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EXCESS AMOUNT OF CHROMIUM TRANSPORT FROM TANNERY TO HUMAN BODY THROUGH POULTRY FEED IN BANGLADESH AND ITS CARCINOGENIC EFFECTS

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ABSTRACT

Poultry farm is the main source of chicken in over the world. In the last few years, tannery waste, owing to high protein content, has been used in the manufacture of poultry feed in Bangladesh. A large amount of chromium, one of the toxic chemicals, is usually found in tannery wastes which are the most direct way of chromium contamination in food chain. At first, here we present the experimental evidence for the transport mechanism of chromium from tannery wastes to poultry meat as well as the human body, and discuss its toxic effects on human being. We found various amounts of chromium deposited in different parts of chicken who were fed such poultry feed, and the values are mostly increased proportionate to feeding time. For two months feeding, 328 to 4561 µg/kg chromium is deposited in different parts of chicken which is 6 to 76-times higher than the standard limits. The excess amount of chromium easily enters the human body through the chicken meat without being destroyed by cooking, leading to the carcinogenic effects on human beings. This is highly alarming for the consumers eating chicken who are fed this poultry feed.

KEYWORDS: Tannery Waste, Chromium, Poultry Feed, Chicken Meat, Human, Carcinogenic Effect

INTRODUCTION

Chromium is one of the naturally occurring toxic elements found in rocks, animals, soil, and in volcanic dust and gases both in hexavalent, Cr(VI) and trivalent Cr(III) forms. It is widely distributed in foods, but most foods provide only small amounts (less than 2 µg/kg)[1]. But the human activities such as metallurgical and chemical industries use a large amount of chromium, both of Cr(VI) and Cr(III). Hexavalent chromium is commonly used in metal finishing and electroplating as well as in wood preservatives. Trivalent chromium is significantly used in leather tanning process. As a result, the existence of chromium in the environment increases.

Chicken is one of the most widely used meats in the world and poultry farm is the main source of chicken. In the last few years tannery waste, tanned skin-cut wastes (SCW), containing a large amount of chromium, have been using for manufacturing of poultry feed in many developing countries like Bangladesh which is the most direct source of chromium contamination in the food chain. In some cases, leather shaving dusts (LSD) are directly used as poultry feed. There is high possibility for the transport of chromium from SCW and LSD to chicken as well as the human body. The present study was carried out to experimentally determine the actual amount of chromium deposited in different parts of chicken for feeding of such chromium contaminated feed and their effect with time and evaluate the possible transport of chromium from tannery waste to the human body through the deposition in poultry meat and also discuss its toxic effect in human beings.

MATERIALS AND METHOD

Collection of Tannery Waste and Poultry Feed

Hazari bagh, Dhaka, is the most important source of tannery waste in Bangladesh where more than 200 tanneries exist[2]. A large amount of tanned leather cut and shaving dust come out from tannery industries, which is considered as an un-useable solid waste. Recently, such tanned leather cut and shaving dust directly and/or in modified formed are being used as poultry feed. Figure 1 shows the manufacturing of poultry feed from tanned skin-cut wastes (SCW) and tanned lather shaving dust (LSD) in which SCW and LSD are boiled or heated with water and dried in sunlight, and finally grinded and mixed with some bone to receive the poultry feed known as Deshi Meat Bone (DMB). Such deshi meat bone and ready poultry feed were collected from market in Dhaka city, and LSD+SCW were collected from Hazari bagh area in Dhaka city for our experimental purpose as shown in Figure 2.

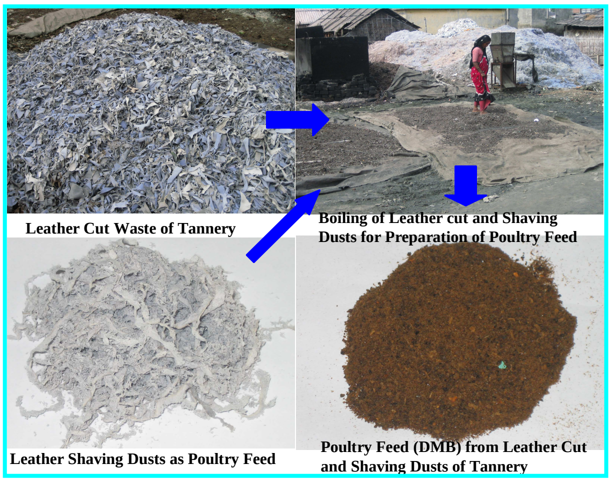

Figure 1: Manufacturing of Poultry Feed From Tanned Skin-Cut Wastes (SCW) and Tanned Lather Shaving Dust (LSD) of Tannery at Hazari Bagh in Bangladesh

Analysis of Chromium in Tannery Waste/Poultry Feed

At first the above three samples mentioned in previous section were analyzed for chromium using Atomic Absorption Spectroscopy, AAS (A Analyst 800, Perkin Elmer; ± 0.005 mg/L). Three dried samples were individually dissolved or digested in nitric acid and perchloric acid mixture (1:1) at 140^{o}C, to make a definite volume before being analyzed for the total chromium by AAS[3]. Analytical data are shown in Table-1.

Table 1 Analytical Data for Total Chromium in Three Types of Collected Poultry Feed

Samples	Amount of total Cr (mg/kg) (±1)
(A) Tanned lather shaving dust and tanned skin-cut wastes (LSD and SCW)	14,085
(B) Deshi meat bone (DMB)	8,210
(C) Ready poultry feed in market (other than LSD+SCW or DMB)	BDL

BDL: below detection limits (±1 mg/kg)

Farming of Chicken in Poultry and Analyze their Body for Chromium

Out of three poultry feed samples, tanned lather shaving dust (LSD) and deshi meat bone (DMB) were considered as our objective source of chromium in feed to perform our experiments. According to the objective of our research, two chicken (Age: ≈16 days) were collected from poultry farm located at Bangobazar area. These two chickens were taken care of in a box of stainless steel net (Figure 2) where tanned lather shaving dust and deshi meat bone were used as their feed. After 15 days one chicken died and another died after 24 days due to sickness due to over dose of chromium containing feed.

Again, the same experiments were started using two chicken (Age: >30 days) as shown in Figure 2 where rice, wheat and ready poultry feed were gave them to eat in addition with tanned LSD and DMB. In that case both of the chickens were living without any problem and grew up. After one month of taking care, one chicken was cut

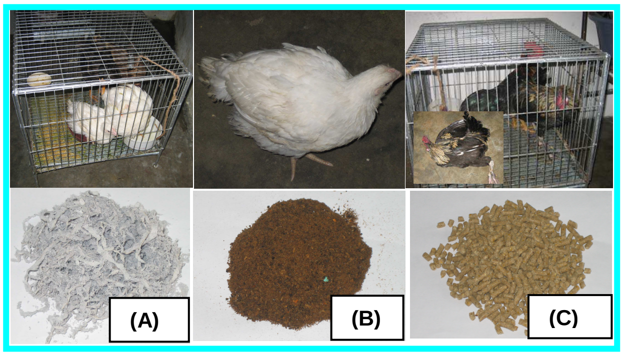

Figure 2: Farming of Chickens Using Chromium Contaminated Poultry Feed (A) Tanned Leather Shaving Dust, (B) Deshi Meat Bone and (C) Ready Poultry Feed

and six different parts of its body (Blood, Flesh, Bone, Liver, Brain and Skin as shown in Figure3) were analyzed for

Total chromium using Graphite Furnace Atomic Absorption spectrophotometer (GBC GF-3000, Graphite Furnace System, Sens AA, GF Scientific Equipment; ± 0.005 μg/L) incorporated with an Auto Sampler (GBC PAL-3000). Digestions of samples were carried out in the process described previously. Experimental data are shown in Table-2. Another chicken was taken care of using the same feed for more than one month i.e. after two months of feeding the 2nd chicken was cut and six different parts of its body as that of the previous one were analyzed for total chromium using the same Graphite Furnace Atomic Absorption spectrophotometer. Analytical results are given in the same Table-2 to compare the data with that for previous one.

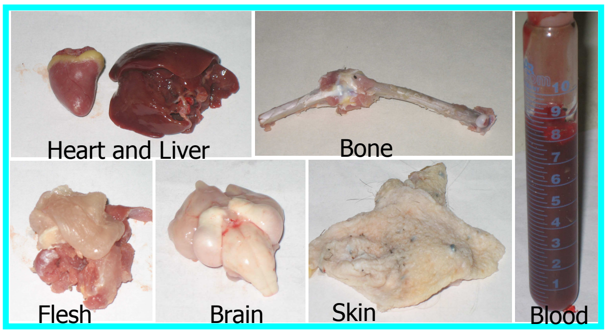

Figure 3 Analytical Parts of Chicken Body for Deposited Chromium at Different Times of Farming with Lather Shaving Dusts, Skin-Cut Wastes and Deshi Meat Bone

RESULTS AND DISCUSSIONS

Chrome alum [$KCr(SO_4)_2$] and/or chromium (III) sulfate [$Cr_2(SO_4)_3{\cdot}12(H_2O)$], are commonly used in the tanning of leather[4]. The chromium (III) stabilizes the leather by cross linking the collagen fibers[5]. Not only chromium salts; more than 30 chemicals are used in the tanning of leather[2]. Chromium tanned leather can contain 2-5 % of chromium, which is tightly bound to the proteins[6]. In our analytical result as shown in Table 1 shows that the tanned lather shaving dust (LSD) and tanned skin-cut wastes (SCW) contained 14,085 mg/kg (~1.4 %) total chromium, and deshi meat bone (DMB) contained 8,210 mg/kg (~0.82 %) total chromium. Decreasing of chromium content in the DMB is due to the heating or boiling of LSD and SCW (shown in Figure 1), and addition of bone powder with LSD and SCW to prepare the DMB. Again, there is high possibility to convert Cr(III) to Cr(VI) in the LSD and SCW during the heating or boiling of LSD and SCW in presence of oxygen to obtained DMB[7]. Reddish-yellow color of DMB in Figure 1 also supports the possible presence of Cr(VI) in DMB. The chromium content in the readily available poultry feed in market (other than LSD and SCW or DMB) is below detection limit of our measurement (AAS-Flame; ±1 mg/kg) i.e. the near absence of chromium in the other readily available poultry feed in market of Bangladesh, which did not use tanned lather shaving dust or tanned skin-cut wastes or deshi meat bone as a source of protein.

In our chicken farming experiments using such chromium contaminated poultry feed, small size chickens (Age ≈16 days) were dead before one month of feeding. This might be due to the deposition of high amount of chromium in different parts of a chicken's body especially in blood and brain.

Again, in the next chicken farming experiments (Chicken age >30 days), chickens were growing up without any problems when the farming was carried out using such chromium contaminated poultry feed, in addition to normal ready poultry feed as shown in Figure 2(C). After one month of feeding of LSD, SCW and DMB to the chicken, it was found that different high levels of chromium in the range of 249 to 1011 µg/kg are deposited in 6 different parts of the chicken's body in a sequence of : bone > brain > blood > liver > skin > flesh as shown in Table-2. Again, the extent of feeding time for two months, deposited amount of chromium is increased in different parts of the chicken body in different multiplications as shown in Table 2, but only for skin the value is decreased to 328 µg/kg from 557 µg/kg which might be due to the low circulation of blood in skin compare with other parts of the body. Maximum deposited amount of chromium is found in brain, 4561 µg/kg due to the maximum circulation of blood in brain. The sequence of the deposition of chromium in the body of chicken after

Table 2: Analytical Data from GF-AAS for Total Chromium in Different Parts of Chicken after Different Time of Farming with Chromium Containing Poultry Feed (LSD, SCW and DMB)

Sample (Parts Of Chicken)	Amount Of Total Cr (µg/Kg) (± 5)	
	After One Month Intake Of LSD, SCW And DMB	After Two Month Intake Of LSD, SCW And DMB
Blood	718	792
Flesh	249	349
Skin	557	328
Bone	1,011	1,990
Liver	570	611
Brain	799	4,561

µg = micrograms, LSD: tanned lather shaving dust, SCW: tanned skin-cut wastes and DMB: deshi meat bone

Two months feeding of LSD, SCW and DMB is : brain > bone > blood > liver > flesh > skin. There is high possibility for the content of chromium in the chicken eggs due to the deposition of chromium in blood and flesh which could be supported by other study[3]. The deposited amount of chromium in all the parts of the chicken's body is higher than the standard limits and the values are increased with the increase of feeding time. According to the International Programme on Chemical Safety (IPCS), the available food data for chromium concentrations in chicken is in the range of 10-60 µg/kg[8]. Kirkpatrick and Coffin (1974) reported the presence of chromium in Canadian chicken meat is 70 µg/kg[9]. But in our experimental data shows that the deposited amount of chromium in the flesh or chicken meat is 349 µg/kg for two months feeding of chromium contaminated feed: LSD, SCW and DMB, prepared from tannery wastes, which is 6-times higher than the maximum limits of WHO[8], and in case of the chicken brain the value (4561 µg/kg) is 76-times higher than the maximum limits. This is a highly alarming situation for poultry meat production using tannery wastes. The above observation of the study can be presented in Figure 4 which shows the transport mechanism of chromium from tannery waste to human body through poultry meat.

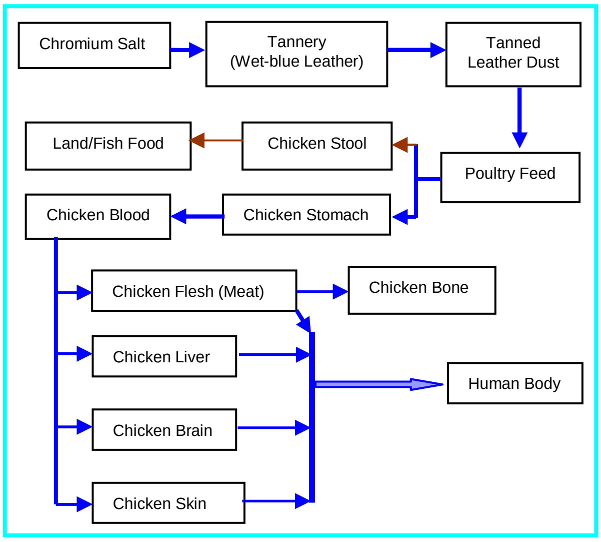

Figure 4: Flow Chart of the Transport Mechanism of Chromium from Tannery Wastes to Human Body

According to the World Health Organization (WHO), hexavalent chromium compounds are highly toxic and carcinogen compare with trivalent chromium[10]. The Department of Health and Human Services (DHHS) has determined that certain chromium (VI) compounds are known to cause cancer in human[11-12]. The Environmental Protection Agency (EPA, 1998) has determined that chromium (VI) in air is a human carcinogen. In the human body, the acidity and action of enzymes on Cr (VI) will promote the formation in small quantities of Chrome, Cr (V)[11]. The reduction product of Cr(V) from Cr(VI) is a known carcinogen and will lodge in any tissue to form cancerous growths. Several studies have shown that chromium (VI) compounds can increase the risk of lung cancer. Breathing high levels of chromium (VI) can cause irritation to the nose, such as runny nose, nosebleeds, and ulcers and holes in the nasal septum[13]. Ingesting large amounts of chromium (VI) can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death if ingested in large doses[12]. Skin contact with certain chromium (VI) compounds can cause skin ulcers. Some people are extremely sensitive to chromium (VI) or chromium (III)[10]. Allergic reactions consisting of severe redness and swelling of the skin have been noted. Figure 5 shows the carcinogenic effect of chromium in liver, kidney and skin[14].

Figure 5 Human Carcinogens by Ingesting Large Amounts of Chromium Caused Kidney and Liver Damage and Skin Contact Lead to Skin Ulcers[14].

Again, chromium (III) is considered as an essential nutrient to balance human and animal diet, works to break down glucose and fat, while helping to balance insulin levels[15-17]. The American Diabetes Association states that there is insufficient evidence to support the routine use of chromium to improve glycemic control in people with diabetes[18]. Thus, a small amount of trivalent chromium is required for human bodies to function properly, although its mechanisms of action in the body are not well known. Tolerable Upper Intake Level (UL) for Cr(III) is not established yet now[19] but according to the Institute of Medicine of the National Academy of Sciences (USA), the "safe and adequate daily dietary intake" range for chromium (III) was 50 to 200 µg for adults[20]. Recent developed Adequate Intakes (AI) of chromium for different ages are provided in Table 3[1]. This is provided by a daily dietary intake of 2–8 µg of chromium (III), equivalent to 0.03–0.13 µg of chromium (III) per kg of body weight per day for a 60-kg adult. But our experimental results show that the poultry chicken contained 349 -4561 µg/kg of total chromium for two months feeding of chromium contaminated feeds. If we consider a person eats 250 g chicken meat in a day, his daily dietary intake will be 87 to 1140 µg of chromium which is too much higher than the proposed limited values for child, man and woman1[1].

Thus the high content of chromium easily enters the human body through the chicken meat without being destroyed by cooking due to the higher boiling point of chromium (2671°C or 2944 K) than the cooking temperature (normally 100- 150 °C). This is a high alarming situation to human beings. Excess amount of trivalent chromium is not good for human health.

Table 3 Adequate Intakes (Ais) for Chromium[1]

Age	Infants And Children (µg/Day)	Males (µg/Day)	Females (µg/Day)	Pregnancy (µg/Day)
0 - 6 Months	0.2			
7 - 12 Months	5.5			
1 - 3 Years	11			
4 - 8 Years	15			
9 - 13 Years		25	21	

Table 3-Cond.,				
14 - 18 Years		35	24	29
19 - 50 Years		35	25	30
> 50 Years		30	20	

The most concentrated amounts of chromium are stored in the spleen, kidneys, and testes with smaller amounts in the heart, pancreas, lungs, and brain, makes adverse effect on human body[21]. As a whole the observation of the present study is presented by a schematic diagram in Figure 6 which shows the transport mechanism of chromium from tannery waste to human body through poultry meat and its toxic effects on human body.

(1) Leather cut wastes of tannery; (2) Boiling of leather cut wastes and shaving dusts of tannery for preparation of poultry feed; (3) Leather shaving dusts as poultry feed; (4) Poultry feed prepared from leather cut wastes and shaving dusts of tannery; (5) Poultry; (6) Carcinogen chromium leads to skin ulcers, kidney and liver damage

Figure 6: Transport Mechanism of Chromium from Tannery to Human Body through Poultry Feed in Bangladesh

CONCLUSIONS

Poultry feed prepared from tannery wastes contained a large amount of chromium. The high amounts of chromium deposited in different parts of chicken are different in a sequence of brain > bone > blood > liver > flesh > skin which are increased with the extent of feeding time of chromium contaminated poultry feed. Chromium can be easily transported from chicken to human body without destroyed by cooking due to the high boiling point of chromium. Thus the excess amount of chromium can be transported from poultry feed to human body through the chicken leading to the carcinogenic effects on human being like cancer, ulcer, liver cirrhosis and kidney damages, etc.

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