Effects of Exogenous Lysolecithin Emulsifier Supplementation on the Growth Performance, Nutrient Digestibility, and Blood Lipid Profiles of Broiler Chickens

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This study aimed to evaluate the effects of dietary supplementation of lysolecithin emulsifier on growth performance, nutrient digestibility, and blood lipid profiles in growing broiler chickens. In total, 1,020 1-day-old male Ross 308 broiler chickens with an average initial live weight of $43 \pm 1.2$ g were randomly allotted to five dietary treatments for a 35 d experiment. The treatments included: (1) NC, negative control (metabolizable energy (ME) = 3,100 kcal/kg for phase 1 and phase 2), (2) PC, positive control (ME = 3,200 kcal/kg), (3) T1, NC + 0.03% lysolecithin, (4) T2, NC + 0.06% lysolecithin, and (5) T3, NC + 0.09% lysolecithin. During days 1–35, the feed conversion ratios (FCR) of broiler chickens fed with T2 and T3 diets were lower than those of broiler chickens fed with NC diet ($P < 0.05$). On day 35, the total tract nutrient retention (TTNR) of gross energy and ether extract of broiler chickens fed with PC and T3 diets was higher than those fed with NC diet ($P < 0.05$). However, serum total cholesterol, triglyceride, and free fatty acid levels were not influenced by lysolecithin supplementation. In conclusion, lysolecithin supplementation improved FCR and TTNR of energy and ether extract when broiler chickens were offered a reduced energy diet.

Key words: blood/lipid profiles, broiler chickens, digestibility, lysolecithin, performance

Introduction

Diet energy density is one of the important factors contributing to the rapid growth of broiler chickens in a short time span. Animal fat and vegetable oil are the main supplements that are usually added to poultry diets for increasing energy concentration and improving growth performance (Blanch et al., 1996). Bile salts act as emulsifiers that disperse fat into small droplets in an aqueous environment after dietary fat enters the gastrointestinal tract. The emulsified fats are hydrolyzed by lipase and the products aggregate with bile salts to form micelles. However, particularly in young birds, the digestive tract is not developed sufficiently to produce and secrete bile salts and lipase, and the absorption and digestion of high levels of dietary lipids is inefficient (Noy and Sklan, 1998; Al-Marzooqi and Leeson, 1999). Therefore, exogenous emulsifiers may be suitable alternatives for overcoming the problems associated with high fat diet and low bile acid excretion. Several previous studies have reported that exogenous emulsifiers increased the growth performance of broiler chickens (Melegy et al., 2010; Guerreiro Neto et al., 2011; Zhang et al., 2011).

Lysolecithin also called lysophosphatidylcholine, is formed by the hydrolysis of phospholipids and is known to be an effective emulsifier in the food industry (Van Nieuwenhuyzen, 1981). The addition of lysolecithin to diet effectively decreased the size of fat globules and increased the active surface of fats for enzymatic digestion (Gu and Li, 2003; Gheisar et al., 2015). This is because fat globules are not easily enzymatically digested and persist as indigestible residues within the intestinal tract. Lysolecithin feeding was recently reported to increase egg weight and feed efficiency in laying hens (Han et al., 2010), and improve growth performance of broiler chickens in the starter period due to increased fatty acid digestibility (Zhang et al., 2011). In addition, dietary emulsifier supplementation increased lipid absorption and decreased the free fatty acid and cholesterol levels in blood (Jones et al., 1992). We hypothesized that lysolecithin might promote the emulsification process in vivo and assist in the efficient digestion of fats. However, studies assessing the effects of various emulsifiers in broiler chickens are limited and inconsistent. Therefore, the objective of this study was to determine the effects of lysolecithin on
growth performance and nutrient digestibility of broiler chickens fed with two dietary levels of metabolizable energy (ME).

**Materials and Methods**

The experimental protocols describing the management and care of animals were reviewed and approved by the Institutional Animal Care and Use Committee of Dankook University (IACUC protocol No. DKU-16-025).

**Experimental Design**

In total, 1,020 male broiler chickens (Ross 308) with an average body weight of 43 ± 1.2 g were randomly assigned to five treatment groups with 17 birds/cage and 12 cages/treatment for a 35-day experiment. The birds were fed diets based on corn and soybean meal in two phases: days 1 to 21 and days 22 to 35 (Table 1). The negative control (NC) diets were formulated to contain 100 kcal/kg less energy than the positive control (PC), based on a previous study (Park and Kim, 2016) that showed significant differences in bird production and blood lipid metabolites. The treatments included: (1) NC (ME = 3,100 kcal/kg), (2) PC (ME = 3,200 kcal/kg), (3) T1, NC + 0.03% lysolecithin, (4) T2, NC + 0.06% lysolecithin, and (5) T3, NC + 0.09% lysolecithin. All broiler chickens were allowed *ad libitum* access to feed and water throughout the experiment, and were housed in an environmentally controlled room. Temperature was gradually reduced from 33°C on day 1 to 23°C by the end of the experiment.

**Experimental Procedures and Sampling**

Body weight and feed intake per cage were recorded from day 1 to 21 of age and day 22 to 35 of age, respectively, and used to calculate body weight gain, feed intake, and feed conversion ratio. At day 32, 0.2% chromium oxide was added to the diet as an indigestible marker for three days before fecal collection to determine total tract nutrient retention (TTNR) of dry matter, nitrogen, ether extract, and gross energy (Fenton and Fenton, 1979). On day 35, fecal samples of 12 replicates from each treatment were collected for TTNR analysis. For blood profiles, 24 birds per treatment (two birds per cage) were randomly selected and blood samples were taken from a vein in the left wing. All blood and fecal samples were stored at −20°C until analysis.

**Laboratory Analysis**

Before chemical analysis, fecal samples were dried at 60°C

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**Table 1. Composition of experimental diets (as-fed basis)**

| Ingredients (%) | Phase 1 1 | Phase 2 2 |
|-----------------|-----------|-----------|
|                 | NC        | PC        | NC        | PC        |
| Corn            | 53.58     | 51.71     | 59.15     | 57.27     |
| Soybean meal    | 25.14     | 24.09     | 19.65     | 18.59     |
| Corn gluten meal| 9.66      | 10.54     | 5.25      | 6.13      |
| Canola meal     | 5.00      | 5.00      | 10.00     | 10.00     |
| Tallow          | 3.00      | 5.00      | 3.00      | 5.00      |
| Tricalcium phosphate | 1.81     | 1.84     | 1.35      | 1.36      |
| Limestone       | 0.84      | 0.84      | 0.93      | 0.92      |
| Salt            | 0.46      | 0.46      | 0.34      | 0.34      |
| DL-Methionine (98%) | 0.16   | 0.17     | 0.05      | 0.05      |
| L-Lysine (99%)  | 0.04      | 0.07      | 0.001     | 0.03      |
| Vitamin premix 2| 0.15      | 0.15      | 0.15      | 0.15      |
| Mineral premix 2| 0.15      | 0.15      | 0.15      | 0.15      |

| Calculated composition | Phase 1 | Phase 2 |
|------------------------|---------|---------|
| ME (kcal/kg)           | 3,100   | 3,200   |
| CP (%)                 | 23.0    | 23.0    |
| Lysine (%)             | 1.10    | 1.10    |
| Methionine (%)         | 0.50    | 0.50    |
| Ca (%)                 | 1.00    | 1.00    |
| Available P (%)        | 0.76    | 0.76    |
| Crude fat (%)          | 5.47    | 7.36    |
| Crude fiber (%)        | 3.12    | 3.04    |

| Analyzed composition   | Phase 1 | Phase 2 |
|------------------------|---------|---------|
| GE (kcal/kg)           | 3,750   | 3,860   |
| CP (%)                 | 22.5    | 22.8    |
| Crude fat (%)          | 5.38    | 7.41    |

1 Phase 1 diet provided during days 1 to 21; Phase 2 diet provided during days 22 to 35.
2 Provided per kg feed: 15,000 IU vitamin A, 3,750 IU vitamin D3, 37.5 mg vitamin E, 2.55 mg vitamin K3, 3 mg thiamin, 7.5 mg riboflavin, 4.5 mg vitamin B6, 24 μg vitamin B12, 51 mg niacin, 1.5 mg folic acid, 0.2 mg biotin, and 13.5 mg pantothenic acid.
3 Provided per kg feed: 37.5 mg Zn, 37.5 mg Mn, 37.5 mg Fe, 3.75 mg Cu, 0.85 mg I, 62.5 mg S, and 0.23 mg Se.
for 72 h, after which they were ground and passed through a 1-mm screen. Feed and fecal samples were analyzed for dry matter (Method 930.15; AOAC, 2007), crude protein (Method 990.03; AOAC, 2007), and ether extract (Method 960.39; AOAC, 2007). Chromium content was analyzed using ultraviolet (UV) absorption spectrophotometry (Shimadzu UV-1201, Shimadzu, Kyoto, Japan). The gross energy values of the diet and excreta samples were measured by measuring the heat of combustion in the samples using a Parr 6100 oxygen bomb calorimeter (Parr instrument Co., Moline, IL, USA). The total tract nutrient retention (TTNR) was calculated using the following formula:

$$TTNR(\%) = \left(100 - \frac{\text{marker in feed}}{\text{marker in feces}}\right) \times \left(\frac{\text{nutrient in feed}}{\text{nutrient in feces}}\right)$$

Blood samples collected for lipid measurements in non-heparinized vacuum tubes were centrifuged (3,000×g) at 4°C for 15 min. The total cholesterol and triglyceride levels in the serum samples were analyzed using an auto analyzer (Automatic Biochemical Analyzer, RA-1000; Bayer Corp., Tarrytown, NY, USA) and colorimetric methods. The free fatty acid content in serum was measured using commercial test kits according to the manufacturer’s instructions (Enzychrom, Bio-Assays Systems, CA, USA).

### Statistical Analysis

The replicates were the experimental units for evaluation of growth performance and total tract nutrient retention. Each broiler was the experimental unit for blood lipid metabolite determination. Data were analyzed using the GLM procedure of SAS as a randomized complete block design (SAS Inst. Inc., Cary, NC, USA). Tukey’s post hoc test was performed to detect the significance of differences among groups. The statistical difference of the values was expressed at $P<0.05$ and results were expressed as means±standard error of the mean (SEM).

### Results and Discussion

The primary objective of this study was to investigate the influence of lysolecithin supplementation and different dietary levels of ME on nutrient digestibility and blood lipid profiles in broiler chickens, and their relationship with productivity.

During phase 1 and phase 2 of this study, tallow and fat content in the PC diet was about 2% higher than that in the NC diet. As a result, broiler chickens fed with PC diet during days 1–35 showed a significant difference in the feed conversion ratio ($P<0.05$), whereas no difference was observed in weight gain and feed intake between the NC and PC groups (Table 2). The feed conversion ratio in broiler chickens fed with T2 and T3 diets containing 0.06% and 0.09% lysolecithin, respectively, improved during day 1–35 compared to those fed with NC diet ($P<0.05$). However, lysolecithin supplementation did not affect weight gain and feed intake or feed conversion ratio during days 1–21, 22–35, or 1–35.

Previous studies indicated that the emulsifier improved homogenization of the ingesta, which may result in enhanced utilization efficiency of dietary fat and improved growth performance and lipid metabolism in broiler chickens and pigs (Dierick and Decuyper, 2004). Although physiological roles of emulsifying activity have been reported, its effects on productivity remain controversial. For example, Melegy et al. (2010), Roy et al. (2010), and Zhang et al. (2011) reported improvements in body weight or feed efficiency with the addition of emulsifiers to broiler chicken feeds. In addition, Overland et al. (1993) suggested that the effect of emulsifiers on growth performance might be more beneficial when animal fats are used. In contrast, Azman and Ciftci (2004) reported that emulsifiers did not have any significant effect on the productivity of broiler chickens in terms of body weight and feed conversion ratio. Overland et al. (1993, 1994) did not observe any benefit in the growth performance of weanling or growing-finishing pigs using soy lecithin. The inconsistent results regarding growth performance could be due to differences in the types and levels of dietary fat sources (soybean oil, palm oil, tallow, poultry fat) and the major component of emulsifying agents (soybean lecithin, lysophosphatidylcholine, glycercyl-polyethylene glycol ricinoleate). Moreover, the results of the present study were similar to those of Khonyoung et al. (2015) reported that no statistical difference occurred in bird body weight gain, but improvement in feed conversion ratio between emulsifier and control treatments was observed. The findings of the present study suggest that the addition of lysolecithin emulsifier to low energy diets alleviated the negative effects and improved feed conversion ratio.

The results presented in Table 3 indicate that supplementing low energy level diets with 0.09% lysolecithin significantly enhanced digestibility of energy and ether extract, and demonstrate that reducing the dietary energy levels in NC diet had a negative impact on the digestibility of energy and ether extract ($P<0.05$); however, emulsifier supplementation (0.09%) of NC diet (low energy diet) improved ($P<0.05$) the digestibility of energy and ether extract, which were equal to those of the PC treatment (high energy diet). Our observations are supported by the results of Guerreiro Neto et al. (2011), Cho et al. (2012), and Abbas et al. (2016), who reported that the addition of emulsifier to diet increased the digestibility of ether extract in broiler chickens. Feeding broiler chickens with dietary emulsifier in the late growth phase has also been reported to enhance energy digestibility (Gheisar et al., 2015). Exogenous emulsifier supplementation reportedly improved fat utilization in young chickens because low lipase levels limit the digestion and intestinal absorption of fat in young birds (Al-Marzooqi and Leeson, 1999). This might be attributed to the action of lysolecithin as a dietary fat emulsifier, which, along with increased lipolysis of triglycerides, results in higher levels of micelle formation, digestion, and absorption of fats (Cho et al., 2012). The present study suggests that the lysolecithin addition to low energy diets alleviated the negative effects and improved the feed conversion ratio by increasing feed digestibility. However, addition of the lysolecithin increased the TTNR of ether extract and energy, although this effect was not translated into improvements in weight gain.
In the present study, inclusion of lysolecithin did not affect serum total cholesterol, triglyceride, or free fatty acid concentrations (Table 4). Previous studies on the effect of emulsifiers on blood lipid profiles of broiler chickens are limited. In addition, the results of studies on the response of lipid metabolites to dietary emulsifier supplementation are inconsistent. Roy et al. (2010) and Guerreiro Neto et al. (2011) reported that serum total cholesterol, triglyceride, and HDL-cholesterol levels of broiler chicken fed with diets containing vegetable oil or animal fat were not affected by emulsifier supplementation (glyceryl polyethylene glycol ricinoleate and caseinate, respectively). Conversely, Cho et al. (2012) reported that broiler chickens fed with diet containing 0.05% emulsifier (sodium stearoyl-2-lactylate) had lower serum
triglycerides than those fed with high-energy diets without emulsifier. We presume that the effect on lipid metabolites may depend on fat sources and emulsifier types. The use of emulsifiers in modulating lipid metabolism in poultry needs to be further investigated.

In conclusion, the current study indicates that reduction in dietary energy levels adversely affected the feed conversion ratio of broiler chickens; however, supplementation of low energy diets with emulsifiers could alleviate these negative effects and improve the feed conversion ratio. The inclusion of an emulsifier in broiler chickens diet also improved the TTNR of energy and ether extract.

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References

Abbas MT, Arif M, Reyad-ul-ferdous M, Hassan MA, Arain MA and Rehman A. Emulsifier effect on fat utilization in broiler chicken. Asian Journal of Animal Veterinary Advances, 11: 158–167. 2016.

Al-Marzooqi W and Leeson S. Evaluation of dietary supplements of lipase, detergent, and crude porcine pancreas on fat utilization by young broiler chicks. Poultry Science, 78: 1561–1566. 1999.

AOAC. Official Methods of Analysis. 18th ed. Association of Official Analytical Chemists, Washington, DC. 2007.

Azman MA and Ciftci M. Effect of replacing dietary fat with lecithin on broiler zootechnical performance. Revue de Medecine Vetrinaire, 155: 445–448. 2004.

Blanch A, Barroeta AC, Baucells MD, Serrano X and Puchal F. Utilization of different fats and oils by adult chickens as a source of energy, lipid and fatty acids. Animal Feed Science and Technology, 61: 335–342. 1996.

Cho JH, Zhao PY and Kim IH. Effects of emulsifier and multi-enzyme in different energy density diet on growth performance, blood profiles, and relative organ weight in broiler chickens. Journal of Agricultural Science, 4: 161–168. 2012.

Dierick NA and Decuypere JA. Influence of lipase and/or emulsifier addition on the ileal and faecal nutrient digestibility in growing pigs fed diets containing 4% animal fat. Journal of the Science of Food and Agriculture, 84: 1443–1450. 2004.

Fenton TW and Fenton M. An improvement procedure for determination of chromic oxide in feed and feces. Canadian Journal of Animal Science, 59: 631–634. 1979.

Gheisar MM, Hosseindoust A, Kim HB and Kim IH. Effects of lysolecithin and sodium stearoyl-2-lactylate on growth performance and nutrient digestibility in broilers. Korean Journal of Poultry Science, 42: 133–137. 2015.

Gu X and Li D. Fat nutrition and metabolism in piglets: A review. Animal Feed Science and Technology, 109: 151–170. 2003.

Guerreiro Neto AC, Pezzato AC, Sartori JR, Mori C, Cruz VC, Fascina VB, Pinheiro DF, Madeira LA and González JC. Emulsifier in broiler diets containing different fat sources. Brazilian Journal of Poultry Science, 13: 119–125. 2011.

Han YK, Jin YH, Lee WI, Lee KT and Thacker PA. Influence of lysolecithin on the performance of laying hens, interior and exterior egg quality as well as fat soluble vitamin and cholesterol content in the yolk. Journal of Animal and Veterinary Advances, 9: 2583–2588. 2010.

Jones DB, Hancock JD, Harmon DL and Walker CE. Effects of exogenous emulsifiers and fat sources on nutrient digestibility, serum lipids, and growth performance in weanling pigs. Journal of Animal Science, 70: 3473–3482. 1992.

Khonyoung D, Yamauchi K and Suzuki K. Influence of dietary fat sources and lysolecithin on growth performance, visceral organ size, and histological intestinal alteration in broiler chickens. Livestock Science, 176: 111–120. 2015.

Melegy T, Khaled NF, El-Bana R and Abdellatif H. Dietary fortification of a natural biosurfactant, lysolecithin in broiler. African Journal of Agricultural Research, 5: 2886–2892. 2010.

Noy Y and Sklan D. Metabolic responses to early nutrition. Journal of Applied Poultry Research, 7: 437–451. 1998.

Overland M, Tokach MD, Cornelius SG, Pettigrew JE and Rust JW. Lecithin in swine diets: I. Weanling pigs. Journal of Animal Science, 71: 1187–1193. 1993.

Overland M, Mroz Z and Sundstol F. Effect of lecithin on the apparent ileal and overall digestibility of crude fat and fatty acids in pigs. Journal of Animal Science, 72: 2022–2028. 1994.

Park JH and Kim IH. Interactive effects of fenugreek (Trigonella foenum-graecum L.) seed extract supplementation and dietary metabolisable energy levels on the growth performance, total tract digestibility, blood profiles, and excreta gas emission in broiler chickens. Animal Production Science, 56: 1677–1682. 2016.

Roy A, Haldar S, Mondal S and Ghosh TK. Effects of supplemental exogenous emulsifier on performance, nutrient metabolism, and serum lipid profile in broiler chickens. Veterinary Medicine International, 2010: 1–9. 2010.

Van Nieuwenhuysen W. The industrial uses of special lecithins. Journal of the American Oil Chemists’ Society, 58: 886–888. 1981.

Zhang B, Haitao L, Zhao D, Guo Y and Barri A. Effect of fat type and lysophosphatidylcholine addition to broiler diets on performance, apparent digestibility of fatty acids, and apparent metabolizable energy content. Animal Feed Science and Technology, 163: 177–184. 2011.