Effects of dietary lead exposure and graded levels of ascorbic acid supplementation on performance and haematology of broiler chickens

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Abstract
The effects of dietary lead acetate (LA) exposure on growth performance and haematological characteristics of broiler chickens and possible ameliorative effect of ascorbic acid (AA) were investigated. One hundred and twenty day-old broiler chicks were randomly divided into six treatment groups of 20 birds with two replicates. Six isonitrogenous and isocalories experimental diets were compounded and fed to birds for seven weeks: T1 (control) received diet I (0mg of LA and AA/kg feed), T2 received diet II (200mg LA/kg feed), T3 received diet III (200mg LA and 50mg AA/kg feed), T4 received diet IV (200mg LA and 100mg AA/kg feed), T5 received diet V (200mg LA and 150mg AA/kg feed) and T6 received diet VI (200mg LA and 200mg AA/kg feed). Finally, two birds per replicate were randomly selected, weighed and slaughtered. For haematology, blood samples were collected into labelled EDTA-bottles. PCV, RBC, WBC and Hb concentration were determined using Auto Haem analyzer. T2 showed significantly (P<0.05) decreased body weight and dressed weight than the control. Although depressive effects of LA on body weight gain, feed intake and feed conversion ratio were significant. Birds in other treatments compared favourably with the control. Dietary lead significantly (P<0.05) reduced WBC in T2, while it significantly (P<0.05) and non-significant (P>0.05) lowered haemoglobin and RBC in T2 and T4 respectively. The PCV was numerically lowered in T2 and T4. However, haematology of AA treated groups, especially those of T3 and T4 compares favourably with the control. In conclusion, dietary lead exposure negatively affects growth performance and haematology of broilers, which was ameliorated by as low as 50mg AA/kg diet supplementation.

Keywords: ascorbic acid, broiler, growth performance, haematology, lead acetate.

Introduction
Lead is a common cause of poisoning in domestic animals throughout the world. Cattle are the most susceptible livestock (Khan et al., 2008). However, lead poisoning can occur in all domestic animals including horses, poultry and dogs (Khan et al., 2008). Animals become intoxicated when they consume lead from contaminated feed and water. The main sources of contamination of feed by lead are soil, industrial pollution and agricultural technology as well as feed processing. A good source of lead contamination of poultry feed is bone and blood meals, majority of which comes from cattle. However, in cattle, highest lead accumulation has been reported to occur in bones (Heaney, 2000). Vegetables constitute essential components of the diet by contributing protein, vitamins, iron, calcium and other nutrients, which are usually in short supply (Suruchi & Pankaj Khanna, 2011). However, vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environment (Zurera-Cosano et al., 1989). It was reported that nearly half of the average ingested lead, cadmium and mercury in food is due to plant origin (fruit, vegetables and cereals). Other sources of lead contamination are leaded gasoline fumes (Genevieve & Greg, 1994); paints used in poultry equipment such as drinkers and feeders to prevent rusting, with either lead based paint or lead-free paint with leaded drying agent. Also, majority of litter material that comes from woods...
previously painted with lead base paints (North & Bell, 1990), constitute another source of lead poisoning to birds. It is common to observe indiscriminate disposal of used batteries and its contents, grease and automobile oil filters in and around poultry houses in the study area.

Ingested lead has resulted in poisoning, poor performance and death in animals (McDowell, 1992; Gurur & Ercal, 2000). Stone & Soares Jr., (1976); Vodella et al. (1997), reported that, dietary lead poisoning in broiler chickens significantly reduced body weight and body weight gain. Erdogan et al. (2005) showed that 200 mg lead/kg diet reduced growth in term of body weight and body weight gain. Bakalli et al. (1995), also reported that feed conversion ratio was significantly poor at a level of 10 mg lead/kg feed. Lead accumulation in kidney and liver of broiler was reported by Erdogan et al. (2005), as well as by Khan et al. (1993), who stated that toxic doses of lead administered orally accumulate in the liver and this could be the source of lead poisoning to humans. In some cases, haematological parameters may provide an indication of lead intoxication. Among the major effects of lead poisoning is anemia, which results from inhibition of the heme synthesizing enzymes with concurrent elevation of protoporphyrin (Lee, 1981). This assertion was further buttressed by Osweiler (1996) who reported that lead slows down haemosynthesis through inhibition of enzymes. A hypochromic, regenerative anaemia was reported to occur in some affected birds poisoned with lead (McDonald, 1988).

According to studies (Stohs & Bagchi, 1995; Mateo et al., 2003), lead has a potential to induce oxidative stress and acts as a catalyst in the oxidative reactions of biological macromolecules. Hence, the toxicities associated with lead might be due to oxidative tissue damage (Gurur & Ercal, 2000; Ercal et al., 2001). To prevent peroxidative tissue damage, there are protective mechanisms in vivo, such as an enzymatic defense system (antioxidant enzymes) and free radical scavengers (antioxidants).

Ascorbic acid (AA) is a well-known antioxidant vitamin involved in several biochemical processes in biological systems. This vitamin breaks the chain of lipid peroxidation in cell membranes and scavenges free radicals such as reactive oxygen species (Carr & Frei, 1999; Kucuk et al., 2003). The antioxidant function of these macronutrients could enhance immunity by preserving the functional and structural integrity of important immune cells, it lower concentration of lead in the blood and restored the levels of iron, calcium and zinc in the blood as well as the lipid balance. AA supplementation offered protection to the cell from expansion or abnormalities in their structural features. Erdogan et al. (2005) reported that the addition of 100mg AA/kg diet tend to reduce the inhibitory effect of lead on growth in broilers. This study was conducted to evaluate the effect of various doses of AA, an antioxidant in ameliorating the inhibitory effects of dietary lead acetate on the haematology and growth performance of broiler chickens.

Materials and methods

Experimental Diets

Six isonitrogenous and isocalories experimental diets were formulated as shown in Tables 1 and 2. Tablets of vitamin C (Vitamin C, 100mg tabs, Michelle Laboratories Limited, Enugu, Nigeria) and lead in the form lead acetate salt (Lab Tech Chemicals, India) were crushed into powder. During feed composition, the smallest feed component by volume were weighed out and spread on a clean cement floor in the feed compounding vat. The next was salt and for those diets that contain lead acetate and or ascorbic acid, these were weighed using top loading balance and mixed with vitamin premix and minerals thoroughly, until a uniform ingredient was obtained. Other feed ingredients were individually weighed using a 20kg kitchen weighing scale and were spread on the clean floor in the feed compounding vat and were thoroughly mixed together manually. Each experimental diet was separately prepared in batches of 100% each and was packed into labelled bags and properly kept until required for use. The control diet I contained neither lead acetate nor ascorbic acid (0mg lead acetate/kg feed and 0mg ascorbic acid/kg feed), while diets II, III, IV, V and VI contained lead acetate at a fixed level of 200mg lead acetate/kg feed. Also diets II contained no ascorbic acid or 0mg ascorbic acid/kg feed. Other diets, i.e. diets III, IV, V and VI contained: 50; 100; 150 and 200mg ascorbic acid/kg feed respectively. These inclusions were done for both starter and finisher rations.

Experimental design

A Completely Randomised Design (CRD) was used. A total of 120 day-old broiler chicks were used. The birds were weighed and randomly distributed into six treatment groups of 20 birds per treatment; i.e. treatments I, II, III, IV, V and VI (i.e.T1, T2, T3, T4, T5 and T6). Each treatment group was replicated twice with 10 birds per replicate; the birds were raised using deep litter system and the experimental diets I, II, III, IV, V and VI were respectively fed to each treatment. Starter diets were fed from day-old to fourth week of age and finisher diets from fifth week of age until the end of the experiment. They were allowed ad libitum access to feed and water for a
period of seven weeks.

Data collection

Performance Parameters: The body weight gain and feed consumption were determined weekly throughout the duration of the study. All the birds in a replicate pen were weighed collectively and divided by the total number of birds in that replicate pen, to determine the average weight per bird for the week. Similarly, the feed consumed by birds in each replicate of the treatment groups was also recorded on weekly basis, by subtracting the leftover at the end of the week from the quantity supplied for the week. The average feed consumed per bird was calculated by dividing the total feed consumed by the number of birds in that replicate pen. The average increase in weight gain per bird in a week was then calculated. This was carried out by subtracting the new week average weight per bird from the previous week. Feed conversion ratio was calculated by dividing the feed consumed per bird per week with average increase in weight gain per bird week. This was done for each treatment group as described by Oluyemi & Roberts (2000).

Haematological Parameters: At the end of the feeding trials, the birds were starved overnight to stabilize them. Two birds were randomly sampled from each replicate, weighed and slaughtered using Halal/Kosher method of slaughtering. For haematology, blood samples were collected from severed jugular vein into labelled sterilized bottles containing Ethylene Diamine-Tetra-acetic Acid (EDTA). The packed cell volume (PCV), red blood cell containing Ethylene Diamine, blood cell (RBC), white blood cell (WBC) and its differentials as well as haemoglobin (Hb) concentrations were determined using Auto Haem Analyzer (Via Guido Borghi 43, 21025 Comerio-Varese – Italy) as described by the manufacturer.

Statistical Analysis

Data obtained were subjected to one–way ANOVA and significant means were compared with post hoc test, using GraphPad InStat 3 software. Results were considered to be statistically significant when P values are less than 0.05 (P<0.05).

Results

The effects of lead and ascorbic acid on body weight, body weight gain, feed intake and feed conversion ratio are presented in Table 3. Supplemental dietary lead significantly reduced body weight (P<0.05), but its effects on body weight gain, feed intake and feed conversion ratio were not significant (P>0.05) between treatment means. No clinical signs of lead toxicity were observed in the broilers administered lead. However, the body weight, body weight gain, feed intake and feed conversion ratio of ascorbic acid treated groups were statistically similar to that of control.

As shown in Table 4, the dietary treatment with lead significantly (P<0.05) lowered WBC in T2 (66.88×10^3/mm^3) and haemoglobin which was significantly (P<0.05) reduced both in T2 (9.85g/dl) when compared with the control and other treatments. T2 and T6 produced numerical anaemia as their RBCs were below normal ranges. The PCV was numerically lowered in T2 and T6. Numerically and statistically, all the haematological parameters of ascorbic acid treated groups, particularly those of T3 and T6 compares favourably with those obtained for the control group (T1).

<table>
<thead>
<tr>
<th>Table 1: Composition of Experimental Diet; Broiler Starter</th>
<th>Percentage composition (%)</th>
</tr>
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<tbody>
<tr>
<td>Ingredients</td>
<td>Diet I</td>
</tr>
<tr>
<td>Maize</td>
<td>55.00</td>
</tr>
<tr>
<td>Groundnut Cake</td>
<td>30.00</td>
</tr>
<tr>
<td>Fish Meal</td>
<td>3.00</td>
</tr>
<tr>
<td>Blood Meal</td>
<td>3.00</td>
</tr>
<tr>
<td>Wheat Offal</td>
<td>5.00</td>
</tr>
<tr>
<td>Bone Meal</td>
<td>0.80</td>
</tr>
<tr>
<td>Limestone</td>
<td>2.50</td>
</tr>
<tr>
<td>Salt</td>
<td>0.25</td>
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<tr>
<td>Vitamin Premix</td>
<td>0.25</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.10</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.10</td>
</tr>
<tr>
<td>Total (kg)</td>
<td>100</td>
</tr>
<tr>
<td>Lead Acetate (mg/kg)</td>
<td>-</td>
</tr>
<tr>
<td>Ascorbic Acid (mg/kg)</td>
<td>-</td>
</tr>
<tr>
<td>Calculated values</td>
<td></td>
</tr>
<tr>
<td>Metabolizable Energy (kcal/kg)</td>
<td>2881.21</td>
</tr>
</tbody>
</table>
Discussion
Dietary treatment with lead acetate in this study significantly (P<0.05) decreased body weight in the experimental broilers, which is in agreement with previous findings by Morgan et al. (1975), and Erdogan et al. (2005). The reduction of body weight might be due to the interruption in absorption and metabolism of feed nutrients essential for health (Marchlewicz et al., 2007). Also, ingestion of lead acetate at 200mg/kg feed did not result in significant (P>0.05) decrease in the body weight gain of broiler chickens. This corroborate the result of Damron et al. (1969), who observed that broilers (4 weeks-old) were relatively resistant to lead poisoning at levels up to 2,000 mg Pb/kg body weight. However, this result contradicts that of Morgan et al. (1975) and Erdogan et al. (2005) who reported that body weight gain was statistically lowered in the lead-treated group than that in the control and ascorbic acid-treated groups. This contradiction could be attributed to environmental factors such as temperature difference, differences in strain of birds used or the variation in dietary composition. On the contrary, birds fed lead plus ascorbic acid produced similar body weight and body weight gain like those of the control. Thus ascorbic acid addition to diet tend to reverse the growth depressive effect of lead in broiler chickens. This might be due to the ability of ascorbic acid to offer protection to the cell
from expansion or induction of abnormalities in their structural features. Alternatively, it may be as a result of its protection and therapeutic role against lead toxicity (Bhattacharjee et al., 2003). This could therefore imply that, in contrast to the result of Erdogan et al. (2005), the adverse effects of dietary lead exposure on body weight gain though not significant, at 200mg lead/kg feed, could be ameliorated with even as low as 50mg ascorbic acid/kg supplementation in the diet. However, the ameliorative effects of ascorbic acid may not be dose dependent.

In agreement with the report by Erdogan et al. (2005), the effects of lead and ascorbic acid on feed intake and feed conversion ratio recorded in the present study were not significant. The findings of Bakalli et al. (1995), in terms of feed conversion ratio contradict the result of this study. This might be due to: different form of lead used, the present study used lead acetate while Bakalli et al. (1995), used lead sulphate and period of exposure, as Bakalli et al. (1995), exposed the birds for 42 days whereas this study exposed the birds for 49 days. However, birds treated with only lead without ascorbic acid revealed decrease feed intake, thus indicating toxic effect of lead and/or alteration in feed palatability resulting into lower average body weights in this group at the end of seventh week, whereas groups exposed to lead as well as varying levels of ascorbic acid revealed increased feed intake per kg gain with decrease in ascorbic acid supplementation. This indicated that an ameliorative effect of ascorbic acid on decreased feed intake due to lead, however, feed intake was best at 50mg ascorbic acid/kg supplementation.

According to the result of this study, the leukopenia observed in T2 could have been due to aplastic anaemia as a result of overwhelming blood poisoning from lead as well as infiltration of bone marrow by lead. Also, significant haemoglobin reduction of birds in T2 with consequent, non-significant lowered PCV and RBC clearly indicated retardation and/or inhibiting effect of lead acetate on haeme synthesizing enzymes (Lee, 1981; Osweiler, 1996). In accordance with the present findings, Khan et al. (2008) observed that following lead acetate administration, there was moderate decrease in haemoglobin and PCV. Similarly, Szmyezak et al. (1983) observed that haemoglobin level was reduced after intoxication with lead acetate at the dose of 400mg/kg of the fodder. Also, Kamruzzaman (2006) observed that following lead acetate administration, there was significant decrease of RBC, WBC and haemoglobin content in rats. The WBC, RBC, PCV and haemoglobin of the ascorbic acid treated groups, especially those of 50mg ascorbic acid/kg feed were within the normal range and this illustrated the ameliorative effects of ascorbic acid on dietary lead exposure as it affects haematology.

In conclusion, the results obtained from the present study showed that, supplementation with ascorbic acid, even as low as 50mg/kg feed may be of immense prophylactic and therapeutic values in exposed broiler chickens. Ascorbic acid caused significant ameliorative effect on lead acetate-induced toxicity by improving the reduced growth performance and haematological values back to normal.

References
Kamruzzaman (2006). Effects of ascorbic acid (vitamin C) and \( \alpha \)-tocopherol (vitamin E) in lead induced toxicities in rats. MSc thesis, department of pharmacology, BAU, Mymensingh.


