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The Effects of Various Levels of Boron Supplementation on the Performance and Some Plasma Mineral and Metabolites of Wethers

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Abstract: In this study, the effects of various levels (0, 15, 30, 45 ppm) of Boron (B) supplementation to the wethers diet on performance parameters such as body weight, body weight gain, feed consumption, feed convertion ratio and serum Ca, P, Mg, glucose, ALP, triglyceride, total cholesterol, blood urea nitrogen, albumin and total protein levels were investigated. As animal material, a total of 32 merino male wethers 8 months age were used. These animals were divided 4 groups consisting 8 animals in each. Animals were housed and fed in individual cage. Before the experiment all animals were weighed and were grouped in equal body weight mean. This trial was made in University of Selcuk, Veterinary Faculty Experimental Farm and was lasted at 56 days. As a boron source, sodium borate was added to the diets. Boron was not supplemented to the diets of control while trial groups (group 2-4) included 15, 30 and 45 ppm B, respectively. Body weight datas were obtained on 14, 28, 42 and 56 days. Ca, Mg, P, glucose, ALP, triglyceride, total cholesterol, blood urea nitrogen, albumin and total protein were determined by spectrophotometer in blood samples obtained by vena jugularis on the 1, 28 and 56 days of the trial. Boron supplementation were increased on body weight gain and feed convertion ratio on some periods ($p<0.05$). Boron additions also significantly affected the serum Ca, Mg and ALP values. In conclusion, boron might be have beneficial effects on performances and some blood parameters of wethers.

Key words: Boron, wether, performance, biochemical parameters, convertion ratio, Turkey

INTRODUCTION

Boron (B) appears to be an essential nutrient for animals in that dietary deprivation of boron consistently results in changed biological functions that are detrimental and that can be corrected by increasing boron intake. However, as yet no specific biochemical function for boron has been discovered.

Boron interacts with elements such as Ca, Mg and P which have efficient role particularly in the bone metabolism of human and animal organism (Naghii and Samman, 1993). Among all parameters which are most largely influenced by B deficiency, plasma and tissue Ca and Mg levels as well as plasma alkaline phosphatase and bone calcifications parameters are included. Negative changes in those parameters are manifested as growth retardation, decrease in efficiency parameters which vary based on the animal species (body weight, feed consumption, laying performance and egg shell quality etc.) and particularly in decreased steroid hormone concentrations.

Several studies have indicated that B is a important mineral for body weight, food consumption, reduced mortality rate, normal cartilago and bone formation in animal models. Rossi *et al.* (1993) investigated the effects of supplementing B in a maize-soybean diet on body weights of broilers. Generally B increased body weights of both male and female broilers. Hunt and Nielsen (1981) supplemented a purified diet containing various levels of B and either adequate or inadequate amounts of vitamin D_3. They found a positive relationship between B and vitamin D_3. Boron supplementation improved chick body weight when the vitamin D_3 content of the diet was adequate (2500 IU kg^{-1}) or inadequate (125 IU kg^{-1}) (Kurtoglu *et al.*, 2001).

The same researches (Hunt and Nielsen, 1987) also reported that 4 weeks of B deprivation resulted in chick growth depression, elevated plasma glucose and increased brain weight to body weight ratio. Elliot and Edwards (1992) used a factorial arrangement of treatments involving the addition of calcium, vitamin D_3 and B to purified diets for broilers. They reported that B

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supplementation tended to increase bone ash and that there was a significant interaction between B, Ca and vitamin D_3.

Most of the current interest of B in animal nutrition began in 1981 with the finding that physiological amounts of boron (3 mg kg^{-1} diet) supplementation to diets low in boron level (<0.3 mg kg^{-1} diet) stimulated growth in vitamin D_3 deficient chicks (Hunt and Nielsen, 1981). Also, data presented by Kurtoglu *et al.* (2001) indicated that B had an influence on plasma Ca and Alkaline Phosphatase, (AP) levels. There is considerable evidence that dietary boron alleviates perturbations in mineral metabolism (Hunt and Nielsen, 1981; Kurtoglu *et al.*, 2001).

Also, Hunt *et al.* (1983) in a series of experiments with 1 day old chicks fed for 30 days indicated a relationship between B and others (Ca, Mg and vitamin D_3). Signs of B deficiency may be related to the level of vitamin D_3, Mg and possibly other nutrients in the diet. Indeed, comparison of the findings on growth from the Boron-Calcium (B-Ca) and Boron-Magnesium (B-Mg) studies suggested that the relationship between B-Mg was stronger than that between Ca or P and B. Nielsen *et al.* (1988) indicated this function of B related its parathormone regulating action. Therefore, B is needed by the parathyroid and has been shown to prevent loss of Ca and bone demineralisation in postmenopausal women.

The aim of this study was to evaluate the effects of B administirations (0, 15, 30 and 45 ppm) to wether diets on body weight, body weight gain, feed consumption, feed convertion ratio and some biochemical parameters during 56 days. Because of limited research worked on small ruminants with B administration, results obtained from present study may be useful this subject area.

MATERIALS AND METHODS

Animals: A total of 32, 8 months age male Merino wethers obtained from University of Selcuk, Faculty of Veterinary Medicine, Animal Husbandry and Research Unit were used in this study. The animals received internal and external anti-parasites treatment before starting the trial.

Experimental design: The experimental period was 56 days. Before experimental period performed 15 days as training period. At the beginning of the experimental period the wethers were induvidually weighed before morning feeding during consequently 2 days and than these means were evaluated as beginning body weigth means. The animals were grouped in equal body weight mean and divided into 4 groups consisting 8 animals in each. To limit the location differences each wether placed in each group was distributed randomly among the different compartments of the cage system. Each animal was housed in a single cage and fed individually. Fresh water was supplied throughout the trial. According to nutrient requirements of animals cited by NRC (1985), amount of feed given to wethers was 2.5% of their body weight on the period of 1-14 days however, on the other periods of study (14-28, 28-42 and 42-56 days) this ratio was 3%. Animals were fed in the same time every day. Feed amount given to each wether were determined according to body weight means evaluated in weighting period (1, 14, 28 and 42 days) and these feed amounts determined were given to each wether by separatelly weighting.

Diet and boron supplementation: The composition and nutrient components of the basal diet is shown in Table 1. The basal diet was supplemented with boron at 0 (control) 15, 30 and 45 ppm and mixed in a feed mixer. Sodium borate ($Na_2B_4O_7 10H_2O$, Merck) was used as B source. In the training period (pre-experimental period), the diets were not supplemented with boron. Because the diet used in the trial contained with adequate amount dried sugar beet pulp, roughage was not given to animals.

Performans parameters determination: Body Weight (BW) values were determined at 1, 14, 28, 42 and 56 days of experiment. Body Weight Gain (BWG), Food Consumption (FC), Food Conversion Ratio (FCR) values were determined at 14 days intervals (Table 2). The rest feed mass were collected, weighted and these values were take into consideration of food consumption determination.

Nutrient composition of experimental diets: Crude protein, dry matter, crude fibre, calcium and phosphor values of the experimental diet were determined by chemical analysis (AOAC, 1984).

Table 1: Composition and nutrient content of diet

Ingredients	Percentage
Dried sugar beet pulp	40.00
Barley	29.50
Sunflower meal	18.00
Wheat bran	10.00
Limestone	1.00
Dicalcium phosphate	1.00
Salt	1.00
Vitamin-mineral premix*	0.50
Chemical analysis of nutrients	
Dry matter (%)	90.54
Crude protein (%)	14.02
Metabolizable energy (Mcal kg^{-1})**	2.52
Crude fibre (%)	11.53
Calcium (%)	0.65
Phosphorus (%)	0.42

*Per 2.5 kg vitamin-mineral premix contains; 15000,000 IU Vit. A; 3000,000 IU Vit. D_3; 30,000 mg Vit. E; 50,000 mg Mn, 50,000 mg Fe, 50,000 mg Zn, 25,000 mg Cu, 500 mg Co, 500 mg I and 500 mg Se; **Calculated

Table 2: Performance means obtained from study

	Groups			
Period (day)	1 (Control)	2 (15 ppm B)	3 (30 ppm B)	4 (45 ppm B)
Body weight (kg)				
1	56.63±0.780	56.61±0.810	56.66±0.770	56.63±0.790
14	57.41±0.750	57.54±0,770	57.50±0.710	57.45±0.820
28	61.04±0.790	60.58±0.970	61.53±0.780	61.28±0.990
42	62.85±0.740	63.28±1.120	64.61±0.790	64.19±1.080
56	64.25±0.780	65.15±1.230	66.18±0.870	65.71±0.990
Body weight gain (g day^{-1})				
1-14	56.25±8.990	66.07±7.110	59.82±7.260	58.93±7.610
14-28	258.93±28.88	216.97±19.47	287.50±31.45	273.22±31.51
28-42	129.11±12.20^{b}	192.86±21.30^{a}	220.27±21.66^{a}	208.13±19.21^{a}
42-56	100.00±10.88^{b}	133.93±11.59^{a}	137.24±8.020^{a}	108.57±10.450^{ab}
1-56	136.07±10.40	152.46±10.11	175.10±11.22	162.21±9.030
Feed consumption (kg^{-1} day)				
1-14	1.42±0.020	1.42±0.020	1.42±0.020	1.42±0.020
14-28	1.72±0.020	1.72±0.020	1.72±0.020	1.72±0.020
28-42	1.83±0.020	1.82±0.030	1.83±0.020	1.82±0.030
42-56	1.88±0.020	1.88±0.040	1.90±0.030	1.92±0.040
1-28	1.57±0.020	1.57±0.020	1.57±0.020	1.57±0.020
1-42	1.66±0.020	1.65±0.020	1.66±0.020	1.65±0.030
1-56	1.71±0.020	1.71±0.030	1.71±0.020	1.72±0.030
Feed convertion ratio (kg feed kg^{-1} body weight)				
1-14	28.93±3.870	24.17±3.720	26.19±3.080	26.95±3.300
14-28	7.49±1.150	8.46±0.850	6.72±0.980	7.09±1.010
28-42	14.98±1.200^{a}	10.13±0.960^{b}	8.95±0.970^{b}	9.25±0.810^{b}
42-56	20.36±2.100^{a}	14.67±1.050^{b}	14.14±0.790^{b}	18.87±1.910^{ab}
1-56	13.17±1.100	11.52±0.460	10.06±0.740	10.81±0.550

^{a,b}Means within rows with no common superscripts are significantly different ($p<0.05$), according to Duncan's multiple range tests

Biochemical measurements: For plasma analysis, blood samples were taken from the all wethers in each group by vena jugularis into heparinised (10 IU heparin mL/blood, Liquemine flacon, Roche, Turkey) tubes on the 1, 28 and 56 experimental days. Plasma were obtained by centrifugation (Megafuge 1.0 R Heraeus Sepatech GmbH) of blood samples in heparinised tubes at 2500 rpm for 10 min at +4°C.

Plasma Calcium (Ca), Magnesium (Mg), Phosphorus (P), Alkaline Phosphatase (ALP), glucose, Blood Urea Nitrogen (BUN), total protein, albumin, triglyceride and total cholesterol levels were measured spectrophotometrically (Shimadzu, UV 2100, Japan) using commercial kits (supplied by Randox Laboratories, Crumlin, UK).

Statistical analysis: Biochemical and performance parameters were expressed as the mean±standart error of the mean. One-way ANOVA and Duncan's multiple range test were used to compare the mean values resulting from the various treatments. These statistical analyses were carried out using the SPSS (1998) for Windows Statistical Software Package (SPSS, 1998).

RESULTS AND DISCUSSION

As it can be shown in Table 2, no statistically significant difference could be obtained in terms of body weight and feed consumption values in any period of the study ($p>0.05$). During day 1-14 of the study increase in daily body weight gain values was found lower than other periods (14-28, 28-42 and 42-56 days). This finding can be explained with the fact that all animals enrolled to the study in the day 1-14 period were fed with a lower ratio in terms of percent of body weight (2.5% of body weight) in comparison with other periods (3% of body weight). Highest increases in body weight gain values were obtained in the group 3 with 30 ppm B supplementation during 28-42 and 42-56 days periods of the study. As it is stated althoughm, significant ($p<0.05$) increased were obtained in the increase of body weight gain via B supplementation during some periods of the study increases obtained throughout the 1-56 days period covering whole study period could not reach statistically significant level. No study could be found which reveals out the effects of the boron on the performance data in sheep.

There was a difference between feed convertion ratio obtained in several periods of the study ($p<0.05$). In the 28-42 days period of the study, significant improvements were observed in the rate of feed convertion ratio in study groups than control group. Similarly, statistically significant improvements in feed convertion ratios were also observed in groups with 15 and 30 ppm B supplementation than control group in the day 42-56 period ($p<0.05$). The numerically higher feed convertion

Table 3: Biochemical parameters obtained from study

		Groups			
Parameters	Period (day)	1 (Control)	2 (15 ppm B)	3 (30 ppm B)	4 (45 ppm B)
Ca (mg dL^{-1})	1	9.01±0.50	9.87±0.76	9.97±0.82	10.28±0.69
	28	9.58±0.97	10.50±0.87	10.56±0.87	11.74±0.85
	56	9.25±0.77^{b}	10.19±0.89^{ab}	12.31±0.66^{a}	12.51±0.72^{a}
P (mg dL^{-1})	1	7.73±0.75	7.25±0.93	6.29±0.61	6.38±0.63
	28	7.61±0.78	7.13±0.77	7.33±0.64	6.40±0.62
	56	6.85±0.63	6.99±0.43	6.81±0.78	6.83±0.56
Mg (mg dL^{-1})	1	2.16±0.07	2.27±0.06	2.03±0.05	2.11±0.07
	28	2.09±0.12	2.17±0.13	2.25±0.17	2.14±0.14
	56	1.87±0.08^{b}	1.89±0.06^{b}	2.17±0.08^{a}	2.21±0.09^{a}
ALP (U L^{-1})	1	149.53±6.09	146.81±6.20	142.18±5.26	1141.83±7.54
	28	152.70±4.97	144.07±5.11	138.46±4.98	1134.11±3.97
	56	154.80±5.60^{a}	142.28±4.80^{ab}	136.01±5.38^{b}	11132.41±5.43^{b}
Glucose (mg dL^{-1})	1	82.03±4.57	80.13±5.96	78.86±4.08	75.77±5.50
	28	78.28±4.75	79.92±4.80	78.87±4.75	73.80±3.76
	56	80.18±3.49	79.43±4.78	74.40±4.66	72.08±3.75
BUN (mg dL^{-1})	1	46.86±3.05	47.74±3.82	52.69±3.48	48.72±3.83
	28	45.75±3.65	44.03±2.98	46.96±3.26	54.78±3.44
	56	44.64±2.30	44.42±1.79	50.27±3.26	54.11±2.31
Total protein (g dL^{-1})	1	9.83±0.60	9.88±0.62	9.58±0.70	8.51±0.88
	28	8.90±1.04	9.04±0.99	8.05±0.72	8.90±1.11
	56	9.55±0.88	9.17±0.74	9.50±0.75	9.35±0.63
Albumin (g dL^{-1})	1	3.50±0.43	3.62±0.44	3.68±0.49	3.31±0.40
	28	3.22±0.41	3.31±0.48	3.10±0.40	3.49±0.53
	56	3.68±0.44	3.73±0.44	3.70±0.49	3.52±0.56
Triglyceride (mg dL^{-1})	1	15.08±3.34	16.16±2.22	16.72±2.87	15.27±3.45
	28	16.62±1.37	16.02±3.73	14.95±1.90	14.54±1.66
	56	17.83±1.58	17.40±1.59	15.70±1.19	15.46±1.06
Total cholesterol (mg dL^{-1})	1	71.18±3.97	75.31±4.87	83.94±3.62	68.70±3.43
	28	58.73±3.67	49.65±2.36	57.11±3.62	53.18±2.18
	56	51.71±4.16	47.10±4.36	51.64±5.15	44.16±3.16

[a,b]Means within rows with no common superscripts are significantly different ($p<0.05$). According to Duncan's multiple range tests

ratios in the 1-14 days period of the study in comparison with all other periods can be explained with the fact that a lower ratio of feed (2.5% of the body weight) was applied in this period. Again in all other periods, feeding all animals at rate of 3% body weight may cause feed convertion ratios be partially obtained numerically higher as this feeding rate may limit a higher level of increase in the body weight. Significant improvements obtained in the feed convertion ratio values in the 28-42 and 42-56 days periods are compatible with increases in body weight gain values in the same period.

There was found statistically effect ($p<0.05$) of B supplementation on Ca, Mg and ALP values on day of 56. But no statistically significant effect could be found on the other biochemical parameters of B in any period of study as shown Table 3.

This study was carried out to evaluate the effects of various levels of B (15, 30 and 45 ppm) supplementation on BW, BWG FC, FCR and some biochemical parameters in wethers. The findings of the present study support the hypothesis that B has an important biological role that influences mineral metabolism via biochemical and haematological mechanisms.

Recently, metabolic effects of B element on living organisms and also impacts on animal nutrition are particularly emphasized. However, studies conducted on livestock, particularly sheep with economical value in relation with boron are scarce. In studies conducted in different animal species, different results were obtained in relation with the effect of boron on the body weight values. Armstrong and Spears (2001) found that body weight significantly increased in piglets during 1-35 and 36-66 days periods via supplementation of 5 and 15 ppm B. In a similar study conducted on porcine (Armstrong *et al*., 2001), it was determined that body weight increased significantly via 5 ppm B (sodium borate) supplementation. Kurtoglu *et al*. (2001) found that body weight of broilers fed with a ratio including sufficient and insufficient amount of vitamin D_3 was significantly high in various periods of the study via B supplementation. On the contrary in another study where normal and semi-purified diet was applied (Armstrong *et al*., 2000) supplementation of 5 and 15 ppm B did not influence body weight in porcine and a similar result was observed in body weight changes of laying hens supplemented with B (Kurtoglu *et al*., 2001). Similar to those reports, 15-45 ppm sodium borate supplementation to sheep in this study provided statistically insignificant increases in the body weight in some periods of the study. In this study, observation of similar body weight values in sheep in the 56 days (end of the study) is also indicative of compatibility with results of other studies. However, BW is negatively affected by the high levels of B supplementation. It has been reported that addition of 300 ppm B in broilers (Rossi *et al*., 1990, 1993) 400 ppm in laying hens (Wilson and Ruszler, 1996, 1998) and 400 ppm in growing pullets (Wilson and Ruszler, 1997) significantly decreased the BW ($p<0.05$).

As it can be shown in the Table 2, a similarity exists in the feed consumption in all periods of the study ($p>0.05$). Constant amount of feed given to all animals throughout the study has influence on this result. Animals were given feed at amount equal to the 2.5% of the body weight during 1-14 days and 3% of body weight was constantly given in other periods. As animals generally consumed almost all feed given in all periods, it is an expected result that there was no difference in feed consumption. Armstrong and Spears (2001) reports that mean daily feed consumption significantly increased in piglets during 0-35 and 36-66 days periods via supplementation of 5 and 15 ppm B to the diet. On the contrary in another study, B supplementation at similar levels (5 and 15 ppm) in porcine had no influence on feed consumption (Armstrong *et al*., 2000). Kurtoglu *et al*. (2001) found significant increases ($p<0.05$) in some periods of the study via B supplementation in broilers and in another study (Kurtoglu *et al*. 2002) they observed that B supplementation in laying hens aged 40 weeks did not have influence of feed consumption. A complete comparison with other studies could not be performed as sheep were given constant amount of feed, determined as percent of body weight in this study.

In different studies conducted with boron supplementation, different results were obtained in the feed convertion ratio values. Armstrong and Spears (2001) could not observe important change in the feed convertion ratios with supplementation of 5 and 15 ppm B in piglets in 0-35 and 36-66 days periods ($p>0.05$). Kurtoglu *et al*. (2002) similarly determined that 50-250 ppm B supplementation had no influence on laying hens. These reports are not fully compatible with the findings. On the contrary in a similar study conducted on porcine (Armstrong *et al*., 2000) feed convertion ratio was not influenced by 5 and 15 ppm B supplementation in the 1st trial of the study while feed convertion ratio in the group with 5 ppm B supplementation was negatively influenced relative to control group and the group with 15 ppm B supplementation in the second trial in which semi-purified diet was applied ($p<0.05$). In another study conducted using 5 and 25 ppm B supplementation to broilers (Kurtoglu *et al*., 2001) B supplementation improved feed convertion ratio in some periods of the study. It is really difficult to compare the study with results of other studies conducted by various researchers, as a particular amount of feed determined as percent of animal's body weight was given to animals in the study. Howeve, in the study, significant improvements in the feed convertion ratios were obtained in some periods of the research similar to the results of aforementioned researchers. Those improvements obtained in this study were largely dependent on difference in the increase of body weight values.

It was observed in the study that B supplementations had no significant influence on p-values (Table 3) while it was striking that it significantly increased Ca values. The increase was numerical in the baseline and 28 days but it was statistical ($p<0.05$) in the data of 56 days. Brown *et al*. (1989) reported that B supplementation increased Ca retention in sheep. Number of studies conducted on sheep in this field is very limited. Besides, positive effects of B supplementations on poultry (Kurtoglu *et al*., 2001; 2002, 2005; Qin and Klandorf, 1991), rats (Hegsted *et al*., 1991; Seaborn and Nielsen, 1994) and in human (Samman *et al*., 1998) were reported. It is reported that positive effects of the boron on mineral metabolism and the bone development dependent on this metabolism are more significant in the vitamin D_3, Ca and Mg deficiency (Kurtoglu *et al*., 2001, 2007; Nielsen and Shuler, 1992). However, it is emphasized that effects of B supplements in the mineral absorption is directly dependent on animal species, age and the yield performance (Kurtoglu *et al*., 2005).

In the study although, significant ($p<0.05$) differences were found in plasma Mg values particularly in 56 days, the inter-group data was within normal ranges. In a similar study conducted on sheep, Brown *et al*. (1989) found that dose of daily 75 and 200 mg B as sodium borate supplementation per animal had no significant effect on absorption and elimination of the Mg.

When Alkaline Phosphatase (ALP) values are examined, it can be seen that values decrease parallel to the increase in B supplementation in all periods and the increase is statistically significant in 56 days ($p<0.05$). The decrease in alkaline phosphatase values may represent the normal bone structure. It was emphasized that in vitamin D_3 and Mg deficiencies due to the decreased Ca absorption and increased Ca mobilization in bones, plasma ALP level increases and this causes destruction in bones (Hunt *et al*., 1983; Hunt and Nielsen, 1981; Hunt, 1989; Kurtoglu *et al*., 2001). In the study conducted on broilers by Kurtoglu *et al*. (2005), it was revealed that significant improvements occurred particularly in the tibia in groups with B and cholecalciferol and in another study of the same investigators Kurtoglu *et al*. (2001), it was found that in vitamin D_3 deficiency, 5 and 25 ppm B supplementations decreased serum ALP values ($p<0.05$) and a significant decrease was observed in blood Ca values due to decreased Ca mobilization from bones. In the study conducted on laying hens with 50, 100, 150, 200 and 250 ppm B supplementations (Kurtoglu *et al*., 2002), blood Ca values increased ($p<0.05$) but no significant difference was obtained in P and Mg values.

Boron is necessary for the synthesis of steroid hormones and the synthesis is performed via activation of cholesterol-centered hydroxylation stages by B (Samman *et al*., 1998). Pursuant to this hypothesis, it is stated that B supplementations may reduce blood cholesterol levels. In other studies conducted on this subject, different outcomes were obtained. It is believed that the differences in results of various studies may arise from difference of animal species used. In the study presented, triglyceride values (Table 3) had a numerical decrease trend in the 28 and 56 days periods in groups with B supplementation while non-statistical decreases in the cholesterol values were also observed in same periods. In the study conducted by Samman *et al.* (1998), researchers could not obtained significant difference in cholesterol, HDL-LDL cholesterol and triglyceride values with 10 mg B supplementation/day for 4 weeks but they found that steroid hormone synthesis (testosterone and estradiol) was significantly decreased ($p<0.05$). Armstrong *et al.* (2000) obtained only numerical changes in the plasma Ca, Mg, P, ALP, cholesterol and triglyceride values in porcine while significant increased were obtained in the groups with 5 and 15 ppm B supplementation (3.2 and 2.9 mmol L^{-1}) in comparison with the control group (2.8 mmol L^{-1}) in plasma cholesterol value in the second trial where semi-purified diet was used ($p<0.05$). Similarly, triglyceride value was found higher in the group with 15 ppm B supplementation (0.69 mmol L^{-1}) than control group (0.52 mmol L^{-1}) in the 2nd trial ($p<0.05$). In the study conducted on milking cows by Basoglu *et al.* (2002) using sodium borate (100 mg kg^{-1} body weight, peros), it was found that hepatic fat rate following the calving was significantly lower in the administration group (6.3 μm^3/100 μm^3) in comparison with the control group (29.1 μm^3/100 μm^3). Pre-natal, natal and post-natal blood cholesterol, triglyceride, glucose, VLDL and total protein levels were not significantly influenced while there were significant changes in the blood urea and HDL values in some periods. In a study conducted on dogs by Basoglu *et al.* (2000), significant decreases in blood triglyceride, VLDL and glucose levels and significant increases in HDL levels were determined and on the contrary, B supplementation did not influence cholesterol and LDL values.

Some hypolipidaemic agents containing B administired to rats have been shown to reduce serum cholesterol, triacylglycerol and Low Density Lipoprotein (LDL) levels and increase the biliary excretion of cholesterol (Hall *et al*., 1989). It is clear however that a longer experimental period will affect the plasma lipid concentrations differently to the pattern observed after 2 weeks. In humans B supplementation in the short term does not create any significant perturbation in lipid metabolism, possibly because of the increase in both plasma testosterone and plasma oestrogen concentrations (Naghii and Samman, 1997).

No significant change in total protein, albumin, BUN and glucose levels was observed in the study presented ($p>0.05$; Table 3). Basoglu *et al.* (2002) found that administration of 100 mg B kg^{-1} body weight (peros) in the pre and post-calving periods did not influence the blood glucose level in cows but 10 g day^{-1} B uptake in dogs (Basoglu *et al*., 2000) decreased blood glucose level significantly throughout 4 weeks period ($p<0.05$). It was reported that boron intake (1.3 mg kg^{-1} feed) increased hepatic 2-phosphoglycerate level in poultry and decreased dihydroxy acetone level (Hunt, 1989) and in the end of those findings, it was revealed that boron is influential in the glycolytic metabolic pathway and thus it has a significant role in the substrate metabolism (Nielsen, 1997). Hunt and Nielsen (1987) reported that addition of B deficiency to the cholecalciferol (vit D_3) deficiency increased plasma glucose levels in poultry.

CONCLUSION

In this study lasted 56 days in sheep supplemented with 15, 30 and 45 ppm B, significant improvements were obtained using B supplementations in the body weight gain and feed convertion ratio values in some periods of the investigation. In all groups with B supplementation, body weight values in 56 days were found higher but the increase could not reach statistically significance level. Blood Ca, Mg and ALP levels were significantly influenced by particularly 30 and 45 ppm B supplementations ($p<0.05$).

Supporting the results obtained in different studies conducting using boron in poultry and porcine by different investigators, results obtained from the current study conducted on male wethers indicates that boron may have influences on animal metabolism and some performance values. New studies are required for better clarifying metabolic effects of boron.

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