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Araştırma Makalesi/Research Article

Effects of magnesium sources and levels on performance, carcass traits and meat quality in broile

Etlik piliçlerde magnezyum kaynağı ve seviyelerinin performans, karkas özellikleri ve et kalitesine etkileri

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ÖZ

This study was carried out to determine the effect of different sources and levels supplemental Mg on performance, carcass traits and meat quality in broilers. Four hundred and fifty one day old broiler chicks (Ross 308) in 6 groups of 75 each (2 x 3 factorial experiment) were randomly allocated. Magnesium sources used was magnesium sulphate (inorganic) and magnesium proteinate (organic). Experimental diets were prepared into the basaldiet by addition of organic and inorganic Mg at 0, 0.2 and 0.4% levels. The experiment lasted 42 days. The result of the study showed that addition of Mg did not significant effect on body weight, weight gain, feed intake and feed conversion ratio (P>0.05). Carcass, liver and wing weight and carcass yield was affected fed with by interaction diets (P<0.05). Carcass weight and carcass yield of group organic 0.2 % of group was higher than the other groups. None of meat quality parameters (water holding capacity, cook loss, pH, meat colour parameters) did not significantly effected by the treatments.

Anahtar Kelimeler: Broiler, Carcass traits, Magnesium, Meat quality, Performance

ABSTRACT

Bu çalışmada, etlik piliç rasyonlarına farklı seviyelerde katılan organik ve inorganik magnezyum (Mg) ilavesinin performans, karkas özellikleri ve et kalitesi üzerine etkisinin araştırılması amaçlanmıştır. Denemede, bir günlük yaştaki 450 adet etlik piliç civcivi, her birinde 75 adet civciv bulunan altı deneme grubuna tesadüfî olarak dağıtılmıştır(2 x 3 faktöriyel deneme). Denemede inorganik Mg kaynağı olarak magnezyum sülfat (MgSO4), organik magnezyum kaynağı olarak magnezyum proteinat kullanılmıştır. Deneme rasyonları; bazal rasyona 0 (kontrol), % 0.2 ve % 0.4 Mg temin edecek miktarda inorganik ve organik Mg kaynakları ilavesiyle oluşturulmuştur.Deneme süresi 42 gün olmuştur. Deneme sonunda Mg ilavesi; canlı ağırlık, canlı ağırlık artışı, yem tüketimi ve yemden yararlanmayı önemli derecede etkilememiştir(P> 0.05). Karkas, karaciğer, kanat ağırlığı ve karkas randımanı kaynak x seviye gruplarında önemli derecede etkilenmiştir(P> 0.05). Organik% 0.2 grubunda karkas ağırlığı ve karkas randımanı diğer gruplara kıyasla daha yüksek olmuştur. Et kalitesi kriterleri (su tutma kapasitesi, pişirme kaybı, pH, et rengi parametreleri) muamelelerden etkilenmemiştir.

Key Words: Etlik piliç, Karkas özellikleri, Magnezyum ,Et kalitesi, Performans

Introduction

The animal protein deficiency required for human nutrition is increasing. People consume nutrients for healty, balanced and sustainable life that should be reliable and not contain risks (Çetin and Göçmen, 2013). Minerals in ration are very important for obtaining desired performance in animal production. Magnesium, an essential cation in the diet of most animals (Lee and Britton, 1980), is involved in many cellular functions and as a cofactor in all major metabolic pathways (Saris et al., 2000; Liu et al., 2007). Mg deficiency may lead to serious biochemical and symptomatic changes (Coudray et al., 2005) and symptoms of deficiency have been described in growing chicks by Almquist (1942), Bird (1949), and Gardiner et al. (1960); in growing ducks by Van Reen and Pearson (1953) and in laying hens by Cox and Sell (1967). Mg requirements of poultry do not exceed 0.6 $g.kg^{-1}$ dry matter (NRC, 1994). Research on Mg metabolism of poultry is limited, probably because common feed stuffs contain sufficient Mg to cover requirements and Mg deficiencies are unheard of (Suttle, 2010). Nevertheless, it has recently been suggested that supplemental Mg in poultry diets can exert positive effects on meat quality and growth in some situations or at certain stages of development (Guo et al., 2003; Gaal et al., 2004; Sahin et al., 2005; Yang et al., 2012). Mg can reduce oxidation and could be used to improve and stabilise chicken meat quality (Guo et al., 2003).

The precise determination of Mg requirements of farm animals is necessary, depending on the stage of growth, performance and reproduction of the animals (Pointillart, 1989). It is assumed that the new breeds of high-producing farm animals (hybrids) require more nutrients and minerals than the former races (Thielscher, 1990).

The purpose of our study that determine effect of addition different levels and sources Mg on performance, carcass traits and meat quality in broilers.

Materials and Methods

Four hundred and fifty one day old broiler chicks (Ross 308) in 6 groups of 75 each (2 x 3 factorial experiment) were randomly allocated. All groups consist of five replicates. There were 15 chickens per replicate pen. The experimental diets were prepared by adding certain amounts of organic (Mg-proteinate) and inorganic ($MgSO_4$) Mg sources which were provided as 0 (control), 0.2 and 0.4 % Mg in basal ration. Starter and grower diets were formulated according to recommendation in the Ross management manual and NRC (1994). The composition of starter and grower diets were showed in Table 1 and Table 2, respectively.

The birds were fed with starter diet until day 21 of age followed by a grower diet afterwards (from day 22 to day 42 of age). Feed and water were provided *ad libitum*. Body weight of broilers and feed intake was determined at the begining at the start 3. week and at the end of the trail. Feed conversion ratio (FCR) was calculated as feed intake / body weight gain (FI/BWG). On the last day (42 days) of the experiment, 4 (two male and two female) broilers from each replicates were randomly selected and slaughtered. In order to determine the effect of the treatments on carcass characteristics, these animals were weighed and cleaned, their internal organs were removed and hot carcass weights were determined. The carcasses were divided into thigh and breast sections, and the parts of the carcass and liver were weighed. The breast and thigh meat were hand-deboned after 24 h storage carcass at 4 ^{O}C. Water holding capacity (Wardlaw et al,1973), pH (AOAC, 2000), color criteria (L, a, b)(Hunt et al, 1985) and cook loss (CL) (Kondiah et al, 1985) were determined.

The experiment was designed as 2 (Mg sources) x 3 (Mg levels) factorial within a randomized complete design. The data were analyzed by using the General Linear Model procedure (GLM) in Minitab (2000). If the treatments were found to be significantly different, then Duncan’s multiple range tests was used to determine the differences among treatments (Mstat-C, 1995).

Table 1. Composition of experimental diets (Starter diets, 0-3 weeks)
Çizelge 1. Deneme rasyonlarının kompozisyonları(Başlatma rasyonları, 0-3 haftalık)

Ingredients (%) *Hammaddeler (%)*	Control	Inorganic Mg ($MgSO_4$)		Organic Mg (Mg-proteinate)	
	Kontrol	0.2 %	0.4 %	0.2 %	0.4 %
Corn	51.30	47.27	44.00	50.50	48.60
Soybean meal	38.80	39.40	39.80	35.40	32.40
Vegetable oil	6.10	7.50	8.45	7.20	8.80
Limestone	1.00	1.00	1.00	1.00	1.05
Dicalcium phosphate	2.10	2.20	2.10	2.10	2.10
Salt	0.30	0.25	0.25	0.25	0.25
Premix[1]	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.02	---	---	0.10	0.20
DL-Methionine	0.13	0.13	0.15	0.13	0.15
Inorganic Mg ($MgSO_4$)	---	2.00	4.00	---	---
Organic Mg (Proteinat)	---	---	---	3.10	6.20
TOTAL	100	100	100	100	100
Calculated Nutrients					
Crude protein (%)	22.08	22.06	22.00	21.98	21.97
Metabolizable Energy (kcal/kg)	3104	3107	3098	3098	3108
Calcium (%)	1.00	1.00	1.00	1.00	1.00
Available phosphorus (%)	0.50	0.50	0.50	0.49	0.49
Methionine (%)	0.48	0.48	0.49	0.46	0.46
Methionine + Cystine (%)	0.85	0.84	0.85	0.79	0.78
Lysine (%)	1.31	1.30	1.30	1.29	1.29

[1]: Vitamin-mineral premix (per kilogram of diet): Vitamin A 15000 IU; Vitamin D_3 1500 IU; Vitamin K 5 mg; Vitamin B_1 3 mg; Vitamin B_2 6 mg; Vitamin B_6 5 mg; Vitamin B_{12} 0,03 mg; Niacin 30 mg; Biotin 0,1 mg; calcium D-pantotenat 12.0 mg; folic acid 1.0 mg; coline chloride 400 mg; Manganese 80 mg; Iron 35 mg; Zinc 50 mg; Copper 5.0 mg; Iodine 2 mg; Cobalt 0.04 mg

Table 2. Composition of experimental diets (Grower diets, 3-6 weeks)
Çizelge 2. Deneme rasyonlarının kompozisyonları(Büyütme rasyonları, 3-6 haftalık)

Ingredients (%) *Hammaddeler (%)*	Control	Inorganic Mg ($MgSO_4$)		Organic Mg (Mg-proteinate)	
	Kontrol	0.2 %	0.4 %	0.2 %	0.4 %
Corn	56.00	51.37	47.50	53.80	51.92
Soybean meal	33.60	34.50	35.00	31.00	28.36
Vegetable oil	6.70	8.30	9.58	8.25	9.60
Limestone	1.20	1.30	1.40	1.25	1.20
Dicalcium phosphate	1.83	1.88	1.82	1.85	1.82
Salt	0.30	0.30	0.30	0.30	0.30
Premix[1]	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.02	---	---	0.10	0.20
DL-Methionine	0.10	0.10	0.15	0.10	0.15
Inorganic Mg ($MgSO_4$)	---	2.00	4.00	---	---
Organic Mg (Proteinate)	---	---	---	3.10	6.20
TOTAL	100	100	100	100	100
Calculated Nutrients					
Crude protein (%)	19.99	20.06	20.01	20.00	20.01
Metabolizable Energy (kcal/kg)	3194	3203	3199	3200	3198
Calcium (%)	0.99	1.04	1.05	1.01	1.01
Available phosphorus (%)	0.44	0.45	0.44	0.44	0.44
Methionine (%)	0.42	0.42	0.44	0.42	0.43
Methionine + Cystine (%)	0.76	0.76	0.79	0.72	0.72
Lysine (%)	1.16	1.15	1.16	1.16	1.17

[1]: Provided (per kilogram of diet): Vitamin A 15000 IU; Vitamin D_3 1500 IU; Vitamin K 5 mg; Vitamin B_1 3 mg; Vitamin B_2 6 mg; Vitamin B_6 5 mg; Vitamin B_{12} 0,03 mg; Niacin 30 mg; Biotin 0,1 mg; calcium D-pantotenat 12.0 mg; folic acid 1.0 mg; coline chloride 400 mg; Manganese 80 mg; Iron 35 mg; Zinc 50 mg; Copper 5.0 mg; Iodine 2 mg; Cobalt 0.04 mg

Result and Discussion

In current study results that Mg source and sources x levels interaction had no significantly effect on BW, BWG, FI and FCR($P>0.05$). While the Mg levels had a significantly effect on BW, BWG and FI which significantly decreased with increasing Mg levels in diet ($P<0.05$). The group containing the highest (%0.4) Mg level that BW and BWG were lower than the other groups (Table 3).

Table 3. Effects of Mg sources and levels on body weight, body weight gain, feed intake, feed conversion ratio.
Çizelge 3. Farklı seviyelerde organik ve inorganik Mg kaynaklarının canlı ağırlık, canlı ağırlık artışı, yem tüketimi, yem değerlendirme oranına etkisi.

Diets *Muameleler*	Body weight (g) *Canlı ağırlık*	Body weight gain (g) *Canlı ağırlık artışı*	Feed intake(g) *Yem tüketimi*	Feed conversion ratio (g:FI/g:CBWG) *Yem değerlendirme oranı*
Mg sources *Mg kaynakları*				
Inorganic	2562 ± 55.4	2520 ± 55.1	4307 ± 76,6	1.71 ± 0,028
Organic	2612 ± 57.4	2569 ± 57.1	4341 ± 77.0	1.70 ± 0.021
P	0.408	0.410	0.505	0.579
Mg levels % *Mg seviyeleri*				
0	2713 ± 44.0 ^{a}	2668 ± 44.0 ^{a}	4601 ± 33.2 ^{a}	1.73 ± 0.021
0.2	2662 ± 57.8 ^{a}	2620 ± 57.5 ^{a}	4386 ± 66.8 ^{b}	1.68 ± 0.025
0.4	2387 ± 54.6 ^{b}	2346 ± 54.5 ^{b}	3985 ± 20.0 ^{c}	1.71 ± 0.041
P	0.000	0.000	0.000	0.569
Source*Level *Kaynak*Seviye*				
Inorganic*0	2734 ± 65.8	2689 ± 66.1	4628 ± 53.8	1.72 ± 0.030
Inorganic*0.2	2556 ± 56.3	2514 ± 56.3	4292 ± 94.9	1.71 ± 0.032
Inorganic*0.4	2397 ± 102.6	2357 ± 102.5	4002 ± 28.7	1.72± 0.079
Organic*0	2691 ± 64.4	2646 ± 64.2	4574 ± 41.4	1.70 ± 0.033
Organic*0.2	2768 ± 79.1	2726 ± 78.4	4480 ± 81.6	1.65 ± 0.038
Organic*0.4	2378 ± 53.2	2336 ± 52.9	3968 ± 28.8	1.70 ± 0.036
P	0.171	0.169	0.105	0.739

a, b : Means with different minuscule in the same column are significantly different at P<0.05

This groups of Mg level (%0.4) can be suppression of growth in these chicks. High doses of Mg can cause negative effects such asdiarrhea and negativities caused by the digestive system. It has been reported that diarrhea caused when diets containing 2 g/kg $MgSO_4$ (Ikarashi et al. 2011). Previous study with broilers have shown that dietary Mg supplementation of 0.255% already increased excreta moisture, although no diarrhea was observed (Hangoor et al. 2013).In the present study result that feed intake was significantly decreased by increasing Mg levels of diets. Guo et al.(2003) and Liu et al.(2007), the tested levels of Mg had a limited effect on broiler performance, although BWG and FI were linearly reduced by increasing dietary $MgSO_4$ level. Guo et al. (2003) reported that organic Mg source is better than inorganic source (MgO) in BWG and FI for 21 days in broilers (using 0.2% MgO and Mg-proteinate as organic source). However, both sources did not cause a significant difference in BWG relative to the control group. Some differences between the results of this study and the current study suggested that this may be due to the this study has been conducted for 21 days.

Main effect of Mg source had no significantly effect on carcass traits while main effect of Mg levels had significantly effect on thigh and breast+back weights which significantly decreased with highest Mg levels in diet (P<0.05). The interactions had significantly effect on carcass, liver weight and carcass yield (P<0.05). The highest carcass weight and carcass yield were observed in group organic Mg 0.2% while the highest liver weight was group inorganic Mg 0.4% (Table 4).

Karasek et al. (2016) reported that the total Mg levels in experimental groups (1.91 $g.kg^{-1}$ diet and 3.21 $g.kg^{-1}$ diet) had a negative effect on carcass weight compared to the control group (2.21 $g.kg^{-1}$ Mg). This trend was noticeable in evaluation of carcass yield as well. The differences between groups were statistically non-significant (P>0.05). Mg additions to broiler diets at different sources and levels adversely affected the carcass weight. Carcass weight significantly decreased with increasing Mg levels in diet (P<0.05).

The effects of dietary Mg supplementation on broiler breast and thigh meat quality parameters according to Mg source and level are presented in Tables 5 and 6. Dietary supplementary Mg sources and levels had no significant effect on water holding capacity (WHC), cook loss (CL), pH and color criteria (L, a, b) in breast and thigh meat in broilers.

Table 4. Effects of Mg sources and levels on carcass weight, thigh weight, breast+back weight, liver weight and carcass yield.
Çizelge 4. Farklı seviyelerde organik ve inorganik Mg kaynaklarının karkas ağırlığı, but ağırlığı, göğüs+sırt ağırlığı, karaciğer ağırlığı ve karkas randımanına etkisi

Diets *Muameleler*	Carcass weight (g) *Karkas ağırlığı*	Thigh weight (g) *But ağırlığı*	Breast+back weight (g) *Göğüs+sırt ağırlığı*	Liver weight (g) *Karaciğer ağırlığı*	Carcass yield (%) *Karkas randımanı*
Mg Sources *Mg Kaynakları*					
Inorganic	1954 ± 40.0	809.6 ± 36.47	858.6 ± 20.08	50.9 ± 1.33	76.3 ± 0.31
Organic	1977 ± 49.1	796.4 ± 22.61	887.0 ± 20.45	48.1 ± 1.15	75.7 ± 0.51
P	0.596	0.466	0.247	0.065	0.259
Mg Levels % *Mg Seviyeleri*					
0	2062 ± 32.3	854.0 ± 15.44 [a]	903.7 ± 15.43 [a]	47.1 ± 1.28	76.0 ± 0.52
0.2	2035 ± 46.3	837.9 ± 19.36 [a]	900.0 ± 23.63 [a]	49.9 ± 1.59	76.5 ± 0.45
0.4	1800 ± 41.0	717.2 ± 12.32 [b]	814.6 ± 25.00 [b]	51.5 ± 1.61	75.4 ± 0.58
P	0.000	0.000	0.008	0.069	0.329
Source*Level *Kaynak*seviye*					
Inorganic*0	2081 ± 45.3 [ab]	872.0 ± 19.28	905.7 ± 25.37	49.2 ± 1.92 [bc]	76.1 ± 0.41 [ab]
Inorganic*0.2	1942 ± 47.2 [bc]	818.5 ± 24.74	850.3 ± 21.68	48.2 ± 2.19 [bc]	76.0 ± 0.76 [ab]
Inorganic*0.4	1839 ± 73.6 [cd]	738.5 ±19.11	819.9 ± 46.62	55.3 ± 1.67 [a]	76.7 ± 0.43 [a]
Organic*0	2042 ± 49.5 [ab]	836.1 ± 23.23	901.8 ± 20.62	45.0 ± 1.19 [c]	75.9 ± 1.03 [ab]
Organic*0.2	2127 ± 56.0 [a]	857.4 ± 29.75	949.7 ± 28.39	51.6 ± 2.28 [ab]	76.9 ± 0.48 [a]
Organic*0.4	1761 ± 37.4 [d]	695.8 ± 9.50	809.4 ± 24.86	47.7 ± 1.31 [bc]	74.1 ± 0.69 [b]
P	0.042	0.139	0.131	0.018	0.041

a, b, c, d : Means with different minuscule in the same column are significantly different at P<0.05

Table 5. Effects of Mg sources and levels on breast and thigh meat water holding capacity (WHC), cook loss (CL) and pH.
Çizelge 5. Farklı seviyelerde organik ve inorganik Mg kaynaklarının göğüs ve but etinin su tutma kapasitesi, pişirme kaybı ve pH özelliklerine etkisi

Diets *Muameleler*	Water holding capacity (%) *Su tutma kapasitesi*		Cook loss (%) *Pişirme kaybı*		pH	
	Thigh *But*	Breast *Göğüs*	Thigh *But*	Breast *Göğüs*	Thigh *But*	Breast *Göğüs*
Mg Sources *Mg Kaynakları*						
Inorganic	15.42 ± 1,598	10.00 ± 0.336	11.41 ± 0.760	6.82 ± 0.524	5.76 ± 0.034	5.61 ± 0.026
Organic	11.67 ± 1.711	12.08 ± 1.289	12.57±0.716	6.36 ± 0.494	5.72 ± 0.024	5.56 ± 0.022
P	0.141	0.292	0.288	0.542	0.374	0.100
Mg Levels % *Mg Seviyeleri*						
0	13.75 ± 2.041	12.50 ± 1.864	12.67 ± 0.764	7.28 ± 0.476	5.71 ± 0.041	5.54 ± 0.030
0.2	13.13 ± 2.175	10.63 ± 1.334	11.21 ± 0.895	6.33 ± 0.603	5.76 ± 0.039	5.60 ± 0.031
0.4	13.75±2.244	10.00 ± 1.667	12.09 ± 1.073	6.17 ± 0.747	5.75 ± 0.029	5.62 ± 0.027
P	0.972	0.554	0.540	0.436	0.624	0.152
Source*Level *Kaynak*Seviye*						
Inorganic*0	13.75 ± 2.338	11.25 ± 3.062	12.85 ± 0.973	7.59 ± 0.614	5.73 ± 0.070	5.54 ± 0.050
Inorganic*0.2	16.25 ± 3.187	8.75 ± 1.531	9.86 ± 1.167	6.77 ± 0.709	5.76 ± 0.070	5.64 ± 0.049
Inorganic*0.4	16.25 ± 3.187	10.00 ± 2.500	11.50 ± 1.624	6.12 ± 1.315	5.80 ± 0.043	5.66 ± 0.019
Organic*0	13.75 ± 3.644	13.75 ± 2.338	12.49 ± 1.290	6.97 ± 0.772	5.70 ± 0.049	5.54 ± 0.040
Organic*0.2	10.00 ± 2.500	12.50 ± 1.976	12.55 ± 1.158	5.88 ± 1.018	5.76 ± 0.045	5.55 ± 0.034
Organic*0.4	11.25 ± 3.062	10.00 ± 2.500	12.68 ± 1.539	6.23 ± 0.881	5.70 ± 0.029	5.58 ± 0.046
P	0.557	0.725	0.518	0.853	0.655	0.538

Table 6. Effects of Mg sources and levels on thigh and breast meat colour criteria (L, a, b).
Çizelge 6. Farklı seviyelerde organik ve inorganik Mg kaynaklarının göğüs ve but etinin renk özelliklerine etkisi (L, a, b)

Diets *Muameleler*	Thigh *But*			Breast *Göğüs*		
	L	a	b	L	a	b
Mg Sources *Mg Kaynakları*						
Inorganic	52.81 ± 0.620	5.32 ± 0.238	2.64 ± 0.420	50.07 ± 0.760	4.48 ± 0.274	1.25 ± 0.175
Organic	54.41 ± 0.435	4.66 ± 0.251	2.45 ± 0.347	50.83 ± 0.735	3.86 ± 0.215	1.17 ± 0.177
P	0.057	0.064	0.746	0.463	0.106	0.734
Mg Levels, % *Mg Seviyeleri*						
0	54.17 ± 0.979	4.68 ± 0.313	3.07 ± 0.452	51.17 ± 0.892	4.08 ± 0.389	1.34 ± 0.224
0.2	53.38 ± 0.600	5.08 ± 0.341	2.29 ± 0.471	51.30 ± 1.047	4.30 ± 0.274	1.36 ± 0.204
0.4	53.28 ± 0.423	5.21 ± 0.293	2.28 ± 0.472	48.89 ± 0.597	4.12 ± 0.292	0.92 ± 0.198
P	0.610	0.436	0.436	0.119	0.879	0.267
Source*Level *Kaynak*Seviye*						
Inorganic*0	53.58 ± 1.712	4.98 ± 0.317	3.23 ± 0.741	51.42 ± 1.480	4.38 ± 0.670	1.32 ± 0.393
Inorganic*0.2	52.59 ± 0.871	5.77 ± 0.333	2.18 ± 0.846	50.95 ± 1.208	4.80 ± 0.320	1.19 ± 0.323
Inorganic*0.4	52.26 ± 0.328	5.21 ± 0.549	2.50 ± 0.661	47.83 ± 0.713	4.25 ± 0.440	1.23 ± 0.246
Organic*0	54.76 ± 1.098	4.38 ± 0.542	2.90 ± 0.597	50.91 ± 1.164	3.78 ± 0.431	1.35 ± 0.268
Organic*0.2	54.17 ± 0.742	4.38 ± 0.410	2.39 ± 0.526	51.65 ± 1.848	3.79 ± 0.332	1.54 ± 0.262
Organic*0.4	54.29 ± 0.427	5.21 ± 0.291	2.06 ± 0.737	49.95 ± 0.735	4.00 ± 0.426	0.61 ± 0.260
P	0.910	0.270	0.879	0.584	0.708	0.265

Norouzi et al. (2014) reported that Mg supplementation of broiler diets at 0.03% and 0.06% levels did not cause a significant pH change, L and a values in thigh meat. Guo et al. (2003) found that different Mg sources (oxides and proteinate) and levels of Mg addition did not cause a significant difference in pH at thigh meat of broilers. The effects of supplemental Mg may not always be comprehensible because the requirement forthis element has been already covered by the basal diet.

Conclusions

As a result, considering that there is no difference performance, carcass traits and meat quality between the organic and inorganic Mg sources in the broiler diets. Also dietary level of 0.4% Mg negatively influenced performance and carcass traits.It can be said that the dietary Mg level should not exceed 0.2%.

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