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ASSESSMENT OF THE EFFECT OF α-LIPOIC ACID SUPPLEMENTATION TO THE DIET WITH DIFFERENT DIETARY ENERGY LEVELS ON BROILER PERFORMANCE AND ATIOXIDANTS STATUS

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SUMMARY

The present study aimed to assess if there is any synergistic or antagonistic effect between α-lipoic acid (ALA) and dietary energy levels in increasing growth performance traits as well as minimizing fat deposition of broiler. Three hundred and sixty one-day-old unsexed Cobb broilers chicks were assigned randomly to 8 equal experimental groups; with three replicates of 15 chicks each. The feeding consists of three stages; the first was (starting period), its basal diet contained 22 % CP and lasted for 3 weeks. The second was (growing period), its basal diet contained 20 % CP and lasted for 2 weeks. The third period was (finishing period), its basal diet contained 18 % CP at the last week of the experiment. Within each protein level used, two levels of energy (3000 and 3200 Kcal / kg diet) were tested with various levels of α-lipoic acid (0, 50, 75 and 100 mg / kg diet). So, the experimental design was a factorial 2 energy levels × 4 α-lipoic acid levels. Results showed that, Significant effects of α-Lipoic acid, diet energy levels and their interaction on chicks weight gain (WG), feed consumption (FC), and feed conversion ratio (FCR). Significant declines in dressing, front part, hind part, giblets, and abdominal fat with increasing α-Lipoic acid level in the diet. Muscle (thigh and breast) antioxidants statuses were vary significantly with α-Lipoic acid, diet energy level, and their interaction. Overall, blood total lipids, triglycerides, and cholesterols have decreased significantly with increasing α-Lipoic acid levels. Moreover, only total lipids increased with increased dietary energy. Remarkable improvements were noticed in the plasma oxidative statues including TAC, SOD, GSH-px, and MDA. From the obtained results, it could be concluded that α-lipoic acid supplementation at the level of 100 mg/kg diet provides significant natural antioxidant which boosts the oxidative status of meat and blood regardless the energy level in the diet.

Keywords: *Broilers, energy, α-lipoic acid, performance and physiological status.*

INTRODUCTION

In the last decade, meat type chicken has been selected for increasing body weight yield. This strategy has resulted in greater growth performance. Undesirable, indirect selection responses such as pronounced fat deposition, increased leg problems and some metabolic disorder have also noticed. Accumulation of fat in carcasses of broiler, particularly in abdominal and visceral areas, represents a waste product to consumers who are increasingly concerned about the nutritional and health aspects of their food. Such fatty broiler will be unattractive to those consumers and thus will lead to decrease salability, which in turn reduces the net returns for the producers. Some of these undesirable selection responses could be partially counteracted by genetic means. However, this will only give satisfactory results in the long term and attention should, therefore, be paid to short term solution which may be nutritional or management factors (Abou El-Ghar and Abd El-Karim, 2016; Akbari *et al*., 2018; Akbari *et al*., 2016; El-Senousey *et al*., 2018).

From the nutritional point of view, α-lipoic acid (ALA) supplementation may participate to some extent in solving factors problem of broiler. Alpha-lipoic acid (1, 2-dithiolane -3- pentatonic acid; 1, 2-dithiolane-3-valeric acid or 6, 8-dithio-octanoic acid) is an organosulfur compound derived from octanoic acid called caprylic acid (Packer *et al.,* 1995). It is a naturally occurring compound that is synthesized by both plants and animals, and is essential for aerobic metabolism. Also, it is manufactured and is available as a dietary supplement in some countries where it is marketed as an antioxidant contains two sulfur atoms (at C6 and C8) connected by a disulfide bond and is thus considered to be oxidized although either sulfur atom can exist in higher oxidation states (Packer *et al.*, 1997 and Senoglu *et al.*, 2009).

Supplementation of α-lipoic acid can reduce adenosine 5-monophosphate which activates the function of protein kinase enzyme in the hypothalamus, causing weight loss in animals by limiting feed intake and increasing energy consumption (Kim *et al.,* 2004 and Kurutas, 2016). In addition, Shen and Du (2005) cited dietary supplementation of ALA is a pragmatic strategy to enhance the oxidative stability of poultry meat and meat-based products by reducing rate of lipid peroxidation leading towards decreased incidence of pale, soft, exudative behavior in processed meat products. So, it is highly effective in improving the characteristics of poultry meat products.

Many researchers evaluated the effects of dietary α-lipoic acid supplementation on broiler performance. Various studies have shown the body weight, weight gain and feed intake of broiler chicks were significantly decreased by increasing the supplementation level of ALA (Arshad *et al.,* 2013; Elsenousey *et al.,* 2013 and Zhang *et al.,* 2014). On the opposite direction, Srilatha *et al.,* (2010); Yoo *et al.* (2016) and Lu *et al.* (2017) reported that body weight, weight gain and feed conversion ratio were significantly improved by ALA by decreasing the supplementation level of ALA.

There are no studies reported in the use of ALA under different levels of energy carried out with broiler. Thus, the present study aimed to assess if there is any synergistic or antagonistic effect between α-lipoic acid and dietary energy levels in increasing growth performance traits as well as minimizing fat deposition of broiler.

MATERIALS AND METHODS

Birds and management:

Three hundred and sixty one-day-old unsexed Cobb chicks were individually weighed and assigned randomly to 8 equal experimental groups of 45 birds each. Birds of each group were further subdivided into three replicates of 15 birds. All chicks were kept under the same managerial, hygienic and environmental conditions throughout the entire experimental period that lasted for 6 weeks.

The experimental diets:

A conventional corn-soybean meal basal diet was used. The feeding period in the current investigation consists of three stages; the first was (starting period), its basal diet contained 22 % CP and lasted for 3 weeks. The second was (growing period), its basal diet contained 20 % CP and lasted for 2 weeks. The third period was (finishing period), its basal diet contained 18 % CP at the last week of the experiment. Within each protein level used, two levels of energy (3000 and 3200 Kcal / kg diet) were tested with various levels of α-Lipoic acid (0, 50, 75 and 100 mg / kg diet). The experimental design was a factorial 2 energy levels × 4 α-lipoic acid levels .The compositions of the diets are detailed in Table (1).

Measurements :

Performance traits and carcass characteristics:

Body weight, weight gain, feed consumption and feed conversion ratio were determined and recorded weekly until 6 weeks of age. At 6 weeks of age, three birds from each replicate were randomly chosen and slaughtered after fasting for 12 hrs. After sacrificing, internal organs (liver, spleen, heart, gizzard, bursa and thymus), were carefully removed and weighed. All organs weight were expressed as a percentage of body weight and subjected to arcsine transformation for statistical analysis. Samples of meat were taken, stored at – 20C° until assay for determination of superoxide dismutase (SOD) and Thiobarbituric acid reactive substances (TBARS).

Biochemical analysis of blood serum and antioxidants status:

At the end of the experimental period (6 weeks), 3 birds from each replicate were slaughtered and blood samples were collected and divided into two parts; the first part was collected in heparinized tubes to obtain plasma while the 2nd part was collected in nonheparinized tubes to obtain serum by centrifugation for 15 minutes at 3000 rpm and stored at – 20C° for later analysis. Total lipid was detected by specific diagnostic kits produced by Biodiagnastic according to method of Zöllner and Krisch (1962). Triglyceride was determined according to the method described by Sidney and Barnard (1973). Total cholesterol was determined according to Allina *et al*. (1974). Total antioxidants capacity (TAC) was determined according to the method of (Miller *et al*., 1993). Superoxide dismutase (SOD) was determined by using colorimetric method according to (Nishikimi *et al*., 1972). Activity of Glutathione peroxidase (GSH-Px) was determined based on the method of (Miller *et al*., 1993). Malondialdehyde (MDA) was determined by using colorimetric method according to (Ohkawa *et al*., 1979).

Statistical analysis:

Data were statistically analyzed using SAS procedure (SAS version 9.1.3, 2007). Tests of significance for the differences among treatments were done according to Duncan (1955). The statistical model used for the analysis of variance to estimate the effect of different levels of α-lipoic acid or/and energy is:

$$X_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk}$$

Xijk: observation
μ : overall mean,
αi : effect of energy
βj : effect of α-lipoic acid
αβij : interaction between energy and α-lipoic acid
eijk : random error

Table (1): Composition and calculated analyses of the experimental diets.

Item	Starter diet		Grower diet		Finisher diet	
	3000 kcal/kg	3200 kcal/kg	3000 kcal/kg	3200 kcal/kg	3000 kcal/kg	3200 kcal/kg
Ingredient, %:						
Yellow corn	55.5	54.2	59	58.5	60.0	60.0
Wheat bran	2.0	-	2.7	-	3.8	-
Soy bean meal	27.5	27	26	25.5	27.9	29.2
Corn gluten meal	8	9.1	5.1	6.30	-	-
Soybean oil	2.3	5	2.5	5	3.6	6.1
Dl-Calcium Phosphate	2	2	2	2	2	2
Limestone	2	2	2	2	2	2
Methionine	0.1	0.1	0.1	0.1	0.1	0.1
Salt	0.3	0.3	0.3	0.3	0.3	0.3
(Premix)*	0.3	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100	100
Calculated analysis**:						
Crud protein, %	22.03	22.02	20.03	20.04	18.00	18.00
Metabolizable energy (K cal/kg)	3002.2	3200	3004.8	3206.4	3002.05	3201.64
Ether extract (EE %).	2.54	2.50	2.59	2.59	2.52	2.51
Crude fiber (CF %)	3.47	3.20	3.48	3.15	3.69	3.36
Calcium	1.28	1.28	1.28	1.27	1.28	1.28
Available phosphorus, %	0.49	0.49	0.49	0.49	0.49	0.49
Lysine, %	0.98	0.96	0.92	0.90	0.93	0.94
Methionine	0.49	0.59	0.45	0.46	0.39	0.39
Methionine + Cystine	0.91	0.93	0.82	0.84	0.70	0.70

***** *Each 3 kg of premix contained: vit. A 12000 IU, vit. D 2200IU, vit. E 10 mg, vit. K3 2000 mg, vit. B1 1000 mg, vit. B2 5000 mg, vit. B6 1500 mg, vit. B12 10 mg, pantothenic acid 10 mg, niacin 30 mg, folic acid 1000 mg, biotin 50 mg, choline chloride 300 mg, manganese 60 mg, zinc 50 mg, copper 10 mg, Iron 30 mg, Iodine 1000 mg, selenium 100 mg, cobalt 100 mg and CaCo3 to 3 g* ****** *According to NRC. 1994.*

RESULTS AND DISCUSSION

Growth performance and nutrient utilization:

Growth performances and nutrient utilization of Cobb broilers chicks fed the tested diets are shown in Table (2). Significant effects of α-Lipoic acid, diet energy levels and their interaction on chicks weight gain (WG), feed consumption (FC), and feed conversion ratio (FCR). Body weight value decreased significantly with increasing α-Lipoic acid in the diet. Moreover, Diet with high energy level (3200 kcal/kg) obviously increased WG and FCR with low feed consumption (FC) when compared with the chicks fed low energy diet (3000 kcal/kg).

In the present study, weight gain and feed utilization of Cobb broilers chicks were affected significantly by Alpha-lipoic acid (ALA) dietary supplementation and diet energy level. Increasing ALA

Table (2): Growth performances and nutrient utilization of Cobb broilers chicks fed the tested diets.

Treatments	Weight gain(g)				Feed consumption(g)				Feed conversion ratio			
	Starter period	Grower period	Finisher period	Total period	Starter period	Grower period	Finisher period	Total period	Starter period	Grower period	Finisher period	Total period
α-Lipoic acid (mg/kg)												
0	668.04^{a}	780.38	405.11^{a}	1853.51^{a}	890.65^{a}	1500.30^{a}	1140.20^{a}	3531.15^{a}	1.33^{a}	1.92	2.81^{a}	1.91^{a}
50	651.34^{b}	776.78	402.55^{a}	1830.68^{b}	877.00^{ab}	1489.05^{ab}	1130.10^{ab}	3496.15^{ab}	1.35^{a}	1.92	2.81^{a}	1.91^{a}
75	603.37^{c}	775.11	389.94^{b}	1754.92^{c}	873.90^{ab}	1484.80^{ab}	1124.35^{ab}	3483.05^{ab}	1.45^{b}	1.92	2.88^{b}	1.98^{b}
100	585.81^{d}	775.11	384.72^{b}	1745.65^{d}	862.00^{b}	1470.95^{b}	1110.60^{b}	3443.55^{b}	1.47^{b}	1.90	2.89^{b}	1.97^{b}
SE	±3.81	±1.47	±7.98	±5.18	±5.92	±6.30	±5.4	±6.85	±0.03	±0.03	±0.03	±0.05
Energy (kcal/kg)												
3000	586.01^{b}	787.13^{a}	377.63^{b}	1750.78^{b}	894.2^{a}	1516.6^{a}	1163.3^{a}	3574.1^{a}	1.53^{b}	1.93	3.08^{b}	2.04^{b}
3200	663.29^{a}	771.11^{b}	413.97^{a}	1848.37^{a}	845.6^{b}	1472.6^{b}	1107.8^{b}	3426.0^{b}	1.27^{a}	1.91	2.68^{a}	1.85^{a}
SE	±3.35	±3.57	±0.92	±4.55	±6.00	±6.40	±5.20	±6.50	±0.03	±0.04	±0.04	±0.06
Interaction Energy × α-Lipoic acid												
0	638.04^{b}	785.44^{ab}	370.11^{f}	1793.54^{b}	902.3^{a}	1523.3^{a}	1170.1^{a}	3595.7^{a}	1.41^{c}	1.94^{b}	3.16^{f}	2.00^{c}
3000 × 50	608.67^{c}	779.45^{ab}	370.11^{f}	1758.24^{c}	899.7^{a}	1520.0^{a}	1168.0^{a}	3587.7^{a}	1.48^{d}	1.95^{b}	3.16^{f}	2.04^{cd}
75	563.70^{d}	784.45^{ab}	395.00^{c}	1716.15^{d}	897.8^{a}	1517.0^{a}	1163.0^{a}	3577.8^{a}	1.59^{e}	1.93^{b}	2.94^{d}	2.08^{d}
100	533.59^{e}	800.00^{a}	374.56^{e}	1708.15^{e}	889.0^{a}	1509.7^{a}	1152.0^{a}	3550.7^{a}	1.67^{f}	1.89^{a}	3.08^{e}	2.08^{d}
0	698.04^{a}	775.33^{b}	440.11^{a}	1913.48^{a}	879.0^{ab}	1477.3^{ab}	1110.3^{ab}	3466.6^{b}	1.26^{a}	1.91^{a}	2.52^{a}	1.81^{a}
3200 × 50	694.02^{a}	774.11^{b}	435.00^{b}	1903.13^{a}	854.3^{b}	1458.1^{b}	1092.2^{b}	3404.6^{bc}	1.23^{a}	1.88^{a}	2.51^{a}	1.79^{a}
75	643.04^{b}	765.77^{bc}	384.89^{d}	1793.70^{b}	850.0^{b}	1452.6^{b}	1085.7^{b}	3388.3^{c}	1.32^{b}	1.90^{a}	2.82^{c}	1.89^{b}
100	638.04^{b}	750.22^{c}	394.89^{c}	1783.15^{b}	840.0^{b}	1435.2^{b}	1069.2^{b}	3344.4^{c}	1.32^{b}	1.91^{a}	2.71^{b}	1.88^{b}
SE	±3.93	±6.67	±1.18	±5.19	±5.80	±6.30	±5.40	±7.3	±0.05	±0.06	±0.06	±0.06
α-Lipoic acid	***	NS	***	***	*	*	*	*	**	NS	**	**
Energy	***	***	***	***	***	***	***	***	**	NS	**	**
Energy × α-Lipoic acid	***	*	***	***	***	***	***	***	**	**	**	**

Means of each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test .

** indicate P<0.05* *** indicate P<0.01* **** indicate P<0.001* *NS indicate Not significant* level in the diet decreased significantly chick's body weight and feed consumption, which is in line with the previous studies (Arshad *et al*., 2013; El-Senousey *et al*., 2018; Zhang *et al*., 2014).The negative effect of ALA supplementation on body weight may be linked to the frustrated feed consumption as a result to AMPK inhibition in the hypothalamus (Kim *et al*., 2004; Maddock *et al*., 2001) or activation of protein kinase enzyme and/or boosting energy utilization causing feed consumption decline which consist with the previous results (Shen and Du., 2005; Tang, *et al.,* 2007). Moreover, low feed consumption following ALA treatment cannot be attributed to the dietary taste as ALA injection treatment resulted a similar situation (Shen, *et al.,* 2005). On the other hand, positive effects of ALA supplementation on body weight and feed utilization were reported (Lu *et al.,* 2017; Srilatha et al., 2010; Yoo *et al*., 2016). In addition, Zhang *et al.* (2009) reported no marked effect of ALA on FCR. Differences in the reported results of the ALA supplementation on body weight and feed utilization may be due to the differences in the used species, age, diet formulation, environmental factors.

Carcass characteristics and antioxidant status:

Table (3) represents carcass characteristics and antioxidant status of Cobb broilers chicks fed test diets for 42 days. Significant declines in dressing, front part, hind part, giblets, and abdominal fat with increasing α-Lipoic acid level in the diet. Meanwhile, remarkable improvements were observed with increasing energy level in the diet. In addition, interactions between dietary α-Lipoic acid and energy levels were significant ($P<0.05$) and chicks fed diet contains 3200 kcal/kg energy and α-Lipoic acid at the level of 0 mg/kg showed higher dressing, front part, hind part, giblets and abdominal fat.

The characteristics of the carcass varied with the addition of ALA and diet energy as well as their interaction. Dropped weight of dressing, front part, hind part, giblets, and abdominal fat could explain the decline in body weight with increasing ALA level in the diet. In accordance with our results, low fat deposition correlated with ALA supplementation was reported (Imik *et al*., 2013; Khan *et al*., 2015; Zhang *et al.*, 2014). In addition, Reed (1973) explained the role of lipoamide dehydrogenase as α-keto acid flavoprotein component in Krebs cycle to promote energy metabolism. On the other hand, No significant effects of ALA on carcass weight, dressing percentage were reported (Schmidt *et al*., 2005; Zhang *et al*., 2009)

Muscle (thigh and breast) antioxidants statuses were vary significantly with α-Lipoic acid, diet energy level, and their interaction (Table 3). SOD values in contrast to TBARS were improved with increasing α-Lipoic acid level and energy level. The highest value of SOD and the lowest TBARS value were observed in chicks group fed diet contain 100 mg/kg α-Lipoic acid and 3200 kcal/kg energy.

The enzymatic antioxidant defense systems is greatly associated to immune system reflect the health status in animals (Chen *et al.*, 2011; El Basuini *et al.*, 2016; Martinez–Alvarez *et al*., 2005; Mruk, *et al.*, 2002). Recently, a considerable number of research have clarified the antioxidant features of ALA in maintaining cellular antioxidant status by boosting the synthesis or regenerating of non-enzymatic antioxidants such as vitamin C, E, and reduced glutathione (Çakatay, 2006; Khan *et al*., 2015; Savitha *et al*., 2005; Shay *et al.,* 2009). Results of the present study showed that muscle and plasma oxidative conditions were improved by ALA treatment. The potent of SOD, TAC and GSH-px increased meanwhile MDA and TBARS were decreased as ALA increased. These results are in consistence with (Hagen *et al*., 2002; Koppenol, 1981; Seaton *et al.*, 1996; Selvakumar *et al.*, 2005; Srilatha *et al*., 2010; Williams *et al*., 2002; Zhang *et al.,* 2009).

Blood chemical parameters and oxidative statues:

The blood parameters of Cobb broilers chicks after 42 days of feeding trial are presented in Table (4). Overall, blood total lipids, triglycerides, and cholesterols have decreased significantly with increasing α-Lipoic acid levels. Moreover, only total lipids increased with increased dietary energy. Interactions between dietary α-Lipoic acid and energy levels showed statistical significances and chicks fed diet contains 3200 kcal/kg energy with no α-Lipoic acid supplementation showed higher total lipids, triglycerides, and cholesterols levels. Remarkable improvements were noticed in the plasma oxidative statues including TAC, SOD, GSH-px, and MDA of Cobb broilers chicks after 42 days feeding period (Table 4). Oxidative statuses were altered significantly with α-Lipoic acid, diet energy level, and their interaction. Values of TAC, SOD and GSH-px contrary MDA were improved with increasing α-Lipoic acid level and energy level.

Blood biochemistry parameters are particular indicators of the physiological response as well as the

Table (3): Carcass characteristics and antioxidant status of Cobb broilers chicks fed test diets.

Treatments	Carcass characteristics					Antioxidants			
						SOD (u/g)		TBARS (n.mol/g)	
	Dressing	Front part	Hind part	Giblets	Abd. fat	Thigh muscles	Breast muscles	Thigh muscles	Breast muscles
α-Lipoic acid (mg/kg)									
0	78.14^{a}	37.94^{a}	33.00^{a}	5.19^{a}	1.98^{a}	36.05^{c}	47.83^{c}	5.59^{a}	4.50^{a}
50	77.17^{b}	37.64^{b}	32.64^{b}	5.05^{b}	1.78^{b}	39.24^{c}	50.05^{bc}	4.73^{b}	4.0^{6b}
75	75.04^{c}	36.38^{c}	32.26^{c}	4.72^{c}	1.69^{c}	44.97^{b}	52.83^{b}	4.01^{c}	3.60^{c}
100	74.07^{d}	36.07^{d}	31.86^{d}	4.61^{d}	1.59^{d}	50.04^{a}	58.67^{a}	3.87^{c}	3.21^{d}
SE	±0.06	±0.06	±0.007	±0.001	±0.003	±0.20	±0.68	±0.24	±0.27
Energy (kcal/kg)									
3000	75.51^{b}	36.72^{b}	32.30^{b}	4.74^{b}	1.64^{b}	41.75^{b}	51.01^{b}	4.60	4.14^{a}
3200	76.70^{a}	37.29^{a}	32.58^{a}	5.04^{a}	1.88^{a}	43.40^{a}	53.68^{a}	4.50	3.54^{b}
SE	±0.15	±0.12	±0.07	±0.09	±0.004	±0.35	±0.42	±0.23	±0.26
Interaction Energy × α-Lipoic acid									
3000 × 0	77.80^{b}	37.85^{a}	32.99^{a}	5.07^{ab}	1.83^{d}	35.72^{f}	47.15^{g}	5.67^{a}	4.92^{a}
3000 × 50	76.39^{c}	37.30^{b}	32.42^{b}	4.84^{b}	1.67^{c}	38.31^{e}	48.62^{f}	4.82^{b}	4.37^{b}
3000 × 75	74.57^{f}	36.20^{d}	32.06^{c}	4.63^{c}	1.55^{b}	43.74^{c}	50.37^{e}	3.99^{c}	3.92^{c}
3000 × 100	73.30^{g}	35.56^{e}	31.75^{d}	4.44^{c}	1.51^{a}	49.26^{a}	57.91^{b}	3.92^{c}	3.38^{d}
3200 × 0	78.49^{a}	38.04^{a}	33.01^{a}	5.31^{a}	2.13^{f}	36.39	48.52^{f}	5.52^{a}	4.08^{c}
3200 × 50	77.95^{b}	37.98^{a}	32.87^{a}	5.27^{a}	1.89^{e}	40.18^{d}	51.48^{d}	4.64^{b}	3.75^{c}
3200 × 75	75.51^{d}	36.56^{c}	32.47^{b}	4.81^{b}	1.83^{d}	46.21^{b}	55.29^{c}	4.02^{c}	3.28^{d}
3200 × 100	74.85^{e}	36.58^{c}	31.97^{d}	4.79^{b}	1.68^{c}	50.82^{a}	59.43^{a}	3.83^{c}	3.05^{e}
SE	±0.08	±0.15	±0.07	±0.13	±0.008	±0.67	±0.83	±0.26	±0.22
α-Lipoic acid	***	***	***	***	***	**	**	**	**
Energy	***	***	***	***	***	**	**	NS	**
Energy × α-Lipoic acid	***	***	***	***	***	**	**	**	**

Means of each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

*** indicate P<0.01   *** indicate P<0.001   NS indicate Not significant*

Table (4): blood parameters of Cobb broilers chicks fed test diets.

Treatments	Blood biochemical			Plasma antioxidants			
	Total lipids (g/L)	Triglycerides (mg/dL)	Cholesterols (mg/dL)	TAC (u/mL)	SOD (u/mL)	GSH-px (u/mL)	MDA (n.mol/mL)
α-Lipoic acid (mg/kg)							
0	4.68[a]	85.50[a]	161.12[a]	4.26[c]	51.20[d]	1533[c]	4.19[a]
50	3.41[b]	69.50[b]	134.5[b]	7.30[b]	52.81[c]	1873[b]	3.60[b]
75	3.20[b]	66.50[b]	102.00[c]	7.65[b]	53.53[b]	1901[b]	2.48[c]
100	3.03[b]	66.37[b]	90.37[d]	9.84[a]	55.00[a]	2029[a]	1.25[d]
SE	±0.15	±1.74	±2.63	±0.63	±0.62	±16.06	±0.27
Energy (kcal/kg)							
3000	3.31[b]	70.37	118.87	7.61[a]	53.56[a]	1908.25[a]	2.70[b]
3200	3.84[a]	73.56	125.12	6.91[b]	52.71[b]	1759.75[b]	3.06[a]
SE	±0.12	±1.45	±2.27	±0.61	±0.66	±18.42	±0.31
Interaction Energy × α-Lipoic acid							
3000 × 0	4.25[b]	83.00[a]	158.75[a]	4.39[d]	51.26[e]	1609[d]	4.02[b]
3000 × 50	3.15[cd]	68.25[b]	133.25[b]	7.87[b]	53.39[c]	1950[b]	3.42[d]
3000 × 75	2.95[d]	65.00[b]	98.00[c]	8.16[b]	53.88[b]	1970[b]	2.34[e]
3000 × 100	2.92[d]	65.25[b]	85.50[d]	10.03[a]	55.72[a]	2104[a]	1.03[g]
3200 × 0	5.12[a]	88.00[a]	163.50[a]	4.13[d]	51.14[e]	1457[e]	4.36[a]
3200 × 50	3.67[bc]	70.75[b]	135.75[b]	6.73[c]	52.24[d]	1796[c]	3.79[c]
3200 × 75	3.45[c]	68.00[b]	106.00[c]	7.15[c]	53.18[c]	1832[c]	2.63[e]
3200 × 100	3.15[cd]	67.50[b]	95.25[c]	9.65[a]	54.28[b]	1954[b]	1.48[f]
SE	±0.15	±1.62	±2.51	±0.94	±0.62	±15.98	±0.26
α-Lipoic acid	*	*	***	**	*	**	**
Energy	**	NS	NS	**	*	**	**
Energy × α-Lipoic acid	***	***	***	**	*	**	**

Means of each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

** indicate P<0.05* *** indicate P<0.01* **** indicate P<0.001* *Ns indicate Not significant* general health condition of animals (Coeurdacier *et al.*, 2011; Sahoo *et al*., 2014; Sharma *et al*., 2012; Wang *et al*., 2008). In the present study, blood total lipids, triglycerides, and cholesterol have decreased significantly with increasing α-Lipoic acid levels while a positive correlation occurred with the diet energy level. Alteration of blood lipid content (total lipids, triglycerides, and cholesterol) with ALA addition indicates its role in lipid metabolism. In line with our results, Hamano *et al.* (1999, 2000) and Imik *et al*. (2013) reported that Alpha-lipoic acid increases plasma triglycerides concentrations and reduces cholesterol.

Economic efficiency:

Table (5) represents economic efficiency of Cobb broilers chicks fed test diets for 42 days. Results showed that, economic efficiency was decreased by increasing α-lipoic supplementation level up to 100mg/kg diet. On the other direction, the increasing of dietary energy up to 3200 Kcal/kg diet was improved the economic efficiency compared to 3000 kcal /kg diet. Interactions between dietary α-Lipoic acid and energy levels showed an improvement in the economic efficiency for chicks fed diet contains 3200 kcal/kg energy with no or 50 mg α-Lipoic acid supplementation level compared to other combination.

Table (5): Economic efficiency of Cobb broilers chicks fed test diets.

Treatment	Price of feed (LE/kg diet)	Average feed consumption (kg/bird)	Total feed cost (Pt)[1]	Average body weight (kg)	Price of body weight (LE)[2]	Net revenue (Pt)[3]	Economic efficiency[4]
α-Lipoic acid (mg/kg)							
0	7.40	3531.15	26.13	1895.60	53.08	26.95	103.14
50	7.65	3496.15	26.75	1872.77	52.44	25.69	96.03
75	7.78	3483.05	27.09	1810.49	50.69	23.60	87.13
100	7.90	3443.55	27.20	1787.72	50.06	22.86	84.03
Energy (kcal/kg)							
3000	7.30	3574.1	26.09	1792.85	50.20	24.11	92.41
3200	7.50	3426.0	25.69	1890.44	52.93	27.24	106.04
Interaction Energy × α-Lipoic acid							
0	7.35	3595.7	26.43	1835.66	51.40	24.97	94.47
3000×50	7.48	3587.7	26.84	1800.33	50.41	23.57	87.81
75	7.54	3577.8	26.97	1785.22	49.99	23.02	85.34
100	7.60	3550.7	26.98	1750.22	49.01	22.03	81.64
0	7.45	3466.6	25.83	1955.55	54.76	28.93	111.98
3200× 50	7.57	3404.6	25.77	1945.22	54.47	28.70	111.35
75	7.64	3388.3	25.89	1835.77	51.40	25.51	98.54
100	7.70	3344.4	25.75	1825.22	51.11	25.36	98.47

CONCLUSION

In conclusion, α-lipoic acid supplementation up to 100 mg/kg diet provides significant natural antioxidant which boosts the oxidative status of meat and blood regardless the energy level in the diet. However, the level of 50 mg α-lipoic/;g diet with dietary energy up to 3200 Kcal/kg leads to a marked improvement in productivity performance and economic efficiency.

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تقييم تأثير إضافة حامض ألفا – ليبويك الي علائق محتوية علي مستويات مختلفة من الطاقة علي الاداء الانتاجي وحالة مضادات الاكسدة لدجاج التسمين

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تهدف هذه الدراسة الي تقييم ما اذا كان هناك تأثير توافقي أو مضاد بين حامض الالفا ليبويك والمستويات المختلفة من الطاقة بعلائق دجاج التمسن علي الاداء الانتاجي ومعدل ترسيب الدهون بالذبيحة. استخدم لهذه الدراسة عدد 360 كتكوت عمر يوم واحد غير مجنسة من سلالة الكب وقسمت عشوائيا الي ثمان مجموعات تجريبية متساوية بكل مجموعه ثلاث مكررات تحتوي علي 15 كتكوت لكل منها. يتكون النظام الغذائي من ثلاث مراحل : المرحلة الاولي وهي البادئ ويقدم للطيور عليقة تحتوي علي 22٪ بروتين خام وتستمر لمدة 3 اسابيع ، أما المرحلة الثانية فهي النامي ويقدم للطيور عليقة 20٪ بروتين خام وتستمر لمدة اسبوعين وفي الاسبوع الأخير يقدم للطيور العلف الناهي والذي يحتوي علي 18٪ بروتين خام. داخل كل مستوي من البروتين المستخدم في كل مرحلة غذائية تم اختبار مستويين من الطاقة (3000، 3200 كيلو كالوري/كجم عليقة) مع مستويات مختلفة من حامض الفا – ليبويك (صفر ، 50 ، 75 ، 100 مجم /كجم عليقه). لذا فان التصميم التجريبي يكون عبارة عن تجربة عامليه 2×4 (مستوين من الطاقة مع اربعة مستويا من حامض الفا-ليبويك). أظهرت النتائج وجود تأثيرات عالية المعنوية لجميع قياسات الاداء الانتاجي نتيجة استخدام مستويات الطاقة او اضافة حامض الفا ليبويك والتداخل بينهما. كما حدث انخفاض معنوي في نسبة التصافي وتراكم الدهون في البطن مع زيادة مستويات حامض الفا – ليبويك. تشير النتائج ايضا الي حدوث تحسن معنوي في مستوي مضادات الاكسدة بعضلات الصدر والفخذ مع زيادة مستوي حامض الفا – ليبويك ومستويات الطاقة او التداخل بينهما. بشكل عام ، انخفضت نسبة الدهون الكلية والجلسريدات الثلاثية والكوليسترول بشكل ملحوظ مع زيادة مستويات حمض ألفا-ليبويك. علاوة على ذلك، زادت نسبة الدهون الكلية فقط مع زيادة مستوي طاقة الغذاء. وقد لوحظ وجود تحسن ملحوظ في مستوي مضادات الاكسدة في بلازما الدم بما في ذلك TAC و SOD و GSH-px و MDA. كذلك يلاحظ ان اضافة حامض الفا – ليبويك بمعدل 50 مجم مع مستوي طاقة 3200 كيلو كالوري ادي الي تحسن ملحوظ في الكفاءة الاقتصادية. من النتائج التي تم الحصول عليها يمكن أن نستنتج أن اضافة حامض الفا - ليبويك حتي مستوى 100 مجم / كجم عليقة توفر مضادات الأكسدة الطبيعية الهامة التي تعزز حالة مضادات الأكسدة في اللحوم والدم بغض النظر عن مستوى الطاقة في النظام الغذائي.