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EFFECT OF BETAINE SUPPLEMENTATION TO METHIONINE ADEQUATE DIET ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, SOME BLOOD PARAMETERS AND ECONOMIC EFFICIENCY OF BROILERS

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ABSTRACT

The objective of this study was to evaluate the influence of supplementing betaine to broiler diets containing adequate concentration of methionine on growth performance, carcass traits and some blood parameters, as well as economic efficiency. Two hundred and sixty day-old Ross broiler chicks were allotted into five equal treatments of four equal replications. Five experimental isonitrogenous and isocaloric diets with graded levels of betaine (0.0, 1.0, 1.5, 2.0 and 2.5 g/kg diet) were formulated and fed to chicks from 1 to 39 days of age.

During the entire experimental period, dietary betaine supplementation had positive effects on mortality rate, economic efficiency and growth performance (weight gain, feed conversion ratio, protein efficiency ratio, efficiency of energy utilization and performance index) of broiler chicks but feed intake was not affected. Broilers fed the betaine-supplemented diets exhibited significantly higher percentages of carcass yield, total edible parts, breast yield and breast meat while those of heart and abdominal fat were decreased but relative weights of giblets, liver and gizzard were not affected compared with their control counterparts. Feeding the betaine-supplemented diets also produced a positive effect on liver and breast meat composition (increased crude protein and decreased ether extract contents of both) compared with the control group. Dietary supplementation with betaine led to significant increases in serum concentrations of total protein, globulin, triglycerides and total cholesterol but levels of glucose and albumin were not affected. Taking the economic aspect into account, it is concluded that supplemental betaine can be used to improve growth performance and carcass quality of broilers fed methionine adequate diets. Based on the present results, a supplemental dietary betaine level of 1.0 g/kg diet is suggested to be enough to exert such beneficial effects.

INTRODUCTION

Feed additives are important materials that can improve the efficiency of feed utilization and animal performance (Abdou, 2011). Recently, betaine has been used as a dietary feed supplement in animal nutrition. Betaine is present in sugar beets, seafoods and other plants and animals (Wang *et al.*, 2004). Nowadays, betaine is also available in several purified forms (anhydrous, monophosphate and hydrochloride betaine).Betaine has two metabolic roles: it is a methyl group donor and it is an osmolyte that assists in cellular water homeostasis (Petronini *et al.*, 1992). Betaine, choline and methionine can serve as a source of methyl (CH3) groups (Kettunen *et al.*, 2001). Some studies (Virtanen and Rossi, 1995) suggested that the response to betaine was greater than that obtained from the addition of methionine, but other studies have failed to demonstrate that the methionine content of the diet could be reduced by supplementation with betaine

(Rostagno and Pack, 1996; McDevitt *et al.*, 2000). However, several studies pointed out that addition of betaine may improve breast meat yield (Schutte *et al.*, 1997; McDevitt *et al.*, 2000). Betaine is indirectly involved in the synthesis of carnitine which is required for transporting long-chain fatty acids across the inner mitochondrial membrane for oxidation (McDevitt *et al.*, 2000) and may result in a leaner carcass. Many consumers prefer the lean products. Therefore, the present study was designed to evaluate the response of broiler chicks fed methionine adequate diets to supplemental betaine.

MATERIALS AND METHODS

Chicks and experimental design:

The present work was conducted in an environmentally controlled house in the Regional Center for Food and Feed (RCFF), Agricultural Research Center, Giza, Egypt. Two hundred and sixty day-old Ross broiler chicks, obtained from a commercial hatchery, were divided into five dietary treatments with four equal replications each. Birds were kept in battery cages and had free access to feed and water, and managed similarly. Birds were vaccinated against New Castle, Avian influenza and Gamboro diseases. After such medical treatments, a dose of vitamins (AD_3E) was offered in the drinking water for three successive days.

Experimental diets:

The experiment was conducted for three phases: starter (14 days) grower (14 days) and finisher (11 days). All birds were fed corn soybean meal-based diets that were formulated to meet all nutrients required by broilers as recommended by NRC (1994). The crude protein (CP) and metabolizable energy (ME) contents of the basal diets destined for the starter, grower and finisher phases were 23.12% CP; 3070 kcal ME, 21.47% CP; 3146 kcal ME and 20.15 %CP, 3198 kcal ME/kg, respectively. Betaine (as anhydrous product) was added to each basal diet at levels of 0.0, 1.0, 1.5, 2.0 and 2.5 g/kg, thus five diets were formulated and used. Composition and calculated analysis of the basal diets are presented in Table 1. The tested feed additive (betaine) was purchased from a local commercial market. Furthermore, the ME values of these diets were also calculated according to NRC (1994).

Composition of vitamin and minerals premix. Each 3 kg of vitamin and mineral mixture contains: 12,000,000 IU vitamin A; 2,000,000 IU; vit. D_3; 10 g vit. E; 1.0 g vit. K; 1.0 g vit. B_1; 5.0 g vit. B_2, 1500 mg vit. B6, 10 mg vit. B_{12}; 10 g pantothenic acid; ,20 g nicotinic acid; 1.0 g folic acid; 50 mg biotin; 500 g choline chloride; 4.0 g copper; 300 mg iodine; 30 g iron; 60 g manganese; 50 g zinc and 100 mg selenium.

Performance criteria:

Live body weights and weight gains (g) of chicks were recorded at 14, 28 and 39 days of age and for the entire experimental period (1-39) days of age, while feed consumption (g) and feed conversion ratio (g feed/g gain) were calculated weekly.

Table (1): Composition and calculated analysis of the basal diets

Ingredients	Starter (1-14 days of age) %	Grower (14-28 days of age) %	Finisher (28-39 days of age) %
Yellow corn	55.710	59.600	61.800
Soybean meal (46 CP%)	30.000	25.500	24.000
Corn gluten meal	7.800	7.900	7.000
Vegetable oil	2.430	2.915	3.545
Di-calcium phosphate	1.740	1.960	1.760
Limestone	0.820	0.560	0.560
DL- methionine	0.210	0.200	0.140
L- lysine-HCl	0.420	0.490	0.320
Common-salt (NaCl)	0.400	0.400	0.400
Vitamin and Mineral premix	0.400	0.400	0.400
Choline chloride	0.070	0.075	0.075
Total	100.000	100.000	100.000
Calculated analysis			
Dry matter, %	87.97	88.11	88.23
Crude protein, %	23.12	21.47	20.15
Crude fat, %	4.78	4.53	4.33
Crude fiber, %	3.65	3.88	3.61
Ash, %	5.85	5.75	5.98
ME (Kcal/kg)	3065.9	3145.55	3197.73
Calcium, %	0.96	0.90	0.85
Avail. Phosphorus, %	0.45	0.48	0.40
Mehionine, %	0.61	0.584	0.500
Mehionine + cystine, %	0.98	0.950	0.850
Lysine, %	1.36	1.300	1.130

Efficiency of protein and energy utilization:

Protein efficiency ratio (PER) and efficiency of energy utilization (EEU) values were calculated during all the studied growth periods according to the equations of Persia *et al.* (2003) and Ali (1999) as follows: PER = (Body weight gain (g)/crude protein consumed (g). EEU = (ME consumed kcal / g body weight gain).

Performance index (PI):

Performance index (PI) was also calculated during the studied growth periods according to the equation of North (1984) and Ali (1999) as follows: PI = (Live body weight (kg) / feed conversion ratio) x100.

Carcass traits:

At the end of the experiment (39 days of age), six birds from each treatment, with average body weight nearly similar to the mean body weight of their respective treatment, were chosen, fasted for about 10 hours. Birds were individually weighed before and after slaughtering and complete bleeding. Feathers were removed with hand to insure complete defeathering.

Head, neck, wings and shanks were cut, and separately weighed. Thereafter, carcasses were cut at the posterior end of sternum and abdominal fat was removed and weighed. Weights of eviscerated carcass and its components (i.e. giblets, breast yield, total edible parts and abdominal fat) were expressed as absolute or percent of LBW at slaughter. The breast meat of each carcass was dissected and weighed. Samples were taken from liver and breast meat and stored at - 20°C for subsequent analyses of crude protein (CP) and ether extract (EE) contents. The weights of the liver without gallbladder, gizzard without feed contents and heart without vessels and blood, were recorded. Dressing percentage (i.e. total edible parts) was calculated as carcass weight plus total giblets weight relative to pre-slaughtered weight of the bird, whereas breast meat yield was calculated as present of the eviscerated carcass weight.

Blood parameters:

Individual blood samples (3 ml) were taken during slaughtering from the individual birds. The blood samples were immediately centrifuged at 3000 rpm for 15 minutes and the serum was stored at -20°C in sealed container till analysis. Serum concentrations of total protein and albumin were determined according to Doumas *et al.* (1981) and Doumas *et al.* (1971), respectively. Globulin concentration was calculated as the difference between serum total protein and albumin. Total cholesterol was determined according to Watson (1960). Plasma triglycerides were determined according to the method of Fossati and and Prencipe (1982). Plasma glucose was determined according to the procedure of Coles (1986).

Economic efficiency:

For economic efficiency (EE) determination, all managerial factors affecting meat production of broilers were considered constants, and the amounts of feed consumption and weight gains per treatment were calculated. Prices of experimental diets and the tested feed additive (betaine) were also calculated according to the prevailing prices of local market at the time of the experiment. Economic efficiency was calculated as net revenue/total cost per bird.

Statistical analysis:

Data from all response variables were subjected to one-way analysis of variance using General Liner Model (GLM) of SAS/STAT software (SAS Institute, 2004). Significant difference among treatment means of different variables were separated using Duncan's multiple range procedure (Duncan, 1955) at 5% probability.

RESULTS AND DISCUSSION

Growth performance:

The effect of feeding diets supplemented with different levels of betaine on live body weight, weight gain, feed intake and feed conversion during starter (1-14), grower (14-28) and finisher (28-39 days of age) phases of growth of broilers are presented in Table 2. The results obtained indicated that feeding betaine-supplemented diets positively affected 39 days old live body weight (LBW) of broiler chicks compared with their control group. The highest LBW was achieved by chicks fed the diet supplemented with 1.0 g/kg betaine, followed by those fed the diets supplemented with 2.0, 2.5, 1.5 and 0.0 g/kg betaine, in a descending order, respectively. The same trend of response was observed in body weight gain (BWG) of chicks fed the betaine-supplemented diets during the whole experimental period compared with their control counterparts.

As indicated in Table 2, the effects of dietary supplementation with betaine on feed intake (FI) of broilers during the different phases of growth were inconclusive. Dietary treatments did not affect F1 of broilers during the starter and finisher phases of growth but had a negative effect on FI of birds during the grower and the entire experimental periods compared with those of the control group. Such slight differences among the different experimental groups of broiler chicks in FI, observed herein, seemed erratic and perhaps are not related to the effect of dietary treatments. However, dietary supplementation with different levels of betaine led to superior means of feed conversion ratio during the three phases of growth and the whole experimental period to those attained by the control group. There were no significant differences in total mortality rates, reported in the present study (Table 2), among the different experimental groups of broilers in response to dietary supplementation with graded levels of betaine.

It is evident that supplementation with betaine to broiler diets produced a positive effect on body weight gain and feed conversion ratio when compared with those of the control group. On the other hand, Esteve-Garica and Mack (2000) stated that the effect of supplemental betaine on body weight and feed to gain of broilers was relatively small and not significant. Moreover, betaine significantly improved body weight and feed conversion of Matrouh chickens at a level of 1.0 g/kg diet (Ezzat *et al.*, 2011).

The results of the present study indicated also that feed intake of broiler was not affected by supplementation levels of betaine in diets. This is in agreement with those obtained by Jahanian and Rahmani (2008), who found that dietary betaine had no effect on feed intake of broilers. It was interesting to note that all birds consuming betaine-supplemented diets had somewhat lower FI values as compared to birds fed the control diet. The reason for reduced feed intake, observed herein, caused by betaine is not known. The results, however, showed that the reduction of feed intake by betaine was not coincided with a negative effect on growth of broiler chickens and therefore led to an improved feed efficiency. However, Honarbakhsh *et al.* (2007) and Dorra *et al.* (2012) indicated that betaine supplementation increased feed intake, which is in contrast to the present results.

In accordance with the present results, Tolba *et al.* (2007) showed that dietary supplemental betaine improved feed conversion and live body weight as compared to the respective control. Honarbakhsh *et al* (2007) stated that betaine supplementation increased body weight and improved feed conversion ratio of broiler chicks in grower and finisher periods. Furthermore, betaine is an osmolyte that could improve intestinal structure and function to increase growth performance (Honarbakhsh *et al.*, 2007; Zulkifli *et al.*, 2004). Generally, a positive effect of betaine was indicated on performance of broiler (Hamidi *et al.*, 2010) and ducks (Wang *et al.*, 2004). The observed values of mortality rate in this study are lower than those obtained previously by Tollba *et al.* (2004), who found that mortality rate was 5% for broiler chicks reared in normal conditions (24°C).

Protein efficiency ratio (PER), efficiency of energy utilization (EEU) and **performance index (PI):**

The effects of feeding broilers diets supplemented with different levels of betaine on PER and EEU and PI of broilers throughout the entire experimental period are summarized in Table 3.

Efficiency of protein and energy utilization:

As illustrated in Table 3, PER of broiler chicks fed the betaine-supplemented diets for the three phases of growth, investigated herein, were significantly better than those of the control birds. During the entire experimental period, the best PER was achieved by broilers fed the diet supplemented with 1.0 g/kg betaine, followed by those of birds fed the diets fortified with 2.5, 2.0, 1.5 and 0.0 g/kg betaine in a descending order, respectively. Similarly, EEU of broiler chicks was positively affected by dietary supplementation with graded levels of betaine during all phases of growth compared with those of their control counterparts (Table 3). In addition, PI values of broiler chicks fed the betaine–supplemented diets were superior to those of the control birds, in a similar trend of response (Table 3).

Carcass characteristics:

Carcass characteristics of broiler chickens as affected by dietary treatments are given in Table 4. The results revealed that birds fed on rations supplemented with betaine showed significantly ($P<0.05$) higher percentages of carcass yield, total edible parts and breast yield than those of the controls. On the other hand, the percentages of liver, gizzard and giblets were not affected by dietary treatments.

The results obtained are in agreement with those obtained by El-Ganzory *et al.* (2004), who found no significant variations in broiler liver percentage in response to supplemental betaine. In this respect, Wang *et al.* (2004) suggested that betaine is more effective in improving carcass quality. Attia *et al.* (2005) indicated that betaine supplementation significantly improved the percentage of carcass yield in chicks. Esteve-Garcia and Mack (2000) suggested that betaine supplementation may improve carcass yield. On the other hand, Deng and Wang (1997) indicated that addition of betaine did not affect dressing percentage of broiler chicks. In addition, Esteve-Garcia and Mack (2000) reported that the effects of betaine on breast yield were relatively small and non-significant. All of these studies indicated that growth of different tissues in broiler chickens responded to betaine supplementation differently.

Table (2): Effect of feeding diets supplemented with different levels of betaine on body weight (BW), weight gain (WG), feed intake (FI), feed: gain ratio (F:G) and mortality rate of broiler chicks

Items	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5
Initial weight (g)	42.1	42.3	42.5	42.1	42.0
BW (g) at:					
14 day	314.4^{c}	332.3^{a}	322.2^{c}	325.4^{ab}	322.3^{b}
28 day	1121.5^{c}	1154.5^{b}	1136.5^{c}	1170.8^{a}	1141.9^{b}
39 day	1853.9^{d}	1959.2^{a}	1898.5^{c}	1931.5^{b}	1929.4^{b}
WG (g) at:					
1-14 day	272.3^{c}	290.0^{a}	279.7^{b}	283.3^{ab}	280.3^{b}
14-28 day	807.1^{c}	822.2^{b}	814.3^{b}	845.4^{a}	819.6^{b}
28-39 day	732.4^{d}	804.7^{a}	762.0^{c}	760.7^{c}	787.5^{b}
1-39 day	1811.8^{d}	1916.9^{a}	1856.0^{c}	1889.4^{b}	1887.4^{b}
FI (g) at:					
1-14 day	361.8	365.4	363.5	366.5	362.7
14-28 day	1287.9	1259.0	1273.6	1270.8	1257.8
28-39 day	1356.8	1351.7	1356.2	1357.8	1363.1
1-39 day	3006.5	2976.1	2993.3	2995.1	2983.6
(F:G) at:					
1-14 day	1.33^{a}	1.23^{c}	1.25^{c}	1.29^{b}	1.29^{b}
14-28 day	1.60^{a}	1.53^{c}	1.52^{c}	1.50^{c}	1.53^{c}
28-39 day	1.85^{a}	1.67^{c}	1.77^{b}	1.78^{b}	1.73^{b}
10-39 day	1.66^{a}	1.55^{c}	1.61^{b}	1.59^{b}	1.58^{b}
Mortality% (1-39 day)	3.85	1.92	1.92	0.00	1.92

a-d: Means at the same row with different superscripts differ significantly ($P<0.05$). .

Table (3): Effect of feeding diets supplemented with different levels of betaine on protein efficiency ratio (PER), efficiency of energy utilization (EEU) and performance index (PI) of broiler chicks

Items	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5
Protein efficiency ratio (PER) at:					
1-14 d	3.25^{c}	3.46^{a}	3.33^{b}	3.34^{b}	3.34^{b}
14-28 d	2.92^{c}	3.05^{a}	2.99^{b}	3.10^{a}	3.04^{a}
28-39 d	2.66^{d}	2.95^{a}	2.79^{c}	2.78^{c}	2.87^{b}
1-39 d	2.75^{c}	2.99^{a}	2.88^{b}	2.92^{a}	2.93^{a}
Efficiency of energy utilization (EEU) at:					
1-14 d	4.07^{a}	3.86^{c}	3.99^{b}	3.97^{b}	3.97^{b}
14-28 d	5.02^{a}	4.82^{c}	4.92^{b}	4.73^{d}	4.83^{c}
28-39 d	5.92^{a}	5.37^{c}	5.69^{b}	5.71^{b}	5.53^{c}
1-39 d	5.25^{a}	4.91^{c}	5.10^{b}	5.01^{d}	4.99^{bc}
Performance index (PI) at:					
at 14 d	23.64^{c}	27.02^{a}	25.78^{b}	25.23^{b}	24.98^{b}
at 28 d	70.09^{d}	81.88^{ab}	78.92^{c}	83.63^{a}	80.42^{b}
at 39 d	111.68^{d}	126.40^{a}	117.92^{c}	121.48^{b}	122.11^{b}

a-d: Means at the same row with different superscripts differ significantly ($P<0.05$)..

Several studies suggested that addition of betaine may improve breast meat yield (Schutte *et al.*, 1997; McDevitt *et al.*, 2000). Betaine is indirectly involved in the biosynthesis of carnitine which is required for transporting long chain fatty acids across the inner mitochondrial membrane for oxidation (De Ridder and Van Dam, 1975) and therefore, may result in a leaner carcass, which is more attractive by many consumers. As shown in Table 4, percentages of abdominal fat of broilers were significantly (P<0.05) reduced as a result of dietary supplementation of betaine. The decrease of abdominal fat of broilers fed betaine-supplemented diets in the present study may be due to increased hepatic synthesis of carnitine and enhanced activity of the hormone-sensitive lipase in the abdominal fat, as reported by Zhan *et al*. (2006).

Table (4): Effect of feeding different levels of betaine on carcass traits of 39-day-old broiler chicks

Items	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5
Live body weight (g)	1880	1860	1873	1898	1837
Carcass yield (%)	72.71^{c}	73.96^{b}	73.88^{b}	74.81^{a}	74.41^{a}
Liver (%)	2.15	1.96	2.04	2.05	2.01
Gizzard (%)	2.02	1.93	2.06	1.81	1.98
Heart (%)	0.60^{a}	0.48^{b}	0.46^{b}	0.46^{b}	0.50^{b}
Giblets (%)	4.77	4.37	4.56	4.32	4.49
Total edible parts (%)	77.48^{c}	78.33^{b}	78.44^{b}	79.44^{b}	79.23^{a}
Abdominal fat (%)	1.72^{a}	1.54^{b}	1.51^{b}	1.36^{c}	1.59^{b}
Breast yield (%)	23.05^{c}	24.73^{b}	25.09^{b}	24.60^{b}	26.49^{a}
Deboned breast meat (%)	17.02^{d}	19.89^{c}	20.82^{b}	21.08^{b}	22.05^{a}

a-d: Means at the same row with different superscripts differ significantly (P<0.05).

The present results are consistent with the findings of Zhan *et al.* (2006). The abdominal fat pad of broilers usually represents a waste product and added dietary betaine may decrease the carcass fat of broilers, as reported by some authors (Saunderson and Mackinlay, 1990). Although betaine is involved in lipid metabolism, a reduction in carcass fat in poultry as result of betaine supplementation is not clearly documented and more research is needed to help clarify this issue.

Table (5): Contents (% DM basis) of crude protein and ether extract in breast meat (BM) and liver of 39-day-old broiler chicks as effected by dietary betaine supplementation

Items	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5
Crude protein (%):					
Breast meat (BM)	78.96^{b}	80.27^{ab}	81.85^{a}	81.91^{a}	81.97^{a}
Liver	67.56^{c}	69.15^{b}	69.49^{a}	69.55^{a}	69.67^{a}
Ether extract (%):					
Breast meat (BM)	4.43^{a}	3.65^{b}	3.45^{b}	3.51^{b}	3.55^{b}
Liver	17.40^{a}	16.11^{b}	15.95^{b}	13.90^{c}	13.55^{c}

a-c: Means at the same row with different superscripts differ significantly (P<0.05).

As shown in Table 5, betaine supplementation had a positive effect (P<0.05) on CP and EE contents of breast meat of broiler chicks. Birds fed supplemental betaine at levels of 1.5, 2.0 and 2.5 g/kg had significantly

($P<0.05$) higher CP contents in their breast meat than those of the control group. Similarly, CP contents in the liver samples of broilers fed betaine-supplemented diets were also significantly ($P<0.05$) higher than that of broilers fed the control diet (Table 5). The current results are in accordance with those observed by McDevitt *et al.* (2000), who found that added dietary betaine improved breast meat yield of broiler chicks. Betaine may have a positive effect on partitioning the nutrients in favor of protein synthesis in breast meat. On the other hand, the EE contents of the breast and liver of broilers fed the diets supplemented with betaine were significantly lower ($P<0.05$) compared with those of the control birds (Table 5).

In this respect, Sun *et al.* (2008) indicated that supplementation of betaine at different levels lead to high concentrations of growth hormone and insulin-like growth factor-1 coincided with increased breast meat yield (%) and its protein content, but reduced abdominal fat and EE content of the breast and liver as compared to those of the control birds. In addition, Xu and Zhan (1998) showed that betaine supplementation enhanced the synthesis of methylated compounds such as carnitine that is required for the transport of long–chain fatty acids through the inner mitochondrial membrane where fatty acid oxidation takes place and this might be involved in reducing carcass and liver lipid contents.

Blood parameters:

Blood represents an important index of physiological, pathological and nutritional status of the organism. Changes in the constituent compounds of blood when compared to normal values could be used to interpret the metabolic status of an animal and perhaps nutrient adequacy of the feed consumed (Nworgu *et al.*, 2007).

The effect of dietary treatments on serum biochemical parameters of 39-day-old broiler chicks are shown in Table 6. Dietary treatments had no significant effect on serum glucose concentration when compared to that of their control birds. It is worth noting that blood serum levels of glucose, reported in this study, were in the normal range (180-250 mg/dl) that previously reported by Bounous *et al.* (2000). However, Zou and Lu (2002) stated that betaine supplementation induced a significant increase in serum glucose in laying hens.

Table (6): Concentrations of some blood serum constituents of broiler chicks as affected by dietary betaine supplementation

Measurements	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5
Total cholesterol (mg/dl)	114.6^{b}	119.2^{b}	138.5^{a}	133.5^{a}	136.6^{a}
Triglycerides (mg/dl)	26.6^{d}	43.8^{a}	39.9^{b}	36.1^{b}	33.8^{c}
Glucose (mg/dl)	194.3	195.5	203.8	196.8	193.3
Alb (g/dl)	1.3	1.4	1.5	1.5	1.4
Total protein (g/dl)	3.05^{c}	3.26^{b}	3.48^{b}	3.26^{b}	3.45^{a}
Globulin (g/dl)	1.75^{c}	1.86^{b}	1.98^{a}	1.90^{b}	2.02^{a}

a-d: Means at the same row with different superscripts differ significantly ($P<0.05$).

Dietary treatments also had no significant effect on serum albumin content of broilers (Table 6). The levels of serum albumin, reported herein, are in line with those obtained by Rama Rao *et al.* (2011), who found that albumin concentrations were not affected by supplementation of betaine in the broiler diet. Blood serum concentrations of triglycerides were significantly (P<0.05) increased in response to dietary betaine supplementation compared with that of the control group (Table 6). The obtained levels of serum triglycerides are in a disagreement with the findings of Rama Rao *et al.* (2011), who found that dietary supplementation of betaine did not significantly affect serum concentration of triglycerides in broiler chicks. However, Zhan *et al.* (2006) found that betaine addition increased the concentration of free fatty acids in serum of broiler chicks.

As given in Table 6, broilers fed the 1.5 to 2.5 g/kg betaine-supplemented diets exhibited significantly higher (P<0.05) levels of serum cholesterol when compared with the control group. Similar results were obtained by Rama Rao *et al.* (2011), who revealed that betaine supplementation significantly increased the concentration of total cholesterol in serum of broiler chicks. However, Konca *et al.* (2008), Attia *et al.* (2005) and Baghaei *et al.* (2011) indicated that betaine supplementation had no significant effect on blood cholesterol level. Yet, all the measured blood parameters of broiler chicks fell within the normal ranges published in the scientific literature. It was observed that the serum total protein and globulin concentrations showed a significant increase (P<0.05) in betaine-supplemented groups than those of the control group (Table 6). These results are in accordance with those obtained by Rama Rao *et al.* (2011), who revealed that dietary betaine supplementation caused a significant increase in serum total protein of broiler chickens. On the other hand, Attia *et al.* (2005) reported slight increase in serum level of total protein due to dietary betaine supplementation in slow growing chicks..

It is of interest to note that the observed increase in concentration of serum total proteins of broiler chicks in the present study was associated with increasing the concentration of both albumin and globulin. In conclusion, the present results suggested that addition of betaine to broiler diets had no effect on some blood parameters of broilers.

Economic efficiency:

Economical evaluation of feeding diets supplemented with graded levels of betaine to broiler chicks from 1 to 39 days of age are presented in Table 7. It is obviously that feeding diets supplemented with betaine numerically decreased production cost kg LBW as compared to that of the control. It is worthy to note that supplementing a low level of betaine (1.0 g/kg feed) to basal diet led to a reduction in feed cost (per bird or per kg LBW) as compared to the higher levels of added betaine.

Average economic efficiency values of different dietary treatments ranged between 0.89 and 1.04, being the best for broilers fed the lowest level of added betaine (1.0 g/kg) to the worst (0.89) for chicks fed the control diet. The relative increases in economic efficiency of broilers due to betaine supplementation ranged between 8.0 and 17.0%. These improvements could be attributed to the improved body weight gain and feed conversion, obtained herein, in response to dietary betaine supplementation.

Table (7): Effect of feeding diets supplemented with different levels of betaine on economic efficiency of broiler chicks from 1 to 39 days of age

Items	Dietary treatments				
	Tr. 1 (control)	Tr. 2	Tr. 3	Tr. 4	Tr. 5
Fixed Cost (LE)[a]	3.50	3.50	3.50	3.50	3.50
Feed intake (g/bird):					
Starter diet	361.8	365.4	363.5	366.5	362.7
Grower diet	1287.9	1259.0	1273.6	1270.8	1257.8
Finisher diet	1356.8	1351.7	1356.2	1357.8	1363.1
Feed cost (LE/bird):					
Starter diet	1.41	1.43	1.42	1.44	1.42
Grower diet	4.83	4.73	4.62	4.79	4.75
Finisher diet	4.95	4.72	4.97	4.98	5.01
Feed cost/bird (LE)[b]:	11.19	10.88	11.01	11.21	11.18
Total cost/bird(LE)[c]:	14.69	14.38	14.51	14.71	14.68
BW (kg)	1.853	1.959	1.899	1.932	1.929
Cost/kg BW (LE):	7.93	7.34	7.64	7.61	7.61
Total income (LE)[d]:	27.80	29.39	28.49	28.98	28.94
Net revenue (LE)e:	13.11	15.01	13.98	14.27	14.26
Economic efficiency[f]:	0.89	1.04	0.96	0.97	0.97
Relative economic efficiency[h] %	100	117	108	109	109

Where: c = (a+b), e = (d-c) and f = (e/c). h = economic efficiency of treatment relative to that of control.
Sale price/kg LBW =15 LE.

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تأثير إضافه البيتايين إلى عليقه ذات مستوى كاف من الميثيونين على مظاهر النمو وخصائص الذبيحة وبعض مقاييس الدم والكفاءه الغذائية لكتاكيت اللحم

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هدفت هذه الدراسة إلى تقييم تأثير التدعيم بالبيتايين لعلائق كتاكيت اللحم التى تحتوى على مستوى كاف من الميثيونين على مظاهر النمو وأجزاء الذبيحة وبعض مقاييس الدم وكذلك الكفاءة الإقتصادية. وقد استخدم فى الدراسة مائتان وستون كتكوتا من نوع الروص عمر يوم تم تقسيمهم إلى خمس مجموعات متساوية ذات أربع مكررات متساوية وخمس علائق تجريبية متساوية فى الطاقة والبروتين ذات مستويات متدرجة من البيتايين (صفر، ١، ١,٥، ٢، ٢,٥جرام/كجم) تم تكوينها وتغذيتها للكتاكيت من عمر يوم وحتى ٣٩ يوما من العمر. وخلال مده التجربة الكلية كان للتدعيم بالبيتايين تأثيرات إيجابية على نسبه النفوق والكفاءة الإقتصادية ومظاهر نمو الكتاكيت (الوزن المكتسب، كفاءة تحويل الغذاء، كفاءة تمثيل الطاقة، دليل المظاهر الإنتاجية) ولكن لم يتأثر المتناول من الغذاء. ولقد اكتسبت الكتاكيت المغذاة على علائق مدعمة بالبيتايين نسبة معنوية مرتفعة من تصافى الذبيحة ومجموع الأجزاء الصالحة للأكل ومحصول الصدر ومحتوى لحم الصدر بينما أنخفض وزن القلب ومحتوى دهن البطن ولكن بمقارنة نسبه الكبد والقانصة والحوصلة نجد أنها لم تتأثر مقارنة بمجموعه الضبط. أيضا تبين أن التغذية على العلائق المدعمة بالبيتايين قد أحدثت تأثيرا إيجابيا على مكونات لحم الكبد والصدر (زيادة محتوى كل منهما من البروتين الخام وانخفاض محتواهما من المستخلص الإيثيري) مقارنه بمجموعه الضبط. وقد أدى تدعيم العلائق بالبيتايين إلى إرتفاع معنوي فى تركيز سيرم الدم من البروتين الكلى والجلوبيولين والدهون الثلاثية والكوليستيرول الكلى بينما لم تتأثر مستويات الجلوكوز والألبيومين. وإذا ما أخذنا الناحية الإقتصادية فى الإعتبار نجد أن التدعيم بالبيتايين يمكن إستخدامه لتحسين المظاهر الإنتاجية وصفات الذبيحة للكتاكيت المغذاة على علائق تحتوى على ميثيونين كاف وعلى أساس النتائج المتحصل عليها يبدو أن التدعيم بمستوى واحد جرام بيتايين لكل كجم علف هو الأكثر فاعلية عن المستويات الأخرى.