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The Effects of Dietary Boron Supplementation on Performance, Carcass Composition and Serum Lipids in Japanese Quails

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Abstract: This study was conducted to investigate the effects of various levels of dietary Boron (B) supplementation on performance, carcass traits and serum lipids in quails. Two hundred and eighty, 1-d-old Japanese quails were divided into 5 groups with 4 replicates and were fed a basal diet or basal diet supplemented with 10, 60, 120 or 240 mg kg^{-1} B until 35 days of age. All levels of B supplementation decreased the weight gain, feed consumption and feed efficiency of the birds. Boron had no any effect on hot and cold carcass yield and percentage of dry matter of meats. Fat and ash percentages in the carcass were increased in all B supplemented males. In females, 120 mg kg^{-1} B increased fat percentage while 240 mg kg^{-1} B increased both fat and ash percentages in the carcass. In all treatment groups, the level of serum triglycerides and total cholesterol decreased. Boron did not have any significant effect on HDL and LDL-cholesterol levels. In conclusion, since all the levels of B in the form of boric acid used in this study adversely affected performance, carcass traits and changed serum lipids, further studies with lower levels of B in the form of boric acid supplementation may be more valuable for the field applications.

Key words: Boron, carcass traits, performance, quail, serum lipids

INTRODUCTION

Boron has been known as an essential element for plant since 1920s[1], but in recent years studies have been focus on the possible role of B in animal and human nutrition. However, inconsistent results have been reported concerning the effects of B on performance[2-9] and lipid metabolism[10-15] in animals. On the other hand, according to the authors' knowledge no any studies have been published investigating the effects of B on performance, carcass traits and serum lipids in quails.

There is no recommended level of B for daily intake in poultry[16]. In addition, cereal grains used widely in poultry diets are low in B[1], therefore poultry diets may be inadequate for B contents. Therefore, this study was conducted to investigate the effects of various levels of dietary B supplementation on performance, carcass traits and serum lipids in quails.

MATERIALS AND METHODS

Animals, diets and management: Two hundred and eighty, 1-d-old Japanese quails (*Coturnix coturnix Japonica*) were divided into 5 groups with 4 replicates consisting of 14 animals each and fed a basal diet containing 0.235 mg kg^{-1} B Control group; Table 1 or the basal diet supplemented with 10, 60, 120 or 240 mg kg^{-1} B (H_3BO_3, Carlo Erba) for treatment groups until 35 days of age. Feed and water was supplied ad libitum. Quails were housed on stainless steel wire cages on a 24 h constant lighting schedule. The room temperature was set to 35°C

Table 1: ngredients and chemical composition of basal diet fed in the experiment

Ingredients	%	Calculated values	%
Corn	35	Crude fibre	6
Wheat	20	ME (MJ/kg)	13.30
Soybean meal (CP 48%)	14.5	Ca	0.91
Full fat soybean	6.5	P	0.53
Barley	5	Na	0.18
Meat and bone meal	5	Measured values	
Corn gluten (CP 65%)	4.5	Dry matter	85.53
Sunflower meal (CP 36%)	4.5	Crude protein	21.82
Vegetable oil	3.5	Crude ash	2.89
Dicalcium-phosphate	0.70	Crude fibre	6.51
Vitamin-mineral premix*	0.30	Boron (mg kg^{-1})	0.235
NaCl	0.25		
Lysine	0.10		
Methionine	0.10		
Antioxidant	0.05		

**Provided by per kg of diet*: vitamin A, 8000I/U; vitamin D_3, 800I/U; vitamin B_2, 4 mg; vitamin B12, 15 µg; vitamin E, 15 mg; vitamin K_3, 3 mg; Mn, 70 mg; Zn, 50 mg

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for the first week of age and then gradually reduced to 28°C with thermostatically controlled electrical heaters.
This study was approved by Ethics Committee of University of Ankara, Faculty of Veterinary Medicine (Approval number, 2004-34-41).

Sample collection and analysis: Live weight of animals and feed consumption were weekly recorded. Feed efficiency was calculated by dividing weekly feed consumption by live weight gain.

At the end of the experiment, 20 quails from each groups (5 from each replicates) were randomly selected, leg banded and weighed, then killed by cervical dislocation for blood sample collection as well as for determination of carcass traits after 12 h feed deprivation. Sera were separated by centrifugation at 1300 g for 15 min following 1-h incubation at room temperature and stored -20°C until the analysis.

Eight female and 8 male quails from each group were used for the measurement of the carcass traits. After the removal of the feet and internal organs, the hot carcasses were weighed and then the carcasses were kept at 2-8°C for 18 h and cold carcass weights were recorded. Cold or hot carcass yields were calculated by dividing the cold or hot carcass weight by live weight of the same animal. Meat was separated from the bone and skin and then mixed thoroughly for homogeneity. The samples of meat were analyzed for dry matter, fat and ash contents according to A.O.A.C.[17].

Basal diet was analysed for B by the method of A.O.A.C.[18] for ICP (AES Varion Vista Model, Sydney, Australia). Serum triglycerides, total cholesterol, High Density Lipoprotein (HDL) and Low Density Lipoprotein (LDL) cholesterol levels were determined by a Shimadzu 1208 UV/VIS spectrophotometer using commercial kits (Valtek, Chile).

Statistical analysis: Data were analyzed by SPSS. 13.0 version for Windows. The differences between groups for data of live weight, carcass yield, chemical composition of meat and serum lipids were determined with variance analysis (one-way analysis of variance [ANOVA]), when the differences were significant, Duncan's multiple range test was performed. The differences between groups for data of feed consumption, weight gain and feed efficiency were determined with Kruskal-Wallis test, when the differences were significant, Mann-Whitney U test was performed. Data were expressed as means±SEMs.

RESULTS AND DISCUSSION

Performance: In previous studies investigating the effects of B supplementation on performance in several animal species, conflicting results were obtained. In this study, live weight changes decreased in all treatment groups ($p<0.05$), Table 2. The quails fed on the 240 mg kg^{-1} B suplemented diet consumed the least amount of food ($p<0.05$), Table 3 which resulted in a reduction in live weight. Similar results were obtained in broilers fed 300 mg kg^{-1} B[4] or 320 mg kg^{-1} B[3] and in layers fed 400 mg kg^{-1} B[5-7,9]. In previous studies, feed efficiency was not affected by 5, 10, 50, 100, 200 and 400 mg kg^{-1} B in laying hens[9], by 80 mg kg^{-1} B in broilers[2], by 5 and 15 mg kg^{-1} B in pigs[8]. However, feed efficiency was negatively affected by B in this study ($p<0.05$), Table 3 as indicated by Rossi *et al.*[3] who supplemented the diet of broiler chicks with 320 mg kg^{-1} B.

Carcass yield and chemical composition of meat: Boron increased bone ash percentage in poultry[4,6,19] and bone lipid percentage in gilts[20]. According to the authors' knowledge, no studies have been published investigating the effects of B on carcass yield, percentage of dry matter of meat as well as fat and ash content of carcass. In present study it was found that boron had no effect on percentage of dry matter of meat ($p>0.05$), Table 4, hot and cold carcass yields ($p>0.05$), Table 5. However, depressed live weight but increased fat and ash percentages ($p<0.05$), Table 4 indicated an adverse effect of B on carcass quality and performance.

Blood chemistry: In previous studies with different B compounds, serum triglycerides in rats[10,14], in mice[11], in dogs[15] and total cholesterol levels in rats[10,11] were decreased. In some other studies, different B compounds either decreased and increased or had no effects on HDL and LDL-cholesterol levels in different animal species[10,15]. Although there were some studies investigating the effects of B on performance and especially mineral metabolism, limited studies investigating the effects of different B compounds on lipid parameters were performed in poultry species and also there was no study using boric acid in quails. Elkin *et al.*[13] reported that 20 and 40% 1-stearylboronic acid supplementation to laying hens diet did not effect plasma triglycerides and total cholesterol levels. Kurtoğlu *et al.*[21] found that orthoboric acid increased plasma total cholesterol levels in broilers. In the present study, B in the form of boric acid decreased serum triglycerides and total cholesterol levels ($p<0.05$) and had no effect on serum HDL and LDL-cholesterol levels ($p>0.05$) Table 6 which are consistent with the results of previous studies[10,11,14,15]. Hall *et al.*[11] speculated that decreases in serum triglycerides and total cholesterol levels, as effect of boron supplementation, either due to the lowered synthesis of cholesterol and triglycerides in the liver or acceleration of deposition of

Table 2: Effects of B supplementation on weekly live weight changes (g) in Japanese quails (mean±SEM)

		Boron (mg kg^{-1} diet)			
Weeks	Control	10	60	120	240
1	35.92±0.93	33.96±0.67	33.94±0.43	33.74±0.41	32.24±0.35
2	75.07±1.30	73.88±0.84	72.79±0.66	71.53±0.59	67.43±0.54
3	118.36±1.65^{a}	116.71±1.15^{a}	115.54±0.96^{a}	113.8±0.83^{a}	108.29±0.72^{b}
4	154.64±2.09^{a}	151.43±1.25^{a}	148.50±0.96^{a}	149.40±0.92^{a}	142.79±0.84^{b}
5	176.57±2.90^{a}	170.73±2.09^{ab}	163.79±1.36^{bc}	164.65±1.06^{bc}	161.70±1.10^{c}

$^{a-c}$: Values within each row with different superscripts differ significantly ($p<0.05$)

Table 3. Effects of B supplementation on weekly feed consumption (g), weight gain (g) and feed efficiency (g/g) in Japanese quails (mean±SEM)

	Boron (mg kg^{-1} diet)					
Day	Parameters	Control	10	60	120	240
1-7	Feed consumption	50.42±2.35a	45.90±1.85ab	43.31±1.62b	44.59±1.41ab	39.92±3.67c
	Weight gain	26.04±1.69	24.65±1.98	24.74±1.15	24.45±1.17	23.02±0.92
	Feed efficiency	1.95±0.07	1.93±0.13	1.77±0.04	1.85±0.04	1.75±0.03
8-14	Feed consumption	95.04±2.96	97.60±3.99	98.32±3.25	95.83±2.96	90.79±2.25
	Weight gain	39.32±0.59abc	39.99±0.49b	38.83±0.40b	37.90±0.50c	35.24±0.33d
	Feed efficiency	2.42±0.04	2.44±0.08	2.54±0.09	2.54±0.10	2.57±0.05
15-21	Feed consumption	120.05±7.73ab	131.67±5.79a	128.31±3.77a	126.54±2.83a	115.71±2.58b
	Weight gain	42.99±1.62abc	42.91±0.38c	42.75±0.22bc	42.34±0.30b	40.95±0.32d
	Feed efficiency	2.79±0.14	3.06±0.11	3.00±0.08	2.99±0.08	2.82±0.05
22-28	Feed consumption	160.51±22.19abc	154.02±1.81a	149.42±1.65a	156.10±1.76b	141.87±1.87c
	Weight gain	36.18±2.21	35.09±2.24	33.22±1.42	35.68±1.00	34.35±0.54
	Feed efficiency	4.47±0.57ab	4.50±0.26a	4.60±0.22a	4.43±0.14a	4.14±0.03b
29-35	Feed consumption	189.09±15.33	196.86±5.09	179.92±7.73	192.19±5.59	189.98±2.22
	Weight gain	23.07±0.33a	19.49±1.23a	15.23±0.73b	15.34±0.62bc	19.33±1.50ab
	Feed efficiency	8.19±0.64c	10.36±0.68b	11.40±0.52b	13.44±0.56a	11.31±1.04bc
1-35	Feed consumption	615.11±49.06abc	626.05±19.56ab	599.28±6.81b	615.25±2.32a	578.27±12.46c
	Weight gain	167.59±2.17a	162.13±2.09b	154.76±0.96c	155.70±1.24c	152.88±1.40c
	Feed efficiency	3.96±0.26bc	4.46±0.13bc	4.66±0.11c	5.05±0.10a	4.52±0.19b

$^{a-c}$: Values within each row with different superscripts differ significantly ($p<0.05$)

Table 4: Effects of B supplementation on chemical composition of meat in Japanese quails (mean±SEM)

			Boron (mg kg^{-1} diet)			
	N	Control	10	60	120	240
Dry matter (%)						
Female	8	25.80±0.33	26.00±0.51	25.72±0.18	26.09±0.21	26.20±0.11
Male	8	25.77±0.42	25.31±0.45	25.91±0.19	24.74 ±0.36	24.41±0.07
Fat (%)						
Female	8	.91±0.18^{cd}	1.69±0.06^{d}	2.16±0.12^{bc}	2.51±0.09^{a}	2.42±0.07^{ab}
Male	8	1.79±0.22^{c}	2.14±0.14^{b}	2.19±0.08^{b}	2.59±0.06^{a}	2.41±0.07^{ab}
Ash (%)						
Female	8	0.95±0.02^{b}	0.99±0.01^{ab}	0.98±0.02a^{b}	0.97±0.01^{b}	1.02±0.01^{a}
Male	8	0.93±0.01^{c}	0.98±0.01^{ab}	0.99±0.01^{ab}	0.97±0.01^{b}	1.02±0.01^{a}

$^{a-b}$: Values within each row with different superscripts differ significantly ($p<0.05$)

Table 5: Effects of B supplementation on carcass yield in Japanese quails (mean±SEM)

			Boron (mg kg^{-1} diet)			
	N	Control	10	60	120	240
Hot carcass yield (%)						
Female	8	68.48±3.02	70.61±1.23	65.90±3.33	69.08±1.04	68.40±2.22
Male	8	73.82±1.87	74.30±0.55	70.21±0.60	74.88±1.52	74.20±1.08
Cold carcass yield (%)						
Female	8	66.73±2.81	68.81±1.23	64.48±3.16	67.84±1.02	66.50±2.09
Male	8	72.21±1.44	72.76±0.64	69.59±0.79	73.00±1.24	72.18±0.85
The difference betweenhot and cold carcass yield						
Female	8	1.74±0.23	1.79±0.05	1.42±0.19	.24±0.07	1.89±0.34
Male	8	1.60±0.47	1.55 ±0.19	0.62±0.68	1.87 ±0.34	2.02±0.23

Table 6: Effects of B supplementation on serum lipid levels in Japanese quails (mean±SEM)

			Boron (mg kg^{-1} diet)			
Parameters	N	Control	10	60	120	240
Triglycerides (mmol/l)	20	7.34±2.16^{a}	6.24±1.11^{ab}	4.13±0.58^{bc}	5.13±0.59^{abc}	2.88±0.47^{c}
Total cholesterol (mmol/l)	20	6.29±0.54^{a}	5.53±0.34^{b}	5.21±0.10^{bc}	4.77±0.25^{c}	4.83±0.09^{bc}
HDL-cholesterol (mmol/l)	20	2.60±0.23	2.80±0.14	2.70±0.10	2.69±0.10	2.99±0.10
LDL-cholesterol (mmol/l)	20	3.56±0.50	3.81±0.36	3.28±0.13	3.10±0.26	3.19±0.10

$^{a-c}$: Values within each row with different superscripts differ significantly ($p<0.05$)

lipids in peripheral tissue. In this study, since increased meat fat percentage and decreased serum triglycerides and total cholesterol levels may suggest deposition of lipids in peripheral tissue.

CONCLUSION

Since all the levels of B in the form of boric acid used in this study adversely affected performance, carcass traits and changed serum lipids, further studies with lower levels of B in the form of boric acid supplementation may be more valuable for the field applications.

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