Using X-ray Fluorescence Technique Propagation of Chromium (Cr) from Poultry Feeds to Different Parts of Chicken including her Eggs†

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Abstract. This paper presents the detection and propagation of heavy metals, particularly Chromium (Cr), in poultry in the Rajshahi area using the X-ray fluorescence (XRF) technique. The investigation was done to assess the possible transfer of heavy metals from poultry feeds to chicken meat. The study was carried out in the Rajshahi including collection feeds to chicken. It was found that a considerable amount of Cr was confirmed in all four locally produced poultry feeds and also assured that the Cr contained in chicken propagates to the chicken meat and egg. Among the four most widely used feeds in the Rajshahi region, “Adorsho Feed (Pabna)” shows a maximum Cr concentration of 17.3 ppm. Six different parts of the chicken for different ages which were grown by “Adorsho Feed” were considered for further study. About 4.3 ppm of Cr was found in Yolk whereas a little small about 2.7 ppm was found in the albumin. The average value of Cr in six parts of chicken remains almost the same, which is 3.74 ppm, irrespective of age. It is found that about 21.6% of Cr was propagated from the poultry feed to chicken flesh and also about 90% of Cr was propagated from the chicken to egg. The experimental results indicate that the investigation of the transmission of heavy metals like Cr from feed to egg and poultry is efficiently evaluated by using X-ray Fluorescence Technique.

Keywords: XRF; Heavy metal contamination; Chrome shaving in tannery; Chromium toxicity for human health

1. Introduction
Poultry is one of the major protein sources, which is cheap and available for people in Bangladesh. Now, the poultry business is growing all over Bangladesh as a promising sector. Large scale feed production activities are considered as poultry is not used to take normal household feed. There are various sources of raw materials for poultry feed production. In many ways, these sources can be associated with anthropogenic heavy metal, in particular Cr, pollution. Nowadays, researchers are concentrated on the probable propagation of heavy metals like Cr into the food chain through the final feeds rather than the different raw materials for feeds. There was news in The Daily Star on July 24, 2010, titled “Toxic poultry feed poses health risk” that expressed concern over the possible presence of heavy metals, particularly Chromium (Cr) in the poultry in

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Bangladesh. Chemical and toxicological behaviors of Cr are observed when Cr is in an oxidation state. USEPA has declared 129 most pollutants material including Cr is one one of them. It can be seen the existence of Cr in many oxidation states but Cr (III) and Cr (VI) show a most stable form. In addition, compare to other oxidation states, Cr (VI) is highly toxic and also responsible for various health hazards like cancer, mutation, and cell damage [1]. Therefore, quantify the Cr in the poultry feed and how much percentage is propagating into the chicken and her eggs take attention to work [2].

In Bangladesh, the tannery, ceramic, textile dyeing, and sulfuric acid-producing industrial sites are especially associated with heavy metal pollution. The disposal points of these sorts of industrial sites are reported to discharge Cd, Pb, Mn, Ni, Cu, and Zn in excessive concentrations which are further concerned with the contamination of soils, vegetation, and water bodies (Kashem and Singh, 1999). Almost all of the tanning industries in Bangladesh tan hides using the chrome tanning method which is associated with vigorous chromium contamination both in liquid and solid waste form disposal. Moreover, arsenic contamination through groundwater is taking severe in many parts of the country. Conventionally, atomic absorption spectroscopy (AAS), Inductively-coupled plasma spectroscopy (ICPS), etc, are extensively used to quantify the heavy metals including Cr, which are costly, lengthy, require a precise sample preparation scheme [3-6]. On the other side, X-ray fluorescence (XRF) is considered a promising instrument to quantify heavy metals as it is fast, low-cost, and no need to waste time to prepare a sample [7-10].

In this study, the four most widely used feeds in Rajshahi, namely Adorsho Feed (Pabna), City Feed (Narayanganj), Mono Feed (Gazipur), Index Feed (Mymensingh) were considered to quantify the Cr. Accordingly, the poultry samples for this study were collected from the farm at Amgchi Bazar in Horiun union of Rajshahi that use these feeds for their chicken raising. The six major parts of the collected poultry, namely brain, liver, kidney, stomach, flesh (fillet), heart were analyzed to quantify the heavy metals, particularly Cr. Poultry chicken of various ages, 22, 29, and 36 days, but of the same batch (same firm and feeding the same feeds) were investigated. Different parts of the egg (Albumin and yolk) for the same poultry are also investigated to quantify the heavy metals, particularly Cr.

2. Experimental Methodology

X-ray fluorescence (XRF) technique was used to identify and also quantify the Cr in poultry feeds and after that in different parts of the chicken and their eggs. The four most widely used feeds in Rajshahi, namely Adorsho feed (Pabna), City feed (Narayanganj), Mono feed (Gazipur), Index feed (Mymensingh) were sampled. Firstly Samples were collected from different vendors at Rajshahi. Samples were collected in pre-cleaned plastic. Without further processing, the feed samples were transformed into pellet using pellet making machine as such shape could be analyzable by the XRF machine. As a grinding purpose, Boric Acid was employed. The shape of the pellet is shown in Figure 1. The different parts of the chicken were analyzed as was without any sample preparation.

Accordingly, Egg was collected from the same farm feeding the same feeds. The boiled egg was desecrated into two parts, albumin, and yolk. Then these two parts of the boiled egg were also analyzed without further sample preparation.

EDX-3600B from Skyray® Instruments Ltd, USA was used for XRF analysis. The Restriction of Hazardous Substance (RoHS) derivatives was employed in this study. RoHS directive was issued in 2003 by the European Commission that restricts the use of six substances, Lead, Mercury, Cadmium, Hexavalent Chromium, Polybrominated biphenyls (PBB) and Polybrominated diphenyl ethers (PBDE) to improve environmental quality. Figure 2 shows a typical energy spectrum that confirms the Cr content.
Figure 1. Optical microscopic image of the measured position of prepared pellet for XRF study.

Figure 2. Typical spectrograph of XRF machine.

Table 1. XRF data for different heavy metals found in a poultry feed (Adorsho feed)

| Heavy metals | Minimum concentration (PPM) | Maximum concentration (PPM) |
|--------------|----------------------------|------------------------------|
| Cadmium      | 0.0232                     | 0.1852                       |
| Lead         | 0.0069                     | 0.07640                      |
| Arsenic      | 0.00690                    | 0.07340                      |
| Mercury      | 0.0116                     | 0.0579                       |
| Selenium     | 0.0069                     | 0.0347                       |
| Chromium     | 0.0926                     | 6.236                        |

3. Results and Discussion

Table 1 shows the XRF data of different heavy metals extracted from a random sample in Adorsho Feed, Pabna. It is observed from Table 1 that only Cr was found to be a considerable level, others should be uncountable. It is suggested that a large amount of Cr was incorporated in the feed which is propagated to the human through the chicken.

The Cr concentration levels in ppm for different feed samples collected from different vendors in Rajshahi city. It is observed in Figure 3 that the maximum Cr concentration of 17.3 ppm was found in the feed collected from Adorsho company, Pabna, on the other side a minimum heavy metal concentration of 3.55 ppm was extracted from Mono Feed, Gazipur. Besides, ~5.25 ppm in Index Feed, Mymensingh, and ~5.58 ppm in City Feed, Narayanganj, have been recorded.
Figure 3. Cr levels in the analyzed feed samples.

Table 2. Distribution of Cr in various parts of chicken with age.

| Sample parts | 22-day old chicken | 29-day old chicken | 36-day old chicken |
|--------------|--------------------|--------------------|--------------------|
| Kidney       | 3.8                | 2.8                | 5.9                |
| Brain        | 3.5                | 5.8                | 2.8                |
| Heart        | 4.7                | 2.7                | 3.5                |
| Liver        | 4.1                | 2.6                | 2.5                |
| Stomach      | 4.0                | 3.5                | 3.4                |
| Heart        | 4.7                | 2.7                | 3.5                |
| Flesh        | 2.8                | 5.8                | 3.0                |

As Adorsho Feed, Pabna was found to be the maximum concentration of Cr. Thus, the further study was carried out with Adorsho Feed, Pabna, only.

The chicken samples were collected from the poultry farm at Amgachi Bazar in Horian union of Rajshahi, the farm’s poultry was feeding Adorsho Feed, Pabna, as Adorsho Feed contains the highest number of Cr. Different parts of the poultry were frozen at −4°C by freeze. Few samples from the frozen parts were dissected for XRF analysis. Table 2 shows the accumulation of Cr in six different parts of the chicken, named, Kidney, Brain, Heart, Liver, Stomach, and Flesh for three different ages like 22, 29, and 36 days old chicken. The value of the Cr distributed in Table 2 is the average of 3 samples, i.e., Cr concentration of 36-day old chicken kidney, 5.9 ppm is an average value of 3 different parts of the same kidney of the 36-day old chicken. It is observed in Table 2 that for the flesh, the maximum Cr concentration was recorded in the middle age (29 days) old chicken whereas the maximum Cr concentration of 5.9 ppm was recorded at the Kidney for 36 days old chicken. The average value of the Cr irrespective of age for six different parts is almost constant, which is 3.75 ppm. But the distribution of Cr was shown varying with the age and different parts of the chicken. The exact reason for such type of distribution is still not clear to us.

Figure 4 shows the distribution Cr in the different parts of boiled eggs, those eggs were...
collected from the same farm stayed in Aamgachi, where Layer chicken was fed the Adorsho feed. Three different parts of each part were considered for the XRF study. It is observed in Figure 4 that the yolk contains more Cr than albumin in the eggs. This result suggests that most of the Cr were propagated to the red part of the eggs.

The chicken parts after cooking were not investigated. So, the effect of cooking is not clear. But it has been pointed out in the published reports that that the cooked fishes contained increased metal content, particularly Cr, from its raw form [11-13]. The percentage of Cr transmitted from poultry feed to chicken has been carried by from the relation below.

\[
\text{Transmitted Cr in chicken from feed} = \frac{\text{Average value of Cr in chicken}}{\text{Average value of Cr in feed}} \times 100\% \\
= \frac{3.74}{17.3} \times 100\% = 21.62\%
\]

By evaluating the above equation and it appears that about 21.6% of Cr in poultry feed is being easily transmitted from the poultry feed to chicken parts. In the same way, the percentage of Cr transmitted from chicken to eggs has been evaluated by the same equation and found about 90% of Cr are transmitted to the eggs from the chicken.

4. Conclusions
Chicken is one of the main sources of protein in Bangladesh. Recently, it is reported in the newspaper that the risk due to Cr contained in the chicken flesh, which is hazardous for human health. We have investigated some poultry feeds to detect and quantify heavy metals, particularly Cr. Unfortunately, a considerable amount of Cr was identified in all four poultry feeds that were under investigation. The poultry feed from Adorsho feed from Pabna shows a maximum amount of Cr of 17.3 ppm. The same considerable amount of Cr was also found in the different parts of the chicken, where the chicken was grown by feeding Adorsho feed. It is also found by the investigation that Albumin of the egg is more appropriate to eat than the red part (Yolk). It is also noted that about 21.6% of Cr was being transmitted to the chicken flesh from the feed.

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