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EFFECT OF DIETARY BETAINE SUPPLEMENTATION ON GROWTH PERFORMANCE AND CARCASS TRAITS OF GROWING TURKEY

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ABSTRACT

The responses of growing turkey to different dietary levels of betaine were investigated during the period from 12 to 20 weeks of age. Therefore, a basal diet was formulated to contain 21.37% CP and 3057 Kcal ME/kg. This diet was supplemented with betaine at levels of 0, 75, 150 and 225 g/100 kg diet. Thus, there were four treatment groups; each was fed to 50 birds (males and females) divided equally into two sub-groups of 25 males and 25 females in each. Results revealed that birds in T3 (150 g betaine/100 kg diet) showed the highest (P≤0.05) final LBW and total weight gain (TWG) as compared to control birds or those in other treatment groups. The superiority in final LBW of birds in T3 was associated with improvement (P≤0.05) in growth measurements including breast width and length of keel, back, shank, tibia and thigh as compared to other groups. Birds in other treatment groups (T2 and T4) did not differ significantly in growth performance parameters from that of the control birds. Males showed better (P≤0.05) growth performance parameters than females. The interaction effect between treatment x sex on all growth performance was not significant. Concentration of total proteins (TP) and albumin (AL) in blood plasma of T3 and T4 groups increased (P≤0.05) as compared to the control ones. Males showed higher (P≤0.05) concentrations of TP, AL and AL: GL ratio than females. Birds in T3 showed the highest (P≤0.05) weights of carcass, giblets, gizzard, liver and heart as well as the highest percentage of giblets. Carcass and gizzard and dressing percentages were not affected by dietary betaine treatments. Males showed higher (P≤0.05) weights of carcass, giblets, gizzard, liver and heart. Females showed the highest (P≤0.05) giblets, gizzard and liver percentages. The interaction effect between treatment x sex on all carcass traits was not significant. Birds in T3 showed the highest economic feed efficiency (EFE %) as compared to other treatment groups. Males showed higher EFE than females.

In conclusion, growth performance, blood parameters including protein metabolism, carcass traits and economic efficiency were improved by supplementing diet of grower turkey with 150 g betaine /100 kg diet.

Keyword: Turkey, betaine, growth performance, carcass quality.

INTRODUCTION

Feed additives are important materials that can improve the efficiency of feed utilization and animal performance. These additives achieve an increase in animal performance, productivity and thereby profit (Abdou, 2001). The chemical products such as antibiotics or hormones as feed additives may cause unfavorable effects. However, the impact of natural feed additives as betaine has evaluated effects on growth and carcass traits, and usually only one level of betaine was fed. The level of betaine used most often has been 0.125% (Cera and Schinckel, 1995; Matthews *et al*., 1998). However, levels as high as 1% (Øverland *et al*., 1999) have been used.

Betaine (glycine betaine, trimethylglcine) is a methylated amino acid and naturally occurring product present in large quantities in aquatic invertebrates and sugar beet from which it can be extracted (Virtanen, 1995 and Wang *et al*., 2004). On the other hand, betaine is not present in large quantities in animal and poultry feedstuffs (Wang *et al*., 2004). Betaine is a tertiary amine formed by the oxidation of choline (Kidd *et al*., 1997; Wang *et al*., 2004) and implicated in methionine sparing, osmoprotective, and fat distribution (Saunderson and Mackinlay, 1990). Methionine, betaine and choline are all sources of labile methyl groups and play an important role in methylation reactions, and the methyl group metabolism of these three compounds is interrelated as illustrated by Kettunen *et al*. (2001). Betaine plays an important role in intracellular osmotic balance, improving osmo-tolerance and cryotolerance of *Listeria monocyto-genes* when subjected to salt and cold stress conditions (Ko *et al*., 1994).

Recently, betaine has been primarily used as a dietary food supplement in animal nutrition. Betaine has been indicated to have a number of metabolic and physiological roles in poultry nutrition (Kidd *et al*., 1997). (Wang *et al*., 2004) observed that betaine was effective in improving growth and feed conversion and indicated that betaine has a methionine sparing effect in ducks. Inclusion of betaine enhanced growth performance and carcass weight, however, stabilized the normal physiological balance, and elevated the humoral and cell-mediated immunity of growing rabbits exposed to heat stress (Hassan *et al* 2009).

Very few researches have been conducted evaluating the effects of betaine on turkey. Therefore, the current study aimed to evaluate different levels of betaine on growth performance, blood parameters and carcass traits of growing turkey. Economic feed efficiency was also studied.

MATERIALS AND METHODS

The present study was carried out at turkey branch, Mehallet Moussa Research Station, kafr El-Sheikh Governorate, belonging to the Animal Production Research Institute, Agricultural Research center, Ministry of Agriculture, during the period from July to September, 2011.

Birds and feeding system:

A total of 200 birds of Bronze turkey strain at 12 weeks of age (100 males and 100 females) were used in this study. The experimental birds were divided into four similar treatment groups according to live body weight (50 birds each), and then each treatment group were divided into two similar sub-groups according to sex (25 males and 25 females). Birds of each sub-group were housed in an open pen. Feed and water were available *ad-libitum* throughout the experimental period of 8 weeks. All birds were kept under similar hygienic, environmental and managerial conditions.

During the experimental period, birds in all groups were fed in group feeding for each sub-group on a basal diet containing 21.37% crude protein and 3057 Kcal/kg as ME and supplemented with the required vitamins as recommended by NRC (1994). The composition of the basal diet throughout the experimental period is shown in Table (1). The experimental birds were divided into four experimental treatments as follows:

T1: Birds in the 1st treatment group were fed basal diet without supplementation and served as control group.

T2: Birds in the 2nd treatment group were fed basal diet supplemented with betaine at a level of 75 g/100 kg of the diet.

T3. Birds in the 3rd treatment group were fed basal diet supplemented with betaine at a level of 150 g/100 kg of the diet.

T4: Birds in the 4th treatment group were fed basal diet supplemented with betaine at a level of 225 g/100 kg of the diet.

Table (1): composition and calculated analysis of the basal diet.

Ingredient	%	Ingredient	%
Yellow corn %	69.00	DL-methionine	0.10
Soybean meal (44 % CP)	20.00	L-Lysine	0.15
Fish meal (64 % CP)	10.00	Premix*	0.10
Di-Calcium phosphate	0.10	Salt (sodium chloride)	0.25
Ground limestone	0.30	Total	100

*** Each 3 kilograms of premix contains the vitamin premix and trace minerals. The vitamin premix contributed the following: vit. A, 12.000.000 IU; vit. D3, 2.200.000 IU; vit. E, 10000 mg; vit. K, 2000 mg; vit. B1, 1000 mg; vit. B2, 4000 mg; vit. B12, 10 mg; vit. B6, 1000 mg; niacin, 20000 mg; pantothenic acid, 10000 mg; folic acid, 1000 mg and biotin, 50 mg. The trace mineral premix contributed the following: copper sulfate, 10000 mg; potassium iodide, 1000 mg; manganese oxide, 55000 mg; zinc oxide, 50000 mg; selenium, 100 mg; iron, 30000 mg and calcium carbons up to 3 kg.**

Experimental procedures:

Growth performance parameters:

Throughout a feeding period from 12 to 20 weeks of age, individual live body weight (LBW) and cumulated feed intake for (each sub-group, n=25 birds) were biweekly recorded, then total weight gain and feed conversion ratio were calculated.

Also, individual growth measurements such as length of keel (from the anterior point to posterior end of the keel), back, shank (from the top of the hock joint to the spure for right shank), tibia and thigh as well as breast width for all experimental birds were estimated in centimeters at 20 weeks of age. Breast width was taken 2.5 cm posterior the cranial process of the keel and 2.5 cm above the ventral surface of the breast.

In addition, mortality rate during the experimental period was recorded and economic feed efficiency (EFE) was computed as the following:

EFE% = {(price of total gain - total feed cost) x 100}**/** total feed cost

Blood sampling:

Blood samples were collected at 20 weeks of age during the slaughter of each bird to evaluate some blood biochemical paramters. Blood samples were taken from 3 birds/ sub-group (3 ml) by brachial vein puncture in heparinized tubes. The blood samples were centrifuged at 3000 rpm for 15 minutes, clear plasma was separated then stored at -20 °C until analyses.

Concentration of total proteins (Gornall *et al*. 1949), albumin (AL, Weichselaum 1946) was spectrophotometrically determined using commercial kits. While, globulin (GL) concentration was calculated by subtracting AL concentration from total proteins. Also AL/GL ratio was computed.

Carcass traits:

At the end of the experimental period (20 weeks of age), 3 birds from each sub-group were randomly chosen. These birds were deprived from feed but not from water for about 16 hours before slaughtering. Birds were weighted before and after slaughtering and bleeding. Feathers were removed with hand to insure complete defeathering. Head, neck, wings, and shanks were cut, weighted separately and recorded. Thereafter, a cut was made at the posterior end of sternum and abdominal fat was removed and weighed. After the birds were eviscerated, the drawn carcass was reweighed to estimate dressing either absolute or as a percentage. The weight of the liver without gall-bladder, gizzard without feed contents and heart without vessels and blood, were recorded. Dressing percentage was calculated as carcass weight plus total giblets weight relative to pre-slaughtered weight of each bird.

Statistical analysis

All data were statistically analyzed by the General Linear Model (GLM) procedures using statistical software SAS (2004), to evaluate the main effect of the experimental group and sex or their interaction, according to the following model:

$$Y_{ijK} = \mu + T_i + S_j + (TS)_{ij} + E_{ijK}$$

Where:

Y_{ijK} = Observation K^{th} individual of J^{th} sex in i^{th} treatment.

μ = Overall mean.

T_i = Effect of i^{th} group, (i = 1- 4).

S_j = Effect of j^{th} sex, (j = 1, 2).

$(TS)_{ij}$ = Effect of interaction between i^{th} group and j^{th} sex.

E_{ijK} = Random error.

The significant differences between group means were tested by the multiple range test according to Duncan (1955).

RESULTS AND DISCUSSION

Growth performance:

Effect of the experimental treatment on growth performance parameters presented in Table (2) revealed that birds in T3 (150 g betaine/100 kg diet) had significantly (P≤0.05) the highest final LBW and total weight gain (TWG) as compared to control birds or those in other treatment groups. There was nearly similarity in total feed intake/bird among the experimental groups, reflecting the best feed conversion ratio of birds in T3 as compared to birds in other groups.

The superiority in final LBW of birds in T3 was associated with significant (P≤0.05) improvement in growth measurements including breast width and length of keel, back, shank, tibia and thigh as compared to other groups. On the other hand, birds in other treatment groups (T2 and T4) did not differ significantly in growth performance parameters from that of the control birds. The negative effect of lower betaine level than 150 g/100 kg diet on growth performance may be attributed to insufficient effect of treatment does in turkey, however, the negative effect of betaine level more than 150 g/100 kg diet may indicate loss of great amount of body fat with the highest betaine level. In this respect, Wang *et al.* (2000) showed that betaine supplementation decreased percentage of dissected abdominal fat ($P \le 0.05$) and subcutaneous fat depth ($P \le 0.05$) of ducks. Wang *et al.* (1999) indicated that betaine exerted an effect on repartitioning of carcass fat in meat ducks by decreasing the activity of NADPH enzyme, increasing the activity of lipase and stimulating the synthesis of carnitine and improving beta -oxidation of fatty acids.

As affected by sex, regardless the effect of treatment, males showed significantly ($P \le 0.05$) better growth performance parameters than females, reflecting higher feed efficiency of males than females during the experimental period. However, the interaction effect between treatment x sex on all growth performance was not significant (Table 2).

Such results indicated benefits of dietary betaine supplementation at a level of 150 g/100 kg diet on all growth performance parameters studied. Similar results were reported by several authors. In this respect, betaine supplementation (800 mg/kg diet) enhanced growth at 21 days and feed conversion efficiency at 42 days of age in broilers fed a diet containing 15 g Met/kg CP (Rao *et al.* (2011). More over betaine significantly ($P \le 0.05$) improved body weight and feed conversion of Matrouh poultry strain at a level of 1 g/kg diet (Ezzat *et al.,* 2011).

In accordance with the present results, Tollba *et al.* (2007) showed that dietary supplemental betaine for 12 or 16 weeks to Fayoumi laying hens improved ($P \le 0.05$) feed conversion and LBW as compared to the respective control hens, without significant effect on feed consumption. Also, Enting *et al.* (2007) showed that the addition of 1 and 2 g/kg betaine to the feed improved feed conversion ratio from 0 to 14 days of age and body weight at 40 days of age. Moreover, Honarbakhsh *et al.* (2007) evaluate the effects of different exogenous betaine levels (0, 0.075, 0.150 and 0.225%) on 576 male broiler chicks (Ross). They observed that betaine supplementation increased body weight and improved feed conversion ratio in grower and finisher periods ($P \le 0.01$). However, they found that betaine supplementation increased feed intake, which is in contrast to the present results. In addition, Attia *et al.* (2005) found that betaine supplementation at either 0.035 or 0.070% significantly improved BW gain of chicks by 5.1 and 9.0%, and feed conversion ratio by 8.4 and 12.0% compared to the basal diet, respectively.

However, (Baghaei *et al.,* 2009; Maghoul *et al.* 2009) found that betaine replacement for choline had no effect on feed intake, weight gain and feed conversion ratio of broiler. The result of the present study indicated that feed intake of turkey birds was not affected by supplementation levels of betafin in diets. Also, Jahanian and Rahmani (2008) found that dietary betaine inclusion had no effect on feed intake of broiler. These findings indicate that dietary betaine inclusion instead of choline had little benefit in terms of performance parameters. El-Husseiny *et al.* (2007) estimated the effect of methionine levels (0.33 and 0.45%) with betaine on broiler performance, revealing that BW gain and feed conversion efficiency were significantly increased with increasing betaine levels up to 0.75 g/kg diet.

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On the other hand, Patil *et al.* (2007) observed that betaine can be used at 300 g/T in the diets with reduction in choline chloride up to 90% and/or DL-methionine up to 30% without any adverse effect on production performance of broilers in terms of growth performance of broilers.

`It is of interest to note that age of bird might be a consideration for using betaine supplements at different levels as birds processed at younger ages might be more responsive to these nutrients (Waldroup and Fritts, 2005). Generally, a positive effect of dietary betaine was indicated on performance of broiler (Hamidi *et al.*, 2010) and ducks (Wang *et al.,* 2004).

Blood parameters:

The effect of the experimental treatments on blood parameters presented in Table (3) revealed that concentration of total proteins and albumin in blood plasma of birds treated with betaine at a level of 150 or 225 g/100 kg diet (T3 and T4) significantly ($P \leq 0.05$) increased as compared to the control group. However, globulin concentration was significantly ($P \leq 0.05$) increased for all treatment groups with the highest level being recorded for the T4 group.

It is of interest to note that the observed increase in concentration of total proteins was associated with increasing the concentration of both albumin and globulin, reflecting insignificant differences in albumin: globulin ratio (Table 3). Also, the observed highest increase in concentration of total proteins and their fractions was associated with the superiority in final LBW, BW gain, feed conversion and body measurements of birds in T3 as compared to other groups (Table 2).

As affected by sex, regardless the effect of treatment, males showed significantly ($P \leq 0.05$) higher concentrations of total protein and albumin as well as albumin: globulin ratio than females, reflecting higher efficiency of protein metabolism in males than females. However, the interaction effect between treatment x sex on all growth performance was not significant (Table 3).

In accordance with the present results, El-Ganzory *et al.* (2004) revealed that serum total protein, albumin and globulin concentrations increased by dietary betaine treatments of broilers. Also, Hao *et al.* (2005) found that betaine significantly increased the concentrations of serum total protein (TP), albumin (AL) compared with the control group ($P \leq 0.01$). In Fayoumi laying hens, Tollba *et al.* (2007) showed significant differences ($P \leq 0.05$) in total plasma proteins as well as albumin and globulin.

Moreover, Tollba and El-Nagar (2008) revealed that betaine supplementation reflected positive effects on total protein as well as albumin and globulin. Ezzat *et al.* (2011) showed that supplementation of betaine (1 g/kg diet) significantly increased ($P \leq 0.05$) concentration of total proteins and globulin of Matrouh poultry strain.

Carcass traits:

Results of the effect of the experimental treatments on carcass quality presented in Table (4) revealed that birds in T3 showed significantly ($P \leq 0.05$) the highest weights of carcass, giblets, gizzard, liver and heart as well as the highest percentage of giblets. However, birds in T2 showed significantly ($P \leq 0.05$) the highest percentage of liver or heart.

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On the other hand, the percent of carcass and gizzard as well as dressing percentage were not affected by dietary betaine treatment (Table 4). Interestingly to observe that the best carcass quality of birds in T3 is in accordance with improving growth performance of birds in this treatment.

As affected by sex, regardless the effect of the experimental treatments, males showed significantly ($P \leq 0.05$) higher weights of carcass, giblets, gizzard, liver and heart. However, females showed significantly ($P \leq 0.05$) higher percent of giblets, gizzard and liver. The interaction effect between treatment x sex on all carcass traits was not significant (Table 4).

In agreement with the present results, regardless betaine level, Wang *et al.* (2004) suggested that betaine is more effective in improving carcass quality. Attia *et al.* (2005) indicated that betaine supplementation at either 0.035 or 0.070% significantly improved percentage carcass yield in chicks. Esteve-Garcia and Mack (2000) suggested that betaine does not replace methionine in its function as essential amino acid in protein metabolism, but may improve carcass yield.

In addition, Su *et al.* (2009) found that geese fed betaine supplemented diet showed increased liver weight as proved in T3 of this study and increased liver/body weight as proved in T2 in this study as compared to the control. El-Ganzory *et al.* (2004) found no significant variations in broiler liver percentages by supplementing betafin. Also, Deng and Wong (1997) indicated that addition of 0.05% betaine did not affect net dressing percentage of broiler chicks.

Generally, betaine could enhance synthesis of carnitine by improving methylation metabolism and could stimulate beta -oxidation of long chain fatty acids in the inner mitochondria membrane of muscle cells (Wang, 2000).

Viability rate and economic feed efficiency:

It is worthy noting that viability rate was 100% in betaine treated groups and even in the control one (Table 5).

Although birds in T3 showed similar feed intake and higher feeding cost, they had the highest total gain and consequently the highest price of total gain. Therefore, from the economic point of view, birds in T3 showed the highest economic feed efficiency (EFE %) as compared to other treatment groups, reflecting the highest EFE relative to the control birds (Table 5).

As affected by sex, males showed higher feed intake, feeding cost, total gain and price of gain than females, reflecting higher EFE for males than females (Table 5).

El-Husseiny *et al.* (2007) found the highest economic efficiency when diet contained the highest levels of betaine. Also, Patil *et al.* (2007) observed that betaine can be used with reduction in choline chloride up to 90% and/or DL-methionine up to 30% without any adverse effect on economics of production.

In conclusion, growth performance, blood parameters including protein metabolism, carcass traits and economic efficiency were improved by supplementing diet of grower turkey with 150 g betaine /100 kg diet.

Table (5): Economic feed efficiency turkey as affected by treatment and sex.

Item	Treatment				Sex	
	T1	T2	T3	T4	Male	Female
Viability rate, %	100	100	100	100	100	100
Total feed intake (kg/bird)	6.34	6.30	6.34	6.37	8.12	4.55
Cost of feeding (L.E.)/bird	22.17	22.18	22.43	22.66	28.62	15.97
Total gain (kg/bird)	1.84	1.89	2.10	1.72	2.61	1.18
Price of total gain (L.E.)/bird	46.00	47.25	52.50	43.00	65.25	29.56
Economic feed efficiency, %	107.48	113.03	134.06	89.76	127.98	85.9
EE relative to control, %	100	105.2	124.7	83.5	-	-
EE relative to female, %	-	-	-	-	150.4	100

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تأثير إضافة البيتاين إلى علائق الرومى على أداء النمو ومواصفات الذبيحة.

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تم دراسة إستجابة كتاكيت الرومى للنمو تحت تأثير مستويات مختلفة من البيتاين أثناء الفترة من 12-20 أسبوع من العمر. العليقة المستخدمة إحتوت على 21.37% بروتين و 3057 ك كالورى/ كجم. وأضيف إلى هذة العليقة البيتاين بمستويات صفر، 75، 150 ، 225 جم/100 كجم عليقة. قسمت الطيور الى أربع مجاميع 50 طائر/ معاملة (ذكور وإناث) قسمت بشكل متساوى الى مجموعتين (25 ذكور) و (25 إناث). توضح النتائج ان المعاملة الثالثة (150 جم بيتاين / 100 كجم عليقة) ارتفعت فى وزن الجسم والزيادة الكلية فى الوزن مقارنة بمجموعة الكنترول او المعاملات الاخرى. كان هناك زيادة معنوية بالنسبة لمقاييس الجسم متضمنة محيط الصدر وطول القص وطول الظهر وطول الساق وطول الفخذ وطول Tibia فى المعاملة الثالثة مقارنة بالمجاميع الاخرى. أظهرت الذكور تحسناً فى مواصفات الجسم عن الاناث عند مستوى معنوية (P≤0.05) ، بينما لم يظهر التفاعل بين المعاملات والجنس فى جميع معاملات اى فروق معنوية. وقد لوحظ زيادة معنوية عند مستوى (P≤0.05) فى تركيز البروتين الكلى والالبيومين فى البلازما بالنسبة للمعاملة الثالثة والرابعة مقارنة بمجموعة الكنترول. كما أظهرت الذكور إرتفاع فى تركيز البروتين الكلى والالبيومين ونسبة (الالبيومين-جلوبيولين) عن الاناث. فى المعاملة الثالثة كانت هناك زيادة عند مستوى معنوية (P≤0.05) فى وزن الذبيحة ، الحوائج ، القونصة ، الكبد و القلب ، بالاضافة الى إرتفاع النسبة المئوية لوزن الحوائج. وزن الذبيحة والقونصة بالاضافة الى أن النسبة المئوية للتصافى لم تتأثر باضافة البيتاين. الذكور اظهرت زيادة معنوية (P≤0.05) فى وزن الذبيحة و الحوائج والقونصة والكبد القلب. الاناث أظهرت زيادة معنوية (P≤0.05) فى أوزان الحوائج والقونصة والكبد. لم يظهرالتفاعل بين المعاملات والجنس أى تأثير معنوى بالنسبة لجميع مواصفات الذبيحة. أظهرت المعاملة الثالثة أعلى كفاءة اقتصادية غذائية مقارنة بباقى المعاملات. وأظهرت الذكور كفاءة اقتصادية غذائية أعلى من الاناث.

الخلاصة :من نتائج الدراسة يمكن استنتاج ان الاداء الانتاجى و مقاييس الجسم وبعض قياسات الدم و مواصفات الذبيحة و الكفاءة الاقتصادية تحسنت باضافة البيتاين الى علائق الرومى النامى بنسبة 150 جم/100كجم عليقة.

قام بتحكيم البحث

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Table (2): Growth performance of growing turkey as affected by treatment and sex.

Item	Treatment (T)				Sex (S)		Inter.
	T1	T2	T3	T4	Male	Female	TxS
Initial LBW, g	2948.4± 75.1	2986.0±75.8	2986.0±69.2	3026.4±67.0	3425.1±29.8[a]	2548.3±19.0[b]	NS
Final LBW, g	4798.2±178.9[b]	4878.6±180.1[b]	5085.0±192.7[a]	4750.6±155.1[b]	6031.7±63.5[a]	3724.5±22.7[b]	NS
Total weight gain (kg/bird)	1.84±0.111[bc]	1.89±0.112[b]	2.10±0.131[a]	1.72±0.093[c]	2.61±0.492[a]	1.18±0.162[b]	NS
Total feed intake (kg/bird)	6.34	6.30	6.34	6.37	8.12	4.55	-
Feed conversion	3.4	3.3	3.0	3.6	3.1	3.8	-
Breast width, cm	26.10±0.632[b]	27.02±0.543[ab]	27.96±0.614[a]	26.12±0.475[b]	29.71±0.340[a]	23.89±0.215[b]	NS
Keel length, cm	16.16±0.252[b]	16.58±0.212[b]	17.30±0.252[a]	16.02±0.212[b]	17.05±0.195[a]	15.98±0.123[b]	NS
Back length, cm	30.92±0.594[b]	31.68±0.540[b]	32.98±0.621[a]	30.70±0.479[b]	34.10±0.387[a]	29.04±0.221[b]	NS
Shank length, cm	16.16±0.252[b]	16.58±0.212[b]	17.30±0.252[a]	16.02±0.212[b]	17.05±0.195[a]	15.98±0.123[b]	NS
Tibia length, cm	19.56±0.348[b]	20.16±0.291[b]	21.08±0.352[a]	19.60±0.266[b]	21.2±0.253[a]	19.0±0.135[b]	NS
Thigh length, cm	15.14±0.255[b]	15.58±0.212[b]	16.28±0.257[a]	15.06±0.223[b]	16.08±0.195[a]	14.95±0.126[b]	NS

Means denoted with different superscripts within the same row for treatments or sex are significantly different at P≤0.05.

Table (3): Concentration of some plasma constituents of turkey as affected by treatment and sex.

Blood biochemical	Treatment				Sex		Inter.
	T1	T2	T3	T4	Male	Female	T x Sex
Protein metabolism:							
Total proteins, g/dl	4.11±0.165[c]	4.61±0.281[bc]	5.35±0.224[a]	5.22±0.209[ab]	5.11±0.218[A]	4.54±0.165[B]	NS
Albumin (AL), g/dl	2.05±0.122[c]	2.35±0.166[bc]	2.94±0.309[a]	2.58±0.138[ab]	2.77±0.177[A]	2.19±0.092[B]	NS
Globulin (GL), g/dl	2.07±0.114[b]	2.27±0.148[ab]	2.41±0.123[ab]	2.63±0.141[a]	2.34±0.126	2.35±0.087	NS
AL/GL ratio	1.01±0.086	1.04±0.077	1.27±0.195	0.99±0.072	1.22±0.101[A]	0.94±0.035[B]	NS

Means denoted with different superscripts within the same row for treatments or sex are significantly different at P≤0.05.

Table (4): Carcass traits of turkey as affected by treatment and sex.

Trait	Treatment				Sex		Inter.
	T1	T2	T3	T4	Male	Female	T x Sex
LBW, g	4599.1±720.1[a]	4488.3±616.4[ab]	4891.6±641.4[a]	4133.3±465.2[b]	5856.6±191.3[A]	3199.5±52.9[B]	NS
Carcass g	3090.0±466.2[a]	3016.6±434.0[a]	3266.6±391.5[a]	2723.3±285.7[b]	3889.5±117.8[A]	2158.7±50.6[B]	NS
Carcass, %	67.4±0.4	66.9±1.7	67.3±1.0	66.2±2.0	66.5±0.9	67.4±1.0	NS
Giblets g	184.6±10.1[c]	215.8±15.4[b]	235.3±16.0[a]	193.8±11.1[c]	234.4±9.0[A]	180.4±4.3[B]	NS
Giblets, %	4.3±0.4[b]	5.0±0.3[a]	5.0±0.3[a]	4.8±0.3[ab]	4.0±0.1[B]	5.6±0.0[A]	NS
Gizzard, g	122.5±0.9[b]	125.0±5.7[b]	140.0±5.4[a]	120.8±7.1[b]	141.2±3.7[A]	112.9±3.6[B]	NS
Gizzard, %	2.8±0.2	3.0±0.3	3.0±0.2	3.0±0.2	2.4±0.0[B]	3.5±0.0[A]	NS
Liver, g	51.3±2.1[b]	71.6±8.0[a]	75.3±6.6[a]	58.0±5.7[b]	71.8±6.1[A]	56.3±1.4[B]	NS
Liver, %	1.2±0.2[b]	1.6±0.08[a]	1.5±0.1[ab]	1.4±0.1[ab]	1.2±0.1[B]	1.7±0.03[A]	NS
Heart, g	10.8±1.2[c]	19.1±3.0[a]	20.0±4.4[a]	15.0±1.8[b]	21.3±2.2[A]	11.1±0.6[B]	NS
Heart, %	0.2±0.03[b]	0.4±0.03[a]	0.3±0.04[a]	0.3±0.03[a]	0.3±0.03	0.3±0.02	NS
Dressing, %	71.8±0.8	72.0±1.7	72.3±1.3	71.1±2.2	70.6±1.0	73.0±1.0	NS

Means denoted with different superscripts within the same row for treatments or sex are significantly different at P≤0.05.
LBW: live body weight pre-slaughter.