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Research Article

Effect of L-carnitine and α-Lipoc Acid on Productve Performance and Physiological Status of Broilers

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Abstract:

The current study was conducted to evaluate the effect of l-carnitine and alpha lipoic acid as feed additives on the production and carcass characteristics of broilers. Total number of 180 one-day-old commercial broiler chicks was used. The broiler chicks were randomly distributed into four equal groups, each with 3 replicates, each with 15 chicks raised on the ground. An experimental diet containing 3000 kcal as representative energy and 23 crude proteins was used during the starter period from one day to 21 days of age, while 3100 kcal as representative energy and 21 crude proteins were used during the starter period until 35 days of age. One of the experimental groups was used as a control without any addition, and the other three groups were fed the supplemented diet with 25 mg l- carnitine or 75 mg alpha-lipoic and 25mg l- carnitine + 75 mg alpha-lipoic acid /kg diet respectively. The obtained results showed that, body weight and feed conversion ratio recorded a significant improvement in birds fed a 25mg l-carnitine/kg diet followed by those fed the mix of l-carnitine and alpha-lipoic acid containing diet, then 75 mg alpha-lipoic acid / kg diet. At the end of the experiment period, there was no significant difference in the relative weight of the carcass and total edible parts in the birds that fed the additives containing diet and the control. However, it was explained that the weight of abdominal fat was significantly ($p \leq 0.05$) decreased when using feed additives compared to the control. Conclusively, it may be concluded that supplementing of l-carnitine (25 mg/ kg), alpha-lipoic (75 mg/ kg) or their mix to broiler chicks' diets could improve productive performance

1. Introduction

Poultry producers are looking for strategies to increase development and feed conversion while decreasing excessive belly and subcutaneous fat deposition, a waste product, for consumers who are becoming increasingly concerned about the nutritional and health elements of their meals. In modern poultry production, a variety of feed additives are frequently used to maintain optimal health, metabolic condition, and performance indices in farm animals. Antioxidants (e.g. L-carnitine) and organic acids (e.g. α-lipoic acid) are two of the most important and widely used. L- carnitine (LC) (L-Trimethyl-3-hydroxyaminobutanoate) is a pseudo vitamin and distorted amino acid identified in 1927 after being isolated from muscle tissues in 1905 (Azizi-chekosari et al., 2021). Poultry diets consist of plant origin components such as corn and soybean and other plant products, which have a low content of carnitine, whereas feedstuffs of animal origin are high in content of l-carnitine (LC) (El-Kelawy and El-Naggar et al., 2017). L- carnitine is reported to have two major functions; facilitating the transport of long-chain fatty acids across the mitochondrial membrane and the removal from mitochondria of short- and medium-chain fatty acids that accumulate as a result of normal and abnormal metabolism (Rehman et al., 2017). So, dietary l-carnitine (LC) supplementation promotes the β-oxidation of these fatty acids to generate adenosine triphosphate (ATP) and improves energy utilization (Madsen et al., 2018). In addition, it participates in biological processes, for example, regulation of gluconeogenesis, stimulation of fatty acid synthesis and ketone, branched-chain amino acid, triglyceride, and cholesterol metabolism (Maruyama et al., 2019). L- carnitine therapy is also a reasonable approach for reducing systemic inflammation and its complications (Khalatbari -Soltani and Tabibi, 2015).

The use of LC in poultry feed helps increase energy efficiency so that poultry can more quickly and easily obtain the energy they need from dietary lipids. Positive effects of LC on reducing feed intake (Khatibjoo et al., 2016 and Mirzapor et al., 2016), live weight gain (Kidd et al., 2009), increased final weight, improved feed conversion ratio, improved carcass characteristics (Hrnčár et al., 2015) and reduced abdominal fat (Babazadeh Aghdam et al., 2015) have been reported for poultry. For all the previous reasons, the addition of LC to diets or drinking water would be beneficial for poultry.

Regarding, alpha-lipoic acid (α-LA), also known as 1,2-dithiolane-3-valeric acid, with the molecular formula $C_8H_{14}O_2S_2$, was first isolated from pig liver (Reed et al., 1951). It is a naturally occurring compound found in microorganisms, plants, and animals, and is considered to be an "ideal antioxidant" or "universal antioxidant" because of its strong antioxidant capacity (Ou et al., 2023). Lipoic acid (LA), is naturally present in broccoli, collards, spinach, beef, and organ meats as a dithiol compound derived from octanoic acid, is a fatty acid that functions as a cofactor in vital energy-producing reactions and thus plays a major role in energy metabolism. Many researchers evaluated the effects of dietary α-LA supplementation on broiler performance (Yoo et al., 2016; Lu et al., 2017a and El-Rayes, 2020). Various studies have shown the body weight, weight gain and feed intake of broiler chicks were significantly decreased by increasing the supplementation level of α-LA (Arshad et al., 2013 and Zhang et al., 2014). In the opposite direction, Yoo et al. (2016) and Lu et al. (2017a) reported that body weight, weight gain and feed conversion ratio were significantly improved by α lipoic acid (α-LA) supplementation.

Therefore, the current study was designed to track the effects of l-carnitine, lipoic acid supplementation, and their mixture on productive performance and carcass traits of broiler chicks.

2. Materials and Methods

The Present study was carried out at a private poultry farm under the supervision of the Animal Production Department, Faculty of Agriculture, Tanta University, during the period from December 2022 to February 2023. A total of one hundred and eighty (180) day-old unsexed Cobb chicks were obtained from commercial hatchery, individually weighed and signed randomly to four equal experimental groups of 45 birds each. Birds of each group were further subdivided into three replicates of 15 birds each and housed in floor pens. Feed and water were available for chicks ad-libitum during the experimental periods. All chicks were kept under the same managerial, hygienic and environmental conditions, throughout the entire experimental period that lasted for 5 weeks.

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

Ingredients	Periods		
	Starter diet %	Grower diet %	Finisher diet %
Yellow corn	56.5	59.8	58.64
Soybean meal (44 %CP)	28.3	25.5	30.80
Corn gluten meal (62 % CP)	10.00	8.5	2.52
Vegetable oil	1.5	2.5	4.88
Di-calcium phosphate	1.7	1.7	1.16
Limestone	1.2	1.2	1.30
Dl-Methionine	0.1	0.1	0.1
L-lysine	0.1	0.1	_
Salts (Nacl)	0.3	0.3	0.3
Premix	0.3	0.3	0.3
Total	100.00	100.00	100.00
Calculated analysis :			
Crude protein (CP %)	23.06	21.1	20.05
Metabolizable energy (kcal/kg)	3010	3106	3200
Ether extract (EE %)	2.773	2.846	2.50
Crude fiber (CF %)	3.554	3.409	3.50
Calcium (%)	1.143	0.949	0.90
Available phosphorus (%)	0.469	0.463	0.35
Lysine(%)	1.148	0.981	1.00
Methionine (%)	0.55	0.520	0.43
Methionine + cystine (%)	0.855	0.789	0.77

A basal corn-soy bean diet was formulated to contain 23 % crude protein and 3000 Kcal ME/kg diet during the starter period till 21 days followed by 21 % crude protein and 3100 Kcal ME/kg diet till 35 days of age (Table 1). The experimental diet was supplemented with some natural feed additives, such as L- carnitine, alpha lipoic acid, or a mixture of them. One of the 4 experimental groups was fed a basal diet as a control group (T1) while, the second and third groups were fed the basal diet supplemented with 25mg/kg L- carnitine(T2), 75mg alpha lipoic/ kg diets (T3), also group 4 was fed basal diets supplemented with the mixture of 25mg l-carnitine +75 mg α-lipoic acid /kg diets respectively. Birds were individually weighed (g) weekly in the morning before being fed during experimental periods. Weight gain was calculated by subtraction of the initial body weight in a certain week from the final body weight in the same period. Feed consumed was recorded every day, according to the replica feeding system. The average daily feed intake(g) per bird was calculated by dividing the consumed by group on chick numbers. Feed conversion was calculated in the form of units of feed intake required to produce a unit of live body weight gain. At the end of the trial, 6 chicks from each group were sacrificed, scalded, de- feathered, and carcasses were eviscerated. Data on dressing yields and weights of eviscerated carcasses, lymphoid organs and abdominal fat pads were collected. The heart, gizzard and liver were excised and weighed. The head, neck, and feet were removed. The carcass yield percentage was calculated by dividing the carcass weight by the live body weight (BW) of birds multiplied by 100 Lymphoid organs (thymus, bursa and spleen) were dissected and their weights were recorded and then expressed as percentages to live body weight.

Statistical analyses were conducted using SPSS (version 26 IBM SPSS Statistics Inc., Chicago. USA). A significant difference between groups was determined using the Duncan multiple range test (Duncan, 1955) test for post -hoc comparison. Differences were considered significant (p≤0.05).

3. Results and discussion

performance traits

Growth performance of broiler chicks as influenced by l-carnitine, alpha lipoic or their mixture is illustrated in Table (2). The initial body weight of all chicks' groups was nearly (p≤0.05) similar (41.24, 41.87, 41.73, and 41.89 g) indicating that birds were randomly distributed into the experimental treatment groups. From the data, it can be noticed that weekly live body weights of broiler chicks during the starter period were not significantly (P>0.05) affected by either l-carnitine, alpha lipoic or their mixture containing diets except the first week of age, recorded a significant increased with feed additive supplementation compared to control. Generally, at the end of the starter period, live body weight values (923.7 and 926.7 g) were insignificantly increased for birds fed dietary T3 and T4 compared to 899.3g and 891.4 g for those fed control diet and T2, respectively. It can be observed , also, body weight of birds during 4 weeks was not significantly (P>0.05) affected by dietary treatments .On the other hand , at the end of 5 weeks of age, the significantly highest (P<0.05) body weight values were 2330.40g of groups fed dietary T2 followed by 2330.40 of those fed dietary T4, then 2282.05g of birds fed dietary T3 compared to 2138.86 g of those fed control diet , respectively. At all events, at the end of experimental periods (35 days of the age) chicks fed dietary T2 and T4 yielded a significantly heavier body weight by 8.9% and 8.2% followed by 6.96% of those fed dietary T3 when compared to the control group, respectively.

The present data (Table 3) revealed that weekly body weight gain during the starter period was not significantly (P>0.05) affected by dietary treatments except during the third week of age. At the end of 3 weeks of age broiler chicks fed dietary T4and T3 gained 508.65and 505.91 g more (P<0.05) than 492.46 g of these fed control basal diet. Also, throughout the starter period, total body weight gain was significantly affected by dietary treatments, whereas the highest (P<0.05) body weight gain values were 884.83and 882.00g of bird groups fed dietary T4 and T3 compared to others, indicating that α-lipoic acid and the mixture of l-carnitine and α-lipoic acid were more influential in this period to achieve superior weight gain of broiler chicks. The same trend was observed during the growing period, weekly and total body weight gain were significantly (P<0.05) affected by dietary treatments. Whereas at the fourth week of age a significantly (P<0.05) highest body gain value was 686.3 g of birds fed dietary T4 followed by, 668.57 and 656.51 g of those fed dietary T2 and T3 compared to 641.76 g of these fed control basal diet (T1), respectively. Also, at 5 weeks of age, the highest body weight gain value was 701.62g recorded by birds fed dietary T4 followed by 701.81and 770.38g of birds fed dietary T3and T2 compared to 597.81g of those fed control diet, respectively. At all events, weight gain over all experiment period was significantly (P<0.05) effected by dietary treatment, whereas the highest values were 2288.53g recorded by birds fed dietary l-carnitine (T2) followed by 2272.75g yielded by those fed mixture of l-carnitine and α-lipoic acid (T4) and 2240.32g of birds fed α-lipoic acid alone compared to 2097.6g of those fed control diets respectively. It can be summarized that total body weight gain improved by 9.1%, 6.8% and 8.34% of birds as a result of birds fed dietary T2, T4 and T3 compared to control, respectively. Indicating that l-carnitine, lipoic acid and their mixture were succeeding as neutral feed additives of broiler diet without any adverse effects. The improvement of live body weight may indicate that, if anti-nutritional factors are presented in l-carnitine or alpha lipoic acid they are ineffective. The obtained results confirmed other studies by Fathi and Farahzadi (2014) showed that l-carnitine improves the intestinal mucosa. The increase in body weight is due to the fact that L-carnitine works to transport long-chain fatty acids across the inner membrane of the mitochondria and controls the rate of oxidation of fatty acids as well. It also plays a role in energy metabolism (Arslan et al., 2003). Also it works to increase the concentration of insulin-like growth factor-I, in plasma, which can stimulate an increase in body weight gain, but when additive l-carnitine by low amount due to no significant (Xu et al., 2003) this opinion is similar to Tufarelli et al. (2020) and the increase in body weight when additive lipoic acid because It regulates energy metabolism as it is an integral part of mitochondria (Bai et al., 2012). It is also an antioxidant that acts as a coenzyme in the metabolism of carbohydrates in broiler chickens (Packer et al., 2001). These results agreed with Sakr et al. (2020) and Lu et al. (2017b). On another hand, Ou et al. (2023) and El-Rayes et al. (2020) found that body weight was decreased by supplementation of lipoic acid. The mixture of materials showed the same trend. This agrees with Ou et al (2023). On another hand, some researchers disagree with them and they found that no significant effects on body weight gain by supplemented lipoic acid such as El-Rayes et al. (2020), Mourad et al. (2020), Elsaadawi et al. (2022) and Preza-Montiel et al., 2021.

Table (2): Effect of dietary treatments on the body weights of broilers during the experimental periods:

Treatments / Age	T1	T2	T3	T4	Sig
Body weight at starter period:					
Initial BW	41.24±0.16	41.87±0.15	41.73±0.16	41.89±0.15	NS
1 week	132.93±2.85 c	138.27±3.08 b	137.70±3.32 b	143.12±4.03 a	*
2 weeks	406.83±21.93	413.63±8.45	417.82±8.18	418.07±8.91	NS
3 weeks	899.29±21.93	891.45±19.32	923.73±13.44	926.72±15.99	NS
Body weight at growing period:					
4 weeks	1541.05±32.69	1560.02±38.22	1580.24±25.59	1613.02±31.89	NS
5 weeks	2138.86±25.64b	2330.40±40.23a	2282.05±30.69a	2314.64±34.91a	***

BW= Body weight, T1= control, T2= 25 mg L-carnitine/ kg diet, T3= 75 mg alpha lipoic acid/ kg diet, T4= 25 mg L-carnitine + 75 mg alpha lipoic acid/ kg diet,

a, b means within the raw with different superscripts are significantly different (P≤0.05), Sig= Significant, NS = non-significant, * =(p≤0.05), ***=(p≤0.001).

Table (3): Effect of dietary treatments on the body weight gain of broilers during the experimental periods

Treatments / Interval	T1	T2	T3	T4	Sig
Body weight gain at starter period					
0-1 week	93.69±1.15	96.4±2.30	95.97±0.86	101.23±2.43	NS
1-2 weeks	273.9±1.73	275.36±0.57	280.12±1.58	274.95±2.07	NS
2-3 weeks	492.46±2.88b	477.82±1.73c	505.91±2.02a	508.65±1.29a	**
0-3 weeks	858.05±2.30b	849.58±4.61b	882.00±1.74a	884.83±2.47a	**
Body weight gain at growing period					
3- 4 weeks	641.76±1.15d	668.57±4.33b	656.51±2.65c	686.30±1.28a	**
4- 5 weeks	597.81±4.04c	770.38±1.58b	701.81±3.17a	701.62±2.59a	**
3-5 weeks	2097.62±1.73d	2288.53±2.16a	2240.32±2.07c	2272.75±1.70b	**

T1= control, T2= 25 mg L-carnitine/ kg diet, T3= 75 mg alpha lipoic acid/ kg diet, T4= 25 mg L-carnitine + 75 mg alpha lipoic acid/ kg diet,

a, b, c: means within the raw with different superscripts are significantly different (P<0.05), Sig= Significant NS = non-significant **= (P<0.01)

Table (4): Effect of dietary treatment on the feed intake of broilers during the experiment periods

Treatments / Item	T1	T2	T3	T4	Sig
FI during starter period	1037.4±18.90	1066.72±1.40	1032.22±0.86	1049.64±2.24	NS
FI during growing period	1981.91±33.36	2012.52±12.05	1955.63±3.19	1994.05±4.04	NS
TFI overall experimental period	3019.32±29.57^{ab}	3079.24±13.24^{a}	2987.86±4.06^{b}	3043.69±6.21^{ab}	*

FI= Feed intake, TFI= Total feed intake, T1= control, T2= 25 mg L-carnitine/ kg diet, T3= 75 mg alpha lipoic acid/ kg diet, T4= 25 mg L-carnitine + 75 mg alpha lipoic acid/ kg diet,

a, b means within the raw with different superscripts are significantly different (P≤0.05), Sig= Significant NS =non-significant * =(p≤0.05)

Table (5): Effect of dietary treatments on feed conversion ratio (FCR) of broilers during the experimental periods:

Treatments / Item	T1	T2	T3	T4	Sig
FCR during starter period	1.20±0.022ab	1.25±0.005a	1.17±0.001b	1.18±0.005b	**
FCR during growing period	1.59±0.034a	1.39±0.006b	1.43±0.001b	1.43±0.005b	***
TFCR overall experimental period	1.43±0.015a	1.34±0.004b	1.33±0.001b	1.33±0.003b	***

FCR= Feed conversion ratio, TFCR= Total feed conversion ratio, T1= control, T2= 25 mg L-carnitine/ kg diet, T3= 75 mg alpha lipoic acid/ kg diet, T4= 25 mg L-carnitine + 75 mg alpha lipoic acid/ kg diet, a, b : means within the raw with different superscripts are significantly different (P≤0.05), Sig= Significant NS =non-significant **=(p≤0.01), ***= (p≤0.001)

Table (6): Effect of dietary treatments on the carcass traits of broilers

Treatments / Item	T1	T2	T3	T4	Sig
Carcass, %	75.115± .52	74.16±0.76	73.04±1.47	72.56±1.46	NS
Gizzard, %	3.63±.20ab	3.68±.18ab	4.49± .28a	3.32±.59b	*
Heart, %	1.56±.11b	1.75±.09ab	1.96±.16a	1.99±.11a	*
Liver, %	7.19±0.24b	7.53±0.25b	8.52±0.14a	7.03± .35b	*
Giblets, %	12.38± .49b	12.96±.41b	14.99±.42a	12.36±.53b	*
Total edible part, %	87.49±.89	87.12±.75	88.03±1.21	84.92±1.30	NS
Abdominal fat, %	3.42±.25a	2.49±.025b	2.55±.37b	1.80±.17b	**

T1= control, T2= 25 mg L-carnitine/ kg diet, T3= 75 mg alpha lipoic acid/ kg diet, T4= 25 mg L-carnitine + 75 mg alpha lipoic acid/ kg diet, a, b, c : means within the row with different superscripts are significantly different (P≤0.05), Sig= Significant NS =non-significant * =(p≤0.05) **=(p≤0.01).

Total feed intake of broiler chicks during either the starter or growing period was not significantly (P≤0.05) affected by feed additives containing diets as shown in Table (4). The insignificant highest values of total feed intake during the starter period were 1066.7g / bird recorded for chicks fed l-carnitine containing diet (T2) followed by 1049.6g of those fed the mixture of l-carnitine and α- lipoic acid containing diet (T4) while, the lowest (P<0.05) feed intake value 1032.2g/ bird recorded by chicks group fed dietary α- lipoic acid supplementation (T3) compared to control, respectively. The same trend was observed in total feed intake during the growing period, whereas the insignificant (p≤0.05) highest values were 2012.5g /bird recorded by birds that received dietary T2 followed by 1994.6g/bird of those fed dietary T4 and 1995.6 g/bird of group fed dietary T3 compared to 1981.9 g/bird of the control group, respectively. Generally, the total feed intake during the overall experimental period was significantly affected by dietary treatments feed intake of birds fed dietary T4 was statistically equal to that of the control group, while the highest(p≤0.05) feed intake recorded of that fed l-carnitine and the lowest recorded of that fed α- lipoic acid supplemented diets.

Data presented in Table (5) demonstrated the effect of dietary treatments on the feed conversion ratio of broiler chicks. The mean of feed conversion ratio during starter all periods were significantly superior and statistically similar (P<0.05) of bird fed dietary control, T3 (alpha lipoic acid) and T4 mixture (T2+T3) containing diet, while T2 recorded a lower feed conversion ratio compared to other groups. While, at the end of the growing period, all feed additives supplemented diet (l-carnitine or α-lipoic acid and mixture) significantly improved feed conversion ratio compared to control one. Generally, overall the experiment period, feed conversion ratio was significantly improved by 6.7% ,7.5% and 7.5 % of birds fed l-carnitine or α-lipoic acid and the mixture containing diet compared to control, respectively.

The present results agree with Abouzed et al., (2019) and Soliman et al., (2020) reported that feed intake significantly increased in birds that received l-carnitine compared to the control group. The decrease in feed intake when alpha lipoic acid is supplemented is due to the inhibition of an (AMPK) is a key regulator of cellular metabolism and energy balance enzyme in the hypothalamus (Kim et al., 2004 and Maddock et al., 2001). Also, this agrees with Ou et al. (2023) and El-Rayes et al (2020) who noticed that additive lipoic acid decreased feed intake. The improvement in FCR may be due to the greater utilization of fatty acids containing diet, thus reducing the bird's need for thermal caloric requirements, and improving the intestinal mucosa (Fathi and Farahzadi, 2014). This agreed with El-Kelawy and El-Naggar (2017), Tufarelli et al. (2020) and Ismail and Ouda (2020). On contrary, no significant differences in feed conversion ratio as a result of l-carnitine supplemented diets compared to control (Arslan and Tufan, 2018 and Abedpour et al., 2017).

Carcass traits of broiler chicks:

Carcass traits of broiler chicks as affected by either l-carnitine or lipoic acid and a mixture of them containing diet are presented in Table (6). Insignificant differences were observed in the carcass weight percentage of broiler chicks and Total edible parts. Data revealed also that significant (P<0.05) differences were observed in the percentages of liver, heart, and gizzard weight percentage of broiler chicks. It must be mentioned that birds fed dietary T4 recorded lower (P<0.05) abdominal fat (1.8%) followed by 2.49 and 2.65% of those fed dietary T2 and T3 compared to 3.42% of the control group, respectively. At the end of the experiment, Data showed that the higher value of giblets was the broiler fed by T3 (alpha lipoic acid), followed by of those fed dietary T2, T4 and the control group. At the end of work, all additives supplementation reduced abdominal fat which, may be due to l-carnitine decreased abdominal fat by preventing the accumulation of adipose tissue reducing calorie requirements and increasing stress tolerance because it works to remove short-chain fatty acids that accumulate as a result of metabolic and non-dietary metabolism. Rabie et al. (1997), worked on the beta-oxidation of fatty acids to produce energy(adenosine triphosphate, ATP) and improve their consumption by transesterifying long-chain fatty acids and converting them to triacylglycerol and storing them in adipose tissue (Xu et al. 2003). This is agreed with Babazadeh Aghdam et al., (2015) and Jafari Golrokh et al. (2016), who showed that abdominal fat was decreased when using l-carnitine additive. Other researchers, such as Fujimoto et al. (2020) and Tufarelli et al., (2020) found no effect significantly on abdominal fat when added l-carnitine. The decreased in fat abdominal may be due to the role of lipoamide dehydrogenase as α-keto acid flavoprotein component in Krebs cycle to promote energy metabolism (Reed, 1973). This agrees with El-Rayes et al. (2020) who said that fat abdominal was low by increased lipoic acid. On the other hand, Preza-Montiel et al. (2021) and Zhang et al. (2014) reported that not significantly on abdominal fat when additive lipoic acid followed by that the broiler fed on a mixture of materiel (l-carnitine and lipoic acid) was decreased abdominal fat on it's by the reaction on the material

4. Conclusion

Conclusively, it may be concluded that supplementing of l-carnitine (25 mg/ kg), alpha-lipoic (75 mg/ kg) or their mix to broiler chicks' diets could improve productive performance.

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S. E., Y. M, and T. E planned and supervised the research. A. A. R and T. E conducted the experimental work and analyzed the data. S. E., Y. M, T. E, and A. A. R wrote the manuscript with the input of all the other authors.

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