American-Eurasian Journal of Toxicological Sciences 11 (1): 11-20, 2019
ISSN 2079-2050
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DOI: 10.5829/idosi.aejts.2019.11.20

Heavy Metals and Essential Elements in Poultry Feeds in Chittagong, Bangladesh

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Abstract: Excessive high concentration of metal intake can have an adverse effect upon the human and animals either it essential or toxic in nature. The study was conducted to determine the concentration of toxic metals and essential metals in the different types of poultry feeds (Starter, grower and finisher) collected from the local market of Chittagong, Bangladesh. The samples were prepared for analysis according to standard method and the heavy metals were determined by Atomic Absorption Spectrophotometry (AAS). The concentration of toxic metals varied for Chromium (Cr): 5.05 ppm-1.45 ppm; Nickel (Ni): 4.40 ppm-23.00 ppm; Lead (Pb): 0.01 ppm-0.15 ppm; Cadmium (Cd): 0.05 ppm-0.50 ppm and Arsenic (As): 0.01 ppm-0.10 ppm. While the amount of essential metals ranged for Calcium (Ca): 14210 ppm -2990 ppm; Magnesium (Mg): 1120 ppm-2543 ppm; Manganese (Mn): 72.8 ppm-147.5 ppm; Zinc (Zn): 57.9 ppm-232.7 ppm; Iron (Fe): 435.8 ppm-231.5 ppm and Copper (Cu): 72.4 ppm-251.5 ppm. Some metals are essential for the growth of poultry but they may become toxic if the concentrations exceeded the permissible limit. In the present study the amount of essential metal is too high compared to international standard and other findings. In terms of toxic metals, Chromium surpassed the allowable limit whereas other metals are within the standard limit. Excess amount of metals uptake by animals find their way to human body, very harmful for human health.

Key words: Heavy Metal · Poultry Feeds · Essential Metals · Atomic Absorption Spectrophotometry (AAS) · Human Health

INTRODUCTION

Poultry farming is one of the most prominent sector of agriculture with commercial layers and broilers. These are contributing in meeting the increasing protein demand of the growing population through eggs and meats [1]. Poultry has become a very popular and promising sector in Bangladesh. People of Bangladesh consume poultry meat and egg to meet their protein demand [2]. In addition it is one of the most important income-generating source for rural women, landless poor and marginal farmers [3]. About 65,000 poultry farm is located in different regions (84) of Bangladesh. So it requires large scale feed production. The feed consist of grains such as corn, wheat or barley, oil seeds, cake meal (Originating mainly from oil producing seeds such as soybeans) sunflower seeds, peanuts, cotton seed and protein products of animal origin such as fish meal, meat and bone meal [4].

Poultry and livestock manures have been used as vital sources of organic fertilizer in agriculture [5]. Lack of some essential metal in feed cause rupture of the aorta, perosis, retarded growth, shortening and thickening of leg bones and enlargement of the hock joint, poor feathering, anorexia and mortality [6,7]. Moreover, copper (Cu), zinc (Zn) and manganese (Mn) used as essential supplemental metals in chickens' diets. Copper inhibits anemia, whereas Zn and Mn act as a catalysts in several enzymatic and hormonal reactions that are closely associated with growth, immunity and skeletal integrity [8].

Feed additives and animal medicines have been used to expedite weight increase and disease prevention for poultry and livestock under intensive farming [9, 10].

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The residue of medicine and feed cause environmental pollution and consequently metal are uptake by these animals [9,10]. Furthermore, Heavy metals are being released from man-made sources (e.g. urbanization, industrialization and agricultural activities) into the aquatic and terrestrial ecosystems, threatening the health of man and animals [11-18]. They are hazardous due to their toxicity, bioaccumulation and biomagnification abilities when recorded in living tissue [19].

Though chromium (III),vanadium, manganese, iron, cobalt, copper, zinc and molybdenum and other mineral elements required as micronutrient for humans and some other animals of nutritional significance which also fit in this category include vanadium, manganese, iron, cobalt, copper, zinc and molybdenum [20, 21].

Globally, heavy metal contaminations of chicken meat, eggs and other products is a matter of concern [22-28]. But attention was not given to the heavy metals pollution in poultry and livestock feeds [29-31]. This phenomenon was also a less important area in Bangladesh for a long period. Recently, people in Bangladesh care about food quality over quantity, when their living level gets to be better considerably compared with decades ago. So, it is necessary to develop green and safe food by using organic fertilizer rather than chemical fertilizer. This study was conducted to assess heavy metals and essential elements of commercially produced poultry feeds along with its effects in Bangladesh.

MATERIALS AND METHODS

Sampling Sites: The study was carried out in Chowdhury Hat and Hathazari, Chittagong, Bangladesh (Figure 1). Chittagong is the second largest city in the country with coastal seaport and financial centre in southeastern Bangladesh. The city consists of more than 2.5 million though the metropolitan area has a population of 4,009,423 reported at the Census of 2011. Poultry occupied a large portion to meet nutrient requirements of these huge population.

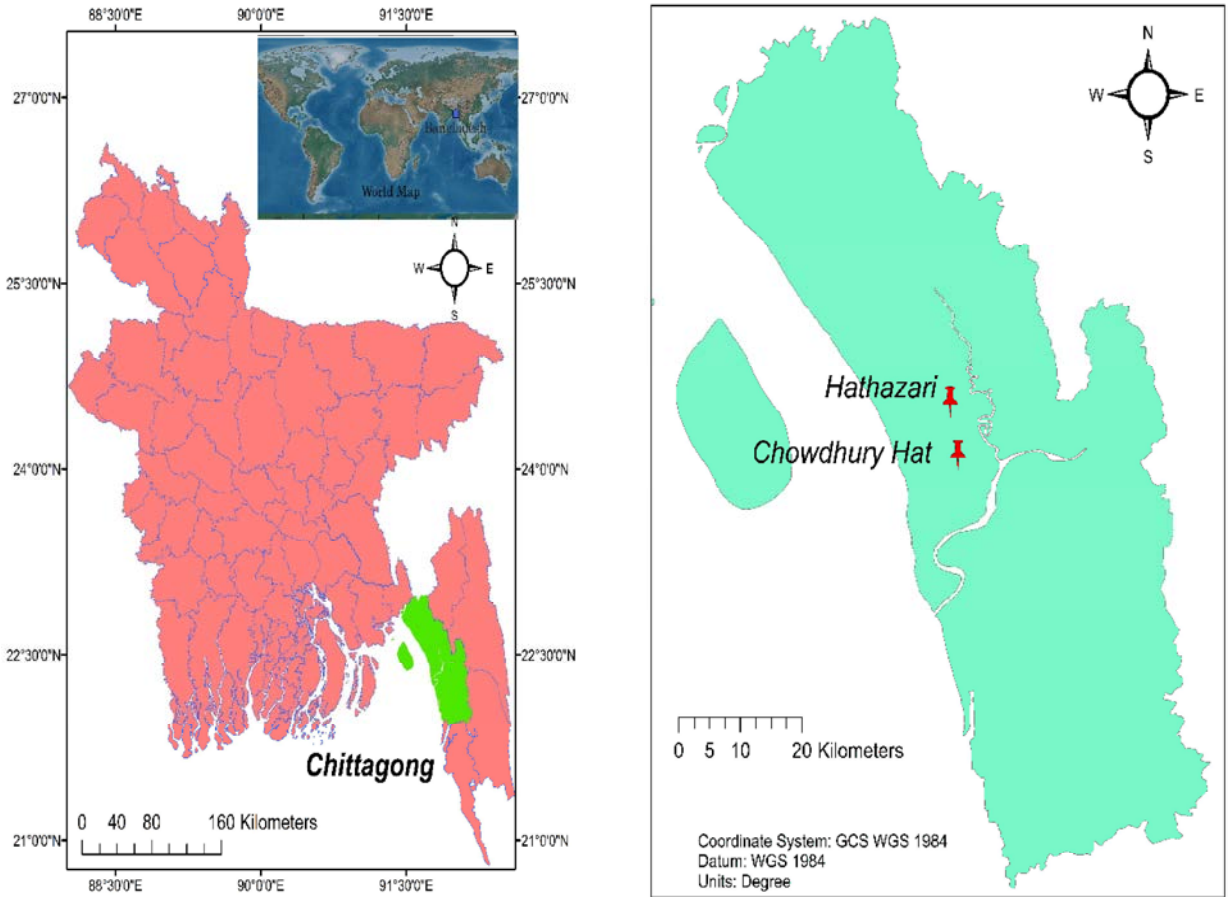

Fig. 1: Map showing the sample collection sites (Map created by ArcGIS v.10.3)

Sample Collection and Analysis: A total of nine samples of feed were collected from the study area. Samples of three types of broiler feed (Starter, grower and finisher) of three different brands were purchased from local markets. These feed brands are commercially available in Chittagong region.

Metal Determination: The metal contents of collected feeds were determined by AAS (Model-iCE 3300, Thermo Scientific, Designed in UK, Made by China) using standard analytical procedure.

Samples were carefully handled to avoid contamination. Glassware was properly cleaned by Chromic acid and distilled water. Analytical grade chemicals and reagents were used throughout the study. Reagents blank determinations were used to correct the instrument readings. The techniques for samples preparation, standard preparation and analysis for metal analyses have been briefly described below.

Samples Preparation: This procedure was used for destruction of organic matter. Precaution was to be taken to avoid losses by volatilization of elements. The samples were weighed accurately a suitable quantity (10 to 20 g) in a tared silica dish [32]. After that the samples were dried at 120°C in a laboratory oven. These dishes were then placed in the muffle furnace at ambient temperature and slowly raised temperature to 450°C at a rate of no more than 50°C/h. The samples were ignited in a Muffle furnace at 450°C for at least 8 hrs. After the samples cool, then the dishes were removed from furnace. Then the sediment samples were digested in desired amount of 50% nitric acid on hot plate. Then the samples were filtrated into a 100 ml volumetric flask using Whatman No. 44 filter paper and washed the residue. Each sample solution was made up to the mark with distilled water. Every metal standard solution was prepared for calibration the instrument for each element being determined on the same day as the analyses were performed due to possible deterioration of standard with time [32].

Analysis of Samples: The atomic absorption instrument was set up and flame condition and absorbance were optimized for the analyte. Then blanks (Deionized water), standards, sample blank and samples were aspirated into the flame in AAS (Model- iCE 3300, Thermo Scientific, Designed in UK, Made by China). The calibration curves obtained for concentration vs. absorbance [32]. Data were statistically analyzed using fitting of straight line by least square method. A blank reading was also taken and necessary corrections were made during the calculation of concentration of various elements.

RESULTS

In the present study the metals were analyzed in poultry feed that are popularly used in hens and chickens farm for their growth.

Toxic Metals: Heavy metals are toxic when these metals exceeded the allowable limit. In the present study the concentration of Cr is ranges from 5.05 ppm to 1.45 ppm (Figure 2). The highest amount of Cr was found in B brand Starter feed and the lowest amount was found in C brand Finisher feed.

The concentration of nickel ranges from 4.40 ppm to 23.00 ppm. The maximum quantity of Ni found in Finisher C branded broiler feed and the minimum was found in Starter A branded broiler feed (Figure 3).

Lead concentrations were ranges from 0.01 ppm to 0.15 ppm in the present study (Figure 4). The C brand grower feed contains highest amount of lead and C brand grower feed contains the lowest amount of Pb. Lead levels of all samples are well within the permissible limit. According to EC [33] and NRC [34] the permissible limit of lead are 5 ppm and 10 ppm respectively.

In this study the concentrations of Cd ranges from 0.05 ppm to 0.50 ppm. A brand grower feed contains highest amount of cadmium and C brand finisher feed contains the lowest amount of Cd (Figure 5).

The range of As was detected 0.01 ppm to 0.10 ppm in the present study. Maximum amount As was recorded 0.01 ppm B brand grower feed while minimum concentration 0.01 ppm was found in C brand finisher feed (Figure 6). As concentration in the present study is far below the permissible limit set by EC [33] and NRC [34]. According to EC [33] and NRC [34] the permissible limit of As are 30 ppm and 2 ppm respectively. Arsenic is an element that raises much concern from the both environmental and human health standpoints.

Essential Elements: Calcium, Magnesium, Manganese, Zinc, Iron and Copper are considered as the essential elements for the nutrition of poultry birds. Some of these elements are added as with the poultry feed and rest of these elements are added as with the poultry feed and rest of them are naturally found in food contents.

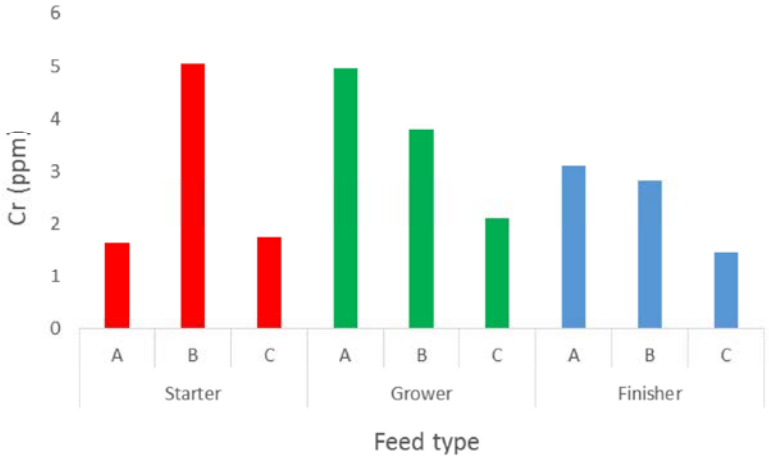

Fig. 2: Concentrations of chromium (Cr) in different poultry feeds

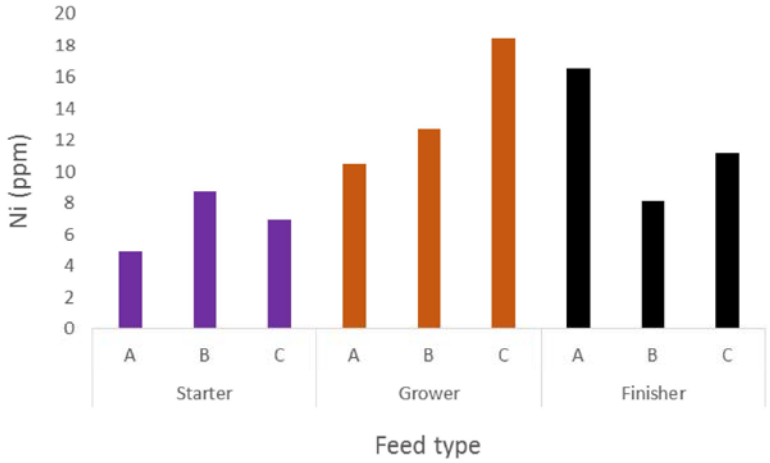

Fig. 3: Concentrations of nickel (Ni) in different poultry feeds

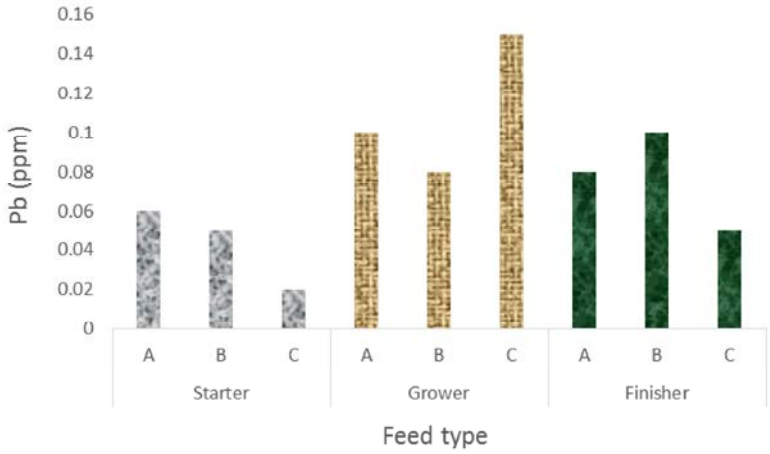

Fig. 4: Concentrations of lead (Pb) in different poultry feeds

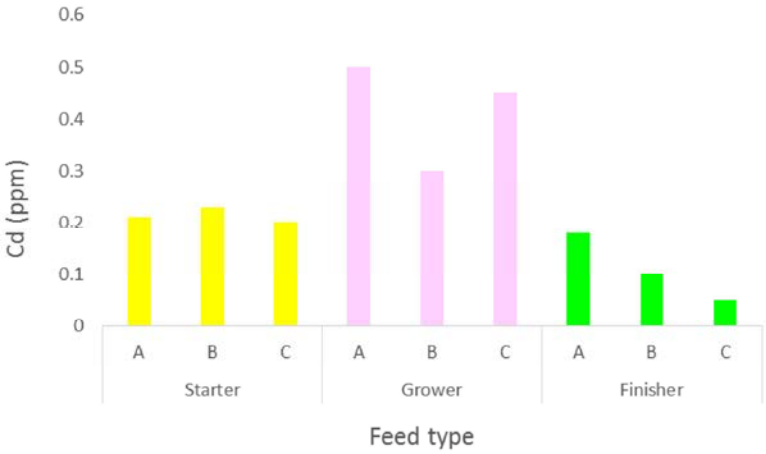

Fig. 5: Concentrations of cadmium (Cd) in different poultry feeds

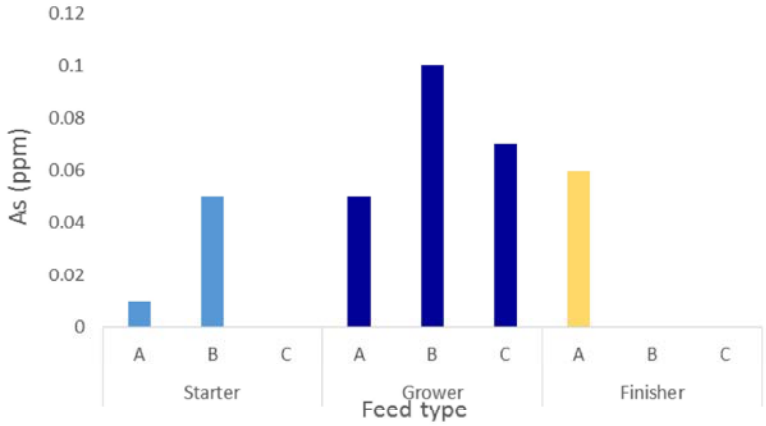

Fig. 6: Concentrations of arsenic (As) in different poultry feeds

Table 1: Detected concentrations (ppm) of essential metal in collected poultry feeds

Metal							
Type	Brand	Ca	Mg	Zn	Fe	Cu	Mn
Starter	A	7400	2047	187.5	260.5	88.4	104.8
	B	6455	1580	198.0	430.4	107.9	113.4
	C	2990	2276	232.7	240.5	72.4	87.1
Grower	A	6820	1890	57.9	418.0	213.5	72.8
	B	5386	1320	128.3	231.5	248.1	123.9
	C	5508	2543	98.5	340.0	176.8	108.5
Finisher	A	4650	1120	190.5	238.9	251.5	115.6
	B	14210	2475	42.45	435.8	139.4	147.5
	C	7490	2014	182.5	235.5	175.8	110.4

Calcium is very essential element for the young growing chicken. It helps to form bone. Brand B of finisher carries the highest amount of Ca while brand C of starter carries the lowest amount (Table 1). The standard value of Ca in three types of feed called starter, grower and finisher are 1%, 0.9% and 0.8% [35].

Natural feed ingredients are rich in magnesium; thus, deficiency is rare and magnesium is never specifically used as a supplement to poultry diets. The ranges of Mg is varied from 1120 ppm to 2543 ppm (Table 1). Finisher feed of A brand contains the lowest amount of Mg and Grower feed of C brand contains the highest amount.

Zinc is another micronutrient for chicken bird. Zinc requirements and signs of deficiency are influenced by dietary ingredients. In young chicks, signs of zinc deficiency include retarded growth, shortening and thickening of leg bones and enlargement of the hock joint, scaling of the skin (Especially on the feet), very poor feathering, loss of appetite and in severe cases, mortality [27]. In the present study, the concentrations of Zn was recorded 57.9 ppm to 232.7 ppm. C brand Starter feed carries the highest amount of Zn whereas A brand Grower feed contains the lowest amount (Table 1).

The present study showed that the concentrations of Fe ranges from 435.8 ppm to 135.9 ppm. The highest amount of Fe was found in Finisher B branded feed and the lowest amount was found in C brand Starter feed (Table 1).

Copper was given as nutrient at (5-8) ppm in starter and grower feeds for broiler and layer feed for layer and (5-10) ppm in finisher feed for broiler [2]. The present observation showed that the concentration of copper ranges from 72.4 ppm to 251.5 ppm. The highest amount (251.5 ppm) of Fe was found in A brand finisher feed and the lowest amount (72.4 ppm) was found in C brand Starter feed (Table 1). The minimum permissible limit of Cu for all types of feed is 8 ppm. All types of feed contains large amount of copper compare to its requirement.

In the present study, the concentrations of Mn ranges from 72.8 ppm to 147.5 ppm. The maximum (147.5 ppm) and minimum amount (72.8 ppm) of Mn was found in B brand Finisher feed and A brand Grower feed respectively (Table 1). Poultry nutrition and feeding guideline suggests that all types of feed requires 60 ppm of Mn for the proper nutrition of poultry birds.

DISCUSSION

Heavy metals are group of elements that extensively diverse in their chemical properties and biological functions. These metals are long persistence in nature and non-biodegradable in environment [36-38]. These metals entering in food chain through uptake by primary producer and then through consumption by consumer. Finally, metals are entering the human body either through inhalation or injection [36].

The maximum permissible limit of Cr is 500 ppm [34]. There is no permissible limit for Cr in feeding stuff given by the EC [33]. Chromium is a major concerned toxic element in Bangladesh. In the present study the maximum amount of Cr was recorded in B brand Starter feed and the lowest amount was found in C brand Finisher feed. 5.7875 ppm and 0.0926 ppm for chromium was recorded by Islam *et al.* [2] in the poultry feed of Bangladesh. The severe poisonous effects after interaction, inhalation, or ingestion of hexavalent chromium compounds pose 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 [39].

There are no regulatory limits ordained by EC [33] for nickel in feeding stuffs; however, the mean amount of nickel was within the range of permissible mean concentration set for nickel in different foods by the EC [33]. On the other hand, nickel levels were below the 250 ppm set by NRC [34].

Lead concentration ranges from 0.01 ppm to 0.15 ppm in the present study. Islam *et al.* [2] recorded the As concentration 20.6498 ppm and 0.6019 ppm for lead in poultry feed in Bangladesh. Lead is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world [40]. Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system [41]. Lead also causes long-term harm in adults, including increased risk of high blood pressure and kidney damage [42]. So the presence of lead in poultry feed is a matter of concern.

The mean level of cadmium in all the feed samples was extremely lower than the NRC [34] limit of 10 ppm but was closer to the limit set by EC [33] of 0.5 ppm. Cadmium has been detected in the ovaries and uteri of dairy cows that may have a negative impact on reproduction. Cadmium is one of the most toxic elements. Cd is efficiently retained in the human body, in which it accumulates throughout life [43]. Cd is primarily toxic to the kidney, especially to the proximal tubular cells, the main site of accumulation [41]. Cd can also cause bone demineralization, either through direct bone damage or indirectly as a result of renal dysfunction [44]. Islam *et al.* [2] recorded 0.1852 ppm and 0.0232 ppm for cadmium in poultry feed in Bangladesh.

The range of As was detected 0.01 ppm to 0.10 ppm in the selected poultry feed. Islam *et al.* [2] recorded the As concentration 0.7640 ppm and 0.0069 ppm in poultry feed in Bangladesh. Arsenic is a protoplastic poison due to its effect on sulphydryl group of cells interfering with cells enzymes, cell respiration and mitosis

[45]. The carcinogenicity and toxicity of the element result from exposure to As (III) [46]. Moreover, indications of contact include severe inflammation of the gastrointestinal tract [47]. In the present study arsenic concentration is low enough for heath safety. Arsenic was found below detection limit in C brand starter and finisher feed.

Deficiency of calcium results in lack of normal skeletal calcification [48]. Rickets is seen mainly in growing birds, whereas calcium deficiency in laying hens results in reduced shell quality and subsequently osteoporosis [48]. From the present observation the amount of Calcium ranges from 14210 ppm (~1.421%) to 2990 ppm (~0.299%).

All kinds of poultry feed require 600 ppm of Mg [35]. Magnesium is very important element of poultry feed. Newly hatched chicks fed a diet totally devoid of magnesium live only a few days [48]. They grow slowly, are lethargic and often pant and gasp. When disturbed, they exhibit brief convulsions and become comatose, which is sometimes temporary but often fatal [48]. Mortality is quite high on diets only marginally deficient in magnesium, even though growth of survivors may approach that of control birds.

Chicks hatched from zinc-deficient hens are weak and cannot stand, eat, or drink. They have accelerated respiratory rates and labored breathing [27]. In semi purified diets, it is difficult to show a response to zinc levels much above 25-30 ppm diet, whereas in practical corn-soybean meal diets, requirement values are increased to 60-80 ppm [49]. Such variable zinc needs likely relate to phytic acid content of the diet, because this ligand is a potent zinc chelator. If phytase enzyme is used in diets, the need for supplemental zinc is reduced by up to 10 ppm diet [48]. Zinc deficiencies result in poor wound healing [50] in both children and adults and it is toxic to plants at higher levels [42]. Poultry nutrition and feeding guideline suggests that all types of feed requires 40 ppm of Zn [35]. According to NRC [34] and EC [33] the standard limit of Zn are 500 ppm and 250 ppm respectively.

Fe was reported in all samples of the present study and found above the allowable limit of 45-80mg/kg as specified by FAO. The minimum permissible limit of Fe is 60 ppm [35]. NRC [34] set the permissible limit of Fe is 500 ppm. Bukar and Said [51] recorded 08.79±0.06-19.74±0.06 ppm Fe in selected poultry feeds available in Kano Metropolis, Nigeria.

Deficiencies of both iron and copper can lead to anemia [8]. Iron deficiency causes a severe anemia. In color-feathered strains, there is also loss of pigmentation in the feathers. Young chicks become lame within 2-4 wk when fed a copper-deficient diet. Bones are fragile and easily broken, the epiphyseal cartilage becomes thickened and vascular penetration of the thickened cartilage is markedly reduced [52]. Copper-deficient chickens may also display ataxia and spastic paralysis. Copper deficiency in birds can lead to rupture of the aorta. The problem can be resolved by feeding higher levels of copper.

Manganese is necessary for humans as pyruvate carboxylase and metallo-enzymes [49]. It is relatively non-toxic to animals though toxic to plants at higher concentrations. A deficiency of manganese in the diet of immature chickens and is one of the potential causes of perosis and chondrodystrophy and also the production of thin-shelled eggs and poor hatchability in mature birds [42]. Islam *et al.* [2] recorded 302.2001ppm and 0.0695 ppm for manganese. Imran *et al.* [53] recorded maximum mean level of manganese's 0.57 ± 0.2 ppm in the poultry feeds.

CONCLUSION

The concentration level of the essential elements (Magnesium, Manganese, Zinc, Iron and Copper) were found to be high compare to the requirements but the amount of Calcium was found below the standard requirement. The toxic metals lead, cadmium, nickel, arsenic and chromium were also detected. The amount of toxic metals were found to be below the maximum permissible limit. The concentration of Chromium was maximum among all toxic metals. No specific standard was set by the concerned authority of Bangladesh. Therefore, a definite standard for heavy metals should be provided as a contaminant so as to maintain the food chain safe from heavy metals. A rigorous study is needed to monitor the effect of poultry feed having high concentration of essential metal.

ACKNOWLEDGMENT

The authors are grateful to the Bangladesh Council of Scientific and Industrial Research (BCSIR), Chittagong.

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