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Effects of Lacquer (*Rhus verniciflua*) Meal Supplementation on Layer Performance

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ABSTRACT : Two experiments were conducted to see the effects of lacquer meal (*Rhus verniciflua*) on layer performance. In Exp. 1, seventy-two Hy-Line brown layers, 46 wk of age were fed 0, 1.5% and 3.0% lacquer added diets for 6 weeks. Diets contained 2,650 kcal/kg ME and 16.50% CP. In Exp. 2, high-energy diets were fed to 72 Hy-line brown layers of 46 wk age for 6 wk. The diets were: control (3,000 kcal/kg ME and 16.50% CP); T1 and T2 contained 1.5 and 3.0% lacquer respectively, in addition to high energy levels. Each treatment had four replicates with 6 birds each in both the experiments. During Exp.1, there was no effect on average daily feed intake, egg production and feed efficiency, however, egg weight was linearly (p = 0.0128) decreased with the addition of lacquer in diets. The egg quality parameters measured at bi-weekly intervals did not reveal any particular trend. In Exp 2., high-energy diets have decreased the feed intake and egg production in all groups. However, feeding lacquer at 1.5% increased the egg production by 9% than control. The yolk fat content was increased due to treatments showing quadratic trend (p = 0.0683). The liver fat content was decreased by 40-43% than control in lacquer added diets. Except palmitic, oleic and arachidonic acids, some yolk fatty acids showed a linear decreasing trend in lacquer diets. The serum triglycerides and total cholesterol levels were not influenced with lacquer in the diets; however, the serum glucose level was linearly decreased with the addition of lacquer. In conclusion, lacquer meal supplementation significantly affected the performance of layers fed high-energy diets. (**Key Words :** Layers, Lacquer, Liver, Egg Production)

INTRODUCTION

Fatty liver syndrome (FLS) is one of the most important metabolic disorders seen in laying hens in the period of high production (Aydin, 2005). FLS is a condition characterized by excessive deposition of fats in the liver due to failure in the fat metabolism (Aydin, 2005; Yousefi et al., 2005). The common symptoms seen are low-level mortality, egg production drop suddenly and the fat content of liver in chicken ranges from 40% to 70% dry weight. Pathologically the liver hemorrhage cause death, enlarged liver, light brown to yellow in color and very friable and large amount of fat in the liver, abdominal cavity and around viscera (Fowler, 1996; Riddell, 1997). Death usually is caused by a fatal internal hemorrhage originating in a portion of the liver.

Lacquer (*Rhus verniciflua*) has been used in Japan, China and Korea for thousands of years as a traditional medicine based on experiences (Hong et al., 1999; Lee et al., 2003). The constituents in the sap and the polymerization mechanism of lacquers have been revealed (Kumanotani, 1995), and biological activities are demonstrated by some researchers. The polysaccharides in the lacquer sap were found to have bioactivity in motivating the growth of leucocytes (Du et al., 1999) and anti-tumor (Lu et al., 2000). Its significant bioactivity against leucopenia was also studied recently (Yang and Du, 2003). It is used as herbal medicine by non-conventional medical agencies to treat gastritis, stomach cancer and arteriosclerosis (Jung, 1998). The stem bark of *Rhus verniciflua* contains a high levels of urushiols, which sometimes causes allergenic reaction, but its heartwood does not contain urushiols and this part of plant has been used as a kind of tonic, for cancer prevention and for removing the intoxication of smoking or lingering (Park et al., 2004).

The sap of lacquer tree is composed of urushiol (60-65%), glycoprotein (2.1-1.8%), gummy substance (6-7%), which contains laccase (0.24%), stellacyanin and some of mono-, oligo- and polysaccharides, and water (Yang et al., 2002). It is a normal practice in Korea to drink the soup prepared from boiling lacquer in water as it is considered to have preventive role in fatty liver. Recently, some studies carried out in our laboratory found significantly reduced fat

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Table 1. Formula and chemical composition (%) of experimental diets during Exp.1

	Control	Lacquer 1.5%	Lacquer 3.0%
Ingredients			
Maize	59.55	60.00	60.50
SBM (44%)	23.55	24.50	25.40
Wheat bran	6.87	3.98	1.08
DCP	1.75	1.75	1.75
Calcium carbonate	7.65	7.65	7.65
DL-methionine (50%)	0.04	0.04	0.04
L-lysine (78%)	0.05	0.04	0.04
Salt	0.30	0.30	0.30
Trace mineral premix [1]	0.14	0.14	0.14
Vitamin premix [2]*	0.10	0.10	0.10
Lacqer	0.00	1.50	3.00
Total	100.00	100.00	100.00
Chemical composition			
ME (Kcal/kg)	2,650	2,650	2,650
CP (%)	16.50	16.50	16.50
Crude fiber (%, analyzed)	3.79	4.51	5.00
Ca (%)	3.38	3.38	3.38
Avail. P (%)	0.45	0.45	0.45
Lysine (%)	0.87	0.87	0.88
Methionine (%)	0.29	0.29	0.29
Methionine+cystine (%)	0.57	0.57	0.57

[1] Supplied per kg diet: 56 mg Fe, 56 mg Cu, 70 mg Zn, 84 mg Mn, 1.4 mg I, 0.07 mg Co, 0.2 mg Se.

[2] vitamin premix per kg diet: vitamin A 9,000 IU, vitamin E 30 IU, 1,800 IU vitamin D, 1 mg vitamin K_3, 1 mg vitamin B_1, 10 mg vitamin B_2, 4 mg vitamin B_6, 0.02 mg vitamin B_{12}, 30 mg niacin, 12 mg pantothenic acid, 0.5 mg folic acid, 0.2 mg biotin.

Table 2. Formula and chemical composition (%) of experimental diets during Exp. 2

	Control	Lacquer 1.5%	Lacquer 3.0%
Ingredients			
Maize	59.80	56.68	53.55
SBM (44%)	25.95	26.55	27.15
DCP	1.75	1.76	1.76
Calcium carbonate	7.65	7.65	7.65
DL-methionine (50%)	0.04	0.04	0.04
L-lysine (78%)	0.02	0.01	0.01
Salt	0.30	0.30	0.30
Trace mineral premix [1]	0.14	0.14	0.14
Vitamin premix [2]*	0.10	0.10	0.10
Soya oil	4.25	5.27	6.30
Lacqer	0.00	1.50	3.00
Total	100.00	100.00	100.00
Chemical composition			
ME (Kcal/kg)	3,000	3,000	3,000
CP (%)	16.50	16.50	16.50
Crude fiber (%, analyzed)	3.13	4.19	4.88
Ca (%)	3.38	3.38	3.38
Avail. P (%)	0.45	0.45	0.45
Lysine (%)	0.87	0.87	0.88
Methionine (%)	0.29	0.29	0.28
Methionine+cystine (%)	0.57	0.56	0.56

[1] Supplied per kg diet: 56 mg Fe, 56 mg Cu, 70 mg Zn, 84 mg Mn, 1.4 mg I, 0.07 mg Co, 0.2 mg Se.

[2] Vitamin premix per kg diet: vitamin A 9,000 IU, vitamin E 30 IU, 1,800 IU vitamin D, 1 mg vitamin K_3, 1mg vitamin B_1, 10 mg vitamin B_2, 4 mg vitamin B_6, 0.02 mg vitamin B_{12}, 30 mg niacin, 12 mg pantothenic acid, 0.5 mg folic acid, 0.2 mg biotin.

content in the pork supplemented with 2 and 4% lacquer meal in the diet of grower and finisher pigs (Song, 2005). We found significant reduction in back fat thickness in barrow, gilts and mixed gender by lacquer supplementation with linear increase in dressing percentage and fat free lean percentages of the pork but the growth performance was not affected. Other study with broilers showed impact on fat metabolism by increasing fat digestibility and reduction in serum cholesterol and triglycerides, without affecting growth (Lohakare et al., 2006).

In view of above, there seems a positive role of lacquer on fat metabolism. Hence the present study was planned to see any effect of lacquer meal on production performance, egg quality parameters and serum biochemical values of commercial layers by providing adequate and high-energy diets.

MATERIALS AND METHODS

Experimental birds and diets

Two experiments were conducted to study the effects of lacquer (*Rhus verniciflua*) meal on layers performance. In Exp. 1, Hy-Line Brown layers (n = 72; 46-wk-old) were divided into three equal groups based on body weight. Each treatment had four replicates with 6 birds each (24 birds per treatment). Hens were caged individually with the cage size as 0.2×0.2 m, and six birds shared a common feed trough between them forming one experimental unit. The photoperiod was set at 17L:7D throughout the 42 days experimental period. The layers were kept under a temperature range of 22±5°C. They were fed corn-soybean basal diet that was formulated to meet the nutrient requirements of layers (NRC, 1994). Diets were supplemented with 3 levels (0, 1.5 and 3.0%) of lacquer as meal in the diets (Table 1).

Table 3. Composition of Lacquer meal (as-fed basis)

Nutrient composition[a]	%
Moisture	8.82
Crude protein (CP)	1.22
Crude fiber (CF)	52.34
Fat	4.12
Ash	1.58
Ca	0.32
P	0.06

[a] Each analysis was done in triplicate.

In Exp. 2, high-energy diets were fed to 72 Hy-line Brown layers of 46 wk age for 6 wk. The diets were: control (3,000 kcal/kg ME and 16.50% CP); T1 and T2 contained 1.5 and 3.0% lacquer respectively, in addition to

Table 4. Effect of lacquer on body weight and production performance of layers in Exp.1

	Lacquer %			SEM[1]	p value	
	0	1.5	3.0		Linear	Quadratic
Initial BW (kg)	2.09	2.03	2.02	0.04	NS	NS
Final BW (kg)	2.04	1.99	2.22	0.09	NS	NS
Feed intake (g)	114.58	114.54	112.62	1.75	NS	NS
Egg production (%)	91.38	92.54	93.12	0.81	NS	NS
Egg weight (g)	63.85	62.94	60.32	0.62	0.0128	NS
Feed efficiency	1.79	1.82	1.87	0.02	NS	NS
Carcass traits*						
Abdominal fat (%)	4.62	5.02	4.01	0.28	NS	NS
Liver weight (%)	1.98	1.92	1.90	0.06	NS	NS

* Expressed as percent of body weight.
[1] Standard error of mean.

Table 5. Effect of lacquer on egg quality parameters of layers measured at bi-weekly intervals in Exp. 1

	Lacquer %			SEM[1]	p value	
	0	1.5	3.0		Linear	Quadratic
2nd week						
Eggshell weight (g)	5.85	6.09	5.92	0.10	NS	NS
Eggshell thickness (mm $\times 10^{-2}$)	36.02	36.25	36.09	0.39	NS	NS
Albumen pH	8.61	9.15	9.10	0.08	0.0001	0.0001
Yolk pH	6.29	6.29	6.34	0.02	NS	NS
Albumen weight (g)	40.93	40.21	39.93	0.39	NS	NS
Yolk weight (g)	16.82	16.68	15.79	0.24	0.0827	NS
Haugh unit	82.42	76.88	78.53	1.25	NS	NS
Strength (kg/cm^2)	2.96	3.21	2.88	0.09	NS	NS
Color	7.75	8.25	8.33	0.11	0.0246	NS
Yolk height (mm)	16.53	16.34	15.79	0.24	NS	NS
4th week						
Eggshell weight (g)	6.01	6.10	5.87	0.06	NS	NS
Eggshell thickness (mm $\times 10^{-2}$)	36.25	35.50	36.50	0.32	NS	NS
Albumen pH	8.93	8.92	9.00	0.02	0.0711	NS
Yolk pH	6.29	6.27	6.30	0.01	NS	NS
Albumen weight (g)	41.64	40.88	39.21	0.59	0.1063	NS
Yolk weight (g)	15.76	15.70	15.30	0.25	NS	NS
Haugh unit	82.76	88.93	81.80	1.66	NS	0.0671
Strength (kg/cm^2)	3.08	2.81	3.09	0.08	NS	NS
Color	7.92	7.83	7.42	0.11	0.0570	NS
Yolk height (mm)	15.49	17.63	16.08	0.36	NS	0.0088
6th week						
Eggshell weight (g)	5.95	6.08	6.07	0.07	NS	NS
Eggshell thickness (mm $\times 10^{-2}$)	35.83	36.92	39.00	0.58	0.0207	NS
Albumen pH	9.15	9.18	9.18	0.01	NS	NS
Yolk pH	6.31	6.26	6.28	0.01	NS	NS
Albumen weight (g)	42.02	41.39	39.96	0.51	NS	NS
Yolk weight (g)	15.85	16.54	15.40	0.22	NS	0.0513
Haugh unit	70.22	70.49	73.69	1.11	NS	NS
Strength (kg/cm^2)	2.87	3.14	3.19	0.09	NS	NS
Color	7.83	8.08	7.84	0.11	NS	NS
Yolk height (mm)	15.23	14.77	15.77	0.23	NS	NS

[1] Standard error of mean.

high energy levels (Table 2). Experiment 2 was similar in all aspects as like Exp.1. except diets.

The lacquer meal was obtained from Gapyeong Livestock Company. Gapyeong-gun, Gyeonggi-do, Korea. The heartwood of the lacquer tree was allowed to sun-dry for around 2-3 months. Then it was reduced to sawdust in a sawmill. The sawdust was then allowed to pass through 1-2 mm mesh-screen and this lacquer meal was used for feeding. At the end of experimental feeding. 3 birds per experimental unit were sacrificed (12 per treatment). Prior to slaughter. 10 ml blood samples were obtained by jugular vein puncture and drawn into test tubes. The blood samples

Table 6. Effect of lacquer on yolk fat and fatty acids, liver fat and serum profile of layers in Exp. 1

	Lacquer %			SEM[1]	p value	
	0	1.5	3.0		Linear	Quadratic
Yolk fat (%)	27.14	27.82	24.65	0.62	0.0753	0.1059
Liver fat (%)	16.34	20.79	15.80	1.52	NS	0.1744
Yolk fatty acids (%)						
Palmitic acid	21.56	22.00	21.46	0.63	NS	NS
Palmitoleic acid	3.85	3.79	2.84	0.25	NS	NS
Stearic acid	10.48	10.65	10.88	0.32	NS	NS
Oleic acid	44.57	43.71	44.94	0.82	NS	NS
Linoleic acid	16.03	16.22	16.05	0.63	NS	NS
Arachidonic acid	3.52	3.64	3.83	0.38	NS	NS
Serum (mg/dl)						
Triglycerides	2,277.73	1,512.09	954.93	216.13	0.0072	NS
Total-cholesterol	248.17	240.85	238.35	5.06	NS	NS
Glucose	186.40	204.93	190.16	5.22	NS	NS

[1] Standard error of mean.

Table 7. Effect of lacquer on body weight and production performance of layers in Exp.2

	Lacquer %			SEM[1]	p value	
	0	1.5	3.0		Linear	Quadratic
Initial BW (kg)	1.98	2.00	2.04	0.02	NS	NS
Final BW (kg)	1.92	1.75	1.81	0.05	NS	NS
Feed intake (g)	95.47	96.47	88.82	3.07	NS	NS
Egg production (%)	77.13	84.31	78.68	2.29	NS	NS
Egg weight (g)	61.85	60.52	60.79	0.48	NS	NS
Feed efficiency	1.54	1.59	1.46	0.05	NS	NS
Carcass traits*						
Abdominal fat (%)	4.96	4.54	4.46	0.19	NS	NS
Liver (%)	2.22	1.93	1.97	0.11	NS	NS

* Expressed as percent of body weight.
[1] Standard error of mean.

were centrifuged at 3,000 rpm for 15 min at 4°C, and serum was collected and stored at -20°C for later analysis. The samples were analyzed for serum biochemical values of glucose, total cholesterol and triglycerides. After slaughter carcass traits like liver weight and abdominal fat were also measured. After slaughter, liver was collected and stored at -20°C for liver fat analysis.

Parameters measured

Body weights were recorded at start and at the end of experimental period. Egg production was recorded daily and expressed as egg produced per hen per day, and egg weights were also recorded. Feed consumption was measured at the end of feeding. Laying rate and feed efficiency (kilograms of feed needed to produce a kilogram of eggs) were calculated at the end of the experiment. At bi-weekly intervals, eggs were collected from each experimental unit for analysis of egg quality parameters. At termination, egg yolk fat and yolk fatty acid analysis was also carried out in both experiments.

Analyses

Yolk color was measured with Roche Yolk Color Fan (RYCF) (Dotterfarbächer Eventail colorimétrique Abanico colorimétrico, USA). Its color values denote the color intensity from 1 to 14 according to the degree of yolk color. Yolk height was measured with vernier calipers in the center of yolk. Haugh units (HU) were calculated according to formula (Eisen et al., 1962) based on the height of albumen as determined using vernier calipers. Yolk and albumen pH was also measured with a digital pH meter as described by Shang et al. (2004). The serum biochemical's were measured by using kits (Alfa Wassermann BV, Woerden, NL) and analyzer (HITACHI 747, Japan). Liver fat content was determined by extracting a sample of oven-dried liver in a soxhlet extractor with petroleum ether of boiling point 60-70°C (AOAC, 1990). Egg yolk lipids were extracted from 3 eggs per replicate at the end and fatty acids were quantified using gas chromatography as described by Hargis et al. (1991).

Statistical analysis

Statistical analysis was conducted by using the GLM procedure of SAS software (1985). The treatments were the main effects. Experimental unit was the replicate for all analysis. Linear and quadratic polynomials were evaluated

Table 8. Effect of lacquer on egg quality parameters of layers measured at bi-weekly intervals in Exp. 2

	Lacquer %			SEM[1]	p value	
	0	1.5	3.0		Linear	Quadratic
2^{nd} Week						
Eggshell weight (g)	5.63	5.78	5.96	0.09	NS	NS
Eggshell thickness (mm $\times 10^{-2}$)	36.59	35.17	40.17	0.87	0.0548	0.0483
Albumen pH	8.75	8.62	8.38	0.06	0.0030	NS
Yolk pH	6.33	6.28	6.53	0.04	0.0005	0.0018
Albumen weight (g)	37.56	40.67	38.63	0.62	NS	0.0488
Yolk weight (g)	15.32	16.15	16.48	0.24	0.0521	NS
Haugh unit	81.86	78.10	88.81	2.17	NS	NS
Strength (kg/cm^2)	2.78	2.66	3.37	0.12	0.0187	0.0476
Color	8.42	8.00	8.17	0.10	NS	NS
Yolk height (mm)	15.57	15.84	15.58	0.28	NS	NS
4^{th} Week						
Eggshell weight (g)	6.02	5.60	5.56	0.13	NS	NS
Eggshell thickness (mm $\times 10^{-2}$)	34.67	37.58	36.25	0.71	NS	NS
Albumen pH	9.11	9.09	9.03	0.01	0.0118	NS
Yolk pH	6.30	5.91	6.34	0.14	NS	NS
Albumen weight (g)	42.86	38.16	39.13	0.97	0.0987	NS
Yolk weight (g)	14.92	14.40	15.21	0.30	NS	NS
Haugh unit	80.74	83.33	95.55	2.18	0.0003	0.0638
Strength (kg/cm^2)	3.15	3.01	2.84	0.11	NS	NS
Color	7.84	7.92	8.09	0.12	NS	NS
Yolk height (mm)	15.50	16.02	17.28	0.38	0.0576	NS
6^{th} Week						
Eggshell weight (g)	6.05	5.74	6.11	0.09	NS	0.0629
Eggshell thickness (mm $\times 10^{-2}$)	37.00	36.25	37.42	0.48	NS	NS
Albumen pH	9.14	9.18	9.19	0.01	0.0019	NS
Yolk pH	6.32	6.34	6.38	0.02	NS	NS
Albumen weight (g)	39.71	39.48	38.17	0.91	NS	NS
Yolk weight (g)	14.39	14.95	14.42	0.29	NS	NS
Haugh unit	76.93	73.67	75.38	1.39	NS	NS
Strength (kg/cm^2)	3.30	2.83	3.69	0.14	NS	0.0120
Color	7.83	8.08	8.08	0.09	NS	NS
Yolk height (mm)	15.23	15.26	15.40	0.17	NS	NS

[1] Standard error of mean.

for increasing lacquer levels. The level of significance was accepted at 0.05% and at 0.10%, unless otherwise noted.

RESULTS AND DISCUSSION

Rhus verniciflua is a plant indigenous to Korea and used traditionally in herbal medicines. It can be easily available on the mountains in many of the provinces in Korea (Kim, 1996). The active components were found to be garbanzol (3,4',7-trihydroxyflavanone), sulfuretin (3',4',6-trihydroxyaurone), fisetin (3,3',4',7-tetrahydroxy-flavone), fustin (3, 3',4',7-tetrahydroxyflavanone), and mollisacasidin (3β,4α,5,7,3',4'-pentahydroxyflavan) in the methanolic extract (Park et al., 2004). Although we did not extracted its active components, but above studies give an idea about its biologically active principles. We supplemented lacquer meal in diet in the present research to study its role on layer performance in adequate and high-energy diets. During Exp. 1, body weights were not different in the treatment groups than the control at the end of the experiment (Table 4). There was no effect on the feed intake, egg production or feed efficiency by feeding lacquer, but there was a linear decrease ($p = 0.0128$) in egg weight. The abdominal fat pad and liver weight was not influenced by lacquer supplementation, suggesting that lacquer has not any adverse effect on carcass traits when optimum energy and protein diets were fed to birds (Table 4).

The egg quality parameters measured at bi-weekly intervals did not reveal any particular trend, although albumen pH and yolk color was linearly increased with lacquer supplementation at 2 weeks (Table 5). A trend of increase in albumen pH followed at 4^{th} wk in lacquer added diets than control, but was non-significant at the end (6 wk). The eggshell thickness was linearly increased ($p = 0.0207$) in lacquer-supplemented diets at 6^{th} wk. In general, egg quality was not significantly different among treatments, suggesting that overall egg quality was not affected by lacquer addition (Table 5).

Table 9. Effect of lacquer on yolk fat and fatty acids, liver fat and serum profile of layers in Exp. 2

	Lacquer %			SEM[1]	p value	
	0	1.5	3.0		Linear	Quadratic
Yolk fat (%)	23.93	27.04	25.75	0.59	0.1721	0.0683
Liver fat (%)	23.48	13.45	14.11	2.47	0.1252	NS
Yolk fatty acids (%)						
Palmitic acid	18.34	16.14	18.39	0.63	NS	NS
Palmitoleic acid	1.92	1.32	0.91	0.16	0.0032	NS
Stearic acids	11.82	13.86	16.81	0.84	0.0066	NS
Oleic acid	40.31	35.71	41.74	3.10	NS	NS
Linoleic acid	23.51	28.35	19.20	1.41	0.0227	0.0013
Linolenic acid	1.04	1.30	0.00	0.21	0.0025	0.0048
Arachidonic acid	3.07	3.31	2.96	0.31	NS	NS
Serum (mg/dl)						
Triglycerides	1,125.21	1,174.31	434.19	207.84	0.1925	NS
Total-cholesterol	220.60	191.44	220.60	18.65	NS	NS
Glucose	225.89	206.43	201.93	4.56	0.0257	NS

[1] Standard error of mean.

The yolk fat content showed a linear increasing trend ($p = 0.0753$) with lacquer addition (Table 6). Liver fat content did not reveal any trend. All the fatty acids measured were not affected by dietary supplementation of lacquer. Neither linear nor quadratic trend was observed for any of the yolk fatty acids. The serum triglyceride level was linearly decreased ($p = 0.0072$) with the addition of lacquer in the diets. However, there was no effect on total-cholesterol and serum glucose level due to dietary treatments (Table 6). A lot of bird-to-bird variation was observed that failed to show any significant effect of dietary treatments.

As expected, during Exp. 2, high-energy diets have lower down the feed intake when compared with the feed intake in Exp. 1, and similar results were noticed for the egg production in all the groups (Table 7). This result was in agreement with Harms et al. (2000), who reported laying hens that received high-energy diets consume less feed than those not receiving high-energy diets. The body weights were also reduced in all the groups because of reduction in feed intake than Exp.1. The egg weight and feed efficiency did not show any linear or quadratic trend because of lacquer supplementation. Although, it was revealed in the present study that feeding lacquer at 1.5% increase the egg production by 9% than to control (Table 7), but the reasons remained obscure. The liver and abdominal fat percent did not reveal any trend by lacquer supplementation, and even though the liver percent, expressed on live weight seems low, but this could be the effect of pronounced reduction in body weights in lacquer added diets.

The egg quality parameters measured at 2^{nd} week showed both linear and quadratic trend in eggshell thickness, yolk pH, and eggshell strength (Table 8). The eggshell thickness, yolk weight and eggshell-breaking strength were improved by 3.0% lacquer supplementation. At 2^{nd} and 4^{th} week the albumen pH, was linearly decreased in lacquer added diets than control, indicating some effect on pH that needs to be traced. The haugh unit and yolk height showed linear increase in lacquer added diets than control at 4^{th} wk, however, quadratic effect was only observed for haugh unit. At 6^{th} week, only albumin pH showed a linear trend ($p = 0.0019$) that was increased by lacquer addition. In nutshell, lacquer showed haphazard effect on egg quality parameters.

The yolk fat content showed an increasing, however, quadratic trend ($p = 0.0683$) at 1.5% lacquer addition but then decreased at 3.0% (Table 9). Liver fat content although decreased by 40-43% than control in lacquer added diets, but failed to reveal any statistical trend. There was no mortality during the experiment in any of the groups, however, there was a drop in egg production and results were in line to that of Riddell (1997). The drop in egg production could be caused by reduced feed intake; however, lacquer supplementation at 1.5% improved egg production by 9% than non-supplemented group with similar feed intake. Palmitic, oleic and arachidonic acids in egg yolk were not influenced by dietary treatments. However, there was a linear decrease ($p = 0.0032$) in palmitoleic acid in lacquer added diets than control with concomitant increase in stearic acid concentration in egg yolk fatty acid content. Linolenic acid was not detected in 3.0% lacquer diet and the reason was not known. The serum triglycerides and total cholesterol levels were not influenced with the addition of lacquer in the diets; however, serum glucose levels were linearly decreased ($p = 0.0257$) in lacquer-supplemented diets than control. In conclusion, lacquer meal supplementation significantly affected the performance of layers fed high-energy diets.

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