Effect of Lacquer (*Rhus verniciflua*) Supplementation on Growth Performance, Nutrient Digestibility, Carcass Traits and Serum Profile of Broiler Chickens

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ABSTRACT : This experiment was conducted to explore the efficacy of lacquer (*Rhus verniciflua*) supplementation on growth performance, nutrient digestibility, carcass traits and serum biochemical values in commercial broilers. Eight hundred and forty Hubbard broiler chicks (1d old) were randomly distributed and allotted to four dietary treatments for five weeks. Each treatment had 5 replicates with 42 birds each. The dietary treatments were (1) control (2) 1% lacquer, (3) 2% lacquer and 4) 4% lacquer supplied as meal in the diet. Supplementation with lacquer improved weight gain ($p = 0.0960$) showing a linear trend during the starter phase (0-3 wk), but weight gain, feed intake and feed conversion ratio remained unaffected at the finisher phase (4-5 wk) and overall (0-5 wk). The nutrient digestibility studies conducted after 18 and 35 days of experimental feeding showed a linear ($p<0.05$) increase in digestibility of CP and ether extract at both measurement timess. The carcass studies were conducted on two birds per replicate (10 per treatment) at the end of both 3 and 5 wk. The dressing percentage, liver weight, heart weight, abdominal fat and the breast meat expressed as a percentage of live weight, did not differ significantly due to treatments at both phases. The serum cholesterol and high-density lipoprotein (HDL) showed a linear decrease ($p = 0.0683$ and $p = 0.0322$, respectively) as the level of supplementation increased at 3 wk; at 5 wk serum cholesterol, HDL and triglyceride levels decreased significantly showing a positive linear effect of lacquer on fat metabolism. The meat color values such as lightness, redness and yellowness did not reveal any significant trend. Overall, it could be concluded that lacquer supplementation at higher levels did not affect growth performance, but had a positive impact on fat metabolism by influencing fat digestibility and reducing serum cholesterol and triglyceride. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 3 : 418-424)***

Key Words : Broilers, Lacquer, Carcass, Growth, Fat, Digestibility

INTRODUCTION

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). Although constituents in the sap and the polymerization mechanism of lacquers have been revealed (Kumanotani, 1995), biological activities are still unclear (Lu et al., 2000). 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 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). Every polysaccharide has its special biological activity because of its special molecular structure (Yang and Du, 2003). The ethanol extract from *Rhus verniciflua* Stokes (RVS) was found to have an antioxidant effect against hydroxyl radicals (Lee et al., 2001), anti-proliferative activity against human cancer cell lines (Kitts and Lim, 2001) and RVS augments the activity of cell-associated detoxifying enzymes in hepatocytes (Lim et al., 2000) has also been reported. 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).

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 (Anonymous, 2004). Recently, the study carried out in our laboratory found significantly reduced fat content in the pork supplemented with 2 and 4% lacquer in the diet of grower and finisher pigs (Song, 2005). Lacquer is used in Korea in the diets of pigs and poultry, although its exact effects are not revealed fully. In view of above, there seems a positive role of lacquer polysaccharides on fat metabolism, which has not been explored yet. Hence the present study was planned to see any effect of lacquer on growth performance, nutrients digestibility, carcass traits and serum biochemical values of broilers.

MATERIALS AND METHODS

Design, animals and sample preparation

For a five-week feeding trial, a total of 840 broiler

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Table 1. Formula and chemical composition (%) of experimental diets during feeding trial for different groups (0-3 wk)

	Ingredients			
	Control	Lacquer1%	Lacquer2%	Lacquer4%
Maize	55.21	53.31	51.39	47.69
Soybean meal (44%)	28.25	28.35	28.40	28.40
Corn gluten meal	8.15	8.32	8.60	9.10
Soya oil	4.20	4.83	5.42	6.62
Lacquer	-	1.00	2.00	4.00
Di-calcium phosphate	1.70	1.70	1.70	1.70
Calcium carbonate	1.40	1.40	1.40	1.40
Choline chloride (50%)	0.20	0.20	0.20	0.20
DL-methionine (50%)	0.21	0.21	0.21	0.21
L-lysine (78%)	0.14	0.14	0.14	0.14
Salt	0.30	0.30	0.30	0.30
Trace mineral premix [1]	0.14	0.14	0.14	0.14
Vitamin premix [2]	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated chemical composition(s)				
ME (kcal/kg)	3,200	3,200	3,200	3,200
CP	22.00	22.00	22.00	22.00
Ca	1.00	1.00	1.00	1.00
Avail. P	0.45	0.40	0.45	0.45
Lysine	1.10	1.10	1.10	1.10
Methionine	0.50	0.50	0.50	0.50
Methionine+cystine	0.87	0.88	0.88	0.87
Arginine	1.26	1.22	1.22	1.23

[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: 9,000 IU vitamin A, 1,800 IU vitamin D, 30 IU vitamin E, 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.

chicks (Hubbard, day-old, average 45 g body weight) were allotted to four dietary treatments. Each treatment comprises 5 pens as replicates containing 42 chicks each. The lacquer was supplemented as meal in the diets at 0% (T1), 1% (T2), 2% (T3) and 4% (T4). On a commercial farm (floor with rice hull bedding), day-old chicks were raised with their respective diets.

Basal diets (mash) were formulated to contain 22.0% and 20.0% crude protein for the starter (0-3 wk) and the finisher (4-5 wk) diets, detailed in Tables 1 and 2, respectively. 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 passed through 2-3 mm mesh-screen and this lacquer meal was used for feeding.

The temperature in broiler house during first week was 34±1°C and was gradually reduced to 26±1°C by 21 days of age, thereafter the chicks were maintained at room temperature. Pen size was 1.0×1.8 meters. Chicks had *ad libitum* access to feed and water.

Body weight and feed intake were recorded at 21 and 35 d of age. At the end of starter and finisher phases, ten chicks per treatment were sacrificed (2 chicks per pen randomly selected representative of pen). Prior to slaughter, 10 mL blood samples were obtained by jugular vein puncture and drawn into test tubes. The blood samples 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, cholesterol, HDL, low-density lipoprotein (LDL) and triglyceride.

After slaughter, organ weight and carcass traits like liver weight; heart weight, dressing percentage; abdominal fat and breast meat percentages were measured. They are expressed as percent of the live weight. Breast meat was also collected and the meat color values were measured freshly. The breast meat was allowed to air-dry for 30 min and Minolta color values were measured for lightness (L*), redness (a*) and yellowness (b*).

For a digestibility trial, forty chicks (10 birds/treatment; 2 per pen) were allocated in individual cages to collect fecal samples. Starter and finisher diets containing 0.25% chromic oxide as an indigestible marker were fed on 15 and 35 days of experimental feeding, respectively. Fecal samples were taken from each bird on the fourth day after feeding the marked diets. Feces were dried in forced-air drying oven at 60°C for 3 days and stored for later chemical analysis.

Analyses

Proximate analysis of samples was made according to the methods of AOAC (1990). Gross energy, and chromium

Table 2. Formula and chemical composition (%) of experimental diets during feeding trial for different groups (4-5 wk)

	Ingredients			
	Control	Lacquer1%	Lacquer2%	Lacquer 4%
Maize	63.24	61.19	59.25	55.32
Soybean meal (44%)	21.80	22.19	22.33	22.70
Corn gluten meal	8.40	8.40	8.57	8.85
Soya oil	2.80	3.47	4.10	5.38
Lacquer	-	1.00	2.00	4.00
Di-calcium phosphate	1.50	1.50	1.50	1.50
Calcium carbonate	1.30	1.30	1.30	1.30
Choline chloride (50%)	0.20	0.20	0.20	0.20
DL-methionine (50%)	0.01	0.01	0.01	0.01
L-lysine (78%)	0.21	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30
Trace mineral premix [1]	0.14	0.14	0.14	0.14
Vitamin premix [2]	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated chemical composition (s)				
ME (kcal/kg)	3,200	3,200	3,200	3,200
CP	20.00	20.00	20.00	20.00
Ca	0.90	0.90	0.90	0.90
Avail. P	0.40	0.40	0.40	0.40
Lysine	1.00	1.00	1.00	1.00
Methionine	0.38	0.38	0.38	0.38
Methionine+cystine	0.73	0.73	0.73	0.73
Arginine	1.07	1.07	1.07	1.08

[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: 9,000 IU vitamin A, 1,800 IU vitamin D, 30 IU vitamin E, 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 3. Composition of Lacquer meal (as-fed basis)

Nutrient composition[a]	%
Moisture	18.60
Crude protein	1.13
Fat	4.32
Ash	1.53
Ca	0.36
P	0.01

[a] Each analysis was done in triplicate.

were measured with an adiabatic bomb calorimeter (Model 1241, Parr Instrument Co. Molin, IL.), and spectrophotometer (Jasco Co. Model V-550, Japan), respectively. Chicken meat color was measured with a color difference meter (Yasuda Seiko Co., CR310, Minolta, Japan). The serum biochemicals were measured by using kits (Alfa Wassermann BV, Woerden, NL) and analyzer (HITACHI 747, Japan), except LDL that is calculated as the difference between total cholesterol and the combined concentration of HDL and very low-density lipoprotein (VLDL). VLDL was estimated as one-fifth of the concentration of triglycerides (Friedewald et al., 1972).

Statistical analysis

Statistical analysis was conducted by using the GLM

Table 4. Effect of lacquer supplementation on growth performance of broilers[a]

	Control	Lacquer (%)			SEM[b]	P-value	
		1	2	4		Linear	Quadratic
0-3 wk							
Weight gain	723	751	746	762	6.87	0.0960	NS
Feed intake	1,033	1,052	1,020	1,044	11.22	NS	NS
FCR	1.43	1.41	1.37	1.37	0.02	NS	NS
4-5 wk							
Weight gain	890	919	879	878	17.88	NS	NS
Feed intake	1,799	1,781	1,755	1,744	22.84	NS	NS
FCR	2.03	1.95	2.02	1.99	0.04	NS	NS
0-5 wk							
Weight gain	1,612	1,670	1,624	1,640	17.77	NS	NS
Feed intake	2,833	2,833	2,775	2,756	24.40	NS	NS
FCR	1.76	1.70	1.71	1.68	0.02	NS	NS

[a] Each treatment has 5 replicates with 42 birds each. [b] Standard error of means.

Table 5. Effect of Lacquer supplementation on nutrient digestibility (%) at 3 and 5 week[a]

	Control	Lacquer (%)			SEM[b]	P-value	
		1	2	4		Linear	Quadratic
3 wk							
DM	79.22	79.61	79.30	79.36	0.107	NS	NS
CP	68.50	71.83	71.75	72.70	0.505	0.0001	0.0086
EE	81.65	82.09	84.97	86.02	0.607	0.0002	NS
Ash	43.29	54.29	52.27	55.71	1.485	0.0001	0.0005
Ca	49.83	50.11	49.61	49.82	0.405	NS	NS
P	37.83	36.70	45.32	42.09	1.254	0.0112	NS
5 wk							
DM	77.78	78.18	77.84	78.51	0.164	NS	NS
CP	64.37	68.71	66.40	72.35	0.966	0.0010	NS
EE	72.45	72.78	75.49	75.76	0.540	0.0024	NS
Ash	45.42	45.80	46.93	45.76	0.421	NS	NS
Ca	33.05	33.03	35.97	36.83	0.768	0.0378	NS
P	49.98	48.98	49.83	48.86	0.777	NS	NS

[a] Each treatment has 5 replicates with 2 birds each. [b] Standard error of means.

Table 6. Effect of lacquer supplementation on carcass traits (percentage of live weight) of broilers[a]

	Control	Lacquer (%)			SEM[b]	P-value	
		1	2	4		Linear	Quadratic
3 wk							
Liver	2.93	2.85	3.02	2.89	0.07	NS	NS
Heart	0.66	0.70	0.74	0.92	0.04	0.0262	NS
Abdominal fat	1.26	1.16	1.05	1.01	0.06	0.1688	NS
Dressing %	57.34	57.76	56.96	58.51	0.44	NS	NS
Breast meat	13.01	12.84	13.45	13.30	0.22	NS	NS
5 wk							
Liver	2.85	2.70	2.63	2.87	0.08	NS	NS
Heart	0.55	0.67	0.70	0.61	0.02	NS	0.0220
Abdominal fat	1.91	1.52	1.78	1.75	0.06	NS	0.1407
Dressing %	59.13	61.14	61.53	59.65	0.57	NS	NS
Breast meat	15.69	15.43	16.58	15.66	0.25	NS	NS

[a] Each treatment has 5 replicates with 2 birds each.
[b] Standard error of means.

procedure of SAS software (1985). The treatments were the main effects. Pen was used as an experimental unit for all analysis. Linear and quadratic polynomials were evaluated for increasing lacquer levels. The level of significance was accepted at 0.05% and at 0.10%, unless otherwise noted.

RESULTS

The crude protein and fat content in the lacquer meal used in present study was 1.13 and 4.32%, respectively (Table 3). The ash content is also very low (1.53%). The calcium and phosphorus content were found to be 0.36 and 0.01 percent.

The weight gain was significantly higher in the supplemented diets showing linear ($p = 0.0960$) trend during starter phase, but the feed intake and feed conversion ratio remained unaffected (Table 4). Neither weight gains nor feed intake or FCR were influenced during finisher phase or overall study showing no effect due to lacquer supplementation.

The nutrient digestibility studies conducted at starter phase showed linear ($p<0.05$) effect for crude protein, crude fat and ash digestibility (Table 5). Also quadratic effects were noted for crude protein and ash. Linear increase in crude protein and fat digestibility was also noted at 5 week. No quadratic effect was found for any of the nutrients digestibility at 5 week.

The carcass traits like liver weight, abdominal fat, dressing percentage or breast meat expressed as percent of live weight measured at 3 wk or 5 wk did not reveal any linear or quadratic effect (Table 6). But the heart weight increased linearly ($p = 0.0262$) with increasing levels of lacquer in diet at starter phase, and showed quadratic ($p = 0.0220$) effect during 5 wk. Abdominal fat percent tended to decrease, but could not achieve a statistical significance at both phases.

The serum cholesterol levels decreased linearly ($p = 0.0683$) at 3 wk and ($p = 0.0514$) at 5 wk measurement but there was no quadratic effect (Table 7). The HDL levels were decreased linearly ($p<0.05$) at 3 wk and 5 wk, also

Table 7. Effect of lacquer supplementation on serum biochemical values of broilers[a] (mg/dl)

	Control	Lacquer (%)			SEM[b]	P-value	
		1	2	4		Linear	Quadratic
3 wk							
Cholesterol	148.8	129.3	130.2	130.3	3.27	0.0683	NS
HDL	63.7	49.3	51.0	51.2	1.96	0.0322	0.0336
Glucose	245.3	232.6	245.1	249.8	3.17	NS	NS
Triglyceride	39.4	42.3	42.0	42.0	1.44	NS	NS
LDL	72.2	71.5	70.8	70.7	1.54	NS	NS
5 wk							
Cholesterol	128.4	114.7	124.3	102.4	3.72	0.0514	NS
HDL	50.7	45.3	50.5	37.3	1.75	0.0208	NS
Glucose	246.6	239.1	250.5	261.0	4.68	NS	NS
Triglyceride	36.8	32.4	32.5	26.3	1.28	0.0054	NS
LDL	70.3	62.9	67.3	59.8	2.27	NS	NS

[a] Each treatment has 5 replicates with 2 birds each. [b] Standard error of means.

Table 8. Effect of lacquer supplementation on meat color values of breast meat of broilers[a]

	Control	Lacquer (%)			SEM[b]	P-value	
		1	2	4		Linear	Quadratic
3 wk							
L*	48.63	45.91	47.99	49.47	0.73	NS	NS
a*	5.36	6.89	5.46	6.70	0.32	NS	NS
b*	12.28	10.49	11.60	12.75	0.45	NS	NS
5 wk							
L*	45.92	48.63	47.19	49.17	0.80	NS	NS
a*	5.51	4.47	4.44	5.27	0.29	NS	NS
b*	8.37	8.91	9.47	9.56	0.33	NS	NS

[a] Each treatment has 5 replicates with 2 birds each. [b] Standard error of means.
L*: Lightness, a*: redness, b*: yellowness of breast meat.

showing quadratic trend at 3 wk. The serum glucose and LDL level did not reveal any influence of lacquer supplementation. Although serum triglyceride levels remained unchanged at 3 wk, but were decreased at 5 wk showing linear effect ($p = 0.0054$).

The meat color parameters like L* (lightness), a*(redness), and b*(yellowness) remained unchanged, evaluated at 3 and 5 wk on fresh breast meat (Table 8).

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 ethanolic extract of RVS that contain Laccase, an oxidase enzyme complex, gives an antioxidant activity (Lim et al., 2001). Also the methanolic extract of the heartwood containing flavonoid complex could be a potent anticarcinogen (Park et al., 2004). 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.

Lacquer was supplemented in diet in the present research to study its role on broiler performance. It was obvious that we could not find any benefit on growth performance at all phases of study because of its low CP content, although at starter phase lacquer tended ($p = 0.0960$) to improve the weight gains linearly. In our earlier studies with growing finishing pigs, we could not find any effect on growth performance of pigs when lacquer was supplemented at 2 and 4% levels for 8 weeks (our unpublished data). The results of the present study are in accordance to our studies in pigs.

The nutrient digestibility study conducted at 3 weeks of age showed higher digestibility in lacquer supplemented groups that might have increased ($p<0.10$) the weight gain during starter phase. One interesting observation that fat digestibility was linearly ($p<0.05$) improved at both starter and finisher phase by lacquer supplementation. The magnitude of fat digestibility was more at starter than finisher phase, which pinpoints the possible effect of lacquer on fat digestion more prominently at earlier age than at later age.

The present study failed to show any effect of lacquer on abdominal fat reduction. Neither the dressing percentage nor the breast meat percent was improved. Although there is

a reduction in abdominal fat percent but the statistical significance could not be achieved. There was a significant reduction ($p<0.001$) in back fat thickness in barrow, gilts and mixed gender by lacquer supplementation with linear increase in dressing percentage and fat free lean percentage of the pork measured at 8 wk after feeding in our earlier studies with pigs. This difference in the results than that in pig could possibly be the species differences. It is obvious that the percentage of subcutaneous fat deposited in pigs is higher as compared with poultry; hence the desired result of fat reduction was more prominent in pigs than in poultry.

At both phases there was a linear increase in heart weight showing linear ($p = 0.0262$) and quadratic ($p = 0.0220$) effect respectively, but the reason for such results remained obscure. It is proved that lacquer addition increases the blood flow, that possibly might have significantly increased the heart weight due to atrophy, but no conclusive evidence could be drawn from the present study. None of the carcass parameters revealed any effect of lacquer addition in the diet that we were expecting. Due to scarcity of feeding trials on lacquer supplementation, we cannot relate the result in swine performance to broilers because of species difference.

The serum biochemical values of cholesterol, HDL at 3 wk and along with triglyceride at 5 wk were significantly ($p<0.05$) reduced by lacquer supplementation showing a linear trend. It pinpoints the possible role of lacquer in reducing the cholesterol level, which is a menace affecting human health. It also possibly explains the role of active polyphenols in lacquer, to play in fat metabolism at metabolic level, but we did not investigate. The reduction in HDL was in proportion to that of cholesterol reduction both at 3 and 5 weeks respectively. When previous research of HDL and LDL was examined, it was concluded that the blood and products of animals had high HDL and low LDL values (Ozdogan and Aksit, 2003; Chen and Chiou, 2005). On the other hand several researchers have mentioned low HDL and high LDL values associated with atheroschelorosis (Bachorik et al., 1991; Grundy, 1991; Park et al., 2005). RVS ethanol extract was found to protect human LDL from oxidative modification and contained significant antioxidant activity in both polar and non-polar mediums (Lim et al., 2001). The antioxidant potential of RVS is closely associated with the polyphenolic compounds such as fustin, quercetin, butein and sulfuretin, thereby suggesting that flavonoids are the major active components responsible for biological activity of RVS as reported by Lee et al. (2004). Although it is well accepted that lacquer polysaccharides had a protective role as a biological agent in reducing leucopenia (Yang and Du, 2003), anti-tumor activity (Lu et al., 2000) and enhancing growth of leucocytes (Du et al., 1999), it is still not being endorsed by medical practitioners because its biological effects have not been fully investigated yet.

In conclusion, this study showed positive results of lacquer supplementation on fat metabolism, however more studies particularly on its specific mode of action should be investigated in future studies.

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