Large	1 : 0.9716	1 : 4.3771 : 1.5439
Minimum value	57.7793	Large	1 : 0.9695	1 : 3.6139 : 1.5480
Maximum value	63.6566	Large	1 : 0.9735	1 : 5.0276 : 2.1221
Mean	59.8401	Large	1 : 0.9714	NA
Standard error	1.0866	NA	0.0005	NA

Table XVI. Physical properties of "Narayanganj - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition
R - 1	57.1362	Large	1 : 0.9724
R - 2	57.9883	Large	1 : 0.9698
R - 3	56.2474	Medium	1 : 0.9740
R - 4	65.1325	Extra Large	1 : 0.9712
R - 5	53.0277	Medium	1 : 0.9753
R - 6	52.3909	Medium	1 : 0.9682
R - 7	61.0535	Large	1 : 0.9768
R - 8	61.1012	Large	1 : 0.9705
R - 9	57.4035	Large	1 : 0.9729
R - 10	61.6967	Large	1 : 0.9689
R - 11	51.8180	Medium	1 : 0.9699
R - 12	64.2368	Extra large	1 : 0.9715
Minimum value	51.8180	Medium	1 : 0.9682
Maximum value	65.1325	Extra large	1 : 0.9768
Mean	58.2694	Large	1 : 0.9718
Standard error	1.2912	NA	0.0008

by a number of cytoplasmic reducing agents. The final cellular form of chromium, Cr (III), becomes trapped intracellularly because it has low cell membrane permeability. This shift from Cr (VI) to Cr (III) allows a concentration gradient to be established such that a continual influx of Cr (VI) ions raises intracellular chromium levels until lethal burdens are achieved. While both valence states of chromium are able to interact with DNA, Cr (III) ions are responsible for decreasing the fidelity of DNA replication. In addition, both Cr (III) and Cr (VI) exhibit a clastogenic potency; however, Cr (VI) possesses the greater activity and is also a powerful mutagen in many prokaryotic and eukaryotic cell systems. These properties of Cr (VI) support the claim that hexavalent compounds are likely to be active carcinogens, although it is more likely that the ultimate species responsible for the carcinogenic/mutagenic effects observed in vivo is the intracellularly derived trivalent form.

Dietary reference intakes for chromium

In 1989, the National Academy of Sciences established an "estimated safe and adequate daily dietary intake" range for chromium. For adults and adolescents that range was 50 to 200 µg (NRC, 1989). In 2001, DRIs

Table XVII. Physical properties of "Munshigonj - Brown" class

Egg sample/ sample statistics	Property 1: weight (g)	USDA size grade	Property 2: whole weight ratio of raw to complete boiled condition
R - 1	41.2333	Peewee	1 : 0.9732
R - 2	37.8868	Peewee	1 : 0.9697
R - 3	38.3685	Peewee	1 : 0.9848
R - 4	40.4977	Peewee	1 : 0.9809
R - 5	38.8135	Peewee	1 : 0.9715
R - 6	38.8066	Peewee	1 : 0.9711
R - 7	39.1801	Peewee	1 : 0.9789
R - 8	38.9298	Peewee	1 : 0.9733
R - 9	39.4001	Peewee	1 : 0.9688
R - 10	41.2473	Peewee	1 : 0.9926
R - 11	41.1069	Peewee	1 : 0.9817
R - 12	44.0106	Small	1 : 0.9915
Minimum value	37.8868	Peewee	1 : 0.9688
Maximum value	44.0106	Small	1 : 0.9926
Mean	39.9568	Peewee	1 : 0.9782
Standard error	0.4981	NA	0.0024

(Dietary Reference Intakes) for chromium were established. The research base was insufficient to establish RDAs (Recommended Dietary Allowances), so AIs (Adequate Intakes) were developed based on average intakes of chromium from food as found in several studies (Institute of Medicine, 2001). Chromium AIs are provided in Table IXX.

Tolerable upper intake level (UL)

Few serious adverse effects have been linked to high intakes of chromium, so the Institute of Medicine has not established a Tolerable Upper Intake Level (UL) for this mineral (Stoecker, 2001; Institute of Medicine, 2001). A UL is the maximum daily intake of a nutrient that is unlikely to cause adverse health effects. It is one of the values [together with the RDA (Recommended Dietary Allowance) and AI (Adequate Intakes)] that comprise the Dietary Reference Intakes (DRIs) for each nutrient.

Assessment of tannery based eco-toxicity

Chromium is quite variable among different lots of foods (Anderson *et al*., 1992) and may be influenced by geochemical factors (Welch and Cary, 1975). One of the direct ways of the tannery based chromium eco-toxicity in Bangladesh should be its bio-concentration into poultry eggs. Out of the 192 samples from 96 eggs, dry weight basis

Table XVIII : Physical properties of "Munshigonj - Brown" class

Sampling districts	Sample ID	Physical properties studied					
		Mean property 1: weight (g)	USDA size grade for mean weight	Mean property 2: whole weight ratio of raw to complete boiled condition	Mean property 3: boiled shell-albumen-yolk weight ratio	Mean property 5: boiled yolk moisture content (%)	Mean property 5: boiled yolk moisture content (%)
Dhaka	Dhaka - Brown	57.6892	Large	1 : 0.9704	NA	83.9143	50.7842
	Dhaka - White	54.5112	Medium	1 : 0.9716	NA	84.5304	51.0150
Narsingdi	Narsingdi - Brown	60.8666	Large	1 : 0.9715	NA	84.7636	50.6563
Kishoreganj	Kishoreganj - Brown	57.2637	Large	1 : 0.9748	NA	84.3678	52.5124
Mymensingh	Mymensingh - Brown	54.8844	Medium	1 : 0.9724	NA	82.8876	51.3941
Tangail	Tangail - Brown	52.8055	Medium	1 : 0.9740	NA	-	-
	Tangail - White	58.4245	Large	1 : 0.9754	NA	-	-
Gazipur	Gazipur - Brown	62.4047	Large	1 : 0.9728	NA	-	-
	Gazipur - White	59.8401	Large	1 : 0.9714	NA	-	-
Narayanganj	Narayanganj - Brown	58.2694	Large	1 : 0.9718	-	-	-
Munshigonj	Munshigonj - Brown	39.9568	Peewee	1 : 0.9782	-	-	-

Table IXX. Adequate Intakes (AIs) for chromium (Institute of Medicine, 2001)

Age	Infants and children (µg/day)	Males (µg/day)	Females (µg/day)	Pregnancy (µg/day)	Lactation (µg/day)
0 to 6 months	0.2				
7 to 12 months	5.5				
1 to 3 years	11				
4 to 8 years	15				
9 to 13 years		25	21		
14 to 18 years		35	24	29	44
19 to 50 years		35	25	30	45
>50 years		30	20		

mean chromium concentration was found to be 1.9016 ppm with a sample standard deviation of 0.1502. The concentration levels were ranged from maximum of 19.8051 ppm to undetectable levels. From the data, it is clearly seen that the mean chromium content of a single egg is 23.3809 µg, which exceeds adequate daily dietary intake of children up to 8 years of age as well as corresponds to major part for other age groups. As the Institute of Medicine, USA has not established a Tolerable Upper Intake Level (UL) for chromium due to its adverse health effects observed in cases of high intakes, any intake exceeding the adequate daily dietary intake level is being considered undesirable. If a single poultry egg can contain more than the amount which should be taken from all dietary intakes in one day, then along with the chromium present in other food items consumed in a day must turn the total amount exceeding the safety limit, especially for the children.

An important fact has been observed that in all sample classes except Gazipur white eggs, the chromium content is higher in albumen than in yolk. From these results, it can be suggested that albumen is more likely to contain chromium (total chromium, irrespective of the valence states) than do yolk for chicken eggs so far as bio-concentration is concerned.

Discussion on region-wise physical properties of the eggs

From Table XVIII, the mean whole weights of eggs at raw condition were within the range of 39.9568 g ('peewee' as per USDA size grading) to 62.4047 g ('large' as per USDA size grading). All the sample classes have 'medium' or 'large' mean USDA size grade except eggs from Munshigonj which had a mean size grade of 'pewee'. The mean whole weight ratio of raw condition to complete boiled condition ranged between "1: 0.9704" to "1: 0.9782", which has a very close interval. From the data presented in Table VII to Table XVII the minimum weight

ratio of boiled shell-albumen-yolk for all sample classes were ranged from "1 : 2.0714 : 1.1549" to "1 : 4.8810 : 2.0677" whereas the maximum weight ratio ranged from "1 : 3.1933 : 1.4557" to "1 : 7.8084 : 3.3818". In this case, the ranges were quite large reflecting the inherent variability of chicken eggs within and among sample classes. The mean moisture content of albumen of boiled eggs varied within the range of 82.8876 % to 84.7636 %, and the mean moisture content of yolk of boiled eggs were between 50.6563 % to 52.5124 %. Though not very wide, these ranges have shown a fairly constant property for all sampled eggs.

Conclusion

A number of facts can be of special importance regarding the findings. It can be likely that, as the exact routes of distribution of largely produced protein-concentrates from SCW are unknown, the affected areas may not be reflected in the areas selected for study. But as the sampling districts comprise the central region of Bangladesh, the tannery based chromium eco-toxicity can be quantitatively described for commercially produced chicken eggs with the results obtained for the mentioned region. Again, as there is no set Tolerable Upper Intake Level (UL) for chromium, as well as the less toxic Cr(III) or the intermediates during reduction of Cr(VI) can be the ultimately responsible species for carcinogenicity, the results obtained for the selected region obviously carry importance, especially in regard to adequate daily dietary intake. But specific researches with the controlled application of the SCW produced protein-concentrates can exactly reveal the potency of the product for the bio-accumulation of chromium in chicken body and eggs. Research on the inventory of distribution routes of the product throughout Bangladesh will also help significantly to assess its eco-toxicity phenomenon. Besides, the inventory of physical properties will be of importance for local-level as well as basic researches on poultry.

References

Anderson, R.A., Bryden, N.A. Polansky, M.M. (1992). Dietary chromium intake. Freely chosen diets, institutional diets, and individual foods. *Biol Trace Elem Res* **32:** 117-121.

Baruthio, F. (1992). Toxic effects of chromium and its compounds; *Biol. Trace Elem. Res.*, **32:** 145-53.

BBS. (2004). Statistical yearbook of Bangladesh. (Bangladesh Bureau of Statistics, Government of People's Republic of Bangladesh).

BRAC. (2005). BRAC Report on Poultry Farms 2005. (BRAC, Dhaka, Bangladesh).

Clark, D.P. (1994). Chromate reductase activity of Enterobacter aerogenus is induced by nitrite. *FEMS Microbiol. Lett.*, **122:** 233-238.

Cohen, M.D. Costa, M. (2000). Chromium. pp. 173-191. In Morton Lippmann (ed.) Environmental Toxicants: Human Exposures

and Their Health Effects, 2/e. (John Wiley and Sons, Inc).

FAO. (2007a).(http://www.fao.org/ag/AGAinfo/subjects/en/eggs.html).

FAO. (2007b). (http://www.fao.org/AG/againfo/subjects/en/subjects.html).

Gillin, Edward. (2003). World Egg and Poultry meat Production, Trade, and Supply: Present and the Future. (www.fao.org/ag/againfo/subjects/documents/eggs/Egg-Poultry-Production.pdf).

Greenwood, N.N. Earnshaw, A. (1997). Chemistry of the Elements, 2/e. (Oxford: Butterworth-Heinemann).

Hossain, A.M.M.M., Monir, T. Rezwan - Ul - Haque, A.M. Kazi, M.A.I. Islam, M.S. Elahi, S.F. (2007). Heavy metal concentration in tannery solid wastes used as poultry feed and the ecotoxicological consequences. *Bangladesh J. Sci. Ind. Res.*, **42(4):** 397-416.

Institute of Medicine, Food and Nutrition Board. (2001). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. (National Academy Press, Washington, DC).

Kebbekus, B.B. Mitra, S. (1998). Environ-mental Chemical Analysis. (Blackie Academic & Professional, London).

Kerger, B.D., Finley, B.L. Corbett, G.E. Dodge, D.G. Paustenbach, D.J. (1997). Ingestion of chromium(VI) in drinking water by human volunteers: Absorption, distribution, and excretion of single and repeated doses. *J. Toxicol. Environ. Health,* **50:** 67- 95.

Kuykendall, J.R., Kerger, B.D. Jarvi, E.J. Corbett, G.E. Paustenbach, D. J. (1996). Measurement of DNA-protein cross-links in human leukocytes following acute ingestion of chromium in drinking water. *Carcinogenesis*, **17:** 1971-1977.

McLean, J. Beveridge, T.J. (2001). Chromate reduction by a pseudomonad isolated from a site contaminated with chromated copper arsenate. Appl. *Environ. Microbiol.*, **67:** 1076-1084.

Mertz, W. (1998). Interaction of chromium with insulin: a progress report. *Nutr. Rev.*, **56:** 174-7.

NRC. (1980). Mineral Tolerance of Domestic Animals. (National Academy Press, Washington, DC).

National Research Council, Food and Nutrition Board. (1989). Recommended Dietary Allowances, 10/e. (National Academy Press, Washington, DC).

Poultry business Directory. (2007). Poultry Business Directory 2007. (Poultry Khamar Bichitra, Dhaka, Bangladesh).

Rahman, M. (2007). Poverty Alleviation and Employment Opportunity through Poultry. (5th International Poultry Show and Seminar 2007, WPSA-BB, Dhaka, Bangladesh).

Stoecker, B.J. (2001). Chromium. pp. 366-372. In Bowman, B., and R. Russell (ed) Present Knowledge in Nutrition, 8/e. (ILSI Press, Washington, DC).

UNIDO. (2000). Regional Programme for Pollution Control in the Tanning Industry in South-East Asia: Chrome Balance in Leather Processing. (United Nations Industrial Development Organization, Vienna, Austria).

USDA. (2000). Egg Grading Manual. (United States Department of Agriculture, www.ams.usda.gov/Poultry/pdfs/EggGrading%20manual.pdf).

Welch, R.M. Cary, E.E. (1975). Concentra-tion of chromium, nickel, and vanadium in plant materials. *J. Agric. Food Chem.,* **23:** 479-482.

Zahid, A., Balke, K.D., Hassan, M.Q. Flegr, M. (2004): Distribution of heavy metals in tannery effluent and their influence on sediments of Hazaribagh leather processing zone, Dhaka. In M. Q. Hassan (ed.) Water Resources Management and Development in Dhaka City. (Goethe-Institut Dhaka).

Received :January 01, 2008;
Accepted : June, 23, 2008.