Effects of Feeding Dried Leftover Food on Growth and Body Composition of Broiler Chicks

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ABSTRACT: This study was conducted to investigate the effects of feeding dried leftover food (DLF) on growth, body composition and feed conversion of broiler chicks. One hundred ninety-six of one-day old Ross broiler chicks were assigned to 7 treatments in a completely randomized design. Each treatment had four replications with seven chicks per replication. The treatments groups included control without DLF, dietary 10% level of DLF, dietary 20% level of DLF and dietary 30% level of DLF, 5% higher protein level of diet containing 10% DLF, 10% higher protein level of diet containing 20% DLF and 15% higher protein level of diet containing 30% DLF than control diet. Body weight gain was slightly higher in control group than that of DLF-fed groups. However, there were no significant differences in body weight gain among those groups fed diets containing different levels of DLF. In general, increasing dietary level of DLF resulted in decreasing feed conversion. Content of crude protein in whole broiler body was slightly higher in control group although any significant difference was not found among treatments (p>0.05). Content of crude fat in whole broiler body was lowest in groups fed diets containing 30% DLF with 15% higher protein level than control diet, showing significant difference from groups fed diets containing 20% DLF (p<0.05). Contents of total cholesterol, free cholesterol, cholesterol ester and LDL- cholesterol in blood of broilers fed DLF-containing diets generally appeared to be higher compared with control group without significant difference (p>0.05). Fatty acid contents in broiler meat were higher in the order of oleic acid, palmitic acid and linoleic acid without significant differences among treatments. Content of DHA in broiler meat was higher in groups fed diets containing DLF than that of control group although there were no significant differences among treatments (p>0.05). (Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 3 : 386-393)

Key Words: Broiler, Dried Leftover Food, Feed Efficiency, Body Weight Gain, Body Composition, Cholesterol, Fatty Acid

INTRODUCTION

Currently, magnitude amounts of waste materials generated from household and industries have become one of the main factors to cause environmental pollution. Especially, as for the leftover food, the portion of leftover food out of total wastes has been continuously increased. Before volume-based waste fee system was effective, it was 31.0% and under volume-based waste fee system it was 38.3% (Ministry of Environment, 1996). Leftover foods can be leached out to act as pollutants in water, air and soil when they are landfilled because of their high moisture content. In addition, high moisture content of leftover foods causes to decrease efficiency during incineration. For this reason, alternative plans to protect environmental pollution from generated leftover foods are urgently required (Lee and Lee, 1998). The rate of recycling leftover food has been increased from 21.3% (1998) to 50% (2002) because of increased number of private or public leftover food recycling facilities. Also, continuous increases in feed cost for animal production motivated to recycle leftover food into animal feed (Sim, 1998). Recycling leftover foods into animal feed has become one of the most important projects to be pursued by Korean government because leftover food has become a social issue most of Korean people concern about (Ministry of Environment, 1997).

One of the methods to recycle leftover foods was to produce soil fertilizer using a fermentation technology although it caused several problems due to its high saline concentration. Therefore, the best recycling method of food waste was to convert it into animal feed (Kim et al., 2001). Converting and recycling of leftover food into animal feed are very important because leftover food can contribute to not only decreasing import of feed ingredients but also decreasing environmental pollution (Yang et al., 2001).

Leftover food currently generated in Korea is known to contain about 3.5% of NaCl but protein, fat and minerals value as feed ingredient are high. It was recognized that leftover food had nutritional values enough to be used as feed resource for broiler and laying hens in a foreign country (Soliman et al., 1978; Hoshii and Yoshida, 1981; Lipstein, 1984, 1985). Considering degree of self-sufficiency that food supply reached only 30% and 2 trillion won in Korean currency were spent on importing feed ingredients to Korea, recycling leftover foods into feed ingredient for livestock animals should have a potential enough to save feed cost of livestock farmers, resulting in improving livestock farmers’ competitiveness as well as protecting environment against pollution derived from food
wastes. Therefore, the objective of this study was to investigate the effects of feeding dried leftover foods on growth and body composition of broiler chicks.

MATERIALS AND METHODS

Animals and experimental design

One hundred ninety-six of one-day old Ross strain broiler chicks were assigned to 7 treatments in a completely randomized design. Each treatment had four replications with seven chicks per replication. All chicks were fed experimental diets for 6 weeks. The treatments included control diet without dried leftover foods (DLF), diet containing 10% DLF, diet containing 20% DLF, diet containing 30% DLF, 5% higher protein level of diet containing 10% DLF, 10% higher protein level of diet containing 20% DLF and 15% higher protein level of diet containing with 30% DLF than control diet.

Experimental diets and feeding

Dried leftover food was processed using fluidized bed dry method with support of local leftover foods processing company (Samneung construction Inc., Gwangju, Korea). Chemical compositions of DLF were 93.70% of dry matter (DM), 20.62% of crude protein (CP), 9.99% of crude fat (EE), 8.87% of crude fiber (CF) and 13.67% of crude ash, 0.41% of lysine and 0.18% of methionine. Experimental diets were formulated for two phases, one for starter (0-3 weeks of age) and one for finisher (4-6 weeks of age). The ingredients and chemical compositions of experimental diets are shown in Table 1 and 2. Broiler chick was housed individually in 3 layer cage and offered the first-term diets from one-day old to 3 weeks old and then the diets for the later term by the end of experiment. Water was provided through automatic waterer.

MEASUREMENTS

Body weight gains and feed efficiency

Body weights were measured on weekly basis from the initial day to the final day of experiment to calculate body weight gain. Feed intake was determined by measuring feed residue on weekly basis since the beginning of the experiment. Feed conversion was obtained by dividing total feed intake by body weight gain.

Weight of internal organs and body composition

At the end of experiment, 8 chicks were randomly selected from each treatment based on body weight for slaughtering. According to the methods devised by Deaton et al. (1974), internal organs were removed and fat tissues were collected from gizzard, intestine and cloaca in the rib and around abdominal muscle to measure abdominal fat pad. Liver, gizzard, pancreas, cecum, heart and crop were weighed to calculate a percentage of each organ to carcass weight. Meats from shank and breast were cut and then grinded with meat chopper (Daewoo, Korea) for analysis of its moisture, CP, EE and crude ash content according to the method of AOAC. (1990).

| Table 1. Formula and chemical composition of the experimental diets (Starter) |
|-----------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Ingredients                 | Control          | DLF 10%          | DLF 20%          | DLF 30%          | AP5+ DLF10%      | AP10+ DLF20%     | AP15+ DLF30%     |
| Corn                        | 55.81            | 47.54            | 42.19            | 35.59            | 45.09            | 36.32            | 25.24            |
| Soybean meal-45             | 26.00            | 24.90            | 19.00            | 15.00            | 15.00            | 22.00            | 21.60            |
| Fish meal                   | 5.00             | 3.20             | 4.90             | 5.00             | 5.46             | 6.90             | 6.90             |
| Corn gluten meal-60         | 6.50             | 6.50             | 6.50             | 6.50             | 6.20             | 6.95             | 7.04             |
| Animal fat                  | 4.62             | 5.68             | 5.56             | 6.03             | 5.86             | 6.30             | 7.65             |
| Salt                        | 0.30             | 0.11             | 0.00             | 0.00             | 0.06             | 0.00             | 0.00             |
| Vit.-Min. premix1           | 0.25             | 0.25             | 0.25             | 0.25             | 0.30             | 0.25             | 0.30             |
| L-lysine-HCL                | 0.00             | 0.05             | 0.05             | 0.05             | 0.00             | 0.05             | 0.15             |
| Methionine                  | 0.14             | 0.20             | 0.20             | 0.23             | 0.20             | 0.20             | 0.27             |
| Tricalcium phosphate        | 1.33             | 1.50             | 1.20             | 1.10             | 1.21             | 0.95             | 0.85             |
| Dried leftover food         | 0.00             | 10.00            | 20.00            | 30.00            | 10.00            | 20.00            | 30.00            |
| Chemical composition2      | ME (kcal/kg)     | 3.200            | 3.200            | 3.200            | 3.200            | 3.200            | 3.200            |
| Crude protein (%)           | 23.03            | 23.01            | 23.07            | 23.00            | 24.17            | 25.30            | 26.45            |
| Lysine (%)                  | 1.13             | 1.10             | 1.10             | 1.10             | 1.16             | 1.21             | 1.27             |
| Methionine (%)              | 0.50             | 0.50             | 0.50             | 0.50             | 0.53             | 0.55             | 0.58             |
| Ca (%)                      | 1.18             | 1.60             | 1.94             | 2.31             | 1.64             | 2.03             | 1.00             |
| Avail. P (%)                | 0.45             | 0.45             | 0.45             | 0.45             | 0.45             | 0.45             | 0.45             |

1 Vit-min. mix provided following nutrients per kg of diet: Vit. A, 9,000,000 IU; Vit. D2, 2,100,000 IU; Vit. E, 15,000 IU; Vit. K, 2,000 mg; Vit. B1, 1,500 mg; Vit. B2, 4,000 mg; Vit. B6, 3,000 mg; Vit. 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. * DLF: Dried leftover food, AP: Additional protein based on control.
Cholesterol content in blood and meat

Eight chicks were randomly selected from each treatment based on body weight and fasted for 12 h to sample 2 ml of blood from jugular vein of each animal. The collected blood was stood for 15 min after sampling. After centrifuging at 3,000 rpm for 20 min, blood plasma was separated from the serum to analyze cholesterol. Total and free cholesterol concentrations of plasma were analyzed using cholesterol-analyzing kit (Eiken Chemical Co., LTD., Japan). Concentrations of cholesterol ester were calculated by subtracting free cholesterol concentration from total cholesterol concentration. Plasma high-density lipoprotein (HDL)-cholesterol concentration was measured with phosphatingstate-MgCl₂ (Burstein et al., 1970) after sedimentation of β-lipoprotein followed by enzyme method.

Cholesterol concentrations of carcass, shank and breast were analyzed according to the method by Brunnekreeft et al. (1983) using a gaschromatography (GC). Meat sample was homogenized with cholestane 100 µg in 0.5 N KOH solution, then put under saponification for 30 min at 55°C. Following extraction by hexane, an ampule of sample was loaded into GC (HP5890 series II). For fatty acid separation, HP-1 (cross-linked methyl silicone, 25 m × 0.32 mm × 0.17 µm) capillary column was used and column temperature was maintained at 290°C.

Fatty acid composition in blood and meat

Five grams of sample was mixed with 100 ml of Folch solution and chloroform (2:1, v/v) mixture and filled with nitrogen (N) gas. After 30 min extraction at room temperature with shaking, the extract was filtered through Bucher filter. After adding 70 ml of distilled water, the extract was separated by liquid phase extraction method and then the organic phase was collected for vacuum distillation.

### Table 2. Formula and chemical composition of the experimental diets (Finisher)

| Ingredients       | Control | DLF 10% | DLF 20% | DLF 30% | AP*5+ DLF 10% | AP10+ DLF 20% | AP15+ DLF 30% |
|-------------------|---------|---------|---------|---------|---------------|---------------|---------------|
| Corn              | 61.66   | 55.39   | 48.32   | 41.67   | 51.72         | 41.25         | 31.79         |
| Soybean meal-45   | 26.70   | 22.80   | 19.40   | 15.50   | 25.80         | 25.00         | 22.70         |
| Corn gluten meal-60 | 5.00    | 5.00    | 5.00    | 5.00    | 5.00          | 5.10          | 6.00          |
| Animal fat        | 4.50    | 4.82    | 5.35    | 5.83    | 5.57          | 6.76          | 7.56          |
| Salt              | 0.30    | 0.05    | 0.00    | 0.00    | 0.05          | 0.00          | 0.00          |
| Vit.-Min. premix¹ | 0.25    | 0.25    | 0.25    | 0.25    | 0.25          | 0.25          | 0.25          |
| L-lysine-HCL      | 0.05    | 0.05    | 0.05    | 0.05    | 0.05          | 0.05          | 0.05          |
| Methionine        | 0.07    | 0.10    | 0.13    | 0.17    | 0.11          | 0.16          | 0.20          |
| Tricalcium phosphate | 1.38  | 1.35    | 1.22    | 1.15    | 1.30          | 1.20          | 1.00          |
| Dried leftover food | 0.00 | 10.00  | 20.00   | 30.00   | 10.00         | 20.00         | 30.00         |

Chemical composition²

- ME (kcal/kg): 3,200
- Crude protein (%): 20.07
- Lysine (%): 1.00
- Methionine (%): 0.38
- Ca (%): 0.93
- Avail. P (%): 0.35

¹ Vit-min. mix provided following nutrients per kg of diet: Vit. A, 9,000,000 IU; Vit. D₃, 2,100,000 IU; Vit. E, 15,000 IU; Vit. K, 2,000 mg; Vit. B₁, 1,500 mg; Vit. B₂, 4,000 mg; Vit. B₆, 3,000 mg; Vit. 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.

### Table 3. Effects of feeding DLF on body weight gain, feed intake and feed efficiency of broiler

| Item                      | Weight gain (g) | Feed intake (g) | Feed efficiency |
|--------------------------|-----------------|-----------------|----------------|
| 1-3 weeks                |                 |                 |                |
| Control                  | 644 a           | 1,023 b         | 0.63 a         |
| DLF 10%                  | 623 ab          | 1,010 bc        | 0.62 ab        |
| DLF 20%                  | 592 bc          | 1,026 bc        | 0.58 bc        |
| DLF 30%                  | 470 c           | 967 c           | 0.49 c         |
| AP 5+DLF 10%             | 528 c           | 918 c           | 0.58 c         |
| AP10+DLF 20%             | 611 ab          | 1,023 b         | 0.60 b         |
| AP15+DLF 30%             | 582 b           | 1,095 a         | 0.53 a         |
| 4-6 weeks                |                 |                 |                |
| Control                  | 1,018 ab        | 2,272 c         | 0.45 a         |
| DLF 10%                  | 998 b           | 2,473 bc        | 0.40 b         |
| DLF 20%                  | 909 c           | 2,468 c         | 0.37 b         |
| DLF 30%                  | 1,110 a         | 2,393 c         | 0.46 c         |
| AP 5+DLF 10%             | 1,123 a         | 2,395 c         | 0.47 a         |
| AP10+DLF 20%             | 962 b           | 2,618 b         | 0.37 b         |
| AP15+DLF 30%             | 1,013 b         | 2,797 a         | 0.37 b         |
| 1-6 weeks                |                 |                 |                |
| Control                  | 1,662 a         | 3,295 b         | 0.50 b         |
| DLF 10%                  | 1,621 ab        | 3,482 b         | 0.47 bc        |
| DLF 20%                  | 1,501 b         | 3,494 b         | 0.43 ab        |
| DLF 30%                  | 1,580 b         | 3,359 b         | 0.47 b         |
| AP 5+DLF 10%             | 1,650 ab        | 3,314 b         | 0.50 b         |
| AP10+DLF 20%             | 1,572 b         | 3,641 ab        | 0.43 bc        |
| AP15+DLF 30%             | 1,596 ab        | 3,892 a         | 0.41 b         |

¹ Mean with different superscripts within the same column are significantly different (p<0.05).

DLF: Dried leftover food, AP: Additional protein based on control.

Cholesterol content in blood and meat

Eight chicks were randomly selected from each treatment based on body weight and fasted for 12 h to sample 2 ml of blood from jugular vein of each animal. The collected blood was stood for 15 min after sampling. After centrifuging at 3,000 rpm for 20 min, blood plasma was separated from the serum to analyze cholesterol. Total and free cholesterol concentrations of plasma were analyzed using cholesterol-analyzing kit (Eiken Chemical Co., LTD., Japan). Concentrations of cholesterol ester were calculated by subtracting free cholesterol concentration from total cholesterol concentration. Plasma high-density lipoprotein (HDL)-cholesterol concentration was measured with phosphatingstate-MgCl₂ (Burstein et al., 1970) after sedimentation of β-lipoprotein followed by enzyme method.

Cholesterol concentrations of carcass, shank and breast were analyzed according to the method by Brunnekreeft et al. (1983) using a gaschromatography (GC). Meat sample was homogenized with cholestane 100 µg in 0.5 N KOH solution, then put under saponification for 30 min at 55°C. Following extraction by hexane, an ampule of sample was loaded into GC (HP5890 series II). For fatty acid separation, HP-1 (cross-linked methyl silicone, 25 m×0.32 mm×0.17 µm) capillary column was used and column temperature was maintained at 290°C.

Fatty acid composition in blood and meat

Five grams of sample was mixed with 100 ml of Folch solution and chloroform (2:1, v/v) mixture and filled with nitrogen (N) gas. After 30 min extraction at room temperature with shaking, the extract was filtered through Bucher filter. After adding 70 ml of distilled water, the extract was separated by liquid phase extraction method and then the organic phase was collected for vacuum distillation.
condensation. Concentrated solution was transferred to the test tubes and dried under N gas and added 5% sulfuric acid-methanol of 3 ml and extracted 3 times by petroleum ether of 3 ml and dried again under N gas and melted with petroleum ether 100 µg and analyzed by GC.

Statistical analysis

Differences among treatment means were analyzed using Duncan’s Multiple Range Test (Duncan, 1955) with SAS program (SAS, 1995).

RESULTS AND DISCUSSION

Body weight gains and feed efficiency

Table 3 shows the effects of feeding DLF on body weight gain, feed intake and feed efficiency of broilers. Body weight gain for the first 3 weeks was 644 g in control group, which was highest among all treatments. However, there were no significant differences between groups fed diet containing 10% and 20% DLF while being significantly higher than groups fed diets containing 30% DLF showing 470 g. Feed intake in control was lowest in groups fed diets containing 10% DLF with 5% higher protein level than control group while feed intake was significantly highest in group fed diets containing 30% DLF with 15% higher protein level representing 2,797 g (p<0.05). Feed conversion was highest in groups fed diets containing 30% DLF representing 0.47. There were no significant differences in feed conversion between groups fed diets containing 10% DLF and 10% DLF with 5% higher protein level. Feed conversion was significantly lower in groups fed diets containing 20% DLF and diets containing 20 and 30% DLF with higher protein level (p<0.05).

Body weight gain for the entire period of experiment (6 weeks) was 1,662 g for control group, which was slightly higher than those of DLF-fed groups without significant differences. Body weight gain was significantly lower in groups fed diets containing 10% DLF and 20% DLF with 5% higher protein level. Feed conversion was significantly lower in groups fed diets containing 20% DLF and diets containing 20 and 30% DLF with higher protein level (p<0.05). There was a tendency that increasing level of DLF in the diet for broilers decreased feed conversion.

Weight of internal organs and body composition

Table 4 shows the effects of feeding DLF on the development of internal organs of broiler chicks (%).

Table 4. Effects of feeding DLF on the development of internal organs of broiler chicks (%)

| Item            | Control | DLF 10% | DLF 20% | DLF 30% | AP5+ DLF10% | AP10+ DLF20% | AP15+ DLF30% |
|-----------------|---------|---------|---------|---------|-------------|--------------|--------------|
| Crop wt./live wt.| 0.38    | 0.38    | 0.40    | 0.44    | 0.36        | 0.40         | 0.49         |
| Heart wt./live wt.| 0.39  | 0.43    | 0.48    | 0.47    | 0.42        | 0.46         | 0.53         |
| Liver wt./live wt.| 1.94  | 1.95    | 1.77    | 2.07    | 1.92        | 1.79         | 2.20         |
| Gizzard wt./live wt.| 2.02 | 2.40    | 2.43    | 2.48    | 2.31        | 2.28         | 2.29         |
| Pancreas wt./live wt.| 0.73 | 0.72    | 0.67    | 0.86    | 0.78        | 0.75         | 0.76         |
| Cecum wt./live wt.| 0.62<sup>a</sup> | 0.78<sup>b</sup> | 0.51<sup>b</sup> | 1.09<sup>a</sup> | 0.61<sup>b</sup> | 0.71<sup>b</sup> | 0.68<sup>b</sup> |
| Ab fat wt./live wt.| 1.67  | 1.75    | 1.81    | 2.16    | 1.87        | 1.68         | 2.06         |

<sup>a,b</sup> Mean with different superscripts within the same column are significantly different (p<0.05).

Table 5. Body composition of broilers fed diets containing DLF at different levels (%)

| Item            | Moisture | Crude Protein | Ether Extract | Crude Ash |
|-----------------|----------|---------------|---------------|-----------|
| Control         | 73.70<sup>a</sup> | 18.84         | 3.13<sup>b</sup> | 1.31<sup>b</sup> |
| DLF 10%         | 72.32<sup>b</sup> | 16.34         | 3.89<sup>ab</sup> | 1.49<sup>ab</sup> |
| DLF 20%         | 72.85<sup>b</sup> | 16.58         | 4.06<sup>ab</sup> | 1.23<sup>b</sup> |
| DLF 30%         | 71.92<sup>b</sup> | 16.48         | 3.74<sup>abc</sup> | 1.41<sup>ab</sup> |
| AP 5+DLF 10%    | 73.12<sup>b</sup> | 16.23         | 3.85<sup>ab</sup> | 1.59<sup>a</sup> |
| AP10+DLF 20%    | 73.82<sup>c</sup> | 17.85         | 2.95<sup>cd</sup> | 1.45<sup>ab</sup> |
| AP15+DLF 30%    | 73.48<sup>d</sup> | 16.68         | 2.82<sup>d</sup>  | 1.43<sup>ab</sup> |

<sup>a,b,c</sup> Mean with different superscripts within the same column are significantly different (p<0.05).
indicated that chicken ingested the feeds containing high fiber content showed an increase in size and weight of intestinal tracts.

The amount of fat in abdominal cavity was slightly increased with increasing level of DLF in the diet without significant differences (p>0.05). As weights of internal organs did not change, the diets containing DLF might not affect physiological status of broiler.

Table 5 shows body composition of broilers fed diets containing DLF of different dietary levels. Moisture content of broilers fed diets containing 30% DLF (71.92) was significantly lower than those fed on control, AP10+DLF 20% and AP15+DLF 30% (p<0.05). There were no significant differences in CP concentration among treatments. However, feeding DLF appeared to decrease body CP concentration compared to control. EE concentration of broilers fed diets on AP15+DLF 30% was (2.82%) lower than the other treatments while that of broilers fed on DLF 20% was significantly higher than the other treatments (p<0.05). Similar observation was reported that body compositions of broilers fed on diets of swine manure and leftover food mixture were not different from those of control group (Kim et al., 2001).

### Table 6. Plasma cholesterol concentrations of broilers fed diets containing DLF at different levels (mg/dl)

| Item       | Total cholesterol | Free cholesterol | Cholesterol ester | HDL-cholesterol | LDL-cholesterol |
|------------|-------------------|------------------|-------------------|-----------------|---------------|
| Control    | 93.14±24.56       | 43.33±16.54      | 49.81±10.97       | 43.11±13.30nb   | 50.03±13.37   |
| DLF 10%    | 103.05±30.74      | 48.36±16.71      | 54.70±14.97       | 41.19±12.65nb   | 61.87±28.15   |
| DLF 20%    | 113.37±18.32      | 48.27±11.33      | 65.10±9.72        | 44.09±5.57nb    | 69.28±15.80   |
| DLF 30%    | 120.01±26.35      | 56.50±13.37      | 63.52±14.01       | 51.51±7.42b     | 68.50±29.17   |
| AP 5+DLF 10%| 103.01±8.50       | 45.49±9.16       | 57.53±13.85       | 41.46±6.20b     | 61.55±8.94    |
| AP10+DLF 20%| 104.51±22.10      | 45.08±12.16      | 59.43±12.67       | 34.62±6.08b     | 69.89±21.33   |
| AP15+DLF 30%| 99.44±19.64       | 49.81±16.32      | 49.63±3.50        | 37.59±9.39b     | 61.85±17.68   |

**a, b** Mean with different superscripts within the same column are significantly different (p<0.05).

### Table 7. Meat cholesterol concentrations of broilers fed diets containing DLF at different levels (mg/g)

| Item       | Cholesterol (mg/g) |
|------------|--------------------|
| Control    | 92.00±14.34        |
| DLF 10%    | 101.18±10.45       |
| DLF 20%    | 102.12±13.89       |
| DLF 30%    | 91.48±9.46         |
| AP 5+DLF 10%| 87.20±11.40        |
| AP10+DLF 20%| 94.30±11.75        |
| AP15+DLF 30%| 90.34±9.38         |

### Table 8. Plasma fatty acids of broiler fed diets containing DLF at different levels (%)

| Item   | Control | DLF 10% | DLF 20% | DLF 30% | AP5+DLF10% | AP10+DLF20% | AP15+DLF30% |
|--------|---------|---------|---------|---------|------------|------------|------------|
| C14:0  | 0.27±0.03 | 0.27±0.03 | 0.21±0.06 | 0.28±0.01 | 0.27±0.07  | 0.36±0.05  | 0.29±0.09  |
| C16:0  | 24.09±2.43 | 22.38±0.41 | 22.54±1.90 | 22.22±1.29 | 23.23±2.06 | 23.27±0.80 | 24.17±1.73 |
| C16:1  | 1.65±0.92b | 1.49±0.47ab | 1.09±0.07abc | 0.57±0.19a | 1.63±0.54a | 0.92±0.13abc | 0.88±0.15bc |
| C18:0  | 14.33±2.29 | 14.46±1.35 | 13.58±0.68 | 13.37±1.91 | 15.23±1.27 | 13.86±2.05 | 12.79±1.85 |
| C18:1e9| 18.70±1.68ab | 18.23±2.77ab | 16.66±1.94ab | 15.85±1.48b | 19.17±2.96e | 17.19±0.64ab | 16.85±1.12ab |
| C18:2e6| 21.21±1.06 | 21.05±2.43 | 19.97±2.44 | 22.45±1.40 | 20.67±1.47 | 21.74±1.33 | 20.08±2.45 |
| C18:3e3| 0.31±0.07b | 14.99±9.73a | 10.55±11.83a | 0.52±0.05b | 0.51±0.14b | 0.41±0.07b | 0.52±0.07b |
| C18:4e3| 0.56±0.19a | 0.39±0.09abc | 0.44±0.41abc | 0.17±0.12 | 0.39±0.06bc | 0.20±0.27 | 0.22±0.15abc |
| C20:1e9| 0.08±0.12e | 0.22±0.15abc | 0.20±0.16abc | 0.13±0.08bc | 0.27±0.13abc | 0.32±0.11abc | 0.34±0.10abc |
| C20:2e6| 0.32±0.14 | 0.36±0.08 | 0.24±0.31 | 0.21±0.15 | 0.38±0.05 | 0.21±0.24 | 0.18±0.22 |
| C20:3e6| 1.14±0.50b | 0.88±0.24ab | 0.90±0.07ab | 0.79±0.23ab | 0.90±0.14ab | 0.75±0.17ab | 0.66±0.28ab |
| C20:4e6| 11.03±1.82 | 10.27±1.13 | 11.27±3.66 | 10.12±0.87 | 9.09±2.84 | 8.90±0.18 | 9.93±0.88 |
| C20:5e3| 0.99±0.26a | 2.09±0.27abc | 2.28±0.70b | 3.45±0.53a | 1.58±0.52ed | 2.16±0.17abc | 2.04±0.20abc |
| C22:6e3| 4.29±0.60d | 6.37±1.21b | 8.75±0.50a | 8.60±0.67a | 5.67±1.84a | 8.31±0.63a | 9.75±2.29a |
| C24:0  | 1.03±0.19 | 0.79±0.22 | 1.57±0.45 | 1.28±0.34 | 1.02±0.36 | 1.51±0.48 | 1.30±0.35 |

**a, b** Mean with different superscripts within the same column are significantly different (p<0.05).

C14:0 (myristic acid), C16:0 (palmitic acid), C16:1 (palmitoleic acid), C18:0 (stearic acid), C18:1e9 (oleic acid), C18:2e6 (linoleic acid), C18:3e3 (linolenic acid), C20:1e9 (eicosenoic acid), C20:2e6 (eicosadienoic acid), C20:3e6 (eicosatrienoic acid), C20:4e6 (eicosatetraenoic acid), C20:5e3 (eicosapentaenoic acid), C22:6e3 (docosahexaenoic acid), C24:0 (lignoceric acid).
higher than those fed on control (43.11), AP10+DLF 20% (34.62) and AP15+DLF 30% (37.59).

Miller and Miller (1975) reported that HDL-cholesterol delivered cholesterol in artery system to the liver to reduce the cholesterol level of blood. Goldstein and Brown (1977) reported that increased LDL-cholesterol level promoted the cholesterol level of blood. Goldstein and Brown (1977) delivered cholesterol in artery system to the liver to reduce eicosapentaenoic acid concentration in plasma.

While contents of myristic acid, palmitic acid, stearic acid, linoleic acid, eicosadienoic acid, eicosatetraenoic acid and lignoceric acid were not significantly different among treatments (p>0.05), plasma concentration of docosahexenoic acid (DHA) was higher in DLF-fed groups than control group. Increasing level of DLF in the diet did increase plasma DHA concentration significantly (p<0.05). Eicosapentaenoic acid well known as EPA was significantly lower in control group representing 0.99% than that of DLF-fed groups (p<0.05).

Meat fatty acids of broilers fed diets containing DLF at different levels are shown in Table 9. Meat fatty acid compositions are listed in the order of palmitic acid, linoleic acid and oleic acid. There were no significant differences in fatty acid compositions of meat among treatments. Content of eicosadienoic acid, eicosatetraenoic acid and lignoceric acid were not significantly different among treatments. Docosahexenoic acid concentrations of DLF-fed groups were not different from that of control.

Whitehead (1986) reported that fatty acids of chicken body consisted of mainly oleic acid and palmitic acid. Our analysis of fatty acids of broilers used in this study showed similar tendency to this. Docosahexenoic acid was concentrated in cortex of brain, retina and sperm in animals including human and its physiological functions were inhibition of thrombocyte aggregation, vasodilatation, enhanced immunity, depression of blood pressure and degradation of cholesterol in blood (Dyeberg et al., 1975; Dyeberg and Bang, 1978; Dyeberg, 1986). From this study, it can be inferred that when DLF was used in feed for broiler, DHA contents in blood and meat could be increased.

**Economic analysis**

The effects of feeding DLF on the economic efficacy in broiler are shown in Table 10. Feed cost per unit kg was decreased with increasing level of DLF in the diet. Feed cost per 1 kg body weight gain during a period of starter was lower in groups fed diets containing 10% DLF while that during a period of finisher was lower in groups fed

### Table 9. Meat fatty acid of broilers fed diets containing DLF at different levels (%)

| Item         | Control | DLF 10% | DLF 20% | DLF 30% | AP5+ DLF10% | AP10+ DLF20% | AP15+ DLF30% |
|--------------|---------|---------|---------|---------|-------------|-------------|-------------|
| C14:0        | 0.92±0.07 | 0.98±0.12 | 0.91±0.05 | 0.97±0.11 | 1.19±0.15 | 0.99±0.10 | 0.91±0.18 |
| C16:0        | 23.77±3.16 | 21.43±0.37 | 22.82±1.53 | 21.92±0.81 | 20.24±0.46 | 22.16±1.95 | 22.33±1.47 |
| C16:1        | 6.78±1.00 | 4.40±0.48 | 5.44±0.90 | 5.85±0.29 | 5.21±0.12 | 5.21±0.52 | 4.98±0.45 |
| C18:0        | 6.95±0.26 | 7.88±0.87 | 7.15±0.80 | 6.68±0.32 | 6.37±0.16 | 7.08±0.16 | 7.57±0.55 |
| C18:1        | 40.40±1.00 | 38.05±1.30 | 39.16±0.61 | 39.69±1.54 | 39.98±0.31 | 39.86±1.24 | 39.52±0.56 |
| C18:2        | 16.23±2.58 | 19.66±1.36 | 17.02±0.47 | 17.07±0.86 | 20.49±0.68 | 17.78±1.01 | 17.80±2.65 |
| C18:3         | 0.68±0.10 | 1.13±0.21 | 0.99±0.06 | 1.09±0.13 | 1.43±0.12 | 1.06±0.13 | 0.94±0.25 |
| C18:4         | 0.19±0.01 | 0.12±0.11 | 0.14±0.02 | 0.17±0.09 | 0.05±0.05 | 0.11±0.02 | 0.18±0.13 |
| C20:1         | 0.46±0.13 | 0.69±0.12 | 0.84±0.32 | 0.75±0.30 | 0.56±0.01 | 0.54±0.04 | 0.54±0.03 |
| C20:2         | 0.20±0.03 | 0.32±0.11 | 0.29±0.08 | 0.33±0.19 | 0.25±0.03 | 0.24±0.02 | 0.29±0.04 |
| C20:3         | 0.40±0.03 | 0.44±0.20 | 0.38±0.04 | 0.37±0.06 | 0.26±0.05 | 0.34±0.05 | 0.50±0.20 |
| C20:4         | 1.94±0.65 | 2.57±0.69 | 2.33±0.58 | 2.24±0.87 | 1.79±0.13 | 2.30±0.32 | 2.15±0.24 |
| C20:5         | 0.18±0.02 | 0.31±0.14 | 0.33±0.02 | 0.45±0.11 | 0.34±0.05 | 0.30±0.08 | 0.35±0.08 |
| C22:6         | 0.54±0.19 | 1.33±0.64 | 1.43±0.60 | 1.72±0.89 | 1.29±0.18 | 1.31±0.42 | 1.33±0.20 |
| C24:0         | 0.37±0.06 | 0.69±0.27 | 0.76±0.28 | 0.69±0.32 | 0.56±0.01 | 0.59±0.11 | 0.62±0.03 |

**Note:** Mean with different superscripts within the same column are significantly different (p<0.05).
diets containing 30% DLF. Feed cost per 1 kg body weight gain during the experimental period was about 4% less in groups fed diets containing 30% DLF than control. There was no significant difference in feed cost per 1 kg weight gain between control and groups fed diets containing 10% DLF. Therefore, it is recommended that in viewpoint of economics DLF could be included at least more than 10% in broiler diet for the starter period and up to 30% in broiler diet for the finisher period.

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