Effects of different sources of boron supplementation to diet on egg shell quality and bone characteristics in laying hens

Y. Cufadar, O. Olgun, Y. Bahtiyarca

Selçuk University, Faculty of Agriculture, Department of Zootechny, 42075, Konya, Turkey

SUMMARY

This study was conducted to determine the effect of different sources of boron supplementation to diet on egg shell quality and bone biomechanical characteristics in layer hens. At 44-wk-old 60 laying hens (Super Nick White) were fed to five dietary treatments during the 44-72 wk periods. Each treatment consisted of six replications of 12 hens (two hens per cage). Five treatments diets consisting of control and plus containing 300 mg/kg boron as boric acids, anhydrous borax, borax pentahydrate and borax decahydrate, respectively. During the experiment, feed and water were used as ad-libitum. The different sources of boron supplementation did not significantly effect on egg shell quality parameters (P> 0.05), except for egg shell thickness during the 60-64 weeks and egg shell strength during the 68-72 week in laying hens (P< 0.01, P<0.05). Tibia shear stress and fracture energy significantly increased supplemental dietary B (300 mg/kg) from different sources in laying hens (P<0.05). As a results of this study indicated that 300 mg/kg of supplemental boron from different sources improved eggshell breaking strength and bone strength characteristics.

Keywords: Boron sources, egg shell quality, laying hens, tibia characteristics

INTRODUCTION

Eggshell quality has always been a problem in the layer industry. Numerous studies have been conducted to solve the problems of poor shell quality. Many of these studies have focused on macro minerals, especially calcium (Ca) and phosphorus (P). Boron (B) is known to influence a variety of metabolic actions, in addition interacts with Ca, vitamin D, magnesium (Mg), which are all important in bone metabolism (Devirian and Volpe, 2003). Boron has been examined as a possible nutritional factor in Ca metabolism and utilization and thus, as a factor in the development and maintenance of normal bones (NRC, 1994). NRC

(1984) suggested that the trace mineral supplements to chemically defined diets should contain at least 2 ppm B. several studies have indicated that B is an important mineral normal bone formation, egg production, eggshell quality parameters in laying hens. Wilson and Ruszler (1995) investigated the effects of supplemental dietary B on egg production and bone strength of laying hens. No significant differences were observed in the bone shear force, shear stress or the shear fracture energy at any of the B concentrations (3.5, 7, 14, 28 or 56 mg/kg B). Qin and Klandorf (1991) indicated that B did not affect shell quality but increase tibia bone ash. Eren et al. (2004) investigated that dietary B supplementation (0, 10, 50, 100, 200 and 400 mg/kg B) effect on egg production, interior and exterior egg quality in laying hens. The egg quality parameters were affected by the dietary B levels. Yeşilbağ and Eren (2008) reported that supplementation dietary B laying hens better eggshell quality. Olgun et al. (2009) reported that B supplementation had no effect on eggshell thickness and eggshell breaking strength in molted laying hens. Mızrak and Ceylan (2009) indicated that dietary supplemental B had no effect on tibia and femur breaking strength in laying hens.

The purpose of this study was to determine the effects different sources of B supplementation to diet on eggshell quality and tibia breaking strength characteristics in laying hens.

MATERIAL AND METHODS

At 44 weeks old 60 laying hens (Super Nick White) were fed to five dietary treatments during the 44-72 weeks periods. Each treatment consisted of six replications of 12 hens (two hens per cage). Five treatments diets consisting of control and plus containing 300 mg/kg boron as boric acids, anhydrous borax, borax pentahydrate and borax decahydrate, respectively. During the experiment, feed and water were used as ad-libitum.

The eggs were subjected to determine characteristics of egg shell quality parameters (shell thickness and shell breaking strength) on all collected eggs produced at the last two days of each period during the experiment. Egg shell breaking strength was measured using a cantilever system by applying increased pressure to the broad pole of the shell using an instrument (Egg Force Reader, Orka Food Technology, Israel). Eggshell thickness was average eggshell measured at 3 locations on the egg (air cell and two location in the equator) using a micrometer (Mitutoyo, 0.01 mm, Japan).

Bone mechanical properties were determined from the load-deformation curve generated from a three point bending test (ASAE Standard S459, 2001) using an Instron Universal Testing Instrument

(Model 1122; Instron, Canton, MA) and the TestWorks 4 software package (version 4.02; MTS System Corporation, Eden Prairie, MN). These mechanical properties of bone are described by Wilson and Ruszler (1996) and Armstrong et al. (2002).

Table 1. Composition of experimental diet

Ingredients	%
Corn	46.0
Barley	7.4
Soybean meal (47.6 % Crude Protein)	22.7
Sunflower meal (30 % Crude Protein)	8.1
Vegetable oil	4.5
Limestone	8.8
Dicalcium phosphate	1.75
Salt	0.40
Premix[1]	0.25
Methionine	0.10
TOTAL	100.00
Calculated nutrients	
ME, kcal kg^{-1}	2802
Crude Protein, %	18.05
Calcium, %	3.85
Available phosphorus, %	0.45
Lysine, %	0.892
Methionine, %	0.374
Methionine + Cystine, %	0.714

[1]Premix provided/kg of diet; Mn: 60 mg; Fe: 30 mg; Zn: 50 mg; Cu: 5 mg; 1, 1.1 mg; Se: 0.1 mg, Vitamin A, 8.800 IU; Vitamin D_3, 2.200 IU; Vitamin E, 11 mg; Nicotinic acid, 44 mg; Cal-D-Pan, 8.8 mg; Riboflavin 4.4 mg; Tiamin 2.5 mg; Vitamin B_{12}, 6.6 mg; Folic acid, 1 mg; D-Biotin, 0.11 mg; Choline: 220 mg

Data were subjected to ANOVA by using General Linear Model procedure (GLM) in Minitab (2000). Duncan's multiple range tests were applied to separate means (Duncan, 1955). Statements of statistical significance are based on a probability of P<0.05.

RESULTS AND DISCUSSION

The supplementation high level (300 mg/kg B) dietary B from different sources did not significantly effect on eggshell thickness, eggshell breaking strength, tibia shear force at the end of the experiment (44-72 weeks) in laying hens. Tibia bone shear stress and fracture energy were increased by supplemental dietary B (300 mg/kg) from different sources in groups (P<0.05). Eggshell thickness was not affected by supplementation of different B sources except for 60-64 weeks of period. Eggshell breaking strength was not affected by supplementation of different B sources except for 68-72 weeks of period.

According to the results of studies in previous years, Qin and Klandorf (1991), Wilson and Ruszler (1996) and Eren et al. (2004) reported similar results. Eggshell breaking strength in older hens (68-72 weeks of age) was positively affected by B supplementation. This result is of great importance, because decline of shell quality with increasing age of layers is serious problem in egg industry. Similarly, Yeşilbağ and Eren (2008) stated that eggshell breaking strength increased by B supplementation in aged laying hens.

All sources of B used in the diet of laying hens caused a positive effect on bone stress and bone strength. Wilson and Ruszler (1998) reported that a similar results of laying hens when from 50 to 200 mg/kg B (as boric acid) was added to their diet. Bone stress and bone strength were positive affected by the 200 mg/kg B. In another study, Wilson and Ruszler (1997) reported that there was a significant increase in the shear force and shear stress of the tibia for leghorn pullets supplemented with 50 and 100 mg/kg of dietary B.

Table 2. Effects of supplemental dietary B (300 mg/kg) from different sources eggshell quality and bone parameters

	Weeks	Diets					SEM
		Control	Boric acid	Anhydrous borax	Borax pentahydrate	Borax decahydrate	
Eggshell thickness, mm	44-48	0.351	0.364	0.367	0.357	0.341	0.0072
	48-52	0.322	0.322	0.322	0.314	0.317	0.0057
	52-56	0.329	0.343	0.351	0.339	0.334	0.0069
	56-60	0.349	0.351	0.348	0.343	0.336	0.0051
	60-64	0.289^{b}	0.301^{ab}	0.324^{a}	0.302^{ab}	0.309^{ab}	0.0075
	64-68	0.330	0.309	0.318	0.307	0.302	0.0076
	68-72	0.323	0.323	0.332	0.325	0.312	0.0068
	44-72	0.328	0.330	0.337	0.327	0.322	0.0044
Eggshell breaking strength, kg	44-48	2.93	2.90	3.08	3.14	2.73	0.229
	48-52	2.64	2.77	2.81	2.83	2.70	0.170
	52-56	2.38	2.18	2.65	2.84	2.52	0.303
	56-60	2.35	2.36	2.52	2.42	2.40	0.154
	60-64	2.32	2.61	2.22	2.18	2.17	0.224
	64-68	2.13	2.15	2.41	2.44	2.14	0.201
	68-72	1.56^{B}	1.78^{AB}	2.18^{A}	2.06^{AB}	2.22^{A}	0.129
	44-72	2.33	2.39	2.55	2.56	2.41	0.117
Shear force, N		596.6	647.2	702.3	694.2	649.7	43.44
Shear strength, N/mm^2		43.15^{b}	52.22^{a}	51.29^{a}	51.54^{a}	48.38^{ab}	1.86
Fracture energy, N.mm		465.7^{b}	659.6^{a}	719.4^{a}	650.3^{a}	707.4^{a}	59.85

A, B: Values in columns are statistically different; P<0.01
a, b: Values in columns are statistically different; P<0.05

CONCLUSIONS

The research results indicated that dietary boron supplementation has positive effects on mineral balance, and therefore improving egg shell breaking strength and bone strength parameters in aged laying hens.

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