Supplementation of alpha lipoic acid on growth performance, nutrient digestibility, mineral availability and lipid peroxidation level in broiler chicken fed with animal fat

Murali P and George Sherin K

DOI: https://doi.org/10.22271/chemi.2020.v8.i3r.9386

Abstract
The aim of the present study was to determine the effects of alpha lipoic acid supplementation on growth performance, nutrient digestibility, mineral availability and lipid peroxidation level in broilers fed diet with animal fat. The trial was conducted using eighty day-old VenCobb commercial broiler chicks which were randomly assigned into two dietary treatment groups with four replicates of ten chicks each. The birds in both the control (T1) and treatment group (T2) were fed with diet containing 5% animal fat, while T2 was supplemented with 100 mg of Alpha lipoic acid. The birds were fed with standard broiler starter ration up to 4 weeks of age and finisher ration up to 6 weeks of age as per BIS (1992) specifications. Alpha lipoic acid supplementation did not have any effect on body weight (g), Feed consumption (g) and feed conversion ratio (%), availability of nutrients and minerals, however, decreased the serum MDA concentration, which is one of the most common indicators of lipid peroxidation. In conclusion, the present study revealed that supplementation of alpha lipoic acid has no effect on growth performance, nutrient and mineral utilisation, but reduces the lipid peroxidation level, thereby improves the quality of meat.

Keywords: Broilers, alpha lipoic acid, animal fat, growth performance and nutrient utilisation, lipid peroxidation

Introduction
Poultry industry is one of the fastest growing fields in agricultural sector with an annual growth rate of 13% per annum. In the intensive feeding system of poultry sector, usage of fat become one of the natural components of the concentrate feed, as an additive for increasing the energy value as well as to improve the tastiness and consistency of feed. (Jefri et al., 2010) [17]. Commonly, Vegetable oils are commonly used as a fat source in broiler diets which is costlier, in turn increases the production cost of feed. (Azman et al., 2004) [41] In recent years, Animal fats are available at cheaper rates compared to vegetable oils, due to the development of rendering technologies. (Mohammed et al., 2011) However, the usage level and type of animal fat influence the carcass fat composition and cause oxidative stress in chicken. This fat deposition causes negative impact to the consumers who are more concern about their health. (Buyse et al., 2001) [7] Dietary modification is one of the practical and preferred ways to manipulate fat deposition and to reduce oxidative stress in chicken. Recently Alpha Lipoic acid a vitamin like substance has been shown to stimulate energy metabolism and act as potent biological antioxidant (Zhang et al., 2009) [30]. Thereby, Alpha Lipoic acid has gained much interest as a feed additive for combating fat deposition and oxidative stress. Lipoic acid (LA) also known as thiotic acid (1,2-dithiolane-3-valeric acid) is a naturally occurring compound in microorganisms, plants and animals. It is described as universal antioxidant since it can combat oxidative stress by quenching a wide variety of reactive oxygen species. (Winiarska et al., 2008) [29]. Dihydrolipoic acid (DHLA), the oxidized form of LA is involved in the recycling of other antioxidants in the body such as glutathione, vitamin C, coenzyme Q10 and vitamin E. Both Lipoic acid and DHLA were able to chelate a wide variety of metals which are associated with increased production of free radicals. Additionally, Lipoic acid generally complex with lysine, called lipoamide, which functions as
an essential co-factor in the mitochondrial dehydrogenase complexes which catalyse the oxidative decarboxylation of α-keto acids that plays a major role in energy metabolism (Marangon et al., 1999) [20].

The previous studies mostly focussed on Lipoic acid supplementation on growth performance and oxidative stress aspects in poultry. The trials also have positive impact on the antioxidation effect in poultry. However, no research trials have conducted on nutrient digestibility and mineral availability in poultry. Therefore, the aim of the present study was to evaluate the effects of Alpha Lipoic acid on growth performance, nutrient digestibility, mineral availability and lipid peroxidation level in broilers fed with diet containing animal fat.

Materials and methods

The present experiment was conducted at Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala using eighty-day old unsexed commercial broiler chicks (VennCobb) and the birds were randomly allotted to two treatment groups (T₁ and T₂) with four replications of ten chicks each in separate pen. The dietary treatments were control group (T₁) fed with standard broiler chicken ration as per BIS (1992) specifications with 5 per cent animal fat and the second treatment group (T₂) was supplemented with alpha lipoic acid at 100 mg/kg diet containing 5 per cent animal fat. The ingredient and chemical composition of the broiler rations are presented in Table 1 and 2.

The birds were fed with starter ration up to 4 weeks of age and finisher ration up to 6 weeks of age. Feed and clean drinking water were provided ad libitum and the birds were maintained under identical management conditions, throughout the experimental period. The body weight and feed intake of broilers was recorded at weekly intervals to study the growth pattern in two dietary treatments. Feed conversion ratio (kg of feed consumed/kg body weight gain) was calculated based on the data obtained on body weight gain and feed intake. At the end of the experimental period, five birds from each treatment were fasted overnight, slaughtered and dressed as per the standard procedures (BIS, 1973).

Table 1: Ingredient Composition of Broiler Starter and Finisher Ration, %

| Ingredients                  | Broiler starter ratios, % | Broiler finisher ratios, % |
|------------------------------|---------------------------|---------------------------|
|                              | T1            | T2            | T1            | T2            |
| Maize                        | 40            | 40            | 48.5          | 48.5          |
| Soybean meal                 | 41.4          | 41.4          | 32.89         | 32.89         |
| Wheat bran                   | 9             | 9             | 9             | 9             |
| Animal fat                   | 5             | 5             | 5             | 5             |
| Dicalcium phosphate          | 2             | 2             | 2.1           | 2.1           |
| DL-methionine                | 0.14          | 0.14          | 0.04          | 0.04          |
| Choline chloride             | 0.1           | 0.1           | 0.1           | 0.1           |
| Trace mineral mixture        | 0.01          | 0.01          | 0.01          | 0.01          |
| Supplements                  | 0.31          | 0.31          | 0.31          | 0.31          |
| Salt                         | 0.25          | 0.25          | 0.25          | 0.25          |
| Total                        | 100           | 100           | 100           | 100           |

_trace mineral mixture containing Manganese sulphate-60 g, Zinc sulphate-50 g, Ferrous sulphate-40 g, Iodide-2 g, Copper-5 g, Cobalt-2 g and Selenium-0.3 g. Supplements containing B complex vitamins, Vitamin AB₃,D,K, Toxin binder, Coccidiostat and Liver supplement.

Table 1: Chemical Composition of Broiler Starter and Finisher Rations*

| Parameters  | Broiler starter ration | Broiler finisher ration |
|-------------|------------------------|-------------------------|
| Dry matter, % | 86.83                  | 87.10                   |
| Crude protein, % | 23.25                 | 20.14                   |
| Ether extract, % | 5.48                  | 5.73                    |
The results on cumulative weekly body weight (g), Feed consumption (g) and feed conversion ratio are presented in Table 2. Throughout the experimental period, Alpha lipoic acid supplementation did not show any effect on body weight, feed consumption and feed conversion efficiency compared to the control group. In a similar study conducted by Hamano (2002, 2012) [14, 15], also couldn’t notice any effect bodyweight of birds by lipoic acid supplementation at 100 ppm in broilers. Likewise, Srilatha et al. (2010) [27] when lipoic acid fed at 20, 40 or 60 ppm, Chen et al. (2011) [10] at 100, 200 and 300 ppm did not show any effect on the feed intake of broilers. While, Zhang et al. (2009) [30] could not observe any effect on feed conversion ratio by supplementing diet with lipoic acid at various levels (0, 300, 600 and 900 ppm) for 42 days. Maddock et al. (2003) [19] supplemented weanling pigs with lipoic acid (8 and 15 mg/kg body weight) in feed and found no significant influence in the feed to gain ratios. In contrast to the present study, Sohaib et al. (2012) [25] noticed that the alpha lipoic acid supplementation increased the body weight gain in broilers. Whereas, Diaz-Cruz et al. (2003) [11] found reduced feed intake and improved the feed conversion ratio in broilers as a result of lipoic acid supplementation. In contrast, Han et al. (2011) observed poor feed conversion ratio in rats fed with 125 and 250 mg of lipoic acid/kg body weight compared to those fed with 0, 12.5 or 25 mg of lipoic acid/kg body weight.

| Mineral Composition | T1 | T2 | P value |
|---------------------|----|----|---------|
| Calcium, %          | 1.41 | 1.37 |         |
| Total phosphorus, % | 1.23 | 1.13 |         |
| Magnesium, %        | 0.37 | 0.35 |         |
| Iron, ppm           | 90.82 | 81.80 |          |
| Copper, ppm         | 19.92 | 16.65 |          |

**Calculated Values**

| Metabolisable energy, kcal/kg | T1 | T2 | P value |
|------------------------------|----|----|---------|
|                             | 2805 | 2900 |         |

**Table 2:** Nutrient availability (%) and nitrogen balance (g/day) of two dietary treatments

The reasons for the discrepancies on body weight, feed intake and feed conversion ratio between the studies were speculative but may be due to the different levels of α-lipoic acid used, age at which α-lipoic acid is added to diet, species, sex and broiler genotype, chick weight or basal diet composition.

The data on nutrient availability (%) and nitrogen balance (g/day) of two experimental rations are presented in Table 3. On statistical analysis of data, there is no significant difference (P>0.05) between the treatment and control groups. Similar to the results of the present study, Attia et al., 2016 did not find any effect on dry matter, ether extract, crude fibre and nitrogen free extract digestibility supplemented with Vitamin -E at 150 mg/kg diet in laying hens. Likewise, Crude protein and fat digestibility was not affected by vitamin-E supplementation in broilers at 200 mg/kg feed (Acikgoz et al., 2010) and (Breines et al., 2008) [18]. In contrast, Chae et al., 2006 observed that, supplementation α-Tocopherol Acetate at 100 & 200 mg/kg feed significantly improved the digestibilities of crude protein, fat & gross energy compared to control. Similarly, Lohakare et al., 2004 [31] also found that addition of vitamin - E either in feed or water improved the digestibilities of crude protein, fat & gross energy.

**Table 3:** Nutrient availability (%) and nitrogen balance (g/day) of two rations

| Parameter          | T1             | T2             | P value |
|--------------------|----------------|----------------|---------|
| Dry matter (%)     | 68.23 ± 3.21   | 68.00 ± 1.47   | 0.61    |
| Crude protein (%)  | 58.72 ± 2.92   | 55.98 ± 2.78   | 0.20    |
| Ether extract (%)  | 73.85 ± 3.29   | 71.35 ± 2.31   | 0.85    |
| Crude fibre (%)    | 34.19 ± 3.06   | 33.86 ± 1.06   | 0.60    |
| Nitrogen free extract (%) | 79.18 ± 3.08   | 79.59 ± 0.90   | 0.90    |
| Energy efficiency (%) | 70.24 ± 3.04   | 70.03 ± 1.31   | 0.46    |

* On dry matter basis
The percentage availability of calcium (Ca), phosphorus (P), magnesium (Mg), copper (Cu) and iron (Fe) as influenced by two dietary treatments are presented in Table 4. There is no difference (P>0.05) between the treatment groups on the availability of minerals. The per cent availability of Ca, P, Mg, Cu and Fe (%) for T1 & T2 were 55.22 & 54.11, 55.31 & 54.57, 54.17 & 55.69, 53.96 & 47.88, 47.95 & 46.38, respectively. In agreement with the results of present study, Rayani et al., 2017 [27] found that vitamin E supplementation at 125 and 250 ppm did not have any effect on mineral availability of Calcium, Phosphorus and zinc in broiler chicken.

Table 4: Mineral availability of two experimental rations, %

| Parameter | Mineral availability†, % | P value |
|-----------|-------------------------|---------|
|           | T1                      | T2      |       |
| Calcium   | 55.22 ± 3.29            | 54.11 ± 3.82 | 0.83   |
| Phosphorus| 55.31 ± 6.65            | 54.57 ± 2.11 | 0.91   |
| Magnesium | 54.17 ± 6.56            | 55.69 ± 2.15 | 0.83   |
| Copper    | 53.96 ± 5.81            | 47.88 ± 3.83 | 0.41   |
| Iron      | 47.95 ± 5.79            | 46.38 ± 1.07 | 0.79   |

†Mean of four values with SE

The Serum malondialdehyde (MDA) concentration (nmol/ml) of birds maintained on two dietary treatments are shown in Table 5 and MDA values were significantly (p<0.05) reduced in alpha lipoic acid supplemented group. In agreement with the results of the present study, Srilatha et al., 2010 [20] noticed that supplementation of Alpha lipoic acid at 80mg/kg feed significantly reduced the serum MDA level in broiler chicken. Similarly, Lipoic acid supplementation in feed reduced the serum MDA concentration at 200 & 300mg/kg (Chen et al., 2011) [10] and at 100, 600 & 900 ppm (Zhang et al., 2009) [30] in broilers. Generally, measurement of MDA concentration is one of the most commonly used method to measure the degree of lipid peroxidation (Halliwell & Chirico, 1993) [13]. Higher MDA concentrations reveals higher peroxidation by producing lower amount of MDA levels. This may be due to the antioxidant activity either by directly scavenging Reactive oxygen species or by recycling endogenous antioxidants such as Vitamins C, coenzyme Q10, glutathione (Busse et al, 1992) [6]. In addition, alpha lipoic acid may have an indirect effect on oxidative stress by chelating redox-active transition compounds such as iron and copper (Ou et al. 1995) [22].

Table 5: Serum Lipid peroxidation level of two dietary treatments

| Parameter      | Lipid peroxidation level † | P value |
|----------------|----------------------------|---------|
|                | T1                        | T2      |
| MDA (nmol/ml)  | 2.13 ± 0.14              | 1.64 ± 0.12 | 0.03   |

a, b – Means bearing different superscripts within the same row differ significantly (P<0.05)

†Mean of five values with SE

Conclusion

The results of the present study indicated that alpha lipoic acid supplementation did not affect the body weight, feed consumption, feed conversion ratio, availability of nutrients and minerals, however, decreased the serum MDA concentration compared to control group. Supplementation of alpha lipoic acid reduced the lipid peroxidation level, thereby improves the quality of meat.

Acknowledgement

The facilities provided by the Kerala Veterinary and Animal Sciences University and Dean, College of Veterinary and Animal Sciences, Mannuthy for conducting this study are gratefully acknowledged. We also thank all the staff members of the poultry farm unit for their assistance during care and feeding of the birds used in this research.

Competing interests: The authors declare that they have no competing interests.

References

1. AOAC. Official Methods of Analysis Association of Official Analytical Chemists, 19 Edn., Washington, D.C., USA, 2012.
2. Acikgo Z, Bayraktar H, Altun O, Akhisaroglu ST, Kirkpinar F, Altun Z. The effects of moderately oxidised dietary oil with or without vitamin E supplementation on performance, nutrient digestibility, some blood traits, lipid peroxidation and antioxidant defence of male broilers. Journal of Science & Food Agriculture. 2011; 91:1277-1282.
3. Attia YA, Abd El-Hamid E, Abedalla AA, Berika MA, Al-Harthi MA, Kucuk M et al. Laying performance, digestibility and plasma hormones in laying hens exposed to chronic heat stress as affected by betaine, vitamin C, and/or vitamin E supplementation. Springer Plus. 2016; 5:1619-1631.
4. Azman MA, Konar V, Seven PT. Effects of different dietary fat sources on growth performances and carcass fatty acid composition of broiler chickens. Revue de medecine vétérinaire. 2004; 156(5):278-286.
5. Bureau of Indian Standards. Code for handling, processing, quality evaluation and storage. IS: 7049-1973. Manak Bhavan, 9, Bahadur Sha Zafer Marg, New Delhi, 1973, 39p.
6. Bureau of Indian Standards. Requirements for Chicken feeds. IS: 1374-1992. Manak Bhavan, 9, Bahadur Sha Zafer Marg, New Delhi, 1992, 1-3.
7. Buyse J, Janssens GPJ, Decuyper E. The effects of dietary L-carnitine supplementation on the performance, organ weights and circulating hormone and metabolite concentrations of broiler chickens reared under a normal or low temperature schedule. British Poultry Science. 2001; 42(2):230-241.
8. Brenes A, Viveros A, Gon I, Centeno C, Ayredy SGS, Arija I et al. Effect of Grape Pomace Concentrate and Vitamin E on Digestibility of Polyphenols and Antioxidant Activity in Chickens. Poultry Science. 2008; 87:307-316.
9. Chae BJ, Lohakare JD, Choi JY. Effects of Incremental Levels of α-Tocopherol Acetate on Performance, Nutrient Digestibility and Meat Quality of Commercial Broilers. Asian-Australian Journal of Animal Science. 2006; 19(2):203-208.
10. Chen P, Ma QQ, Ji C, Zhang JY, Zhao LH, Zhang Y et al. Dietary lipoic acid influences antioxidant capability and oxidative status of broilers. International Journal of Molecular Sciences. 2011; 12:8476-8488.
11. Diaz-cruz A, Serret M, Ramirez G, Avila E, Guinzberg R, Pina E. Prophylactic action of lipoic acid on oxidative stress and growth performance in broilers at risk of developing ascites syndrome. Avian Pathology. 2003; 32(6):645-653.

12. Fraga CG, Leiboritz BE, Toppel AL. Lipid peroxidation measured as TBARS in tissue slices. Characterization and comparison with homogenates and microsomes. Free Radical Biology & Medicine. 1988; 4:155-161.

13. Halliwell B, Chirico S. Lipid peroxidation: Its mechanism, measurement, and significance. American Journal of Clinical Nutrition. 1993; 57:715-725.

14. Hamano Y. Influence of lipoic acid on lipid metabolism and β-adrenergic response to intravenous or oral administration of clenbuterol in broiler chickens. Reproduction Nutrition Development. 2002; 42:307-316.

15. Hamano Y. Alleviative effects of α-lipoic acid supplementation on acute heat stress induced thermal panting and the level of plasma nonesterified fatty acids in hypothyroid broiler chickens. British Poultry Science. 2012; 53(1):125-133.

16. Han P, Yin J, He P, Ma X. Dose effect study of alpha lipoic acid on growth performance in weaned rat model. Journal of Animal Biotechnology. 2011; 2(1):27-34.

17. Jeffri D, Firman H, Kamyab A. Comparison of soybean oil with an animal/vegetable blend at four energy levels in broiler rations from hatch to market. International Poultry Science. 2010; 9:1027-1030.

18. Lohakare JD, Hahn TW, Shim JY Choi, Chae BJ. Effects of feeding methods (feed vs. water) of vitamin E on growth performance and meat quality of broilers. Asian-Australian Journal of Animal Science. 2004; 17:1260-1265.

19. Maddock KR, Caroll JA, Berg EP. Evaluation of the potential role of alpha lipoic acid with regard to health and performance of weanling pigs. Journal of Animal and Veterinary Advances. 2003; 2(10):554-563.

20. Marangon K, Devaraj S, Tirosli O, Packer L. Comparison of the effect of alpha-lipoic acid and alpha-tocopherol supplementation on measures of oxidative stress. Free Radical Biology and Medicine. 1999; 27:1114-1121.

21. Mohammadi Y, Yousefi J, Kuhi HD, Ahmadi M. Effect of dietary saturated and unsaturated fats on body performance and accumulation of abdominal in broiler chickens. Iranian Journal Applied Animal Science. 2011; 1(2):87-90.

22. Ou P, Tritschler HJ, Wolff SP. Thiocyst (lipoic) acid: a therapeutic metal chelating Antioxidant. Biochem Pharmacol. 1995; 50(1):123-126.

23. Rayani TF, Mutiab R, Sumiati. Supplementation of Zinc and Vitamin E on Apparent Digestibility of Nutrient, Carcass Traits, and Mineral Availability in Broiler Chickens. Media Peternakan. 2017; 40(1):20-27.

24. Snedecor GW, Cochran WG. Statistical Methods. Eighth edition. The Iowa State University Press, Ames, IA, 1994, 314p.

25. Sohaib M, Anjum FM, Khan MI, Arshad MS, Shahid M. Enhancement of lipid stability of broiler breast meat and meat products fed on alpha lipoic acid and alpha tocopherol acetate supplemented feed. Lipids Health Disease. 2012; 11:57.

26. SPSS. 16.0.2008. Statistical Procedures Companion. Prentice Hall press, India.

27. Srilatha T, Reddy VR, Qudratullah S, Raju MVLN. Effect of alpha lipoic acid and vitamin E in diet on the performance, antioxidation and immune response in broiler chicken. International Journal of Poultry Science. 2010; 9(7):678-683.

28. Summers JD, Grandhi R, Leeson S. Calcium and phosphorus requirements of the laying hen. Poultry Science. 1976; 55(1):402-413.

29. Winiarska K, Malinska D, Szymanski K, Dudziak M, Bryla J. Lipoic acid ameliorates oxidative stress and renal injury in alloxan diabetic rabbits. Biochimie. 2008; 90:450-459.

30. Zhang Y, Hongtrakul K, Ji C, Ma QG, Liu LT, Hu XX. Effects of dietary alpha lipoic acid on antioxidative ability and meat quality in Arbor Acres broilers. Asian-Australian Journal of Animal Science. 2009; 22(8):1195-1201.