Effects of boron glycerinate supplementation on some tibia and femur characteristics in broilers

FERENC KELEMEN[1] – ZSUZSA RIGÓ[2] – TAMÁS TÓTH[3]

[1] Novartis Hungary Ltd.

[2] Budapest and Pest County Agricultural Administrative Authority
Directorate for the Safety of the Food Chain and Animal Health

[3] University of West Hungary
Faculty of Agricultural and Food Science
Department of Animal Nutrition
Mosonmagyaróvár

SUMMARY

Our feeding trials were conducted with a total of 1,500 *Cobb-500* broiler cocks. Two treatments and three replicates (250 cocks/replicate) were used. The birds had free access to feed and water and were fed with a basal diet supplemented with 0 and 2.5 mg boron glycerinate for 38 days. After the 38-day-rearing period 15–15 cocks of similar weight (2,100 ± 50 g) were exterminated from both groups. The following parameters were determined: length and weight of tibia and femur, ash, calcium (Ca) and phosphorus (P) content of the tibia. The length and weight of tibia and femur in the group supplemented with boron glycerinate were significantly higher ($P < 0.05$). Ash percentages in the tibia of broilers were slightly higher due to boron glycerinate supplementation (control group: 36.04 g/kg dry matter, experimental group: 38.15 g/kg dry matter, NS). Calcium and phosphorus content of tibias were significantly higher ($P < 0.05$) in the experimental group fed with 2.5 mg boron glycerinate (calcium content: 13.25 g/kg dry matter and 14.21 g/kg dry matter, phosphorus content 6.58 g/kg dry matter and 7.04 g/kg dry matter, respectively). According to our preliminary data it is concluded that boron supplementation can be a useful additive in developing the strength of skeleton in quick growing broilers.
Keywords: boron glycerinate, boron supplementation, broiler, tibia, femur.

INTRODUCTION

The beneficial effects of boron supplementation in plants have been well recognized and documented. Boron can be found in fruits and vegetables, in oily seeds and in legumes, as well (*Kelly* 1977). Although the essentiality of boron has not been proven, an increasing number of studies conducted during recent years presumed that boron could be essential in animals, since its deprivation in both experimental animals and humans causes changes in biological function.

The indirect evidence of its effectiveness is that boron as proton-donor influences the structure and function of cell-membrane (*Barr et al.* 1996). It has been conducted that boron supplementation influences the metabolism of minerals and functions of some hormones in human (*Nielsen et al.* 1987, *Nielsen* 1994). The beneficial effects of boron supplementation on calcium metabolism have been investigated in humans. It was stated that boron supplementation helped reducing the excretion of calcium via urea, especially if the intake magnesium was low (*Nielsen et al.* 1987).

In livestock animals there is no accepted level of boron demand, and the mode of action is not clarified. It has been sustained that boron in broilers supports calcium transfer; hereby promotes bone construction in case of lack of vitamin D and magnesium (*Mézes* 2003). The enzyme-activating (e.g. serine-proteases, oxidoreductases) effects of boron have been proved (*Mézes* 2003). In broilers, the beneficial effects of boron supplementation on natural characteristics were proved in several studies (*Rossi et al.* 1993, *Kurtoglu et al.* 2001, *Lin* and *Ying* 2003). Furthermore, it has been stated that 5–60 mg/kg dry matter boron supplementation positively influences the solidity and weight of tibia (*Rossi et al.* 1993). Boron excess is well-tolerated in broilers, the symptoms of toxicity can be observed over the dose of 300 mg/kg DM (*Underwood* and *Suttle* 1999). In laying hens, hatchability decreases due to boron over dosage, while the symptoms in calves are the decreasing of daily weight gain and appetite (*Underwood* and *Suttle* 1999).

In our previous study, the effects of dietary boron glycerinate supplementation on main characteristics and meat production were evaluated (*Rigó et al.* 2009). It was stated that 2.5 mg/kg feed boron glycerinate supplementation had no significant effect on the live weight of Cobb-500 cocks between the age of 21 and 38 days comparing to the control group. Meanwhile the energy- and protein utilization was observed to be slightly better in the broilers of the experimental group. There were no significant effects of dietary boron glycerinate supplementation noticed on the nutritional (dry matter, protein, fat, ash) content of breast and thigh meat, however, the fat content of thigh meat (105.4 g fat/kg meat) of cocks in the experimental group was higher than of the control group (94.1 g fat/kg meat).

Data are mainly available about boron acid (H_3BO_3). *Kurtuglu et al.* (2001) stated that 5 and 25 ppm, while *Lin* and *Ying* (2003) found that 20, 40, 60, 80, 100 and 120 mg/kg dietary boric acid supplementation had favourable effects on weight gain and feed conversion in broilers. In the latter case the most effective dose proved to be 60 mg/kg in the first 3 weeks of fattening period. Due to dietary boric acid supplementation a significant increase of boron content in tibia was observed. In the feeding trials with Leghorn laying hens (*Wilson* and *Ruszler* 1995) a proportional increase of boron content in meat and bone samples was assessed parallel to the increasing boric acid content of the diet (3.5, 7, 14, 28 and 56 mg/kg). The authors concluded that through 56 mg/kg boric acid supplementation (the highest rate) the boron content of liver was 3.3 times higher, breast and thigh meat was

1.8 and 2.7 times higher, while in bones it was 2.4 times higher comparing to the levels of boron in different tissues in the control group.

In another study of *Wilson* and *Ruszler* (1998) with laying hens it is summarized that boron content of breast and thigh meat, liver and bone increased after supplementing the basal diet with 50, 100, 200 and 400 mg/kg boric acid.

Lin and *Ying* (2003) conducted that 20, 40, 60, 80, 100 and 120 mg/kg dietary boric acid supplementation significantly increased the boron content of the tibia compared to that of the liver in broilers. *Rossi et al.* (1993) found that 60, 120, 240 and 300 mg/kg boron supplementation improved the boron content of breast meat and liver in broilers, but the doses under 240 mg/kg did not have remarkable effects in the first 3 weeks of age. By data of the regression analysis of *Fassani et al.* (2004) the most favourable dose of boric acid supplementation proved to be of 37.4 ppm from day 1 to 21, and 57 ppm between 1–42 days of age. In the same time 30, 60, 90, 120 and 150 ppm dietary boric acid supplementations did not show significant effect on main parameters of broilers. The two feeding trials of *Elliot* and *Edwards* (1992) resulted that 5, 10, 20, 40 and 80 mg/kg boron supplementation had no significant effects on weight gain, feed conversion and the level of minerals in blood serum in broiler chickens.

In the last decade the object of selection was increasing of lean meat production in broilers. The large scale broiler meat production is based on strong skeleton, to be able to sustain the rapid growing of lean body mass. Therefore it is essential to develop heavy-duty skeleton in broilers via feeding. The aim of this study was to investigate the effects of boron glycerinate supplementation on the length and weight of tibia and femur, the calcium, phosphorus and ash content of tibia.

Materials and methods

The feeding trial was conducted with a total of 1,500 Cobb-500 broiler cocks at University of West Hungary, Faculty of Agricultural and Food Science broiler stable. Three replicates (750 cocks/treatment) were used, 250 cocks were housed in each compartment.

The following treatments were used in the trial:

1. Control
2. B-supplemented (2.5 mg boron glycerinate*/kg feed)

* Note: The boron glycerinate was produced by the authors.

The birds were randomly divided into experimental groups. The composition and nutritional characteristics of the diets and complete premixes fed throughout the experimental period are summarized in *Table 1.* and *2*. Boron glycerinate supplementation as premix was added to the basal diet. Broilers were fed in the growing phases (starter, grower and finisher) according to Cobb-technology guidelines (Cobb-Vantress Inc., USA, 2005).

By the end of the trial, after the 38-day-rearing period 15–15 cocks of similar weight were exterminated from control and experimental groups (2100 ± 50 g). The extermination was carried out humanely due to the Committee of Animal Welfare (MÁB), Regulation on Animal Tests (2006).

Table 1. Composition and nutrient content of broiler feeds

Feed and/or nutrient		Starter	Grower	Finisher
Corn	kg	332.0	378.5	391.5
Extracted soybean meal (46% CP-content)	kg	259.0	164.0	157.0
Wheat	kg	180.0	200.0	200.0
Full-fat soya	kg	80.0	95.0	100.0
Flour	kg	40.0	40.0	40.0
Fish meal (64% CP-content)	kg	35.0	25.0	
Energomix-40 (sunflower oil-based product)*	kg	30.0	30.0	40.0
Biometin* (DL-methionine based product)	kg	4.5	4.0	4.0
Biolizin* (L-lysine-HCL based product)	kg	4.5	8.5	12.5
Florisoy** (extracted sunflower meal, fine fraction)	kg		20.0	20.0
KBP-560-Maxiban/E* (premix)	kg	35.0	35.0	
KBP-562-E* (premix)	kg			35.0
Total	**kg**	**1,000**	**1,000**	**1,000**
Calculated nutrient content				
Dry matter	%	88.56	88.57	88.55
AME_n	MJ/kg	12.64	13.06	13.18
Crude protein	%	22.51	19.50	18.01
Ether extract	%	5.10	5.69	6.01
Crude fibre	%	3.44	3.21	3.23
Lysine	%	1.33	1.17	1.10
Methionine	%	0.62	0.56	0.50
Ca	%	1.02	0.96	0.89
P (total)	%	0.74	0.70	0.65
Na	%	0.17	0.16	0.15

Producer: * TENDRE Feed Ltd. (Nagyigmánd, Hungary), ** ABO MIX Co. (Nyíregyháza, Hungary)

Table 2. Guaranteed values of mineral, methionine and vitamin content of broiler premixes

Guaranteed values		KBP-560-Maxiban/E*	KBP-562-E*
Ca	%	21.5	22.5
P	%	7.0	7.5
Na	%	3.2	3.5
Methionine	%	4.5	4.0
Vitamin A	NE/kg	342,950	285,750
Vitamin D3	NE/kg	114,320	85,729
Vitamin E	mg/kg	1,143	914

Moreover: vitamin K3, B1, B2, B6 and B12, pantothenic acid, folic acid, niacin, biotin, betaine, iron, zinc, manganese, copper, selenium, cobalt, iodine, antioxidant and coccidiostatic
Producer: * TENDRE Feed Ltd. (Nagyigmánd, Hungary)

The right-leg-femur and tibia of broilers were prepared, cooked and cleaned mechanically. The bones were placed into 40 °C dryer case for 24 hours.
The length of femur and tibia was determined with calliper, and were measured with scale METTLER PC 440 (*Mettler Instrumente AG,* Zürich, Switzerland).

Calcium and phosphorus content of tibia and experimental diets were determined by methods of *Hungarian Feed Codex* (2004)
Statistical analysis of results was carried out with independent-samples t-test, using *SPSS 12.0. for Windows* programme (*SPSS Inc.,* Chicago, USA). Homogeneity assay of variances was evaluated with *Levene-test.* Significance level was P < 0.05.

Results and discussion

The effects of 2.5 mg/kg dietary boron glycerinate supplementation on the length, weight of femur and tibia and the calcium, phosphorus content of tibia is summarized in *Table 3.* According to these data the length and weight of femur and tibia were significantly (P < 0.05) improved due to boron glycerinate supplementation.
In our feeding trial the effect of dietary boron glycerinate supplementation was not significant on ash content of the tibia. *Wilson* and *Ruszler* (1997) concluded that 50, 100 and 200 mg/kg boric acid supplementation significantly increased the ash content of tibia in *Leghorn* laying hens. The most favourable dose proved to be 50 mg/kg boric acid supplementation. The results of the studies of *Qin* and *Klandorf* (1991) showed that 100 ppm boron supplementation for one and two weeks, and/or 60 ppm for 3, 4 and 5 weeks had gained the ash content of the tibia in parent stock. Contrary, the conclusion of the feeding trials of *Rossi et al.* (1994) with Cobb broiler chickens was that 60 mg/kg boric acid dietary supplementation did not influence the ash content of the tibia.

Table 3. Effect of boron glycerinate supplementation on the length and weight of femur and tibia and on the ash, calcium and phosphorus content of tibia

Examined parameter	Control	Boron-glycerinate
Femur length (cm)	6.71±0.29^{a}	6.93±0.22^{b}
Femur weight (g)	6.14±1.04^{a}	7.58±1.14^{b}
Tibia length (cm)	8.60±0.42^{a}	9.24±0.26^{b}
Tibia weight (g)	8.07±1.28^{a}	9.76±2.03^{b}
Ash content of tibia (g/kg DM)	36.04±2.94^{a}	38.15±2.81^{a}
Calcium content of tibia (g/kg DM)	13.25±1.13^{a}	14.21±1.07^{b}
Phosphorus content of tibia (g/kg DM)	6.58±0.54^{a}	7.04±0.46^{b}

a, b: different superscripts within a row indicate significant differences (P < 0.05)

Boron glycerinate supplementation proved statistically (P < 0.05) beneficial effects on calcium and phosphorus content of tibia as shown in *Table 3.* Similarly, *Kurtoglu et al.* (2001) found that 5 and 25 ppm dietary boron supplementation positively influenced the calcium and phosphorus content of tibia in broiler chickens. Doses of boric acid between 50–250 ppm had significant effect on calcium content of blood plasma in laying hens (*Kurtoglu et al.* 2002). The same result can be found in the feeding trial report of *Wilson* and *Ruzler* (1997) that 50 ppm boric acid supplementation enhanced ash content. *Rossi et al.*

(1994) found that the ash content of tibia was slightly influenced by calcium, phosphorus and vitamin D3 (cholecalciferol) content of basal diet. 60 mg/kg boric acid dietary supplementation had neither effect on ash content of tibia, nor influence on frequency of occurrence of tibia-deformity (dyschondroplasia, TD). It was found that low levels of vitamin D3 (4, 8 and 100 IU/kg) had negative effect on live weight of animals and increased the frequency of occurrence of TD (*Rossi et al.* 1994). Contrary, in case of inadequate (125 IU/kg) and adequate (2000 IU/kg) vitamin D3 levels 5 and 25 ppm boron supplementation had favourable effects (*Kurtoglu et al.* 2001). In our study the vitamin D3 levels of feeds was the following: 4001 IU/kg in grower and 3000 IU/kg in finisher broiler diet. *Fassani et al.* (2004) also found that boric acid supplementation had no effects on the ash and calcium content of the tibia. The standpoint of latter authors is that the other microelements in feed interact with boron therefore they might modify the results.

Conclusion

In our feeding trial the starter, grower and finisher broiler feed had adequate levels of calcium (1.02, 0.96 and 0.89%, respectively), phosphorus (0.74; 0.70 and 0.65% total phosphorus, respectively) and vitamin D3 (4001 IU/kg in starter and grower and 3000 IU/kg in the finisher feed), and we found that 2.5 mg/kg boron glycerinate supplementation had beneficial effects on some parameters of tibia and femur. It is important to mention that boron supplementation for livestock animals has not been covered by EU legislation; it has not been registered yet as a feed additive. Irrespectively of EU legislation in force, the effects of boron supplementation on the production parameters of intensive growing broiler have been tested in many countries. According to our preliminary data it is concluded that boron supplementation can be a useful additive in developing the strength of skeleton in quick growing broilers.

A bór-glicerinát kiegészítés hatása a brojlercsirkék tibia és femur csontjának néhány paraméterére

KELEMEN FERENC[1] – RIGÓ ZSUZSA[2] – TÓTH TAMÁS[3]

[1] Novartis Magyarország Kft.
Budapest

[2] Fővárosi és Pest Megyei Mezőgazdasági Szakigazgatási Hivatal
Élelmiszerlánc-biztonsági és Állategészségügyi Igazgatóság
Budapest

[3] Nyugat-magyarországi Egyetem
Mezőgazdaság- és Élelmiszertudományi Kar
Állattudományi Intézet
Takarmányozástani Intézeti Tanszék
Mosonmagyaróvár

Összefoglalás

1500, *Cobb-500* genotípusú kakassal, 3 ismétlésben végzett etetési kísérletben (250 állat/ismétlés) a kezeletlen kontroll csoport mellett, 2,5 mg/takarmány kg bór-glicerinát kiegészítést alkalmaztak. A 38 napig tartó etetési kísérlet végén kezelésenként 15–15 átlagos testsúlyú (2100 ± 50 g) egyedet levágtak és meghatározták a femur és a tibia csontok hosszát, súlyát, illetve a tibia Ca-, P- és hamutartalmát. A femur és a tibia hosszúsága és súlya a bór-glicerinát kiegészítésben részesülő egyedek esetében szignifikánsan ($P < 0,05$) nagyobb volt. A tibia csont nyershamu-tartalma kismértékben növekedett az alkalmazott bórkiegészítés hatására (kontroll: 36,04 g/kg szárazanyag, bór-glicerinát: 38,15 g/kg szárazanyag, NS különbség). A tibia Ca- és P-tartalma szignifikáns mértékben ($P < 0,05$) nagyobb volt a 2,5 mg/kg bór-glicerinát dózis hatására (Ca-tartalom: 13,25 g/kg sz.a. és 14,21 g/kg sz.a., P-tartalom: 6,58 g/kg sz.a. és 7,04 g/kg sz.a., az előző sorrendben). Előzetes adataink azt igazolták, hogy a nagy növekedésű erélyű brojlerek esetében a csontváz megfelelő szilárdságának kialakításában a bórkiegészítés hatékony segítséget jelenthet.
Kulcsszavak: bór-glicerinát, bórkiegészítés, brojler, tibia, femur.

References

Barr, R. D. – Barton, S. A. – Schull, W. J. (1996): Boron levels in man: preliminary evidence of genetic regulation and some implications for human biology. Med. Hypotheses. **46,** 286–289.

Cobb-technology guidelines (Cobb-Vantress Inc., USA) (2005)

Committee of Animal Welfare, Regulation on Animal Tests (University of West Hungary) (2006)

Elliot, M. A. – Edwards, H. M. (1992): Studies to determine whether an interaction exists among boron, calcium, and cholecalciferol on the skeletal development of broiler chickens. Poult. Sci. **71,** (4) 677–690.

Fassani, E. J. – Bertechini, A. G. – Brito, J. AG. – Kato, R. K. – Fialho, E. T. – Geraldo, A. (2004): Boron supplementation in broiler diets. Rev. Brasil. Cienc. Avic. **6,** (4). 213–217.

Kelly, G. S. (1997): Boron: A review of its nutritional interactions and therapeutic uses. Alt. Med. Rev. **2.,** (1) 48–56.

Kurtoglu, V. – Kurtoglu, F. – Coskun, B. (2001): Effects of boron supplementation of adequate and inadequate vitamin D3-containing diet on performance and serum biochemical characters of broiler chickens. Res. Vet. Sci. **71.,** (3) 183–187.

Kurtoglu, V. – Kurtoglu, F. – Coskun, B. – Seker, E. – Balevi, T. – Cetingul, I. S. (2002): Effects of boron supplementation on performance and some biochemical parameters in laying hens. Rev. Med. Vet. **153.,** (12) 823–828.

Lin, L. – Ying, Y. (2003): Effect of boron on the performance and deposition of boron in tissues and organs of broilers. Acta Zoonutrimenta Sinica. **15.,** (1) 49–53.

Magyar Takarmánykódex (Hungarian Feed Codex) (2004) (Budapest)

Mézes M. (2003): Mikroelemek. In: Schmidt, J. (szerk.): A takarmányozás alapjai. Mezőgazda Kiadó. Budapest. 89–90.

Nielsen, F. H. – Hunt, C. D. – Mullen, L. M. (1987): Effect of dietary boron on mineral estrogen and testosterone metabolism in postmenopausal women. FASEB. J. **1.,** 394–397.

Nielsen, F. H. (1994): Biological and physiological consequences of boron deprivation in humans. Envirn. Health Pres. **102.,** 59–63.

Qin, X. – Klandorf, H. (1991): Effect of dietary boron supplementation on egg production, shell quality, and calcium metabolism in aged broiler breeder hens. Poult. Sci. **70.,** (10) 2131–2138.

Rigó Zs. – Kelemen F. – Tóth T. (2009): A bór- és krómkiegészítés hatása a brojlercsirkék termelési mutatóira és a hús táplálóanyag összetételére. Állattenyésztés és Takarmányozás. **58.,** (3) 255–264.

Rossi, A. F. – Butcher, G. D. – Miles, R. D. (1994): The interaction of boron with calcium, phosphorus and cholecalciferol in broilers. J. Appl. Anim. Res. **6.,** (4) 151–160.

Rossi, A. F. – Miles, R. D. – Damron, B. L. – Flunker, L. K. (1993): Effects of dietary boron supplementation on broilers. Poult. Sci. **72.,** (11) 2124–2130.

Underwood, E. J. – Suttle, N. F. (1999): Occasionally beneficial elements (boron, chromium, lithium, molybdenum, nickel, silicon, tin, vanadium). In: Mineral Nutrition of Livestock. Third Edition. CAB International. 514–517.

Wilson, J. H. – Ruszler, P. L. (1995): Effects of dietary boron on poultry bone strength. Trans. ASAE. **38.,** (1) 167–170.

Wilson, J. H. – Ruszler, P. L. (1997): Effects of boron on growing pullets. Biol. Trace Elem. Res. **56.,** (3) 287–294.

Wilson, J. H. – Ruszler, P. L. (1998): Long term effects of boron on layer bone strength and production parameters. Br. Poult. Sci. **39.,** (1) 11–15.

Address of the authors – A szerzők levélcíme:

KELEMEN Ferenc
Novartis Hungary Ltd.
H-1114 Budapest, Bartók Béla u. 43–47.

RIGÓ Zsuzsa
Budapest and Pest County Agricultural Administrative Authority
Directorate for the Safety of the Food Chain and Animal Health
H-1135 Budapest, Lehel u. 43–47.

TÓTH Tamás
University of West Hungary
Faculty of Agricultural and Food Sciences
H-9200 Mosonmagyaróvár, Vár 2.
E-mail: ttamas@mtk.nyme.hu