Egyptian Poultry Science Journal

http://www.epsaegypt.com

ISSN: 1110-5623 (Print) – 2090-0570 (Online)

EFFECTS OF L-CARNITINE ON PRODUCTION PERFORMANCE, BLOOD PARAMETERS, LIPID METABOLISM AND ANTIOXIDATIVE PROPERTIES OF BROILER CHICKS.

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Received: 10/08/2017 Accepted: 29/08/2017

ABSTRACT: This study aimed to investigate the effects of L-carnitine (LC) on productive performance, carcass composition, blood parameters as well as the lipid metabolism, immune response and antioxidative properties of broiler chicks from day 7 to 35 of age. A total of 280 unsexed Cobb chicks were assigned equally into four treatment groups. The first group fed a basal diet (control), while the other three groups were fed basal diet supplemented with 50, 100 and 150 mg of LC/ kg diet. Supplementation of LC to diets significantly increased BW, BWG, decreased FI and improved FCR, economical efficiency and production index. Where, Chicks fed basal diet supplemented with 50 mg of LC had significantly higher final BW and BWG, lower FI and better values of FCR, economical efficiency and production index followed by those fed basal diet supplemented with 100 and 150 mg LC compared to the control group. Treated groups significantly decreased serum urea, creatinine, alanine amino transferase (ALT), aspartate amino transferase (AST), total lipids, triglycerides, cholesterol and low-density lipoprotein (LDL) while increased glucose, high-density lipoprotein (HDL), total protein, total antioxidant capacity (TAC), superoxide dismutase (SOD), glutathione peroxidase (GPX), glutathione (GSH), triiodothyronine (T3), thyroxine (T4), hemoglobin, packed cell volume (PCV), red blood cell (RBC's), white blood cell (WBC's), lymphocyte, globulin, α -globulin, globulin -β and globulin-γ, immunoglobulins (IgG, IgM and IgA), bactriocide activity (BA), lymphocyte transformation test (LTT), phagocytic activity (PA) and index (PI) compared to control group. Feeding diet with LC significantly increased carcass dressing and total edible parts and decreased abdominal fat compared to the control. In conclusion: L- carnitine supplementation to broiler diets improved productive performance, economical efficiency, immune response and antioxidative properties of broiler.

Keywords: L-Carnitine, growth, blood parameters, lipid metabolism, Immunology, broilers .

INTRODUCTION

Poultry producers are looking for ways that allow greater growth and better feed conversion , as well as to decrease excessive abdominal and subcutaneous fat deposition (Waller, 2007). L-Carnitine, (β-hydroxy-γ-trimethylammonium butyrate) a zwitterionic compound, is a naturally occurring vitamin-like compound that acts as a carrier to transport long-chain fatty acids into mitochondria for β-oxidation (Bremer, 1983). Thus, L-Carnitine (LC) addition in diets lessens the measure of long-chain fatty acids availability for esterification to triacylglycerols and storage in fat tissue (Xu et al., 2003). Besides, the ability to avoid the catabolism of proteins to obtain energy by increased bringing the fatty acid into the mitochondria for oxidation. Thus, animals may have more protein energy available for growth as a result of feeding on diets with high content of LC (Dikel et al., 2010). Poultry diets consist of plant origin components such as ,corn and soybean and other plant products, which have low content of carnitine, whereas feedstuffs of animal origin is high in content of LC. The containment of poultry feed in high percentages of cereals can lead to carnitine deficiency (Baumgartner and Blum, 1997). Since , the addition of LC to diets or drinking water would be beneficial for poultry (Arslan et al., 2004). The important role of LC in lipid metabolism appears in the transfer of long chain fatty acids into the mitochondria for oxidation (Bremer, 1983).Several studies have showed that LC supplementation of broiler diets improved growth rate, feed conversion efficiency, breast and thigh meat yield and reduced abdominal fat in broilers(Abou-Zeid et al., 2007; Hossininzhad et al.,2011; Parsaeimehr et al., 2014; Zhang et al., 2014). Awad et al., (2016) found that dietary LC supplementation for Domyati ducklings could improve the productive and physiological performance, carcass traits and quality as well as economical efficiency during growth period. There are many studies confirmed the beneficial effect of LC in reducing serum lipid constitutes including total lipids , cholesterol and triglycerides(Xu et al.,2003; Hassan et al.,2011; Parsaeimehret al., 2012; Ardekanet al.,2012). Moreover, LC may work as an antioxidant to scavenge free radicals (Agarwal et al., 2005). DietaryLC had a positive effect in enhancing the humoral immune response (Mast et al.,2000; Geng et al., 2007; Hassan et al.,2011).

Therefore, the objectives of the present study were to investigate the effects of L-carnitine on growth performance, carcass composition, blood parameters as well as the lipid metabolism, immune response and antioxidative properties of broiler from day 7 to 35 of age.

MATERIALS AND METHODS

This study was conducted at the Poultry Research Unit (El-Bostan Farm), Department of Animal and Poultry Production, Faculty of Agriculture, Damanhour University, Damanhour, Egypt, from December 2016 to January 2017. Two hundred and eighty unsexed seven-day-old Cobb broiler chicks, obtained from a commercial hatchery, were randomly distributed into four groups, each group contain ten replicates (7 chicks per replicate) and reared on similar managerial conditions and were submitted to the following dietary treatments: the first group was fed a basal diet without any supplementation and

served as control, while the 2nd, 3rd and 4thgroups were fed basal diet supplemented with 50,100 and 150 mg LC / kg diet. The experimental diets were formulated according to NRC (1994) as shown in Table (1)..

Chicks were housed in battery brooders in semi-opened room equipped with two exhaust fans to keep normal ventilation. The averages of initial live BW at 7 days of age of different groups were nearly similar. All diets and water were available ad libitum. A light schedule similar to commercial conditions was applied until the 7th day being 23 h light followed by 20 h light from the 8th day until 3 days before slaughter test (35 days of age). Average air temperature of the animal chamber was maintained at approximately 33°C during the first week, then decreased gradually to get a constant temperature of 24°C during the rest of the experiment.

Chicks in each replicate were weighed (g) weekly between 7 and 35 d of age, and the BWG (g/chick) was calculated. Feed intake was recorded for each replicate (g/chick) and thereby FCR (g feed/g gain) was calculated. Production index (PI) was measured throughout the experimental period (7-35d of age), according to Attia et al. (2012) as follows :-

$$PI = \frac{BW\ (kg) \times SR}{PP \times FCR} \times 100$$ Where:

PI = Production Index.BW = Body weight (kg)

SR = Survival rate (100% - mortality)PP = Production Period (days)

FCR = Feed conversion (kg feed / kg gain)

Forty blood samples were taken at the time of slaughter for hematobiochemical analysis. The blood samples were divided into two parts, the 1stone was collected in heparinized tubes while the 2nd part was collected in non-heparinized tubes to obtain serum. Plasma and /or serum were separated by centrifugation of the blood at 3000 rpm for 20 minutes and stored at –20°C for later analysis. Biochemical indicators such as : Glucose, Urea, Creatinine, ALT, AST(U/L), Alkaline phosphatase, Total Lipids , Triglycerides, Cholesterol, HDL, LDL, Total antioxidant capacity (TAOC), glutathione peroxidase (GPX), glutathione (GSH), superoxide dismutase (SOD), T3, and T4 were determined by using available Commercial Kits .Hematological traits such as RBC's, Hemoglobin, PCV %,MCV,MCH, MCHC, WBC's, Lymphocytes, Monocytes, Basophils , Eosinophils، Heterophiles and Immune indices including Total protein, Albumin, Globulin, α , β,γ globulins , Lysozyme activity (LA), Bactericidal activity (BA), Lymphocyte transformation test (LTT), Phagocytic index (PI),Phagocytic activity (PA), immunoglobulins (IgY, IgM and IgA)) were measured as described previously by (ELnaggar et al., 2016).

Finally, samples of breast and thigh meat and experimental diets were chemically analyzed according to (AOAC, 2004). Breast and thigh total antioxidant capacity (TAOC) was determined by the ORAC assay (Cao and Prior, 1999).

Data obtained were analyzed using the GLM procedure (Statistical Analysis System (SAS, 2002) by one-way ANOVA using the following model:

$$Y_{ik} = \mu + T_i + e_{ik}$$

Where, Y is the dependent variable; μ is the general mean; T is the effect of experimental treatments; and e is the experimental random error. Before analysis, all percentages were subjected to logarithmic transformation ($\log_{10}x+1$) to normalize data distribution. The differences among means were determined using Duncan's new multiple range test(Duncan, 1955).

RESULTS

Broiler chickens Performance

The production performance, economical efficiency and production index of broilers fed diet supplemented with LC during days 7-35 of age are shown in Table 2. Supplementation of LC to diets significantly increased BW, BWG and improved FCR, economical efficiency and production index compared to the control. Where, Chicks fed basal diet supplemented with 50 mg of LC had significantly greater final BW and BWG and better FCR, economical efficiency and production index followed by those fed basal diet supplemented with 100 and 150 mg LC compared to the control group. On the other hand, chicks fed basal diet supplemented with 50 mg of LC had significantly lower FI during whole period followed by those fed basal diet supplemented with 100 and 150 mg LC compared to the control group.

Blood constituents

The biochemical blood serum constituents of broilers fed diets supplemented with LC are shown in Table 3. L-carnitine supplementation at all levels decreased urea, creatinine, AST and ALT compared to control group. Moreover, Urea, creatinine,AST and ALT were lower in chickens fed diet with 50 mg of LC than that in the other experimental groups. Chicks fed basal diet supplemented with LC had significantly lower total lipids, triglycerides, cholesterol, and LDL than the control group. Furthermore, total lipids, triglycerides, cholesterol, and LDL were lower in chickens on diet with 50 mg of LC than that in the others. Chicks fed basal diet supplemented with LC had significantly higher glucose,T3 and T4 compared to control group. Moreover, T3 was higher in chickens fed diet with 50 mg of LC than that in the other LC groups. Chicks fed basal diet supplemented with LC exhibited higher values of HDL, TAC, GPX , SOD and GSH than the control group. Moreover, HDL was lower and TAC was higher in chickens fed diet with 50 mg of LC than that in the other LC groups.

Feeding diet with LC significantly increased RBC's, hemoglobin, packed cell volume, WBC's and lymphocytes compared to control group and was higher ($P<0.05$) in chickens on diet with 50 mg of LC than that in the other experimental groups. No significant differences were recorded in MCV, MCH, MCHC, monocytes, basophils, eosinophils and heterophiles among the different groups.(Table 4).

Immunization parameters

Feeding diet with LC significantly increased total protein, globulin,α - globulin, globulin -β**,** globulin-γ and immunoglobulins (IgG, IgM and IgA) compared to control group whereas diet with 50 mg of LC gave higher values than the other groups.Moreover, Feeding diet with LC significantly increased lysozyme activity, bactriocide activity, lymphocyte transformation test, phagocytic activity and index compared to control diet whereas diet with 50 mg of LC shows higher value of lysozyme activity, bactriocide activity and lymphocyte transformation test, than the other experimental groups.(Table 5).

Carcass characteristics

L-carnitine supplementation at all levels increased percentage of carcass dressing and total edible parts and decreased abdominal fat compared to control group. Moreover, percentage of dressing and total edible parts were higher in chickens fed diet with 50 mg of LC than that in the others while, no significant effect was observed due to LC between different

groups with respect to the other studied body organs. Feeding diet with different levels of LC increased protein and TAC and decreased fat in meat compared to control group. However, Chicks fed basal diet supplemented with 50 mg of LC had significantly higher protein and TAC and lower fat in meat than other supplemented groups (Table 6).

DISCUSSION

Growth performance

Chicks fed basal diet supplemented with 50 mg of LC had significantly heavier BW and BWG and better FCR, economical efficiency and production index followed by those fed basal diet supplemented with 100 and 150 mg LC compared to the control group. Several reports reported that dietary LC improved BW and BWG of broilers (Abou-zeid et al., 2007 and Hossininzhad et al.,2011).Moreover, Celik et al. (2003) mentioned that, growth performance traits improved significantly with LC supplementation. The improvement in BWG caused by dietary LC supplementation may be partially explained by an increase in the concentration of plasma insulin-like growth factor-I, which has the potency to stimulate BWG (Xu et al., 2003). Also, it could be attributed to the improve in the utilization of dietary ingredients as a result of LC function in transferring the long-chain fatty acids across the inner mitochondrial membrane and controls the rate of β- oxidation of long-chain fatty acids as well as it plays a pivotal role in energy metabolism (Arslan, 2003). Similarity, Abdel-Fattah et al. (2014) showed that dietary supplementation of LC significantly increased live BW and cumulative BWGs for Japanese quail. Parsaeimehr et al. (2014) reported that dietary LC supplementation (300 mg/kg) had significantly improved BW and BWG for broilers. Also, Taklimi et al. (2015) found that bird's BWG significantly increased by supplementing LC in diet for broilers. Fallah and Mirzaei (2016) indicated that diet supplementation with LC increased ostrich chickens weight at 8 weeks of age in comparison to other treatment groups. Also, Awad et al. (2016) indicated that dietary LC supplementation resulted in a significant ($P \leq 0.01$) improvement in live BW of Domyatti ducklings at 63 and 84 day of age, while BWG were significantly ($P \leq 0.01$) improved as compared to the control group during the overall experimental period (21-84 day of age).

Feed Intake

The reduction in FI caused by dietary LC supplementation could be attributed to that birds are able to compensate their FI according to their energy requirements since the experimental diets had similar metabolizable energy (Awad et al., 2016). This result is similar to that of Bayram et al. (1999) who detected significant decreases in FI in quails fed diet supplemented with 500 mgLC /kg. Awad et al. (2016) indicated that feed consumption was significantly decreased by 6.21 % for ducklings fed diet supplemented with 150 LC/kg at the period of 21-42 day of age, while it was significantly decreased by 4.42% as a result of supplementing 450 mg LC/kg diet during the period of 63-84 day of age than those fed the control diet. However, Xu et al. (2003) reported that the supplementation of dietary LC did not affect FI of broilers and young turkeys. Besides, Muraliet al.(2015) reported that dietary LC (900 mg/kg diet) supplementation did not affect feed consumption in broilers during growing period (0-6 wks).

Feed conversion ratio

It is well kown that the improvement in FCR is associated with the decrease in FI and the increase in BWG of broiler chicks. So , chicks fed diet supplemented with LC recorded better FCR values than the control. The improvement in FCR in this study could be attributed to that LC enhances fatty acid burning, thus decreasing calorie requirements, as well as, it improves intestinal mucosal membrane by active and passive mechanisms (Fathi and Farahzadi, 2014). These results are similar with those obtained by Rabie et al.(1997a) and Abou-Zeid et al. (2007) who reported that adding LC to the diet of broiler chicks caused an improvement in FCR as compared to the control group fed diet without supplementation. Also, Denz and Turkmen, (2007) concluded that FCR was significantly improved by carnitine supplementation. Moreover, Ghods-Alavi et al. (2010) reported that FCR of white Leghorn hens was improved ($P<0.05$) when LC was supplemented, (50, 100, 150 mg/kg diet) to diets. Similarly, Hassan et al. (2011) and Hossininezhad et al. (2011), found that Ross-308 broiler strain fed 0, 50, 100, 150 and 200 mg/kg of LC from one-day showed significant improvement in FCR through the total period of the study ($P<0.05$). Ardekani et al. (2012) and Hajibabaei and Casey.(2012), reported that Black Neck ostrich chick fed diets containing 125 mg/kg of LC from one day to 60 days of age, showed the lowest FI and FCR responses over the total period, whereas there was no difference between control and 250 mg/kg of LC. Parsaeimehr et al. (2014) reported that dietary LC supplementation improved FCR of broilers during growing period (45 day). Also, Abdel- Fattah et al. (2014) reported that a significant improvement in FCR of quails was occurred as a result of dietary supplementation with LC than the control. Awad et al. (2016) indicated that FCR was improved for ducklings fed diets supplemented with different LC levels during different experimental periods with or without significance than those fed the control diet.

Production Index

The improvement in production index value caused by dietary LC supplementation could be attributed to that LC improves BWG and FCR as well as not increases FI during the overall experimental period. Also, it could be attributed to that LC has the ability to improve the use of dietary nitrogen, whether directly through sparing its precursors (methionine and lysine) for protein biosynthesis and other cellular functions or indirectly by optimizing the balance between essential and nonessential amino acids within the cell (Sarica et al. , 2005), which subsequently improved growth performance. These results are in agreement with those of Awad et al. (2016) who found that ducklings production index value was significantly higher for ducklings fed diet supplemented with LC as compared with those fed the control during the overall experimental period (21-84 day of age).

Economical efficiency

The improvement in economical efficiency caused by dietary LC supplementation could be attributed to that LC improve LBW as well as not increases FI during the overall experimental period. Similarity, Awad et al. (2016) reported that net return and economical efficiency for Domyatti ducklings were significantly higher by feeding diet supplemented with different LC levels than the control.

Blood constituents

Chicks fed basal diet supplemented with LC had significantly lower serum urea, creatinine, AST, ALT, total lipids, triglycerides, cholesterol, and LDL and higher values of glucose, HDL, TAC, GPX, SOD, GSH , T3 and T4 compared to control group.

There are a big number of studies confirmed the beneficial effect of LC in reducing serum lipid constitutes including total lipids, cholesterol and triglycerides(Xu et al.,2003; Hassan et al.,2011; Parsaeimehret al., 2012; Ardekan et al.,2012). The present results agree with those of Sanjay and Singh (2010) and Elgazzar et al.(2012) who found that dietary LC significantly decreased the serum concentration of AST and ALT enzymes. These findings also coincide with another study reporting that LC supplementation significantly decreases serum AST and ALT (Ahmed et al., 2010). Also, the results of Ardekani et al. (2012) indicated that supplementation of LC had significant ($P < 0.05$) decreasing effect on serum uric acid concentration in broilers. The results of Kheiri et al. (2011) indicated that LC (60 mg/kg) significantly ($p<0.05$) reduced blood urea nitrogen. Fallah and Mirzaei (2016) reported that supplementation with LC increased blood glucose concentration of ostrich chickens at 8 weeks of age and decreased uric acid concentrations in comparison to other treatment groups. On the otherhand , Cao et al. (2011) reported that there was an increase in plasma concentrations of glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), catalase and total antioxidative capacity due to LC administration. The decrease of serum triglycerides level for birds fed diets supplemented with LC probably related to increasing oxidation of fatty acids by increasing the transportation capacity of fatty acids to inner mitochondrial membrane (Shuenn et al., 2012). Also, it could be attributed to that LC increased the activity of lipase and decrease activity of lipoprotein lipase, thereby leading to a higher concentration of fatty acid in serum by accelerating hydrolysis of triglycerides to glycerol and fatty acids (Zhang et al., 2010). The reduction of serum total cholesterol by LC supplementation was attained mostly via a decrease of cholesteryl esters rather than by a decrease in free cholesterol. Moreover, it could be attributed to an increase in biliary sterol excretion or an increase in the conversion of cholesterol to bile acids (Maritza et al., 2006). Similarity, Xu et al. (2003) reported that adding LC to diet significantly decreased the level of serum triglycerides in broilers. Also, the results of Parsaeimehr et al. (2012) showed significant reduction in concentrations of cholesterol and LDL, due to supplementations of LC to diet. Fallah and Mirzaei (2016) and Awad et al. (2016) found that serum triglycerides and total cholesterol level were significantly decreased for ducklings fed diet supplemented with LC than those fed the control diet.

Chicks fed basal diet supplemented with LC had significantly increased RBC's, hemoglobin, packed cell volume, WBC's and lymphocytes compared to control group. Similarity, Jameel (2014) reported that RBCs count and hemoglobin content were increased for chicks fed diet supplemented 50 mg LC/ Kg as compared with those fed the control diet. Awad et al. (2016) reported that hemoglobin content and Lymphocyte cells (%) were significantly ($P\leq0.01$) increased for ducklings fed diets supplemented with LC than the control.

Immunization parameters

Feeding diet with LC significantly increased total protein, globulin, α - globulin, globulin -β, globulin-γ, immunoglobulins (IgG, IgM and IgA), lysozyme activity, bactriocide activity, lymphocyte transformation test, phagocytic activity and index compared to control group. Dietary LC had a positive effect in enhancing the humoral immune response (Mast et al.,2000; Geng et al., 2007; Hassan et al.,2011). Also, Mast et al. (2000) reported that dietary LC 100 mg/kg diet supplementation appeared to be beneficial in enhancing specific humoral responses to vaccination in broilers. Geng et al. (2007) showed that serum IgG was improved by LC supplementation by using levels of 75 and 100 mg /kg dietSimilarly, Hassan et al. (2011) noted that using LC significantly increased antibody titters against both avian Newcastle and Influenza diseases compared with control and the relative weights of spleen and thymus were significantly increased by using LC compared with control group. Also, Jalali et al. (2015) reported that LC supplementation significantly increased total protein, globulin and antibody titer against Newcastle disease in broiler chicks.

Carcass characteristics

Feeding diet with LC significantly increased carcass dressing and total edible parts and decreased abdominal fat compared to the control. The improvement of eviscerated carcass and total edible parts percentage could be attributed to improving the final live weight and decreasing un-edible parts as a result of supplementing LC to the diet. The current findings are in agreement with those obtained by Ibrahiem et al. (2011) who reported that carcass percentage of geese was significantly ($P \leq 0.05$) improved by supplementing 150 mg LC /kg diet as compared to the control group. Oladele et al. (2011) found that dressing percentage significantly ($P \leq 0.05$) increased with increasing inclusion levels of LC in broiler diets. Also, Abdel- Fattah et al. (2014) showed that supplemental LC (400 mg/kg diet) significantly increased the dressing percent of quails. Awad et al. (2016) revealed that eviscerated carcass and total edible (%) for ducklings were significantly improved, while abdominal fat (%) was significantly decreased by supplementing different LC levels to the diets as compared to the control. The results of Hossininezhad et al. (2011) showed that the percentages of carcass, thigh, breast and back percentage were significantly increased with including LC in the diet. Fat percentage decreased when LC levels increased. One of the major findings of the present study is that a significant ($P < 0.001$) reduction in abdominal fat percentage was observed due to addition of LC in the diet. One of the most important effects of dietary LC is its vital role in reducing the abdominal fat content (Rabie et al., 1997a,b; Xu et al., 2003; Hassan et al.,2011; Kheiril et al., 2011). The same results were obtained by Rabie et al. (1997 a and b), as they indicated that abdominal fat contents either expressed as absolute weight or as percentage of BW of broiler chicks were significantly reduced in response to added dietary LC, irrespective to the level of supplementation. The decrease of abdominal fat could be attributed to that LC prevents fatty tissue buildup, decreases the calorie requirement and increases the tolerance to effort because it may plays a major role to facilitate the removal of short and medium-chain fatty acids from the mitochondria that accumulate as a result of normal and abnormal metabolism and

promotes the β-oxidation of these fatty acids in order to generate adenosine triphosphate (ATP) energy and improve energy utilization by reducing the amount of long- chain fatty acids availability for esterification to triacylglycerols and storage in the adipose tissue (Xu et al. 2003).These results are similar to that of Parsaeimehr et al. (2014) who found that supplementing LC (300 mg/kg) significantly reduced abdominal fat percentage of broilers.

Feeding diet with different levels of LC increased protein and TAC and decreased fat in meat compared to control group. These results could be attributed to that LC may acts to decrease the total activities of glucose-6 phosphate dehydrogenase, malic dehydrogenase, iso-citrate dehydrogenase and lipoprotein lipase and total activities of carnitine palmitoyltransferase-I in breast muscles (Xu et al., 2003). Or, it accelerate lipid flux into oxidative metabolism , and consequently reduce the body lipid accumulation (Shuenn et al., 2012). In this connection , Awad et al. (2016) revealed that crude protein and ether extract content (%) for breast and thigh muscles were significantly higher by LC supplementation than the control.

IN CONCLUSION

L- carnitine supplementation at 50, 100 and 150 mg/kg of deit improved productive performance, production index , economical efficiency , immune response and antioxidative properties , without any adverse effects on blood components of broiler chicken . However, the level of 50 mg/kg diet was the best .

Table (1): Ingredients and analyzed composition of the starter-grower diet fed during 1-28 days of age and finisher diet fed during 29-35 days of age as fed basis (%)

Ingredients	Diets % as fed	
	Starter-grower	Finisher
Maize	51.3	51.9
Rye	0.00	5.00
Soybean meal (44% CP)	32.8	24.4
Vegetable oil	2.25	2.00
Full fat soybean meal	10.0	13.0
Dicalcium phosphate	1.80	1.60
Limestone	1.00	1.00
L-Lysine HCl	0.10	0.15
DL-Methionine	0.15	0.20
Vit+min premix*	0.30	0.30
NaCl	0.30	0.45
Total	100	100
Determined[1] and calculated[2] composition (% as fed basis)		
Dry matter[1]	89.15	88.85
ME (kcal/kg)[2]	3042	3103
Crude protein[1]	22.8	21.2
Lysine[2]	1.33	1.23
Methionine[2]	0.50	0.52
Meth+cysteine[2]	0.87	0.87
Ash[1]	5.41	5.76
Calcium	0.91	0.85
Available phosphorus[2]	0.46	0.41
Ether extract[1]	6.42	6.68
Crude fiber[1]	3.55	4.48

*Vit+Min mix. provides per kilogram of the diet: Vit. A, 12000 IU, vit. E (dl-α-tocopheryl acetate) 20 mg, menadione 2.3 mg, Vit. D3, 2200 ICU, riboflavin 5.5 mg, calcium pantothenate 12 mg, nicotinic acid 50 mg, Choline 250 mg, vit. B_{12} 10 µg, vit. B_6 3 mg, thiamine 3 mg, folic acid 1 mg, d-biotin 0.05 mg. Trace minerals (mg/ kg of diet): Mn 80 Zn 60, Fe 35, Cu 8, and Selenium 0.1 mg.

Table (2): Effect of different levels of L-carnitine (L-Car) on production performance, economical efficiency and production index of broiler chickens

Items	**Control**	**50 mg L-Car**	**100 mg L-Car**	**150 mg L-Car**	**SEM**	**Sig**
Live body weight (g) at:						
7 d	146	152	146	142	3.13	0.464
21	819^{b}	873^{a}	881^{a}	853^{a}	10.1	0.001
35 d	1772^{c}	2029^{a}	1940^{b}	1941^{b}	17.52	0.0007
Body weight gain (g) from:						
7-21d	672^{b}	721^{a}	735^{a}	711^{a}	8.47	0.001
22-35d	954^{c}	1156^{a}	1059^{b}	1088^{b}	13.96	0.0002
7-35d	1626^{c}	1876^{a}	1793^{b}	1799^{b}	16.63	0.0007
Feed intake (g/day) from:						
7-21d	1272^{a}	1121^{c}	1165^{b}	1249^{a}	10.46	0.004
22-35d	1896^{b}	1650^{c}	1919^{a}	1827^{b}	25.59	0.001
7-35d	3168^{a}	2771^{c}	3084^{b}	3076^{b}	27.01	0.009
Feed conversion ratio(g feed/g gain) from age:						
7-21d	1.89^{a}	1.56^{c}	1.59^{c}	1.76^{b}	0.027	0.006
22-35d	1.99^{a}	1.43^{d}	1.82^{b}	1.68^{c}	0.038	0.001
7-35d	1.95^{a}	1.48^{c}	1.70^{b}	1.71^{b}	16.63	0.0007
Economical efficiency and production index:						
Economical efficiency	9.78^{c}	33.3^{a}	16.7^{b}	14.4^{b}	1.62	0.0001
Production index	260^{c}	393^{a}	323^{b}	325^{b}	8.58	0.0011

^{a,b} Values within a row with different superscripts differ significantly at P<0.05.
SEM, Standard error of mean's

Table(3): Biochemical constituents of blood serum of broiler chickens fed diet supplemented with different levels of L-carnitine (L-Car).

Items	Control	50 mg L-Car	100 mg L-Car	150 mg L- Car	SEM	Sig
Urea (mg/dl)	28.7[a]	22.0[c]	24.0[b]	25.7[b]	0.585	0.0076
Creatinine (mg/dl)	0.967[a]	0.690[c]	0.800[b]	0.807[b]	0.034	0.0240
Urea/ Crea	33.4	32.8	31.9	36.6	1.532	0.0925
AST(U/L)	64.3[a]	54.3[c]	59.0[b]	58.3[b]	0.758	0.0010
ALT (U/L)	67.0[a]	58.0[c]	60.3[b]	60.8[b]	0.376	0.0001
ALT/AST	1.10	1.12	1.16	1.11	0.020	0.2337
Glucose(mg/dl)	144[b]	149[a]	150[a]	150[a]	2.297	0.024
T.Lipids(mg/dl)	435[a]	366[c]	396[b]	378[c]	6.275	0.002
Triglycerides(mg/dl)	193[a]	187[c]	187[b]	186[b]	0.913	0.0072
Cholesterol (mg/dl)	196[a]	183[c]	188[b]	189[b]	1.149	0.003
HDL(mg/dl)	34.3[c]	42.0[b]	44.7[a]	46.0[a]	.601	0.002
LDL(mg/dl)	123[a]	105[c]	108[b]	106[bc]	1.071	0.001
T3(ng / ml)	2.18[c]	2.34[a]	2.24[b]	2.27[b]	0.013	0.0022
T4(ng / ml)	6.82[c]	8.77[a]	8.92[a]	8.32[b]	.144	0.001
TAC	416[c]	431[a]	422[b]	423[b]	0.683	0.0004
GPX (U/dl)	0.373[b]	0.486[a]	0.463[a]	0.463[a]	0.007	0.0011
GSH (U/dl)	981[b]	1000[a]	996[a]	998[a]	1.765	0.0037
SOD (U/dl)	234[b]	253[a]	254[a]	257[a]	0.707	0.0002

[a,b] Values within a row with different superscripts differ significantly at P<0.05.

SEM, Standard error of mean's; AST=aspartate amino transferase; ALT=alanine amino transferase; HDL=high-density lipoprotein; LDL=low-density lipoprotein; T3= triiodothyronine; T4=thyroxine; TAC=total antioxidant capacity; GPX =glutathione peroxidase; GSH= glutathione; SOD=superoxide dismutase

Table(4): Blood hematological of broiler chickens fed diet supplemented with different levels of L-carnitine (L-Car).

Items	**Control**	**50 mg L-Car**	**100 mg L-Car**	**150 mg L- Car**	**SEM**	**Sig**
RBC's (10^6/mm^3)	1.30^c	1.63^a	1.50^b	1.53^b	0.030	0.0078
Hemoglobin (g/100ml)	10.6^c	14.0^a	11.6^b	11.3^b	0.224	0.0074
PCV %	29.0^c	38.0^a	33.0^b	34.0^b	0.316	0.0027
MCV	82.1	79.6	84.7	80.6	1.844	0.2742
MCH (Ug)	82.1	79.6	84.7	80.6	1.844	0.2742
MCHC (%)	33.3	35.1	35.1	36.2	0.535	0.0900
WBC's (10^3/mm^3)	21.0^b	23.3^a	23.0^a	22.3^a	0.342	0.0009
Lymphocytes (%)	29.3^c	37.3^a	33.3^b	34.3^b	0.428	0.0001
Monocytes (%)	15.7	16.6	15.0	14.3	0.224	0.0812
Basophils, (%)	0.678	0.999	1.00	1.33	0.129	0.0814
Eosinophils, (%)	14.3	16.3	15.6	17.0	0.224	0.0722
Heterophils, (%)	30.7	37. 3	34.0	33.0	0.713	0.0901

^{a,b} Values within a row with different superscripts differ significantly at $P<0.05$.
SEM, Standard error of mean's; RBC's=red blood cell; PCV=packed cell volume; MCH=mean corpuscular hemoglobin; WBC's=white blood cell

Table(5): Immune indices of broiler chickens fed diet supplemented with different levels of L-carnitine (L-Car).

Items	**Control**	**50 mg L-Car**	**100 mg L-Car**	**150 mg L-Car**	**SEM**	**Sig**
Total protein(g/dl)	5.20^{c}	6.10^{a}	5.86^{b}	5.80^{b}	0.058	0.0004
Albumin(g/dl)	3.30	2.90	2.77	3.10	0.029	0.0903
Globulin(g/dl)	1.87^{c}	3.20^{a}	2.90^{b}	2.70^{b}	0.066	0.0001
A/G ratio	1.82^{a}	0.906^{c}	0.825^{c}	1.16^{b}	0.032	0.0007
α –globulin(g/dl)	0.833^{c}	1.35^{a}	1.17^{b}	1.19^{b}	0.023	0.0003
globulin –β(g/dl)	0.887^{c}	1.30^{a}	1.16^{b}	1.11^{b}	0.045	0.0002
Globulin –γ(g/dl)	0.147^{c}	0.863^{a}	0.613^{b}	0.567^{b}	0.060	0.0021
LA (IU %)	0.120^{c}	0.187^{a}	0.1667^{b}	0.153^{b}	0.003	0.0004
BA (%)	37.0^{c}	43.6^{a}	42.0^{b}	41.3^{a}	0.408	0.0030
LTT(%)	24.3^{c}	33.3^{a}	27.0^{b}	28.6^{b}	0.500	0.0070
PI (%)	1.46^{b}	1.73^{a}	1.66^{a}	1.66^{a}	0.029	0.0045
PA (%)	17.0^{b}	20.6^{a}	20.0^{a}	20.6^{a}	0.258	0.0043
IgA(mg/100 ml)	73.3^{c}	82.7^{a}	77.7^{b}	76.3^{b}	0.796	0.0037
IgM(mg/100 ml)	226^{c}	253^{a}	244^{b}	240^{b}	0.908	0.0024
IgG(mg/100 ml)	944^{c}	985^{a}	965^{b}	953^{b}	0.837	0.0001

^{a,b} Values within a row with different superscripts differ significantly at $P<0.05$.

SEM, Standard error of mean's; LA= lysozyme activity; BA=bactriocide activity ; LTT=lymphocyte transformation test; PI=phagocytic index; PA =phagocytic activity

Table (6): Carcass characteristics and relative weight of immune organs and Chemical composition of meat of Cobb broiler chickens fed diet supplemented with different levels of L-carnitine (L-Car).

Items	Control	50 mg L-Car	100 mg L-Car	150 mg L- Car	SEM	Sig
Carcass characteristics						
Dressing, %	71.9^{c}	84.1^{a}	76.5^{b}	78.3^{b}	1.768	0.002
Total edible parts, %	72.4^{c}	89.2^{a}	81.8^{b}	82.7^{b}	1.93	0.001
Abdominal fat, %	0.959^{a}	0.508^{b}	0.549^{b}	0.460^{b}	0.051	0.0001
liver %	2.54	2.12	2.38	1.85	0.228	0.199
gizzard %	1.43	1.46	1.35	1.18	0.067	0.09
heart %	0.485	0.505	0.484	0.448	0.014	0.078
Pancreas %	0.178	0.145	0.173	0.14	0.021	0.505
Proventriculus %	0.291	0.288	0.265	0.265	0.013	0.366
Intestinal length %	7.72	7.59	7.68	7.81	0.437	0.986
Intestinal Weight %	5.07	4.35	4.26	5.87	0.238	0.089
Immune organs						
Spleen %	0.065	0.087	0.083	0.08	0.003	0.0708
Bursa %	0.051	0.042	0.04	0.038	0.003	0.096
Thymus%	0.392	0.42	0.368	0.363	0.015	0.088
Chemical composition of meat						
Protein	21.0^{c}	29.0^{a}	26.0^{b}	25.0^{b}	1.492	0.008
Lipid	2.98^{a}	2.00^{c}	2.30^{b}	2.41^{b}	0.135	0.007
Ash	12.9	11.9	11.8	11.9	0.695	0.658
Fiber	1.5	1.4	1.4	1.3	0.08	0.425
TAOC	415^{c}	473^{a}	446^{b}	449^{b}	24.898	0.008

^{a,b} Values within a row with different superscripts differ significantly at $P<0.05$.
SEM, Standard error of mean's; TAOC=total antioxidant capacity

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الملخص العربى

تأثير ل- كارنيتين علي الأداء الإنتاجي وقياسات الدم وميتابولزم الدهون والمناعة والخصائص المضادة للأكسدة في دجاج اللحم

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هدفت الدراسة لتقييم تأثير ل- كارنيتين على الأداء الإنتاجي وصفات الذبيحة وخصائص الدم وميتابولزم الدهون والاستجابة المناعية والخصائص المضادة للأكسدة لكتاكيت اللحم من 7 – 35 يوم من العمر. تم استخدام عدد 280 كتكوت (كب) عمر 7 ايام تم تقسيمها بالتساوي عشوائيا الى أربع مجموعات تجريبية. تغذت المجموعة الأولى على العليقة الأساسية بدون أي إضافة (كنترول) ، بينما تغذت المجاميع التجريبية الأخرى على العليقة الأساسية مضاف إليها 50 و 100 و 150 مجم من ل- كارنيتين لكل كجم عليقة. أدت إضافة ل- كارنيتين للعليقة لزيادة معنوية في وزن الجسم والزيادة في وزن الجسم وخفض كمية العلف المأكول وتحسن معامل التحويل الغذائى والكفاءة الاقتصادية ودليل الإنتاج . سجلت الدجاجات المغذاه على العليقة الأساسية مضاف إليها 50 مجم من ل- كارنيتين لكل كجم عليقة أعلى القيم لكل من وزن الجسم النهائي والزيادة في وزن الجسم وأقل علف مأكول وأفضل معامل تحويل غذائي وكفاءة اقتصادية ودليل انتاج تليها المجموعة التي تغذت على العليقة الأساسية مضاف إليها 100 و150 مجم من ل- كارنيتين لكل كجم عليقة مقارنة مع المجموعة الكنترول. أدت التغذية على ل- كارنيتين إلى انخفاض معنويا في تركيز يوريا السيرم و الكرياتينين ونشاط إنزيم ناقل الألانين (ALT) ونشاط إنزيم ناقل الأسبارتات (AST) والدهون الكلية والدهون الثلاثية والكوليسترول والكولسترول منخفض الكثافة (LDL) ، في حين أدت الي زيادة تركيزالجلوكوزوالكولسترول عالي الكثافة (HDL) والبروتين الكلي ونشاط إنزيمات الأكسدة TAC وGPX و SODوهرمون T3 وهرمون T4 والجلوتاثيون والهيموجلوبين وحجم كرات الدم الحمراء وكرات الدم الحمراء وكرات الدم البيضاء وكرات الدم البيضاء الليمفاوية والجلوبيولين والألفا والبيتا والجاما جلوبيولين والجلوبيولينات المناعية (IgY - IgM - IgA) ومعامل تحويل الخلايا الليمفاوية (LTT) ونشاط مقاومة البكتريا والنشاط البلعمي ودليل النشاط البلعمي مقارنة بمجموعة الكنترول. أدت التغذية على عليقة تحتوي ل- كارنيتين إلى زيادة معنوية في نسبة التصافي والأجزاء المأكولة و خفض الدهون في منطقة البطن مقارنة بمجموعة الكنترول

الخلاصة: بناء على النتائج السابقة وتحت ظروف التجربة إتضح أن إضافة ل- كارنيتين لعلائق دجاج اللحم يمكن أن يحسن الأداء الإنتاجي والكفاءة الاقتصادية والإستجابة المناعية والخصائص المضادة للأكسدة في كتاكيت اللحم .