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Effects of Replacing Soy-oil with Soy-lecithin on Growth Performance, Nutrient Utilization and Serum Parameters of Broilers Fed Corn-based Diets*

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ABSTRACT : This study was conducted to examine the effects of different soy-oil and soy-lecithin levels on growth performance, nutrient utilization and serum parameters in broiler chickens. Two hundred and forty 1-day-old Arbor Acres chicks were randomly divided into 4 groups and treated as follows: basal diet with 2% soy-oil (SO); soy-oil and soy-lecithin mixture in proportion of 75/25 (SOL1), 50/50 (SOL2) and 2% lecithin (SL). At the end of the trial (42 d), birds in SOL1 group grew faster ($p<0.05$) and had better feed conversion efficiency ($p<0.05$) than other groups while SL group had the lowest performance ($p<0.05$). The utilization of ether extract was improved in SOL1 group ($p<0.05$) but apparent metabolizable energy (AME) and utilization of other nutrients decreased in SOL2 and SL group from 19 to 21 d. No significant effects were observed in apparent metabolizable energy, dry matter, crude protein and ether extract but the utilization of calcium and phosphorus was significantly improved in SL group ($p<0.05$) during 39 to 42 d. The birds fed with lecithin had lower serum total cholesterol and triglyceride than the control group (SO). Broilers fed with 2% lecithin (SL) had the highest insulin level ($p<0.05$). The results implied that soy-lecithin and soy-oil in a proportion of 25:75 had the highest growth performance and that soy-lecithin had cholesterol lowering capacity. (**Key Words** : Soy-lecithin, Soy-oil, Chicken, Performance, Serum Parameter)

INTRODUCTION

Fats and oils are usually added to broiler diet as dietary energy-yielding ingredients to improve productivity, thus efficient fat digestion is crucial for chicken growth. But fats utilization was limited in young birds because of the lack of several digestion enzymes. Fats were not efficiently used until lipase activity reached its maximum level (Krogdahl and Sell, 1989). However, the addition of high level of saturated fat to broiler rations may result in excessive visceral fat, loss of vitamin A and E which was found beneficial for growth and meat quality (Chae et al., 2006; Zulkifli et al., 2007). Fats rich in unsaturated fatty acids are better digested and absorbed than saturated fats by broilers (Atteh and Leeson, 1984; Leeson and Atteh, 1995). Fat is water-insoluble, thus an emulsion step is required in fat absorption. Studies found that dietary supplementation of bile salts improves emulsion formation and fat digestibility in chickens (Polin et al., 1980; Kussaibati et al., 1982). Phospholipids are known to have surface active properties. They are important in the emulsification of lipids and may influence the absorption of fatty acids in the small intestine (Jenkins et al., 1989).

Soy-lecithin, a by-product from the processing of soybean oil, not only provides energy to broilers but also serves as an emulsifier and has the potential to enhance utilization of dietary fat by animals. Jin et al. (1998) reported that the addition of lecithin to tallow increased digestibility of gross energy, dry matter, ether extract and crude protein in piglets. Lecithin has been widely used in animal diets, such as sheep (Jenkins and Fotouhi, 1990), lambs (Lough et al., 1991), horses (Holland et al., 1998), fish and crustacean larviculture (Coutteau et al., 1997; Liu et al., 2004), swine (Overland et al., 1994; Soares and Lopez-Bote, 2002). Soy-lecithin is also very popular for its possible benefits in lowering blood cholesterol levels (Tompkins and Parkin, 1980; Spilburg et al., 2003; Ipatova et al., 2004). But the effects of lecithin on chicks are scarce and inconsistent. Some studies indicated positive effects (Emmert et al., 1996; Cox et al., 2000), while others reported lecithin did not induce any significant increase of broiler performances (Azman and Ciftci, 2004).

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Table 1. Formulation and calculated composition of diets

Item	1-21 d				21-42 d			
	SO	SOL1	SOL2	SL	SO	SOL1	SOL2	SL
Ingredient (%)								
Maize	61	61.3	61.7	62.4	68	69.3	68.5	68.6
Soybean meal	29.3	29.2	29.1	29	23	23.4	23.3	23.3
Fishmeal	2	2	2	2	2	2	2	2
Soybean oil	2	1.5	1	-	2	1.5	1	-
Lecithin	-	0.5	1	2	-	0.5	1	2
Limstone powder	2.35	2.15	1.85	1.25	1.5	1.28	1.15	1.12
Dicalcium phosphate	1.76	1.77	1.77	1.77	1.6	1.53	1.56	1.5
Methionine	0.2	0.2	0.2	0.2	0.1	0.14	0.14	0.14
Premix[a]	1	1	1	1	1	1	1	1
Salt	0.39	0.38	0.38	0.38	0.4	0.35	0.35	0.34
Total	100	100	100	100	100	100	100	100
Calculated analysis								
ME (MJ/kg)	12.26	12.26	12.26	12.26	12.55	12.55	12.55	12.55
Crude protein	20	20	20	20	18	18	18	18
Calcium (%)	1.3	1.3	1.2	1	1	0.89	0.9	0.87
Available phosphorus (%)	0.47	0.47	0.47	0.47	0.4	0.44	0.43	0.43
L-lysine (%)	1.1	1.1	1.1	1.1	0.9	0.9	0.9	0.9
Methionine+cystine (%)	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7

[a] Provided per kg of diet: iron, 60 mg; copper, 7.5 mg; zinc, 65 mg; manganese, 110 mg; iodine, 1.1 mg; selenium, 0.4 mg; Bacitracin Zinc, 30 mg; vitamin A , 4500 IU; vitamin D_3, 1,000 IU; vitamin E, 20 mg; vitamin K, 1.3 mg; vitamin B_1 2.2 mg; vitamin B_2, 10 mg; vitamin B_3, 10 mg; choline choride, 400 mg; vitamin B_5, 50 mg; vitamin B_6,4 mg; Biotin, 0.04 mg; vitamin B_{11}, 1mg; vitamin B_{12}, 1.013 mg.

SO = Basal diet with 2% soy-oil; SOL1= Basal diet with 0.5% soy-lecithin and 1.5% soy-oil;

SOL2 = Basal diet with 1% soy-lecithin and 1% soy-oil; SL = Basal diet with 2% soy-lecithin.

Table 2. Fatty acid composition of soy-oil and soy-lecithin, % of fatty acids

Fatty acid	Soy-oil	Soy-lecithin
C16:0	10.35	10.92
C18:0	4.22	4.28
C18:1	24.5	23.06
C18:2	53.04	54.21
C20:0	0.33	0.31
C18:3	5.75	6.7
Saturated	14.9	15.51
Unsaturated	83.29	83.97
U:S	5.59	5.41

The aim of the present study was to determine whether soy-lecithin could enhance the utilization of soy-oil in broiler chickens in terms of growth performance, the apparent digestibility of nutrients and the effects of soy-lecithin on some serum parameters were also been studied.

MATERIALS AND METHODS

Animals, diets and feeding treatment

Two hundred and forty 1-day-old Arbor Acres chicks obtained from a commercial hatchery (Hewei, Anhui, China) were randomly assigned to 4 treatment groups consisting of 10 replicates of 6 birds. The average body weight had no significant differences among the four groups at the beginning of the experiment. Chickens were fed corn-soybean basal diets supplemented with 2% soy-oil (SO), basal diet with 0.5% soy-lecithin and 1.5% soy-oil (SOL1); basal diet with 1% soy-lecithin and 1% soy-oil (SOL2); basal diet with 2% soy-lecithin (SL), respectively. The percentage of all other major ingredients remained similar among treatments. The diets were formulated to meet the nutrient requirements of the broilers (NRC, 1994). The ingredients and composition of diets are shown in Table 1. The birds were fed a starter diet until 21 d of age followed by a grower diet from 21 to 42 d. Birds were allowed to consume both feed and water on an *ad libitum* basis and housed (six per box) in an environmentally controlled room maintained at 34-36°C during 1 to 14 d and then was reduced progressively to reach 26°C at the end of the experiment with a 12-h light-dark cycle (06:00-18:00 h light). The lecithin source used in these experiments was crude soy-lecithin and it contained a large proportion of unsaturated fatty acids (83.9%), of which linoleic acid (18:2) was predominant (Table 2). Fatty acids of soy-oil and soy-lecithin were saponified and methylated using 2% NaOH in methanol, 14% BF3/methanol and heptane. Fatty acid methyl esters (FAME) were analyzed by gas chromatography as described by (Soares and Lopez-Bote, 2002).

Growth performance

Mean body weight of chickens in every cage was determined at the beginning of the experiment (1 d), 21 d and at the end of the experiment (42 d). Feed was

Table 3. Average daily gain (ADG), feed intake (ADFI), feed conversion efficiency (FCE) and mortality of broilers fed corn basal diets supplemented with different proportion of soy-oil and soy-lecithin

Item	SO	SOL1	SOL2	SL
No. of replicates	10	10	10	10
No. of broilers	60	60	60	60
Initial weight (g)	41.99±0.34	42.82±0.02	42.29±0.56	42.07±0.11
Final weight (kg)	1.982±0.05[a]	2.14±0.06[b]	2.101±0.06[ab]	1.705±0.04[c]
Day 0-21				
ADG (g)	27.66±0.01[a]	28.21±0.11[a]	26.19±0.01[a]	22.87±0.2[b]
ADFI (g)	35.95±0.18[a]	36.73±0.22[a]	35.97±0.48[a]	33.52±0.02[b]
FCE (g/g)	1.3±0.01[a]	1.3±0.07[a]	1.37±0.1[a]	1.47±0.01[b]
Mortality (%)	5	3.333	3.333	8.333
Day 21-42				
ADG (g)	66.72±0.18[a]	73.7±0.09[b]	73.86±0.11[b]	58.32±0.01[c]
ADFI (g)	148.35±0.20[a]	148.28±0.33[a]	146.68±0.19[a]	137.66±0.67[b]
FCE (g/g)	2.22±0.03[a]	2.01±0.09[b]	1.99±0.02[b]	2.36±0.00[a]
Mortality (%)	0	1.68	0	1.6
Day 0-42				
ADG (g)	47.19±0.47[a]	50.95±0.55[b]	47.86±0.22[ab]	40.6±0.17[c]
ADFI (g)	90.44±0.69[a]	90.75±0.88[a]	87.3±0.59[a]	84.13±0.97[b]
FCE (g/g)	1.92±0.00[a]	1.78±0.01[b]	1.82±0.01[c]	2.07±0.02[d]
Mortality (%)	5	5	3.33	5

SO = Basal diet with 2% soy-oil; SOL1= Basal diet with 0.5% soy-lecithin and 1.5% soy-oil.
SOL2 = Basal diet with 1% soy-lecithin and 1% soy-oil; SL = Basal diet with 2% soy-lecithin. Values are means±SE.
n = 10. Values in a row not sharing same superscript are different at $p<0.05$.

withdrawn 12 h and water was provided for *ad libitum* consumption before weighing at 21 d and 42 d. Feed intakes were recorded every day, and the feed conversion efficiency (FCE) was calculated at 21 d and 42 d. Mortality was recorded as it occurred and percentage mortality was determined at 21 d and at the end of the study. Mean body weight, feed intake, and FCE were used to determine the performance of birds.

At the end of 6 week, the birds were forbidden from feed for 12 h with free access to water, and 10 birds from each treatment were randomly selected and killed by severing the jugular vein. The birds were weighed before they were sacrificed. Liver, heart, kidney, and spleen were excised and weighed. The relative weight of organs was calculated as follows: Weight of organ (g)/Body weight (kg).

Nutrient utilization

On day 19 to 21, birds (10 birds from each group) were placed into individual cages, and trays were placed under each cage, and a 3-day total collection of excreta was conducted. Before the collection of excreta, birds were fasted for 12 h with free access to water, and then fed experimental diets *ad libitum* for 3 days followed by a 12 h fast. Feathers and scales were removed carefully from the trays to avoid contamination. Excreta were collected and frozen (-20°C) each day. At the end of the 3 collection days, feed intakes were recorded and excreta of each cage were mixed. Samples of the mixture were taken and dried to a constant weight in a hot air oven at 65°C for 24 h and grounded through a laboratory mill fitted with 1 mm screen. On day 40 to 42, another 3-day total collection of excreta was conducted in the same way.

Samples of diets and dried excreta were analyzed according to the standard method (AOAC, 1990) for apparent metabolizable energy (AME), dry matter (DM), crude protein (CP), ether extract (EE), calcium (Ca) and total phosphorus (P).

Serum measurements

At the end of the experimental period, 10 birds from each treatment group were randomly selected and sacrificed to get blood. Blood samples were centrifuged at 1,500×g 4°C for 15 min after keeping at 4°C for 12 h. The serum was separated and stored at -20°C until analyzed. Total serum cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), were measured using commercial kits purchased from Nanjing Jiancheng Bioengineering Institute (Nanjing, China). Triiodothyronine (T_3), thyroxine (T_4), thyrotropic-stimulating hormone (TSH) and insulin (INS) measured with the RIA kits provided by Beijing North Institute of Biotechnology (Beijing, China).

Statistical analysis

Data were analyzed by one-way ANOVA. Duncan's multiple range test was used to determine whether means were significantly different ($p<0.05$). Values were expressed as mean±SE. All the statistical analyses were performed

Table 4. Relative weight of organs (g/kg) of broilers fed corn basal diets supplemented with different proportion of soy-oil and soy-lecithin at 42 d

Item	SO	SOL1	SOL2	SL
Liver	19.8±0.041[a]	18.59±0.06[a]	19.19±0.07[a]	24.46±0.09[b]
Heart	4.3±0.02[ab]	3.81±0.01[a]	4.1±0.02[ab]	4.42±0.01[b]
Kidney	5.2±0.04	4.99±0.04	5.38±0.03	5.72±0.04
Spleen	1.25±0.01	1.40±0.01	1.46±0.01	1.49±0.01
Thymus	3.92±0.05[a]	4.07±0.04[a]	4.22±0.04[a]	5.82±0.05[b]

SO = Basal diet with 2% soy-oil; SOL1 = Basal diet with 0.5% soy-lecithin and 1.5% soy-oil.
SOL2 = Basal diet with 1% soy-lecithin and 1% soy-oil; SL = Basal diet with 2% soy-lecithin. Values are means±SE, n = 10.
Values in a row not sharing same superscript are different at $p<0.05$.

using SPSS statistical software (Ver.11.5 for windows, SPSS). Cage means were used as experimental units in growth experiment, and individual observations were used as experimental units in other experiments.

RESULTS AND DISCUSSION

Effects on performance

The results of growth performance of the broilers are presented in Table 3. The present study demonstrated that the performance of birds fed with 0.5% soy-lecithin and 1.5% soy-oil (SOL1) was better than other groups, while the birds fed with 2% lecithin (SL) showed poorer performance ($p<0.05$). A previous study has shown that the body weight of groups supplemented with lecithin at 21 days and 35 days were not significantly different from those of the control group (Azman and Ciftci, 2004). In current study, the final body weight was significantly improved when 0.5% lecithin was included in the diet which contained 1.5% soy-oil after 42 days. During the starter period (from 1[st] to 21[st] day), broilers fed with 2% lecithin (SL) had the lowest average daily gain (ADG), feed intake (ADFI) and its FCE was the worse compared with other groups ($p<0.05$). During the grower period (from 22[nd] to 42[nd] day), a significant increase of ADG and FCE were obtained in SOL1 group and SOL2 group ($p<0.05$), whereas the SL group presented the lowest performance ($p<0.05$). When calculated on the basis of the entire experimental period (0-6 weeks), ADG and FCE were significantly improved in SOL1 group ($p<0.05$) while the SL group had the lowest performance ($p<0.05$). Lecithin suppresses gastric emptying and food intake in rats, and these results depend mainly on the enhancement of CCK release by intestinal lecithin-containing lipid (Nishimukai et al., 2003). In human, high doses of lecithin can produce side effects such as sweating, nausea, vomiting, bloating, and diarrhea (Lawhon, 2007). In the present study, 2.0% lecithin maybe a high dose for broilers, because diarrhea was observed in the broilers fed with 2.0% lecithin in the starter period (from 1[st] to 21[st] day) but not in the grower period (from 22[nd] to 42[nd] day). This indicates that broilers utilized lecithin better when they got older.

The effects of lecithin on relative weights of liver, heart, kidney, spleen and thymus are shown in Table 4. SL group has the highest relative liver weight and thymus weight ($p<0.05$). Relative weight of kidney and spleen were not affected by dietary treatment ($p>0.05$). The relative weight of liver can be improved by soy-lecithin in broilers, and this is consistent with what was observed in a previous study (Wang et al., 1999). Soy-lecithin is a good emulsifier and it has the potential to facilitate fat absorption (Lechowski et al., 1999). In avian species, liver is the most important organ for the intermediary metabolism of lipids (Theil and Lauridsen, 2007) and lipogenesis takes place primarily in the liver and the liver accounts for 95% of the de novo fatty acid synthesis (Griffin et al., 1992). The effect that lecithin can improve the relative weight of liver maybe correlated with the enhanced lipid metabolism in liver.

Effects on nutrients utilization

The effects of lecithin on nutrients utilization are shown in Table 5. The utilization of EE was improved in SOL1 group in the starter period, but the utilization of EE had no difference in the grower period. The digestibility of fat is limited in young chickens, as the lipase they secrete is not enough. Although some published data indicate that the daily net duodenal secretion of lipase increases 20-fold as the bird ages (Noy and Sklan, 1995) and the activities of lipase also increase with age (Krogdahl and Sell, 1989), the secretion of lipase when calculated per gram of feed intake is less dramatic. This indicates that the lipase secretion of young birds may not be as inadequate as expected when their feed intake is considered (Meng et al., 2004). Bile salts also play an essential role in the digestion of lipid but the secretion of bile salts is considered to be the principal limitation for lipid utilization during the first weeks after hatching (Knarreborg et al., 2004). In the present study, the utilization of EE was improved ($p<0.05$) in broilers fed with diets containing soy-oil and soy-lecithin in a proportion of 25/75 (SL1) during 19-21 d. When soy-lecithin completely replaced soy-oil (SL), the utilization of EE did not enhance from 19 to 21 d. Some researchers considered that the possible beneficial effect of lecithin on digestibility, rather than being due to a specific emulsifying effect, might be the

Table 5. Apparent metabolizable energy (AME), dry matter (DM), crude protein (CP), ether extract (EE), calcium (Ca) and total phosphorus (P) of broilers fed corn basal diets supplemented with different proportion of soy-oil and soy-lecithin

Item	SO	SOL1	SOL2	SL
Day 19-21				
ME (MJ/kg)	13.5±0.28^{a}	13.6±0.24^{a}	11.7±0.24^{b}	12.25±0.61^{b}
DM (%)	83.53±0.27^{a}	83.34±0.42^{a}	73±1.7^{b}	77.03±0.88^{c}
CP (%)	77.21±0.45^{a}	75.77±0.18^{a}	65.99±0.79^{b}	62.13±0.95^{b}
EE (%)	75.37±1.33^{a}	80.68±0.23^{b}	70.29±1.7^{c}	72.27±0.8^{ac}
Ca (%)	59.64±0.075^{a}	54.47±0.74^{b}	53.62±0.56^{bc}	52.88±0.23^{c}
P (%)	70.79±0.47^{a}	65.26±0.62^{ab}	61.12±1.6^{bc}	55.32±3.3^{c}
Day 40-42				
ME (MJ/kg)	13.39±0.18	13.33±0.05	13.33±0.12	13.36±0.02
DM (%)	83.52±0.87	83.29±0.28	82.88±0.57	83.72±0.13
CP (%)	80.6±1.075	76.27±1.00	78.56±2.49	82.1±1.59
EE (%)	77.88±2.42	78.09±2.7	73.7±0.98	72.08±1.78
Ca (%)	62.92±10.01^{a}	62.66±1.73^{a}	63.86±0.2^{a}	70.42±2.36^{b}
P (%)	61.82±2.92^{a}	60.95±1.03^{a}	61.98±1.79^{a}	65.09±3.04^{b}

SO = Basal diet with 2% soy-oil; SOL1 = Basal diet with 0.5% soy-lecithin and 1.5% soy-oil.
SOL2 = Basal diet with 1% soy-lecithin and 1% soy-oil; SL = basal diet with 2% soy-lecithin. Values are means±SE. n = 10.
Values in a row not sharing same superscript are different at $p<0.05$.

Table 6. Serum parameters of broilers fed corn basal diets supplemented with different proportion of soy-oil and soy-lecithin 42 days after feeding

Item	SO	SOL1	SOL2	SL
TC (mmol/L)	3.6±0.14^{a}	3.59±0.16^{a}	3.35±0.17^{ab}	3.1±0.14^{b}
TG (mmol/L)	0.59±0.02^{a}	0.39±0.04^{b}	0.28±0.07^{b}	0.54±0.03^{a}
HDL-C (mmol/L)	2.31±0.15	2.3±0.12	2.24±0.08	2.35±0.12
LDL-C (mmol/L)	1.15±0.11^{a}	0.83±0.08^{b}	0.87±0.03^{b}	0.78±0.05^{b}
HDL-C/LDL-C	1.97±0.3^{a}	2.61±0.29^{ab}	2.62±0.22^{ab}	3.18±0.06^{b}
T3 (nmol/L)	0.51±0.06^{a}	0.84±0.06^{ab}	0.59±0.21^{a}	1.44±0.41^{b}
T4 (nmol/L)	44.79±4.73	44.32±1.54	32.49±2.53	33.92±4.59
TSH (IU/L)	0.18±0.02	0.22±0.02	0.21±0.03	0.25±0.07
INS (mIU/L)	5.06±0.92^{ab}	6.46±0.29^{ac}	5.23±0.1^{b}	6.64±0.2^{c}

SO = Basal diet with 2% soy-oil; SOL1 = Basal diet with 0.5% soy-lecithin and 1.5% soy-oil.
SOL2 = Basal diet with 1% soy-lecithin and 1% soy-oil; SL = Basal diet with 2% soy-lecithin. Values are means±SE. n = 10.
Values in a row not sharing same superscript are different at $p<0.05$.

result of an indirect increase in fatty acid unsaturation (Soares and Lopez-Bote, 2002). This was not the case in the present experiment. Table 2 shows the fatty acid concentrations of soy-lecithin and soy-oil in the experiment. Lecithin contained a large proportion of unsaturated fatty acid (83.98%) of which linoleic acid (C18:2) was predominant. The unsaturated to saturated fatty acid (U:S) ratio of lecithin was 5.41 which was similar to that of soy-oil (5.59). The feeding of soybean oil improved mean coefficient of apparent lipid digestibility (Dei et al., 2006). Both soy-oil and soy-lecithin contained a large proportion of unsaturated fatty acid, and this may be the reason why the utilization of lipid had no differences among the four groups in the grower period. Lecithin had no effects on the utilization of AME, DM, and CP during 39 to 42 d ($p>0.05$), but the utilization of calcium and phosphorus was significantly improved in SL group ($p<0.05$). There were no significant effects of fatty acids supplementation on calcium retention (Atteh and Leeson, 1985), and increasing dietary fat, although beneficial for growth, was detrimental to calcium retention (Atteh et al., 1983).

Effects on serum parameters

Effects of soy-lecithin on serum parameters for all broilers after 42 d are shown in Table 6. Serum level of cholesterol was significantly decreased in SL group ($p<0.05$) and this is consistent with what was observed in pigs (Jones et al., 1992) and in human (Tompkins and Parkin, 1980; Wilson et al., 1998). Triglyceride levels were significantly decreased in SOL1 and SOL2 group ($p<0.05$). There had no significant differences in high-density lipid cholesterol (HDL-C) level in the four treatments ($p>0.05$). The level of low-density lipid cholesterol (LDL-C) was significantly decreased when lecithin was added to the diets ($p<0.05$). Soy stanol-lecithin powder reduce cholesterol absorption and LDL cholesterol (Spilburg et al., 2003) and fecal sterol excretion was increased when polyunsaturated phosphatidylcholine (PC) was added to diet (Greten et al., 1980). People use soy-lecithin and other soy-products to prevent cardiovascular diseases (Samsonov et al., 1997; Ristic et al., 2003; Choi et al., 2006; Ristic et al., 2006). But some studies showed that lecithin had no effect on lowering plasma and hepatic cholesterol levels (Oosthuizen et al., 1998; Shin et al., 2004). Serum level of triiodothyronine (T_3) was significantly improved in SL group compared with control (SO) ($p<0.05$). No significant differences were observed in thyroxine (T_4) but a decreasing tendency was presented among the four treatment groups ($p>0.05$). Dietary T_3 increased plasma T_3 but decreased body weight and feed efficiency of chickens (Rosebrough et al., 2004), and this is consistent with the result in growth performance. The circulating levels of insulin were increased when soy-lecithin was involved in the diets of broilers in a proportion of 2% compared with the control group ($p<0.05$). Key plasma metabolic hormones (insulin, glucagon and T_3) are important factors that determine the level of hepatic lipogenesis in birds (Hillgartner et al., 1995). It is not clear through which mechanism that soy-lecithin induces its plasma cholesterol-lowering efficacy. Findings in the present study are in agreement with another study which suggests that the cholesterol-lowering efficacy of soy-lecithin cannot be attributed solely to its linoleate content (Wilson et al., 1998), as the soy-oil and the soy-lecithin used in the experiment had similar percentage of linoleic acid (C18:2).

IMPLICATIONS

The data presented in the current study demonstrate that soy-lecithin and soy-oil in a proportion of 25:75 had the highest growth performance compared with other groups and that soy-lecithin is effective in reducing plasma cholesterol and triglyceride concentration in Arbor Acres broilers. Properties of soy-lecithin cannot be completely explained by its unsaturated fatty acid content. Some other possible components maybe also contributed to the responses of broilers fed with lecithin.

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