Effects of Lysophospholipids, L-Carnitine, and Alpha-Lipoic Acid on Growth Performance of Broiler.

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Abstract

This experiment aimed to determine the effects of some elements of lipid metabolism on the development of 120 seven-day-old broilers. Lipid metabolism enhancers L-carnitine and alpha-lipoic acid (ALA) and L-lyso phospholipids (LPL) were used. For the experiment there were six treatment groups: A1, control; A2, addition of lyso-phospholipids (LPL; 250 mL/L drinking water); A3, LPL in drinking water plus oral administration of L-carnitine capsules (5 mg/kg live body weight); A4, LPL in drinking water plus oral administration of alpha-lipoic acid (20 mg/kg live body weight); A5, oral administration of L-carnitine capsules (5 mg/kg live body weight); and A6, oral administration of alpha-lipoic acid capsules (20 mg/kg live body weight). had the highest live body weight and total weight gain($P \leq 0.05$), and the best feed-conversion ratio. However, administration of L-carnitine or ALA alone decreased the weight gain compared to the group A2. In addition, it was observed that combinations of LPL with either L-carnitine or ALA did not induce any statistically significant synergistic effects on growth. Feed-conversion ratios were significantly better in groups A1, A2 and A3 compared with group A6 for the different treatments in the entire experiment. Dressing percentages were similar among treatments, although relative weights of some organs (heart, liver and abdominal fat) differed. In particular, liver weight was higher in the combination of LPL and ALA. In conclusion, the present study revealed that supplementation of rapidly hydrolyzed phospholipids improved broiler performance and the metabolism modulators reduced carcass fat did not significantly alter relative lymphoid organ weights.

Key words: Lyso-Phospholipids, L-carnitine, alpha-lipoic acid, Broiler

Introduction

Improving the productive efficiency of broiler chickens is a central objective of contemporary poultry-nutrition research, particularly under the challenges associated with rising feed costs, reduced efficiency of energy utilization, and increased exposure to environmental stressors that negatively affect productive performance and the health status of birds. These challenges have encouraged increasing interest in the use of functional feed additives designed to

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improve digestion and absorption efficiency, enhance nutrient metabolism, and reduce oxidative stress (Ravindran, 2020; Upadhaya & Kim, 2022) [1][2].

Due to the highly concentrated feed and the balanced energy needs of the livestock, the use of fats is highly recommended. However, the digestion of fats depends on the degree to which fats are emulsified and the fats are available into the digestive tract. Therefore, lyso-phospholipids (LPL) are recommended feed additives that aid the emulsification of fats and are highly efficient (possess low surface tension) when coupled to micelle. Hence, the use of LPL improves the utilization of energy. [3], and [4] contend recent studies show LPL improved productive performance, feed-conversion, intestinal health, and positive regulation of gene expressions catering to lipid oxidation and function of the liver.

L-carnitine facilitates mitochondrial transport of long-chain fatty acids for beta-oxidation.that provides a positive response. L-carnitine is an essential metabolic compound in lipid metabolism. It acts as a carrier that transports long-chain fatty acids into the mitochondria for beta-oxidation and energy production. Recent studies have indicated that supplementation of broiler diets with L-carnitine may improve productive performance, reduce fat deposition, enhance the blood lipid profile, reduce oxidative stress, and improve the efficiency of energy utilization [5]

Alpha-lipoic acid (ALA) has the potential of acting as a very powerful anti-oxidative and is the only antioxidant that can operate in both oil-and-water environments. These qualities provide it with a unique capacity of reducing the stress of oxidation and the destruction of cells through the process of oxidation. ALA supplementation in livestock may increase the immune and physiological indicators while decreasing the impacts of heat stress and oxidation [6][7]

Despite an increase in the number of studies focusing on the individual roles of LPL, L-carnitine, and ALA, what is more evident is that there are limited information is available the synergistic and interactive roles of these elements in one of the dietary schemes.

Hence, the purpose of the current study is to fill the gap by analyzing the interactive and individual roles of these elements on productive performance and biological markers.

Materials and Methods

The experiment took place in one of the broiler-rearing halls of the Tikrit University College of Agriculture. A total of 120-day-old unsexed broiler chicks ROSS-308 were used with an initial average weight of 43 g. At seven day of old distributed into treatments.

Poultry House Management

The broiler chicks were placed in a 4 x 5 m poultry hall with three-tier metal cages. Each tier of the cages contained two compartments and each compartment housed five birds. The hall was equipped with an exhaust fan and two thermometers with a hygrometer. The hall was also equipped with both electric and gas heaters. Each compartment of the cages was supplied with a feeder and a drinker. The hall was lit for 24 hours for the experiment.

Bird Feeding

The birds were fed two different commercial diets. The first diet was a starter diet which has 3000 kcal of metabolizable energy and 23% of crude protein. The second diet was a grower diet and that diet had 3250 kcal of metabolizable energy and 20% of crude protein. Feed and water were given ad libitum.

Experimental Design The study followed a randomized design with six treatments. There were also four replicates per treatment and five birds in each replicate.:

Capsule-administered material	Addition in drinking water	Treatment
Capsules containing carrier material	None	A1
Capsules containing carrier material	LPL (250 mg LPL/L drinking water)	A2
Capsules containing carrier material + L-carnitine (5 mg/kg live body weight)	LPL (250 mg LPL/L drinking water)	A3
Capsules containing carrier material + alpha-lipoic acid (20 mg/kg live body weight)	LPL (250 mg LPL/L drinking water)	A4
Capsules containing carrier material + L-carnitine (5 mg/kg live body weight)	None	A5
Capsules containing carrier material + alpha-lipoic acid (20 mg/kg live body weight)	None	A6

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Studied Traits

Productive Traits

Weekly live body weight (g), body-weight gain (g), weekly feed intake (g), and feed-conversion efficiency were used to estimate productive traits weekly.

Dressing yield without edible giblets (%)

At the end of the experimental period, at 35 days of age, 24 birds were randomly selected from all treatments, with four birds taken from each treatment. Their live body weights were recorded first. The birds were then slaughtered, defeathered, and the head and legs were removed. The carcasses were thoroughly eviscerated, cleaned, and washed with water in order to calculate the dressing percentage based on carcass weight without the edible internal organs.

To estimate the relative weights of the heart, liver, gizzard, spleen, bursa of Fabricius, thymus gland, and abdominal fat, these organs and tissues were excised, cleaned, and then weighed. Their relative weights were subsequently calculated as a percentage of the live body weight.

Statistical Analysis

The data were analyzed statistically using SAS (2001) and the effect of treatments on the measured traits (CRD). The significance of differences among the means was established using Duncan's multiple range for the means. The following mathematical model was adopted:

$$Yij = \mu + Ti + eij$$

Result and discussion

Productive Performance Indicators.

Table 1 shows that LPL supplementation by itself or with L-carnitine and ALA affects the average body weight of the growing broiler chickens at different ages. For broiler chickens aged 7 days, no body weight differences attributed to the treatments were recorded. However, at 14 days of age, A4, A5, and A6 treatments showed reduced body weight as compared to A1, A2, and A3.

By 3 weeks of age (21d), broiler chickens in all treatments, except for A6 showed no body weight differences as compared to the controls. A6 also had significantly reduced body weight as compared to A2. Treatments A5 and A6 also had significantly lower body weights than A2. At 28 days of age, treatment A6 had the A6 recorded the lowest live body weight at 28 days ($P \leq 0.05$).

of live body weight (as compared to all the other treatments).

By the time the broiler chickens were 35d, treatments A2, A3, A4, and A5 have effect of live body weight were not significantly different as compared to A1. A6 had a significantly reduced body

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weight. A2 also significantly surpassed A4 and A5 body weight.

In assessing the impact of the treatment on body weight gain in the different age groups, it was observed that A1 and A2 had a significant effect at 7 to 14 days as compared to A4, A5, and A6 treatments; and the 28-35-day period. Meanwhile, A2 demonstrated a particularly significant improvement in feed-conversion efficiency against A1, A3, and A4. Feed-conversion efficiency did not vary statistically among any treatments when measured from 7-14 and 14-21 days. However, some differences did appear when measured over 21-28 and 28-35day periods. Feed-conversion efficiency when measured over the 21-28-day period did not vary statistically among any treatments, but did show significant differences when measured over the 28-35 days period. In the 28-35-day period, Treatment A2 actually showed a significant improvement in feed-conversion efficiency against the remaining treatments, while all remaining treatments showed no significant differences against one another. During A2's period of significant improvement, the control treatment's feed was significantly lower only when measured against Treatment A3's feed conversion, which allowed the researcher to conclude that the control treatment's feed conversion was actually improvement. When looking at feed efficiency or total feed cost, Treatment A1 demonstrated that control treatment could improve feed efficiency. while treatment A4 and control treatments (compared with A3, A2, and A5 respectively) did not show significant differences in treatment cost or feed efficiency. In contrast to the average feed conversion losses displayed by A2 over the first twelve days of the study, Treatment A4 demonstrated remarkably improved feed efficiency over the first twelve days of the study. the 7-14-day period. During the periods from 14 to 21, 21 to 28, and 28 to 35 days of age, no significant differences were observed among all study treatments. Over the total experimental period from 7 to 35 days of age, a significant improvement in feed-conversion efficiency was observed in treatments A1, A2, and A3 compared with A6.

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Table (1). Effect of adding lysophospholipids (LPL), alone or supplemented with L-Carnitine and alpha-lipoic acid (ALA), on some productive traits of broiler chickens during successive age stages.

A6	A5	A4	A3	A2	A1	Treatments / Age (days)
Average live body weight (g)						
227±3.7 a	226.6±1.0 a	227.1±1.1 a	226.5±2.8 a	225.9±4.4 a	226.3±3.9 a	**7**
524±15 c	538.1±17 c	561.5±5.1 bc	595±6.0ab	613.1±15 a	612.8±6.3 a	**14**
1024± 34 c	1105±53 bc	1109.3±14 abc	1174±26 ab	1210.6±29 a	1173.7±15 ab	**21**
1713.7±65 c	1798.1±57 bc	1896.8±27 ab	1970.6±47 a	2008.1±46 a	1982.4±13 a	**28**
2243.85± 85d	2400.34 ± 34c	2490.9±24 bc	2577.8±39 ab	2661.7±43 a	2524.6±19 abc	**35**
Average weight gain (g)						
324.0±12c	311.5±18c	334.0± 18bc	368.4±8.8a b	387.1±13a	386.4±7.7a	**7-14**
500±26b	566.8±50a b	547.8±17a b	579.0±20a b	597.5±16a	560.9±10a b	**14-21**
689.6±36a	693.1±87a	787.4±16a	796.5±26a	797.5±16a	808.7±3.5a	**21-28**
529.7±107 a	601.9±71a	594.0±34a	607.2±21a	653.6±31a	542.2±16a	**28-35**

ISSN 2072-3857

2043.4±89 d	2173.3±35 cd	2263.8±25 bc	2351.2±41 ab	2435.8±43 a	2298.3±22 abc	**7-35**
Feed intake (g)						
430.6±6.7a	436.9±10a	437.8±3.8a	444.1±5.5a	442.1±5.4a	442.8±4.9a	**7-14**
590.6±19a b	560.9± 31 b	591.2±18a b	608.3±10a b	648.7± 40a	590.9±10a b	**14-21**
889±16a	869.9±27a	915.6±17a	855.3±103 a	936.5±36a	872.8±16a	**21-28**
1016.5±22 b	1029.4±27 ab	1076.8±15 ab	1104.3±12 a	1104.6±46 a	1081.1±19 ab	**28-35**
2926.8±26 ab	2897.2±71 b	3021.3±28 ab	3013.1±96 ab	3131.9±11 5a	2987.6±20 ab	**7-35**
Feed conversion efficiency						
1.33±0.0 ab	1.39±0.0a	1.30±0.0ab	1.19±0.0bc	1.15±0.0c	1.14±0.0c	**7-14**
1.19±0.0a	1.01±0.1a	1.08±0.0a	1.05±0.0a	1.08±0.0a	1.05±0.0a	**14-21**
1.30±0.0a	1.32±0.1a	1.16±0.0a	1.07±0.1a	1.17±0.0 a	1.07±0.0a	**21-28**
2.30±0.6a	1.80±0.2a	1.83±0.1a	1.82±0.0a	1.70±0.0a	1.99±0.0 a	**28-35**
1.44±0.0a	1.33±0.0ab	1.33±0.0ab	1.28±0.0b	1.28±0.0b	1.30±0.0b	**7-35**

A1: Control group. A2: LPL supplementation in drinking water at 250 mL/L. A3: LPL supplementation in drinking water at 250 mL/L plus oral administration of L-Carnitine at 5 mg/kg live body weight. A4: LPL supplementation in drinking water at 250 mL/L plus oral administration of alpha-lipoic acid at 20 mg/kg live body weight. A5: Oral administration of L-Carnitine at 5 mg/kg live body weight. A6: Oral administration of alpha-lipoic acid at 20 mg/kg live body weight.

Note: Values are presented as mean ± standard error. Means within the same row bearing different superscript letters differ significantly at **P ≤ 0.05**.

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The treated broiler performance was enhanced substantively, likely due to LPL improvements in physiological mechanisms. LPL has a higher efficacy in the emulsification of fats [8] Since fats are insoluble in water, there is a need to emulsify fats with bile salt for effective digestion and absorption. Bile salt of lipids-digesting enzymes, in their early usage, is presumed to be active in a lower productive range, thus reflecting for an equally lower fat utilization.[9] indicates efficacy of lyso-phospholipid beyond lecithin and bile salts. Lipolytic bile salts of the micelle of the fat's bile salts are towards efficiency of increased motility of the lipolytic. LPL can prompt higher usage of the fat lipids through increased formation of micelles, which is a lipolytic fat digestive process. This has a positive effect on energy utilization and growth. [10] as shown that LPL has an effect of emulsification on the lipid. Therefore, the impression of increased productive performance, which was an effect on the positive growth, was higher in the case of the addition of the LPL as opposed in the case of the higher lecithin. The current outcome showed that LPL-induced live body weight and excitability have been observed in lower case. Improved productive performance was not observed with the addition of L-carnitine to the higher case broiler diet consumers. The results of the present study showed that dietary supplementation with L-carnitine in broiler diets led to a significant decrease in live body weight, without producing a significant effect on feed conversion efficiency. Moreover, combining L-carnitine with rapidly hydrolyzed phospholipids did not result in a noticeable improvement in productive performance.

This effect may be attributed to the pivotal role of L-carnitine in lipid metabolism. L-carnitine facilitates the transport of long-chain fatty acids across the inner mitochondrial membrane through the carnitine transport system, thereby enhancing β-oxidation of fatty acids [11][12] Increased fatty acid oxidation shifts energy utilization from fat storage toward energy production, which consequently reduces lipid deposition in adipose tissues, particularly abdominal fat. This is consistent with the results presented in Table 2, which showed a reduction in the percentage of abdominal fat.

Accordingly, the decrease in live body weight may not necessarily indicate impaired growth, but rather a reduction in body fat content. Similar findings have been documented in several studies on broiler chickens [13][14] L-carnitine may alter nutrient partitioning following the principle of energy partitioning where under increased oxidation proteins, carbohydrates and fats become factors in energy production and the balance of metabolism [15] Enhanced activity of mitochondria and fatty acids may increase the basal metabolism level, energy production and limit weight gain

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[16] The lack of a significant effect of carnitine on feed-conversion efficiency observant indicates that the effect of carnitine on the efficiency of feeding may be stable. This could be as a result of a proportional decrease in feed intake and weight gain or, improved metabolic efficiency. Lipogenesis, which is an energy-demanding process, is eased by carnitine resulting in greater energy production through fat oxidation, which is a more efficient process [17] Hence, dietary energy is used more efficiently by the birds without an increase in live body mass.

The lack of natural performing enhancement between carnitine and LPL can be explained by the difference of those mechanisms. Phospholipids (PL) essentially boost fat digestion and fat absorption [18] by promoting emulsification in the gut, in contrast, carnitine applies cellular control over the mitochondrial fatty-acid oxidation process. Phospholipids further performance if digestion and absorption of fat are bottleneck, otherwise, they may be limiting. The absence of synergetic effect, this may suggest metabolic saturation, extremely fastening fatty-acid transports and mitochondrial oxidation, and subsequently, preventing any further productive effect[19]. It is not unlikely, that availability of fat thanks to phospholipids can be reduced due to intensive oxidation caused by carnitine.

Interestingly, ALA decreased live body weight of the supplemented chicks of broilers and decreased average affected feed intake, and LPL as well as the control combination, in conjunction to a statistically significant change of feed conversion ratio toward the supplemented cases. In non-supplemented instances, ALA primarily affected the energy and nutrient utilization other than the feed intake. In favor of these instances, due to ALA functioning as a cofactor of the citric acid cycle, oxidation of (additional) fatty acid substrate and subsequently vertical shift of body energy metabolism from storage sequestration to depot oxidation (and subsequently decreased energy body fat stores) were documented. In all instances, and contrary to various other reported cases [20] ALA consumption (and subsequently oxidation) and the subsequently decreased broiler body weight and energy storage, were documented to least perturb the feed intake and consumption (i.e. utilization) of broilers.

ALA may regulate energy through the AMPK pathway. This stimulates energy conservation through the inhibition of biosynthetic processes, such as lipid and protein synthesis, and promotes the catabolism of fatty acids. This may go some way in explaining the weight loss in the absence of a decrease in feed intake. The energy spent by the body in the maintenance of its mass, rather than in its growth as the feed intake was the

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same, was consequently not available to make muscle tissue. The absence of ALA and LPL interaction may be explained by LPL's function, which improves the absorption of fats from the diet, and ALA's function, which promotes the oxidation of fats at the cellular level. The absorption of additional gut energy was possibly counteracted by oxidative metabolism. ALA may promote improved metabolic activity under heat and/or oxidative stress, as ALA's role as an antioxidant becomes more important in these situations. Increased metabolic activity may not yield clear productive benefits in the absence of such stress[21]

Indicators of Lymphoid Organs, heart, liver, abdominal fat, dressing yield.

Relative liver weight increased for the treatment with LPL plus alpha-lipoic acid (20 mg/kg live body weight) above the control treatment and treatments A2 and A3. Furthermore, A5 and A6 with L-carnitine (5 mg/kg live body weight) and with alpha-lipoic acid (20 mg/kg live body weight) also showed significant increases in relative liver weight compared to the control treatment.

As for relative heart weight, none of the treatments showed any significant differences compared to the control besides the significant increase of treatment A4 compared to the control. In addition, treatment A6 also showed a significant decrease in relative abdominal-fat weight compared to A4, showing no significant differences compared to the control as seen in the results in Table 2.

Table 2. Effect of rapidly hydrolyzed phospholipids (LPL), alone or in combination with L-Carnitine or alpha-lipoic acid (ALA), on dressing yield and relative weights of selected vital and immune organs in broiler chickens

A6	A5	A4	A3	A2	A1	Treatments	Parameter
75.9 ± 0.7^{a}	74.8 ± 0.3^{a}	76.4 ± 0.6^{a}	76.0 ± 0.5^{a}	77.3 ± 1.2^{a}	76.6 ± 0.9^{a}	Dressing yield (%)	
2.2 ± 0.0^{ab}	2.2 ± 0.0^{ab}	2.3 ± 0.0^{a}	2.1 ± 0.0^{bc}	2.1 ± 0.0^{bc}	1.9 ± 0.07^{c}	Heart relative (%)	
0.5 ± 0.0^{ab}	0.5 ± 0.0^{ab}	0.6 ± 0.0^{a}	0.5 ± 0.0^{ab}	0.5 ± 0.0^{ab}	0.5 ± 0.0^{b}	Liver relative (%)	
0.5 ± 0.0^{b}	0.6 ± 0.0^{ab}	0.7 ± 0.0^{a}	0.7 ± 0.0^{ab}	0.7 ± 0.0^{a}	0.6 ± 0.0^{ab}	Abdominal fat (%)	
0.2 ±	0.2 ±	0.1 ±	0.1 ±	0.1 ±	0.1 ±	Bursa of Fabricius (%)	

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0.0[a]	0.0[a]	0.0[a]	0.0[a]	0.0[a]	0.0[a]	
0.4 ± 0.0[a]	0.4 ± 0.0[a]	0.4 ± 0.0[a]	0.3 ± 0.0[a]	0.4 ± 0.0[a]	0.4 ± 0.0[a]	Thymus (%)

A1: Control group. A2: LPL supplementation in drinking water at 250 mL/L. A3: LPL supplementation in drinking water at 250 mL/L plus oral administration of L-Carnitine at 5 mg/kg live body weight. A4: LPL supplementation in drinking water at 250 mL/L plus oral administration of alpha-lipoic acid at 20 mg/kg live body weight. A5: Oral administration of L-Carnitine at 5 mg/kg live body weight. A6: Oral administration of alpha-lipoic acid at 20 mg/kg live body weight.

Note: Values are presented as mean ± standard error. Means within the same row bearing different superscript letters differ significantly at **P ≤ 0.05**.

As for relative lymphoid organ weight, the control treatment, and treatments in the reference group for relative bursa of Fabricio's and thymus weight showed no significant differences, as revealed by the statistical analysis results in Table 2 on the effect of LPL supplementation (either alone or in a combination of specified lipid-metabolism stimulants) on the relative weights of selected vital organs as well as the dressing percentage in broiler chickens.

These results correlate with [22] who observed that ALA, acting as an antioxidant in tissues, did not significantly change relative organ weights. Unlike the previous cited articles, the current treatments did not significantly affect relative thymus weights.

Changes in relative liver weight with the LPL + ALA combination may result from increased hepatic lipid metabolic activity. ALA is a strong antioxidant and a metabolism stimulator [23]. This likely results in functional changes in the size of organs that conduct the metabolic processes [24]. Concerning abdominal fat, treatment A6, containing ALA, achieved a significant reduction of 0.5% in abdominal fat relative to some other treatments, such as A2 and A4. This is ALA's main effect, as it reduces fat accumulation through inhibiting the expression of genes coding for lipogenic enzymes and promoting the oxidation of fat. ALA supplementation has been shown to reduce fat deposition in the abdomen, improving the quality of the carcass [25]

Conclusion.

The inclusion of quickly hydrolyzed phospholipids (LPL) in broiler chicken diets significantly enhanced the majority of broiler chicken productive performance parameters, while the inclusion of L-Carnitine and ALA had a negative impact. On the other hand, the inclusion of phospholipids and fat-burning enhancers produced carcasses

with a lower fat percentage and did not negatively affect immune organ parameters.

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