Metals Profile of Broiler Poultry Feeds Produced in Karachi

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(Received 4th January, 2003, revised 20th January, 2004)

Summary: Cu and Zn are among the important nutritional constituents of feed. Deficiency and excess of essential metals like Cu and Zn in the poultry ration is a poorly understood problem in the poultry industry of Pakistan. This study has been carried out for the first time in the country to determine the metals profile of poultry feeds prepared at the pilot plant scale at PCSIR laboratory Karachi alongwith the commercial feeds collected from various feed mills in the vicinity of Karachi. Some of the ingredients and commercial feeds prepared therefrom show high levels of Cu, Pb, Cr and low levels of Zn, Cd and Co, whereas adulterated fishmeals with leather shavings contain excessive amount of chromium. The study indicates the presence of some toxic metals in the feed ingredients and feeds in the concentrations above toxic threshold limits.

Introduction

The toxic effects of heavy metals like Pb, Cr and Cd when ingested are slowly cumulative and have been recognized as potential health hazards. Effective means of control are required to ensure protection to the poultry from heavy metal contamination. Essential elements such as Co, Cu, Fe, Mn, Se, Zn, etc. either initiate a biochemical process or act as a cofactor in enzymatic body metabolism. However, they may adversely affect the normal biological functions, if their concentrations become higher than the required nutritional level.

Essential metal Cu has attracted considerable attention because of its role in cardiovascular function as well as immunocompetency. Pharmacological doses of Cu (100-250mg/kg) from $CuSO_4$. $5H_2O$ are routinely used as a growth promoter in growing chickens [1]. The beneficial effects of dietary $CuSO_4$ are minimal at 169ppm [2] and that Cu addition can be toxic at 500ppm [3]. The concentration of Cu in the range of 75 to 225 ppm has improved the growth but more than 300ppm has depressed the development of growing chicks [1]. The accumulation of $CuSO_4$ in the litter may account for ingestion of additional copper in birds as reported by Fisher *et al* [4]. The growth improved when $CuSO_4$ was added to a wheat-based diet, but the growth was depressed when $CuSO_4$ was added to a corn based diet [5]. In the same study, feed conversion was improved in male birds fed on 250ppm supplemented $CuSO_4$ but the feed conversion of female birds which were fed on the same diet was adversely affected. It was observed that female birds fed on a corn-soybean diet supplemented with copper sulphate had the production problems including unevenness of growth and decreased feed efficiency. Much of this variation may be due to level of Cu supplementation, growing condition, type of diet and length of treatment.

Essential metal Ni is an important trace metal and its adaquate level is required for optimal growth. However, the metal may influence carcass composition and may cause pigmentation of broiler. It may also cause most allergic eczema [6].

The National Research Council has recommended the Zn requirement for broiler chicken to be 40ppm, which is based upon corn-soybean meal ration [7]. However, it has been reported that the additions of 25-30ppm of Zn to the above-required NRC level are used for the maximum weight gain of broiler [8].

Most of cereals and protein sources of poultry feed in Pakistan are the by-products or the low quality commodity rejected as the human food. The various sub-standards of poultry feed that have come up are further deteriorating the situation. Generally, there is no data available on the occurrence and distribution of major and minor metals in the poultry feed in Pakistan. Very few papers have been published on the metals contents and their distribution in wheat and wheat by-products in the country [10].

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This study has been carried out to determine the concentration of toxic metals viz Pb, Cr and Cd in poultry feeds for which many countries have established legal limits [9]. Essential metals viz. Cu, Zn, Co and Ni for which recommendations regarding their safe and adequate daily intake are already available, have also been studied. The study would help in assessing the metals contamination of the poultry feeds available in the local market and that of their ingredients, and also in providing baseline levels of both toxic and essential metals in the locally produced broiler ration.

Results and Discussion

Table 1 shows the concentration of seven heavy metals in the broiler feeds prepared in the laboratory and procured from the local market, whereas Table 2 shows the concentration ranges and the mean values of the metals in the analyzed samples. It would be observed from the analytical data (Table 1) that the level of Zn in all commercial and laboratory feed samples is almost double the level recommended by National Research Council (NRC) for the broiler feeds. However, its concentration range in all the commercial starter and finisher feed samples collected from the local three mills is almost similar (Table 2). The concentration of Zn in broiler starter sample collected from laboratory pilot plant is noticeably higher than other samples. Because of the several factors which influence Zn absorption and its bioavailability, it is difficult to establish a specific Zn requirement for humans and animals. However, minimal level of Zn required for chicks to gain weight through a chemically defined purified diet is 10.6ppm. This is substantially less than the National Research Council's recommended requirements of 35 to 40ppm for young broiler chicks consuming diets containing isolated soy protein. The value is also higher in all the poultry feeds. Samples of ingredients for vegetable and animal source of protein, commonly used in the preparation of poultry feed, contain good level of Zn whereas bulk cereal are found to be marginally appropriate as a source of Zn (Table 3).

It would be noted (Table 2) that the content of Cu in the Laboratory feed is quite low as compared with the NRC recommended requirement. However, no detrimental effects have been observed when this low Cu content feed was fed to the broiler chicks. On the other hand feed mill No.1 had been adding $CuSO_4$ to the broiler feed at a toxic level (627±15.6ppm for the starter feed and 453±65.9ppm for the finisher feed). The high Cu feed of the mill was reported to produce lesions in the broiler chicks at local farms, which were similar to that of Cu toxicity and were wrongly diagnosed as microbial diseases. The level of Cu in feed from feed mill No. 2 and No. 3 was also less than the recommended levels of NRC for this type of feed.

The level of Cr in the broiler feed prepared at the pilot plant was the lowest of all the feed samples. It was 4.42±1.44ppm for the broiler starter and 4.79±1.89ppm for the broiler finisher feed, indicating the good quality of fishmeal used for the feed (Table

Table 1 : Some micro-elements in the prepared and commercial broiler feed (ppm)

	Zn	Cu	Cr	Pb	Ni	Co	Cd
Laboratory Poultry Feed							
Broiler starter	103.00±2.68	9.75±0.23	4.42±0.12	1.48±0.03	1.56±0.04	2.32±0.06	0.28±0.006
Broiler finisher	78.35±1.96	9.00±0.21	4.79±0.11	1.33±0.03	0.41±0.009	4.29±0.10	0.20±0.004
Feed Mill#1							
Broiler starter	72.30±1.71	627.30±15.6	7.08±0.16	7.76±0.16	2.33±0.05	0.57±0.01	0.18±0.004
Broiler finisher	67.80±1.49	453.14±9.54	6.23±0.14	7.35±0.15	1.65±0.04	0.56±0.01	0.29±0.006
Feed Mill#2							
Broiler starter	77.63±1.54	17.18±0.34	426.70±8.43	3.25±0.07	2.31±0.05	0.69±0.02	0.13±0.003
Broiler finisher	84.26±2.45	38.94±1.12	411.20±10.15	7.40±0.18	2.86±0.08	0.72±0.02	0.11±0.003
Feed Mill#3							
Broiler starter	76.76±1.62	15.99±0.34	41.86±0.95	2.04±0.05	2.09±0.05	0.65±0.02	0.13±0.002
Broiler Finisher	77.47±1.65	16.49±0.32	46.04±0.98	1.34±0.03	2.32±0.06	0.60±0.01	0.1±0.0030

Table-2: Mean Values* and Concentration Ranges of Trace Metals (ppm)

Elements	Broiler	Starter	Broiler	Finisher
Zn	82.4	(72.3-103.0)	76.97	(67.8-84.26)
Cu	167.67	(9.75-627.8)	129.39	(9.0-453.14)
Cr	120	(4.42-426.7)	117.06	(4.79-411.2)
Pb	3.63	(1.48-7.76)	4.35	(1.33-7.76)
Ni	2.07	(1.56-2.33)	1.81	(0.41-2.86)
Co	1.05	(0.57-2.32)	1.54	(0.56-4.29)
Cd	0.81	(0.13-0.28)	0.17	(0.1-0.29)

*Mean values outside parenthesis, ranges within the parenthesis

Table-3: Metals Contents in Feed Ingredients for Broiler Poultry Feed (ppm)

		Zn	Cu	Cr	Pb	Ni	Co	Cd
1	White Maize	33.90±0.26	1.60±0.01	0.54±0.01	0.26±0.004	2.11±0.03	2.15±0.04	0.62±0.01
2	Yellow Maize	69.67±1.23	7.50±0.11	2.08±0.03	6.29±0.09	2.44±0.04	2.82±0.04	0.38±0.006
3	Rice	30.43±0.42	2.80±0.04	1.65±0.03	0.33±0.006	2.38±0.04	1.32±0.019	0.09±0.002
4	Wheat	40.49±0.72	3.70±0.06	2.60±0.05	0.12±0.002	3.43±0.06	1.60±0.03	0.12±0.002
5	Wheat Bran	101.33±1.95	8.40±0.15	4.30±0.09	0.17±0.004	2.91±0.06	1.69±0.04	0.14±0.003
6	Guar Meal	56.00±1.15	6.30±0.12	nd	nd	5.51±0.13	2.06±0.05	0.06±0.002
7	Cottonseed Meal	85.03±2.12	8.80±0.2	nd	0.25±0.005	2.83±0.008	2.18±0.05	0.08±0.002
8	Sunflower meal	111.20±2.65	21.90±0.48	1.95±0.04	1.30±0.03	2.32±0.04	0.83±0.02	0.20±0.004
9	Rapeseed Meal	84.81±2.12	5.80±0.13	0.85±0.02	0.21±0.006	3.33±0.07	2.08±0.06	0.16±0.004
10	Corn Gulten 60%	43.30±1.15	13.20±0.38	1.80±0.04	0.84±0.02	2.47±0.04	1.24±0.02	0.26±0.005
11	Fish Meal	112.00±2.4	8.90±0.18	3.58±0.07	4.27±0.09	4.04±0.09	2.61±0.06	0.75±0.009
12	Blood Meal	84.86±1.6	4.93±0.09	nd	3.48±0.08	3.57±0.07	1.64±0.03	0.04±0.002

nd = not detectable

1). The feeds from feed mill No.2 contained highest levels of Cr, i.e. 426.7±97.8ppm for the broiler starter and 411.2±22.39ppm for the finisher feed. The investigations revealed that the fishmeal supplied to the feed mill No.2 was adulterated with the material containing high level of Cr. Although the levels of Cr in the starter and finisher feeds from the feed mill No.3 were less than those of the feed mill No.2, the same were still marginally toxic i.e. 41.86±3.18ppm for starter and 46.04±.86ppm for finisher feeds (Table 1).

The levels of Co were slightly higher in the feed prepared at the laboratory pilot plant (starter 2.32+0.69ppm and finisher 4.29±0.68ppm) as compared with the three commercial feeds. Similarly, Cd levels in the laboratory prepared feed were higher than that of the commercial feeds.

Insignificant variation was found in the level of Ni in all the rations of broiler feed and its ingredients. According to Oscar [6], 2.4ppm of Ni in the basal diet is sufficient to promote optimal growth performance and carcass quality. The levels of Ni determined in the feed samples were little lower than the recommended level reported in the literature.

Most of the available feed ingredients for the manufacturing of broiler feed, analyzed for various metals profile, were found to contain low levels of heavy metals (Table 3). Generally, agricultural products are affected through the municipal and industrial wastewater and their consequent phyto-sanitary products. The most important factor which increases the levels of Pb contamination in the environment is the atmospheric pollution from industrial or motor vehicle emissions, representing 73 to 95% of the total Pb in plants. According to the Food and Drug Administration (FDA) U.S.A., food and feed crops provide approximately 34 to 44% of the dietary intake of Pb [11]. Since Pb is a highly toxic element there is exigency to accurately detect even very low concentrations of Pb (parts per billion) in foods and also to assess it possible increases due to contamination resulting from environmental pollution so that necessary preventive and corrective measures may be taken. The levels of Pb, found in the feeds, which were investigated in this study, do not pose an imminent toxicological risk. However, periodic determinations are essential because large amount of these products that are consumed as a part of the poultry ration, inevitably end up in human diet.

Experimental

The feeds samples were collected from three poultry feed mills located in the vicinity of Karachi. They were collected during the pelletizing and crumbling processes. Larger samples of various batches were pooled and passed through automatic sample divider to yield one-kilogram sample. Various feed ingredients samples collected from the local wholesale market, were also reduced to one-kilogram sample through the sample divider. All the samples were initially ground in the roller mill and then 200g sample was randomly collected from each and ground in the Tecator Cyclotec mill to pass mesh size 60. This was done to avoid the disadvantage of improper distribution of metals in the small quantity of samples required for the wet digestion method.

Weighed accurately 300 mg, in triplicate, of the each representative sample and put into a flask fitted with an air condenser, thereafter concentrated HNO_3 (15 ml) was added to each flask and left overnight. The mixture was then heated on water bath at 50°C for 30 minutes and cooled to room temperature. Concentrated HNO_3 (10 ml) was again

added and heated until white fumes evolved and the sample reduced to about 8-10 ml. After cooling, $HClO_4$ (2ml) was added and digestion continued almost to dryness. The residue was then dissolved in deionized water, filtered and diluted to 50ml in volumetric flask and used for the estimation of metals. Blank samples were also prepared similarly under identical conditions.

All reagents were ultrapure of analytical grade. High purity water, used for preparation and dilution of reagents and standards, was prepared by passing tap water through a cellulose adsorbent and 2 mixed bed ion-exchange columns. The deionized water was then double distilled in a Corning all-glass unit. Reference standards were prepared from BDH Spectrosal AA standards (1000 ppm).

Hitachi atomic absorption spectrophotometer Z-8000 with Zeeman effect background correction, equipped with a graphite furnace, microprocessor and a built-in printer, was used for the determination of the concentration of metals in the samples. Pb, Ni, Co and Cd were analyzed by flameless (ETAAS) and Zn, Cu and Cr by flame (FAAS) atomic absorption spectrophotometry. In addition to the standard addition technique, APDC-MIBK (Ammonium Pyrrolidine Dithiocarbamate-Methyl Isobutyl Ketone) method was also used to determine the concentrations of Cd, Co, Cr, Ni and Pb. The detection limits for Zn, Cu, Cr Pb, Ni, Co and Cd were found to be 0.0006, 0.001, 0.002, 0.005, 0.002, 0.003 and 0.004 ppm respectively.

Each sample was analysed in triplicate to get representative results and the analytical data reported in ppm. Precision of the methods was determined from the co-efficient of variation (CV), calculated from triplicate analyses. All CV values were found to be below 10%.

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