Effect of Green Tea By-product on Performance and Body Composition in Broiler Chicks

C. J. Yang*, **I. Y. Yang, D. H. Oh, I. H. Bae, S. G. Cho, I. G. Kong, D. Uuganbayar, I. S. Nou**[1] **and K. S. Choi**[2]
Department of Animal Science and Technology, Sunchon National University, Suncheon 540-742, Korea

ABSTRACT : This experiment was conducted to determine the optimum level of green tea by-product (GTB) in diets without antibiotics and to evaluate its effect on broiler performances. A total of 140 Ross broilers were kept in battery cages for a period of 6 weeks. Dietary treatments used in this experiment were antibiotic free group (basal diet as a control), antibiotic added group (basal+0.05% chlortetracycline), GTB 0.5% (basal+GTB 0.5%), GTB 1% (basal+GTB 1%) and GTB 2% (basal+GTB 2%). Antibiotic added group showed significantly higher body weight gain than other treatments ($p<0.05$). However, no significant differences were observed in feed intake and feed efficiency among treatments ($p>0.05$). The addition of green tea by-product to diets tended to decrease blood LDL cholesterol content compared to control group although there were no significant differences among treatments ($p>0.05$). Addition of green tea by-product increased docosahexaenoic acid (DHA) in blood plasma and tended to decrease cholesterol content in chicken meat, but a significant difference was not observed ($p>0.05$). The values of TBA in chicken meat decreased in groups fed diets with green tea-by product and antibiotics compared to control group ($p<0.05$). The crude protein content in chicken meat was decreased slightly in treatments with green tea by-product and antibiotics supplementation. The abdominal fat was increased in chickens fed with diets with green tea by–product compared to the control ($p<0.05$). ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 6 : 867-872)***

Key Words : Green Tea By-product (GTB), Antibiotics, Feed Efficiency, Cholesterol, Broiler

INTRODUCTION

Antibiotics have been widely used as feed additives for swine and poultry since the early 1950s (Cromwell, 1991). The antibiotic supplementation improves growth rate and feed efficiency by 2 to 16 % as well as having disease control effects (Hays, 1977; Zimmerman, 1986) and provides substantial economic benefits to pig and poultry producers. However, antibiotic supplementation in animal feed results in bacterial resistance to the antibiotics and a residue of the antibiotics in animal products, which is a hazard to human health.

In 1999 the European Union banned the use of several antibiotics in animal feeds, because of the fear of development of "cross-resistance" in bacteria, that is resistance-genes may be exchanged between bacteria (Zinc-bacitracine, Spiraycine and Viriginiamycine; Bowman, 1998). So, nowadays, antibiotic supplementations have been limited in poultry and pig diets. The development of antibiotic free diets is a major problem in poultry production.

Recently, green tea has attracted attention as a natural product that is non-toxic. There have been several reports that green tea provides several functional activities related to free radicals and reduction in the incidence of cancer (Mukhtar and Ahmad, 1999), blood cholesterol (Muramattsu et al., 1986), and to blood pressure (Ikeda et al., 1992). Also, green tea has anti-tumor and anti-diabetes effects in the human body (Itaro et al., 1988; Isigai et al., 1991).

Since the beginning of 2000, studies have been made at Sunchon National University on the use of green tea by-product (GTB) as a substitute for antibiotics in poultry diets. The objective of this study was to to evaluate the effects of GTB on productivity and body composition in broiler chicks.

MATERIALS AND METHODS

Animals and design

A total of 140 Ross broilers at 1 day old housed in battery cages were used in this experiment. The chicks were allotted to 5 treatments in a completely random design (CRD) in 4 replicates per treatment with 7 chicks per cage. Experimental diets and drinking water were provided *ad libitum.*

The body weight, feed intake and mortality were recorded weekly. The room temperature was maintained at 22±2°C through a supplemental heating system and there was 24h lighting.

Diets

The green tea by-product used in this experiment was provided from the Green Tea Experimental Station (Bo-sung, Korea). The five dietary treatments were negative

* Reprint request to: C. J. Yang. Tel: +82-61-750-3235, Fax: +82-61-750-3239, E-mail: yangcj@sunchon.ac.kr
[1] Department of Horticulture, Sunchon National University, Suncheon 540-742, Korea
[2] Department of Food Science & Technology, Sunchon National University, Suncheon 540-742, Korea
Received April 2, 2002; Accepted February 3, 2003

Table 1. Formula and chemical composition of the basal diets

Ingredient (%)	Starter	Finisher
Corn grain	53.18	63.78
Wheat bran	2.00	2.00
Soybean meal-45	25.80	19.20
Fish meal	5.00	4.40
Corn gluten meal-60	6.50	5.30
Animal fat	5.45	3.50
Salt	0.30	0.30
Vit-min. mix[1]	0.30	0.30
L-lysine·HCL	0.00	0.12
Methionine	0.14	0.00
Tricalcium phosphate	1.33	0.90
Chemical composion[2]		
ME (kcal/kg)	3,200	3,202
Crude protein (%)	23.02	20.03
Lysine (%)	1.13	1.03
Methionine (%)	0.50	0.39
Ca (%)	1.25	0.90
Avail. P (%)	0.45	0.35

[1] Supplied per kg of premix: Vitamin A, 9,000,000 IU; Vitamin D3, 2,100,000 IU; Vitamin E, 15,000 IU; Vitamin K, 2,000 mg; Vitamin B1, 1,500 mg; Vitamin B2, 4,000 mg; Vitamin B6, 3,000 mg; Vitamin B12, 15 mg; Pan-Acid-Ca, 8,500 mg; Niacin, 20,000 mg; Biotin, 110 mg; Folic-Acid, 600 mg; Fe, 40,000 mg; Co, 300 mg; Cu, 3,500 mg; Mn, 55,000 mg; Zn, 40,000 mg; I, 600 mg; Se, 130 mg.

[2] Calculated values.

control basal diet (control), positive control (basal diet+ 0.05% chlortetracycline and HCL+cyanobalamine, green tea by-product 0.5% (basal+GTB 0.5%), green tea by-product 1% (basal+ GTB 1%) and green tea by-product 2% (basal+GTB 2%). The two basal diets (table 1) were formulated to meet or exceed nutrient requirements (NRC, 1994). The composition of the GTB is shown in table 2.

Cholesterol content in plasma

At the end of the experiment (42 days of age) 2 chickens of each treatment were fasted for 12 hours and slaughtered. For analysis of cholesterol 2ml of blood was taken from the jugular vein of each selected chick and centrifuged at 3,000 rpm for 20 minutes. The blood plasma was stored at -30°C until the analysis of cholesterol content. Free cholesterol was determined using an enzymatic kit (Eiken Chemical Co., LTD., Tokyo, Japan). The cholesterol ester content was calculated by subtracting free cholesterol from total cholesterol. The high-density lipoprotein (HDL)-cholesterol content was measured by the same enzymatic method after precipitating the β-lipoprotein by phosphotungstate-$MgCl_2$ (Burstein et al., 1970).

Table 2. Chemical composition of green tea by-product (%)

Content	Green tea by-product
Tannin (%)	5.95
Caffeine (%)	1.29
Chlorophyll (mg/g)	115
Moisture	9.05
Crude ash	4.77
Crude fiber	62.03
Crude protein	21.16
Ether extract	2.99

Cholesterol content in carcass

For the analysis of cholesterol content in carcass, 5 g of mixture of leg and breast meat with 100 μg of 5 α-cholestane was homogenized with 0.5 N KOH solution and then saponified for 30 minutes at 55°C. The cholesterol content was extracted through hexane before injecting to gas chromatography (HP5890 series II); column used with GC was HP-1 (cross-linked methyl silicone, 25 m×0.32 mm×0.17 μm) capillary column and the column temperature was maintained at 290°C (Brunnekreeft's method 1983).

Composition of fatty acid in blood and carcass

For fatty acid composition analysis 5 g of mixture of leg and breast meat and 2 ml of blood plasma sample were collected. Each sample was dissolved separately into 100 ml of Folch solution (chloroform : methanol 2:1 v/v) and blended for 30 minutes. The samples were flushed with nitrogen gas for 30 minutes in an evaporator then filtered through a Buchner funnel. The filtrate was transferred into 70 ml of distilled water, blended gently and then kept at 5°C in refrigerator until it separated into 2 layers. After phase separation, the bottom layer was evaporated at 35°C with nitrogen gas. Then the concentrate was dissolved in 3 ml of 5% sulfuric acid methanol. The tubes were heated in a water bath at 95°C for 45 minutes and cooled. When cooled, the fatty acid methyl ester was extracted three times with 3 ml of petroleum ether, dried with nitrogen gas, dissolved again with 100ml petroleum ether and then injected to gas chromatography.

Body composition : At the end of the experiment (42 days of age) 8 broilers from each treatment were selected and slaughtered for determination of body composition. The leg and breast meats were separated from the carcass, dried at 60°C, and ground (Tecator cyclotec 1093). The moisture, crude ash, crude protein and crude fat contents of the carcass were determined by the methods of the AOAC (1990).

Carcass rancidity

For this analysis each carcass sample selected was weighed and dissolved into a TBA solution and centrifuged at 2,500 rpm for 15 minutes. Absorption by the supernatant at 530 nm was measured with a UV-Spectrophotometer (KONTRON 942, Italy).

Organ weight

Internal organs (crop, heart, liver, gizzard, pancreas,

Table 3. Effects of dietary green tea by-product levels on performance of broilers

Treatments	Body weight gain (g)	Feed intake (g)	Feed efficiency (%)
1-6 weeks			
Control	1,620[ab]	3,563	0.46
Antibiotics	1,672[a]	3,491	0.48
GTB 0.5 %	1,571[ab]	3,377	0.47
GTB 1 %	1,526[b]	3,358	0.45
GTB 2 %	1,554[ab]	3,456	0.45

[a,b] Means with different superscripts within the same column are significantly different (p<0.05).

Table 4. Effects of dietary green tea by-product levels on broiler mortality (%)

Weeks \ Items	Control	Anti-biotics	Green tea by-product (%) 0.5	1	2	Total
1	-	-	-	-	-	-
2	-	-	-	-	-	
3	4	-	-	-	2	6
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	2	-	-	-	-	2
Total	6	0	0	0	2	8
Mortality (%)	21.43	0	0	0	7.14	5.71

cecum, kidney and abdominal fat) were removed from the carcass and weighed. The relative ratios of lipid and weight of internal organs were calculated on carcass weight basis.

Statistical analysis

The data from this study were analyzed by SAS Package Program (1989) to estimate variance components. Duncans' multiple comparison tests were used to compare the significant differences between treatment means.

RESULTS AND DISCUSSION

Productive performance

Weight gain, feed intake and feed efficiency are given in table 3. At the end of the experiment (at 42 days of age) the body weight gain was significantly (p<0.05) increased in the group fed with antibiotic diet compared to groups that received control and GTB treatments (0.5%, 1% and 2%). The different inclusion levels of green tea-by product in experimental diets affected weight gain of the chicks. When broilers received a diet with 1% of GTB, the weight gain was reduced significantly (p<0.05) compared to chicks that consumed the antibiotic supplemented diet. In general the body weight gain tended to decrease with increasing levels of GTB which is probably due to the high tannin and high fiber contents of the GTB used in experiment. Fuller et al. (1962) and Rostagono et al. (1973) reported that the growth of broiler chicks had a negative relationship with dietary tannin content though Damoron et al. (1980) found no such relationship. Vohra and Kratzer (1964) reported that growth rate of broiler chicks was decreased when they consumed diets high in fiber.

The feed intake was higher in chicks fed control and antibiotic supplemented diets compared to chicks receiving diets with GTB though differences were not significant (p>0.05), nor were those in feed conversion efficiencies which were slightly lower in the 1% and 2% GTB groups.

Mortality

Mortality during the whole experimental period is shown in table 4. Mortality was observed only in chicks fed the control and 2% GTB diets. The average viability of the broilers in entire rearing period was 94.29 %.

Cholesterol content in blood

Effects of dietary GTB on plasma cholesterol are given in table 5. Total cholesterol content and cholesterol ester were higher for groups fed the control and 0.5% GTB diets compared to the group that received the antibiotics diet (p<0.05). Free cholesterol content was relatively lower for treatments with antibiotic and GTB 1% compared to treatments with GTB 0.5% and 2% respectively. There were no significant differences in total cholesterol content in egg yolk from hens fed 1 and 2% GTB compared with control. The free cholesterol and HDL cholesterol content were not significantly (p<0.05) different among treatments but the free cholesterol content tended to decrease with added GTB perhaps because of its crude fiber content. Balmer et al. (1974) reported that fiber is an indigestible feed component affecting cholesterol metabolism and concentration of cholesterol in blood. Tasi et al. (1976) reported serum cholesterol levels in rats were decreased as dietary fiber content was increased. Similar results were observed in laying hens (Menge et al., 1974). Also, saponin-like

Table 5. Effects of dietary green tea by-product levels on plasma cholesterol in broilers (mg/dl)

Treatments	Total cholesterol	Free cholesterol	Cholesterol ester	HDL cholesterol	LDL cholesterol
Control	151.76±26.49[a]	37.89±8.18[1]	118.88±21.79[a]	78.32±22.61	63.75±19.86[ac]
Antibiotics	121.89±21.14[b]	27.65±6.05	94.24±15.98[b]	87.45±13.24	34.44±10.72[c]
GTB 0.5 %	161.90±26.95[a]	34.49±10.66	127.41±20.95[a]	97.95±16.21	63.95±18.41[ab]
GTB 1.0 %	132.98±36.52[ab]	26.50±9.79	106.49±28.21[ab]	79.06±29.41	53.93±20.62[ab]
GTB 2.0 %	140.84±21.79[ab]	28.92±5.60	111.92±17.21[ab]	92.94±9.15	47.90±15.38[bc]

[a,b,c] Means with different superscripts within the same column are significantly different (p<0.05).

[1] Standard error of the mean.

Table 6. Effects of green tea by-product on cholesterol in broiler meat (mg/dl)

Treatments	Cholesterol
Control	1.58±0.38[1]
Antibiotics	1.60±0.47
GTB 0.5 %	1.41±0.33
GTB 1 %	1.36±0.27
GTB 2 %	1.54±0.15

[1] Standard error of the mean.

substances in feedstuff could affect blood cholesterol and level of tissue cholesterol (Newman et al., 1958; Cheeke, 1971). The cholesterol ester and LDL cholesterol contents were reduced significantly in groups fed with antibiotics diet ($p<0.05$). In general, LDL cholesterol content was reduced in groups fed 1% and 2% GTB diets. Miller and Miller (1975) suggested that HDL cholesterol transferred from artery tissue to liver had a function to decrease concentration of cholesterol in blood and had effects to prevent arteriosclerosis. Goldstein and Brown (1977) reported that an increase in LDL caused promotion of arteriosclerosis. The results of our study indicated that an addition of green tea by-product in broiler diets tended to increase HDL levels, except 1% GTB, and to decrease the LDL levels in blood plasma except in the chicks fed diets with green tea by-product 0.5%.

Cholesterol content of carcass : The cholesterol content of broiler meat is shown in table 6. The content was lower in chicks fed GTB than in control, and lowest with 1% GTB, but differences were not significant.

Fatty acid in blood

Table 7 shows the fatty acid composition of blood plasma. The contents of palmitoleic and oleic acids in blood plasma from broilers fed GTB were significantly higher and of linoleic acid were significantly lower compared to control group ($p<0.05$). No significant differences ($p>0.05$) were observed among GTB treatments as the dietary level was increased. The content of docosahexaenoic acid (DHA) tended to increase when GTB level was increased. The results agree with Whitehead (1986) who stated the major fatty acids in the poultry body are palmitic and linoleic acids.

Fatty acid composition of carcass

The fatty acid composition of breast and leg muscle of the broiler is shown in table 8. There was a significant decrease in linoleic acid when the broilers received a diet with antibiotic supplementation compared to control diet

Table 7. Effects of dietary green tea by-product on plasma fatty acid in broilers (%)

Treatments / Fatty acid	Control	Antibiotics	GTB 0.5%	GTB 1%	GTB 2%
Palmitic acid (16:0)	24.27±0.94[1]	24.99±1.54	24.22±1.63	25.29±0.82	23.91±1.42
Palmitoleic acid (16:1(ω7))	0.76±0.35[c]	1.43±0.54[ab]	1.25±0.49[b]	1.46±0.39[ab]	1.76±0.47[a]
Stearic acid (18:0)	15.94±1.2[a]	13.02±1.90[b]	15.21±1.60[a]	15.56±1.10[a]	15.45±1.20[a]
Oleic acid (18:1(ω9))	13.37±1.10[b]	14.88±1.9[ab]	14.71±2.50[ab]	15.10±1.40[ab]	17.05±3.00[a]
Linoleic acid (18:2(ω6))	29.24±2.50[a]	26.01±2.90[b]	26.12±2.20[b]	25.75±2.90[b]	24.89±2.60[b]
Linolenic acid (18:3(ω3))	1.00±0.71	0.60±0.42	0.72±0.30	0.75±0.21	0.67±0.22
Arachidonic acid (20:4(ω6))	10.67±0.90[b]	12.72±1.70[a]	12.72±3.20[a]	10.54±1.00[b]	10.83±1.10[ab]
Eicosapentenoic acid (20:5(ω3))	1.16±0.38	1.05±0.26	1.15±0.36	1.36±0.26	1.18±0.33
Docosahexaenoic acid (22:6(ω3))	3.62±0.59[b]	5.30±1.19[a]	3.92±0.92[b]	4.20±1.11[b]	4.26±0.67[b]

[a,b,] Means with different superscripts within the same column are significantly different ($p<0.05$)

[1] Standard error of the mean

Table 8. Effects of green tea by-product on fatty acid in broiler meat (%)

Treatments / Fatty acid	Control	Antibiotics	GTB 0.5%	GTB 1%	GTB 2%
Palmitic acid (16:0)	22.19±1.31[ab]	22.96±2.00[a]	23.69±1.30[a]	1.12±1.20[b]	22.02±2.00[ab]
Palmitoleic acid (16:1	3.52±0.53	3.52±1.28	3.66±1.30	3.39±0.88	3.72±0.75
Stearic acid (18:0)	9.47±1.24	9.32±3.76	9.85±1.24	9.39±0.71	9.68±0.57
Oleic acid (18:1(ω9))	32.97±1.96	33.98±3.42	33.42±4.69	34.76±2.74	35.96±3.00
Linoleic acid (18:2(ω6))	26.19±2.10[a]	23.54±2.70[b]	22.55±2.20[b]	24.89±2.60[ab]	22.33±2.00[b]
Linolenic acid (18:3(ω3))	1.27±0.32	0.92±0.21	1.05±0.22	1.28±0.34	1.18±0.61
Arachidonic acid (20:4(ω6))	2.65±1.01	3.53±1.18	3.61±2.03	2.96±1.09	2.89±0.91
Eicosapentenoic acid (20:5(ω3))	0.40±0.10	0.57±0.29	0.42±0.11	0.52±0.13	0.53±0.19
Docosahexaenoic acid (22:6(ω)3)	1.36±0.53	1.66±0.92	1.75±0.95	1.69±0.71	1.70±0.64

[ab] Means with different superscripts within the same column are significantly different ($p<0.05$)

[1] Standard error of the mean

Table 9. Effects of green tea by-product on TBA value of broiler meat (umol/100g)

Treatments	μmol/100 g
Control	39.00[a]±11.11[1]
Antibiotics	9.42[b]±2.96
GTB 0.5 %	8.52[b]±4.00
GTB 1 %	9.54[b]±3.74
GTB 2 %	11.47[b]±2.24

[a,b] Means with different superscripts within the same column are significantly different (p<0.05)
[1] Standard error of the mean

Table 10. Effects of antibiotics and green tea by-product on the carcass composition of broiler (%)

Treatments	Moisture	Crude protein	Ether extract	Crude ash
Control	70.50[b]	25.37[a]	1.56[b]	1.75
Antibiotics	70.45[b]	24.76[a]	1.90[ab]	1.44
GTB 0.5%	72.32[a]	22.84[b]	2.56[a]	1.44
GTB 1 %	72.41[a]	23.06[b]	1.89[ab]	1.54
GTB 2 %	72.66[a]	23.00[b]	1.94[ab]	1.52

[a,b] Means with different superscripts within the same column are significantly different (p<0.05).

(p<0.05) however, there were no significant differences between groups received different levels of the green tea by-product. The content of docosahexaenoic acid (DHA) tended to increase with increasing GTB although there were no significant differences among treatments (p>0.05). Dyeberg et al. (1975) reported an optimum level of docosahexaenoic acid, belonging to ω3 group, may play an important role in control of blood pressure and blood cholesterol content.

Carcass rancidity

Stahl (1962) reported that tea polyphenol, especially a distinctive catechin component epigallocatechin gallate (EGC g), had antioxidant effects. The inclusion of green tea by-product in broiler diet may reduce the rancidity of the broiler meat and its effects on TBA value, a measure of rancidity, are given in table 9. The values of the TBA contents were reduced significantly in the meat from broilers fed diets with antibiotic and green tea by-product diet compared to control (p<0.05) but there were not significant differences observed in TBA values of the chicks fed different levels of GTB.

Analysis of body composition

The effect of GTB on body composition is shown in table 10. The moisture content of chicken meat from broilers fed diets with different levels of GTB was significantly higher than for those fed antibiotic added and control diets (p<0.05). However, the content of crude protein in carcass was significantly decreased with addition of green tea by-product (p<0.05), and the crude fat content was significantly higher than in the control group (p<0.05). The content of crude ash was slightly higher in control group although there were no significant differences between treatments.

Organ weight

Weight of internal organs such as crop, heart, liver, gizzard, pancreas, cecum, kidney and abdominal fat pad are shown in table 11. When the level of GTB increased the percentage of internal organ to body weight tended to increase. This result was similar to reports of Savory and Gentle (1976a, b) that chicks consuming much fiber had larger and heavier guts. The percentage of abdominal fat was significantly higher for the 0.5% GTB group than the control group (p<0.05), but when the green tea by-product level was increased then percentage of abdominal fat slightly decreased. Cho (1992) reported that percentage of body fat decreased with addition of pot marigold in broiler diets.

IMPLICATIONS

The results of this study demonstrated that green tea by-product slightly reduced body weight gain but did not affect feed intake and feed efficiency of broiler chicks. Inclusion of green tea by–product in broiler diet appeared to reduce the cholesterol content in broiler meat, an effect that required further investigation.

Table 11. Effects of green tea by-product levels on various organ weights (%)

Items \ Treatments	Control	Antibiotics	GTB 0.5%	GTB 1 %	GTB 2 %
Crop wt. (g)/live wt. (g)	0.51[b]	0.53[b]	0.59[ab]	0.59[ab]	0.62[a]
Heart wt. (g)/live wt. (g)	0.61	0.62	0.68	0.71	0.66
Liver wt. (g)/live wt. (g)	2.65[b]	2.35[b]	3.17[a]	2.82[ab]	2.79[ab]
Gizzard wt. (g)/live wt. (g)	3.00	2.71	2.89	3.00	2.76
Pancreas wt. (g)/live wt. (g)	1.18	1.12	1.19	1.19	1.22
Cecum wt. (g)/live wt. (g)	0.71[ab]	0.69[ab]	0.83[a]	0.78[ab]	0.65[b]
Kidney wt. (g)/live wt. (g)	0.21[ab]	0.15[b]	0.27[a]	0.19[b]	0.19[b]
Abdominal fat wt. (g)/live wt. (g)	0.45[b]	0.71[ab]	0.97[a]	0.95[a]	0.86[ab]

[ab] Means with different superscripts within the same column are significantly different (p<0.05)

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