Effects of dietary boric acid and borax supplementation on growth performance and some biochemical parameters in broilers

M. EREN1*, F. UYANIK2, B. KOCAOĞLU GÜÇLÜ3, M. ÇINAR4

1Department of Biochemistry, Faculty of Veterinary Medicine, University of Erciyes, 38 039 Melikgazi, Kayseri, TURKEY.
2Department of Animal Nutrition and Nutritional Diseases, Faculty of Veterinary Medicine, University of Erciyes, 38 039 Melikgazi, Kayseri, TURKEY.
3Department of Biochemistry, Faculty of Veterinary Medicine, University of Kırıkkale, Yahşihan, 71 451 Kırıkkale, TURKEY.
4Department of Biochemistry, Faculty of Veterinary Medicine, University of Kırıkkale, Yahşihan, 71 451 Kırıkkale, TURKEY.

*Corresponding author: erenmeryem@hotmail.com

SUMMARY

This study was performed to investigate the effects of dietary supplementation with 2 boron compounds, boric acid and borax, on growth performance and some biochemical parameters in broilers. A total of 216 one day old broiler chickens were randomly assigned to 9 equal groups fed with commercial diets supplemented with 0 (control group) and 10, 50, 100, 250 mg/kg of diet B from either boric acid (BA) or sodium tetraborate decahydrate (borax, BX) for 42 days. Body weights and weight gains, food consumption and food efficiency were weekly recorded and on day 42, serum AST, ALT, GGT, ALP, CK activities and glucose, triglyceride, total cholesterol, HDL and LDL-cholesterol, total protein, albumin, globulin, creatinine, Ca, P and Mg concentrations were determined. Boron supplementation has not significantly affected growth although food efficiency was negatively altered with 250 mg/kg borax. Decreases in AST, ALT and CK activities as well as in Ca, Mg, P (insignificantly), triglyceride and LDL-cholesterol concentrations coupled to an increase in HDL-cholesterol concentrations were observed particularly in borax treated birds whereas glycaemia was markedly depressed in 50, 100 and 250 mg/kg boric acid treated chickens. These results indicate that boron mainly as borax form may act on general metabolisms, electrolyte balance and lipid profiles but further studies are needed to identify with accuracy boron metabolic actions.

Keywords: Broiler, boron, boric acid, borax, dietary supplementation, growth, biochemical parameters, electrolytes, lipid profile.

RéSUMÉ

Effets d’une supplémentation alimentaire par l’acide borique ou le borax sur la croissance et quelques paramètres biochimiques chez les poulets

Cet étude a été réalisée pour étudier les effets d’une supplémentation alimentaire par le bore administré sous forme d’acide borique et de borax sur la croissance et certains paramètres biochimiques chez le poulet de chair. Un total de 216 poussins de 1 jour ont été aléatoirement répartis en 9 groupes égaux nourris avec des aliments commerciaux complété par 0 (groupe témoins) et 10, 50, 100, 250 mg/kg d’aliment de B sous forme d’acide borique (BA) ou de décahydrate de tétraborate de sodium (borax, BX) pendant 42 jours. Les poids vifs, les gains de poids, l’ingéré alimentaire et l’efficacité alimentaire ont été déterminés de façon hebdomadaire et les activités sériques de l’AST, ALT, PAL, GGT et de CK ainsi que les concentrations de glucose, de protéines totales, d’albumine, de globulines, de créatinine, de Ca, Mg, P de triglycérides et de cholestérol total ou associé aux HDL et LDL ont été mesurées à J42. La supplémentation alimentaire en Bore n’a pas eu de répercussions significatives sur la croissance bien que l’efficacité alimentaire ait été altérée chez les poulets traités par 250 mg/kg de borax. Une diminution des activités sériques d’AST, d’ALT et de CK ainsi que des concentrations en Ca, Mg, P (non significative), en triglycérides et en cholestérol associé aux LDL couplées à une augmentation de la concentration de cholestérol associé aux HDL ont été observées particulièrement chez les oiseaux traités par le borax alors que la glycaémie a été notablement diminuée chez ceux traités par 50, 100 et 250 mg/kg d’acide borique. Ces résultats indiquent que le bore essentiellement sous forme de borax agit sur le métabolisme général et notamment sur la balance en électrolytes et les profils lipidiques mais des études complémentaires sont requises afin d’identifier avec précision les effets métaboliques du bore.

Poulet de chair, bore, acide borique, borax, supplémentation alimentaire, croissance, paramètres biochimiques, électrolytes, profil lipidique.

Introduction

Boron (B) is an essential element for plants, animals and humans. Fruits, vegetables and legumes are good sources of B, while whole grains contain very little B, though grains are widely used in poultry diets [41, 42]. But, there is no recommended level of B for daily intake in poultry diet [34]. Boron supplementation to diet may have important effects on various metabolic and physiological systems in animals and humans. It is reported that B is required for bone [10, 28, 39, 43, 44], mineral [12, 18, 26], lipid [5, 6, 11, 16, 30] and energy metabolisms [4, 21], immune [2, 3] and endocrine functions [2, 7, 27, 29-31], lipid peroxidation and antioxidant systems [6, 22, 23, 36] as well as DNA damage repair [22, 40]. Boron distinctive chemical properties allow it to form complexes with organic molecules containing hydroxyl groups, and therefore to interact with various metabolites and enzymes to influence cellular activity, hormone reception and transmembrane signalling [32, 35]. Boron may act as a metabolic regulator in several enzymatic systems [19]. However, biochemical functions of B are not fully understood in animals and man [41]. Although there were some studies investigating the effects of B on application for growth and metabolism of birds are of great significance.
performance [10, 14, 25, 38, 39, 45], limited studies investigating the effects of different B compounds on blood parameters [18, 25, 26, 45] were performed in broilers. Therefore, the study was conducted to investigate the effects of dietary added different boron compounds, boric acid and borax, on growth performance and some biochemical parameters in broilers.

Material and Methods

ANIMALS, DIETS AND EXPERIMENTAL DESIGN

A total of 216 one day old broiler chickens were used in this study. Birds were randomly assigned to 9 equal groups with 3 replicates 8 chickens each. They were kept in separated pens on floor with a 24-hour constant light schedule. The broilers were fed with commercial diets (starter and grower) supplemented with 0 (control group) and 10, 50, 100, 250 mg/kg of diet B from either boric acid (BA) (H₃BO₃, Carlo Erba) or sodium tetraborate decahydrate (borax, BX) (Na₂B₄O₇·10H₂O, Carlo Erba) (treatment groups) for 42 days. Ingredients and chemical composition of the basal diet fed to broilers was shown in Table I. Feed and water was supplied *ad libitum*. This study was approved by Ethics Committee of University of Erciyes, Faculty of Veterinary Medicine, Approval number, 2004-45-59.

PERFORMANCE ANALYSIS AND BIOCHEMICAL ANALYSES

Body weights and food consumption were weekly recorded. Food efficiency was calculated by dividing food consumption by body weight gain.

Blood samples from 12 broilers from each group were collected from V. brachialis puncture in sterile tubes without antiocoagulant at the end of the experiment (Day 42). After clotting for 1 hour at room temperature (24°C) and centrifugation at 1300 g for 10 minutes at room temperature, sera were carefully harvested and stored at -20°C until analysis. Sera were analysed by a spectrophotometer (Shimadzu UV Model 1700) using commercial kits for aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma glutamyl transferase (GGT), alkaline phosphatase (ALP), creatine kinase (CK) activities, glucose, creatinine, total protein, albumin, calcium (Ca), phosphorus (P), magnesium (Mg), (Biolabo, France), triglycerides, total cholesterol, HDL and LDL-cholesterol (AMP, Austria) concentrations. The serum globulin concentrations were calculated by subtracting the albumin values from the total protein values. Chemical composition of the diet was analysed by the method of A.O.A.C. [1]. Boron content in basal diet was determined by ICP (AES Varion Vista Model, Sydney, Australia).

STATISTICAL ANALYSIS

Statistical analyses were performed by SPSS 15.0 version for Windows. One-way analysis of variance (ANOVA) was used for the differences between groups. When the F values significant, Duncan’s Multiple Range Test was performed. All data were expressed as means ± standard error of the mean (SEM). Differences were considered as significant when $P$ value was less than 0.05.

Results

Boric acid and borax additions into diets have not significantly affect body weights and weight gains except for the 29th-35th day period; the lowest mean weight gain was recorded in birds treated with 50 mg/kg boric acid whereas supplementation with the same dosage of borax has led to the highest gains. By contrast, weight gains were slightly depressed but...
not significantly with 250 mg/kg borax compared to boric acid addition. Food consumption tended to increase with B supplementation, particularly with boric acid at 10 and 50 mg/kg during the first 3 weeks. On the other hand, food efficiency was significantly altered for the whole period compared to the controls when 250 mg/kg borax was added to the diet (P < 0.05). In addition, food efficiency was significantly affected compared to the controls with boric acid (50, 100 and 250 mg/kg) and borax (10, 100 and 250 mg/kg) supplementation during the 8th-14th day period (P < 0.05) and with 250 mg/kg borax supplementation during the 22nd-28th day period (P < 0.05) (Table II).

Dietary added boron as boric acid or borax forms had no significant effect on serum creatinine, total protein, albumin, globulin, P and total cholesterol concentrations as well as on serum GGT and ALP activities compared to the control not supplemented chickens (Table III).

As shown in Table III, glycaemia was significantly depressed by all dosages of boric acid (P < 0.001), whereas borax appeared to have no effect and for 50, 100 and 250 mg/kg B compounds into diets, glycaemia was significantly lowered in boric acid treated birds compared to those treated with borax. Decrease in calcium were significant in 50 mg/kg boric acid and in 10, 50 and 250 mg/kg borax treated groups compared to the control group (P < 0.01), however no significant difference was evidenced between boric acid and borax treated groups for the same dosage. Compared to the control and boric acid supplemented groups, magnesium concentrations significantly decreased only in borax supplemented groups (P < 0.001). Serum triglyceride concentrations markedly decreased in birds treated with high doses of boric acid (100 and 250 mg/kg) and with all doses of borax (P < 0.001), whereas decreases in total cholesterolemia remained insignificant in all B supplemented groups. Additionally, it was also noticed significant increase in HDL-cholesterol concentrations in broilers receiving 50, 100 and 250 mg/kg borax compared to the controls (P < 0.01), while LDL-cholesterol concentrations compared to the control values were highly lowered in all borax treated groups and also in birds treated with the highest dose (250 mg/kg) of boric acid (P < 0.001) (Table I).

Table II: Effects of boric acid (BA) and borax (BX) dietary supplementation for 42 days on growth performance, food intake and food efficiency in broiler chickens. Results were expressed as mean ± standard error of the mean (SEM).

<table>
<thead>
<tr>
<th>Week Parameters</th>
<th>0 (control)</th>
<th>10</th>
<th>50</th>
<th>250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (g)</td>
<td>43.2 ± 0.9</td>
<td>43.2 ± 0.8</td>
<td>42.6 ± 0.7</td>
<td>43.1 ± 0.7</td>
</tr>
<tr>
<td>1-7 Final weight (g)</td>
<td>130.9 ± 3.2</td>
<td>136.6 ± 3.2</td>
<td>135.6 ± 3.2</td>
<td>137.4 ± 2.5</td>
</tr>
<tr>
<td>days Weight gain (g)</td>
<td>87.7 ± 2.4</td>
<td>93.4 ± 3.6</td>
<td>93.0 ± 1.3</td>
<td>94.6 ± 2.4</td>
</tr>
<tr>
<td>50</td>
<td>95.0 ± 6.2</td>
<td>87.1 ± 2.4</td>
<td>83.4 ± 5.8</td>
<td>92.6 ± 1.7</td>
</tr>
<tr>
<td>Food intake (g)</td>
<td>1160.1 ± 22.2</td>
<td>1268.3 ± 60.3</td>
<td>1173.0 ± 54.3</td>
<td>1171.5 ± 97.6</td>
</tr>
<tr>
<td>50</td>
<td>1203.8 ± 40.4</td>
<td>1121.2 ± 42.2</td>
<td>1086.1 ± 30.2</td>
<td>1087.2 ± 18.8</td>
</tr>
<tr>
<td>Food efficiency (g/g)</td>
<td>1.96 ± 0.08a</td>
<td>2.09 ± 0.05ab</td>
<td>2.09 ± 0.05bc</td>
<td>2.09 ± 0.05ab</td>
</tr>
<tr>
<td>15-21 Final weight (g)</td>
<td>600.6 ± 2.7</td>
<td>651.6 ± 15.1</td>
<td>624.6 ± 15.9</td>
<td>614.1 ± 15.2</td>
</tr>
<tr>
<td>10</td>
<td>674.8 ± 15.6</td>
<td>601.5 ± 15.6</td>
<td>593.9 ± 11.3</td>
<td>613.8 ± 13.7</td>
</tr>
<tr>
<td>50</td>
<td>743.3 ± 14.0</td>
<td>692.8 ± 17.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>22-28 Weight gain (g)</td>
<td>277.3 ± 9.5</td>
<td>316.3 ± 9.2</td>
<td>346.0 ± 30.3</td>
</tr>
<tr>
<td>10</td>
<td>374.3 ± 33.5</td>
<td>351.3 ± 15.6</td>
<td>351.0 ± 3.5</td>
<td>354.6 ± 16.8</td>
</tr>
<tr>
<td>50</td>
<td>382.5 ± 19.3</td>
<td>298.8 ± 16.6</td>
<td>319.8 ± 3.3</td>
<td></td>
</tr>
<tr>
<td>Food intake (g)</td>
<td>839.6 ± 25.8</td>
<td>869.3 ± 37.6</td>
<td>848.7 ± 30.7</td>
<td>878.0 ± 25.4</td>
</tr>
<tr>
<td>10</td>
<td>808.1 ± 86.0</td>
<td>816.8 ± 30.2</td>
<td>806.7 ± 13.0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>850.5 ± 62.8</td>
<td>811.9 ± 6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food efficiency (g/g)</td>
<td>1.75 ± 0.07</td>
<td>1.68 ± 0.06</td>
<td>1.73 ± 0.03</td>
<td>1.80 ± 0.18</td>
</tr>
<tr>
<td>10</td>
<td>1.65 ± 0.06</td>
<td>1.70 ± 0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1.81 ± 0.07</td>
<td>1.80 ± 0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>1.87 ± 1.00</td>
<td>1.84 ± 0.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food efficiency (g/g)</td>
<td>1.75 ± 0.07</td>
<td>1.68 ± 0.06</td>
<td>1.73 ± 0.03</td>
<td>1.80 ± 0.18</td>
</tr>
<tr>
<td>10</td>
<td>1.65 ± 0.06</td>
<td>1.70 ± 0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1.81 ± 0.07</td>
<td>1.80 ± 0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>1.87 ± 1.00</td>
<td>1.84 ± 0.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Different superscripts a,b,c in the same row indicate significant difference (P < 0.05 or more) between groups.
groups was systematically higher than in the borax treated groups for the same dosage used (P < 0.001) (Table III).

Discussion

KURTOĞLU et al. [25] demonstrated that 5 and 25 mg/kg B supplementation did not affect performance parameters in broilers. YILDIZ et al. [45] also reported that 60 mg/kg boric acid supplementation to broiler diet did not influence performance parameters. In the present study, boric acid and borax additions have no significantly affected body weights, food intake and weight gains (except for 50 mg/kg boric acid due to the 5th week of experiment), but food efficiency for the intake and weight gains (except for 50 mg/kg boric acid) supplementation to broiler diet did not influence performance parameters. In the present study, boric acid and borax supplementation to broiler diet did not influence performance parameters.

Serum AST and ALT activities were significantly lowered in the whole experimental period was negatively affected mainly by 250 mg/kg borax as indicated by ROSSI et al. [13] who have supplemented the broiler diets with 320 mg/kg B including CCl4-induced hepatotoxicity [23] were also decreased by B. Serum AST and ALT enzyme activities in B supplemented groups were not significantly different from control group in the present study, but the enzyme activity in borax treated groups was markedly lower than in boric acid treated groups, suggesting that borax was again more effective than boric acid on muscle metabolism.

On the other hand, boric acid (10-250 mg/kg) supplementation has induced marked decreases in glycaemia whereas borax has had no effect in the present study. Previous studies in broilers [18], in laying hens [13] and in rats [20] have also shown that boric acid decreased plasma or serum glucose concentrations. The biological effects of boric acid may be related to its affinity for cis-hydroxyl groups [18, 42], leading to reversible and concentration dependent binding responding to clearance mechanisms [42]. In this study, the decreases in serum glucose concentrations may result from boric acid binding to hydroxy groups of α-glucosidase [18, 42].

Calcemia decreased in B treated chickens, significantly with in 50 mg/kg boric acid and with 10, 50 and 250 mg/kg borax groups, and compared to the control and boric acid treated groups magnesium concentrations were also markedly depressed in borax supplemented groups independently of the dosage used while phosphatemia tended to decrease but not significantly in all treatment groups. The decreases in circulating electrolyte concentrations observed here were in agreement with previous studies showing decreases in calcemia [8, 21, 24, 25, 33, 37], in phosphatemia and magnesiemia [8, 24] in B treated animals and may result from either reduction of their assimilation in the gastrointestinal tract [8, 21] or improvement of urinary losses [8, 15, 21] due to B supplementation as already reported in broilers [25, 37], in quails [24] and in rats [8, 21, 33].
ELKIN et al. [9] reported that 20 and 40% 1-stearilboronic acid supplementation to laying hens diet did not significantly affect plasma triglyceride and total cholesterol concentrations. Similarly, YILDIZ et al. [45] reported that serum total cholesterol and triglyceride concentrations were not affected by 60 mg/kg B in broiler diets. However, HUNT [18] reported that 3 mg/kg B supplementation to diet increased plasma cholesterol and KURTÖGLU et al. [26] also found that orthoboric acid increased plasma total cholesterol in broilers. In previous studies with different B compounds, it was reported that B supplementation decreased serum triglyceride concentrations in rats [16, 30], mice [17], dogs [5], rabbits [6], laying hens [13], and in quails [12], total cholesterolemia in rat and mice [16, 17], rabbits [6], laying hens [13], and in quails [12] and LDL-cholesterol concentrations in laying hens [13], rabbits [6] and in rats [16]; however one B source reduced HDL-cholesterol concentrations were diversely affected by the nature of B supplementation in rats [16] and in laying hens [13]. HALL et al. [17] using boron analogues of phosphonooacetates suggested that boron analogues appeared to lower lipid concentrations by several mechanisms: firstly, they lowered the synthesis of cholesterol and triglycerides in the liver, secondly, they accelerated the excretion of lipids into the bile and faeces and thirdly, they modulated LDL and HDL-cholesterol contents in a manner which suggests that they reduced the lipid deposition in peripheral tissues, and accelerated the movement of cholesterol from tissues to the liver for excretion into the bile. In the present study, in agreement, serum triglyceride concentrations decreased in 100 and 250 mg/kg boric acid and in all borax treated groups, but decreases in total cholesterolemia were insignificant in all B supplemented groups. Serum HDL-cholesterol concentrations significantly increased in broilers treated with 50 mg/kg or more borax whereas LDL-cholesterol concentrations markedly decreased in all borax treated groups and severely in the 250 mg/kg boric acid treated group. Circulating decreased concentrations of triglycerides, total cholesterol and LDL-cholesterol and increased HDL-cholesterol concentrations may indicated that B can be considered as a hypolipidemic agent and that borax again has appeared more effective than boric acid on lipid profiles.

As a conclusion, the present results indicated that supplemented diets with boron as either boric acid or borax forms did not significantly affect growth performance parameters albeit food efficiency was impacted with 250 mg/kg borax but significantly modified some biochemical parameters in broilers by probably acting on liver, muscle and gastrointestinal tract and on lipid profiles. Further studies are needed to identify the possible mechanisms of actions of boron compounds.

Acknowledgement

This research was supported by Erciyes University Research Fund. Project no: VA-05-01.

References


