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

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Table 1. Formula and chemical composition of the experimental diets (Starter)

Ingredients	Control	DLF 10%	DLF 20%	DLF 30%	AP*5+ 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	25.62	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. premix[1]	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 composition[2]							
ME (kcal/kg)	3,200	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. D_3, 2,100,000 IU; Vit. E, 15,000 IU; Vit. K, 2,000 mg; Vit. B_1, 1,500 mg; Vit. B_2, 4,000 mg; Vit. B_6, 3,000 mg; Vit. B_{12}, 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.

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

Ingredients	Control	DLF 10%	DLF 20%	DLF 30%	AP*5+ DLF10%	AP10+ DLF20%	AP15+ DLF30%
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. premix[1]	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 phosohate	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 composition[2]							
ME (kcal/kg)	3,200	3,200	3,200	3,200	3,200	3,200	3,200
Crude protein (%)	20.07	20.01	20.01	20.01	21.02	22.05	23.02
Lysine (%)	1.00	1.00	1.00	1.00	1.04	1.10	1.15
Methionine (%)	0.38	0.38	0.38	0.38	0.40	0.42	0.44
Ca (%)	0.93	1.31	1.68	2.06	1.37	1.81	2.22
Avail. P (%)	0.35	0.35	0.35	0.35	0.35	0.35	0.35

[1] Vit-min. mix provided following nutrients per kg of diet: Vit. A, 9,000,000 IU; Vit. D_3, 2,100,000 IU; Vit. E, 15,000 IU; Vit. K, 2,000 mg; Vit. B_1, 1,500 mg; Vit. B_2, 4,000 mg; Vit. B_6, 3,000 mg; Vit. B_{12}, 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^{ab}	1,026^{b}	0.58^{abc}
DLF 30%	470^{d}	967^{c}	0.49^{d}
AP 5+DLF 10%	528^{c}	918^{d}	0.58^{bc}
AP10+DLF 20%	611^{ab}	1,023^{b}	0.60^{ab}
AP15+DLF 30%	582^{b}	1,095^{a}	0.53^{cd}
4-6 weeks			
Control	1,018^{ab}	2,272^{c}	0.45^{a}
DLF 10%	998^{ab}	2,473^{bc}	0.40^{ab}
DLF 20%	909^{b}	2,468^{bc}	0.37^{b}
DLF 30%	1,110^{a}	2,393^{bc}	0.46^{a}
AP 5+DLF 10%	1,123^{a}	2,395^{bc}	0.47^{a}
AP10+DLF 20%	962^{ab}	2,618^{ab}	0.37^{b}
AP15+DLF 30%	1,013^{ab}	2,797^{a}	0.37^{b}
1-6 weeks			
Control	1,662^{a}	3,295^{b}	0.50^{a}
DLF 10%	1,621^{ab}	3,482^{b}	0.47^{abc}
DLF 20%	1,501^{b}	3,494^{b}	0.43^{cd}
DLF 30%	1,580^{ab}	3,359^{b}	0.47^{ab}
AP 5+DLF 10%	1,650^{ab}	3,314^{b}	0.50^{a}
AP10+DLF 20%	1,572^{ab}	3,641^{ab}	0.43^{bcd}
AP15+DLF 30%	1,596^{ab}	3,892^{a}	0.41^{d}

[a,b,c] 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 phosphotingstate-$MgCl_2$ (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. p layer was collected for vacuum

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[ab]	0.78[ab]	0.51[b]	1.09[a]	0.61[ab]	0.71[ab]	0.68[ab]
Ab fat wt./live wt.	1.67	1.75	1.81	2.16	1.87	1.68	2.06

[a, b] 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[a]	18.84	3.13[bcd]	1.31[ab]
DLF 10%	72.32[ab]	16.34	3.89[ab]	1.49[ab]
DLF 20%	72.85[ab]	16.58	4.06[a]	1.23[b]
DLF 30%	71.92[b]	16.48	3.74[abc]	1.41[ab]
AP 5+DLF 10%	73.17[ab]	16.23	3.85[ab]	1.59[a]
AP10+DLF 20%	73.82[a]	17.85	2.95[cd]	1.45[ab]
AP15+DLF 30%	73.48[a]	16.68	2.82[d]	1.43[ab]

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

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 was lowest in groups fed diets containing 10% DLF with 5% higher protein level than control group while feed intake was significantly higher in groups fed diets containing 30% DLF with 15% higher protein level ($p<0.05$) than control diet. Feed conversion was highest in control group showing 0.63 but there were no significant differences between groups fed diets containing 10 and 20% DLF. Feed intake was lower in groups fed diets containing 30% DLF than those on diets containing 10 and 20% DLF ($p<0.05$).

Body weight gain for the last 3 weeks (4-6 weeks of age) was highest in groups fed diets containing 10% DLF with 5% higher protein level showing 1,123 g. Body weight gain was significantly lower in group fed diets containing 20% DLF than the other groups ($p<0.05$). Feed intake was lowest in control representing 2,272 g 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 20% DLF showing 1,501 g ($p<0.05$) than those on diets containing different levels of DLF. Feed intake was increased with increasing level of DLF in the diet. Feed intake was significantly higher in groups fed diets containing 20 and 30% DLF with higher protein levels ($p<0.05$). Feed conversion showed no significant differences between control groups and groups fed diets containing 10% DLF. 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. The proportion of crop, heart, liver and gizzard to body weight was increased with increasing level of DLF in the diet without significant differences ($p>0.05$). In general, pathogenic microorganisms could generate toxins and other forms of toxins derived from DLF. However, as any difference in liver weight was not detected, DLF used in this study might not be harmful to broiler. This disagreed with the report by Savory and Gentle (1976a,b) who

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±13.30[ab]	50.03±13.37
DLF 10%	103.05±30.74	48.36±16.71	54.70±14.97	41.19±12.65[ab]	61.87±28.15
DLF 20%	113.37±18.32	48.27±11.33	65.10±9.72	44.09±5.57[ab]	69.28±15.80
DLF 30%	120.01±26.35	56.50±13.37	63.52±14.01	51.51±7.42[a]	68.50±29.17
AP 5+DLF 10%	103.01±8.50	45.49±9.16	57.53±13.85	41.46±6.20[ab]	61.55±4.94
AP10+DLF 20%	104.51±22.10	45.08±12.16	59.43±12.67	34.62±6.08[b]	69.89±21.33
AP15+DLF 30%	99.44±19.64	49.81±16.32	49.63±3.50	37.59±9.39[b]	61.85±17.68

[a, b, c] 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 7. Meat cholesterol concentrations of broilers fed diets containing DLF at different levels

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

Cholesterol content in blood and meat

Plasma cholesterol concentrations of broilers fed diets containing DLF at different levels are shown in Table 6. Feeding dried leftover food to broilers slightly increased blood cholesterol concentrations although there were no significant differences in blood total cholesterol, free cholesterol, cholesterol ester and LDL-cholesterol concentration among treatments. Unlike other cholesterol concentrations, HDL concentration of blood from broilers fed diets containing 30% DLF (51.51) was significantly

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±0.92[a]	1.49±0.47[ab]	1.09±0.07[abc]	0.57±0.19[c]	1.63±0.54[a]	0.92±0.13[abc]	0.88±0.15[bc]
C18:0	14.33±2.29	14.46±1.35	13.58±1.68	13.37±1.91	15.23±1.27	13.86±2.05	12.79±1.85
C18:1ω9	18.70±1.68[ab]	18.23±2.77[ab]	16.66±1.94[ab]	15.85±1.48[b]	19.17±2.96[a]	17.19±0.64[ab]	16.85±1.12[ab]
C18:2ω6	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
C18:3ω3	0.31±0.07[b]	14.99±9.73[a]	10.55±11.83[a]	0.52±0.05[b]	0.51±0.14[b]	0.41±0.07[b]	0.52±0.07[b]
C18:4ω3	0.56±0.19[a]	0.39±0.09[ab]	0.44±0.41[ab]	0.17±0.12[b]	0.39±0.06[ab]	0.20±0.27[b]	0.22±0.15[ab]
C20:1ω9	0.08±0.12[c]	0.22±0.15[abc]	0.20±0.16[abc]	0.13±0.08[bc]	0.27±0.13[abc]	0.32±0.11[ab]	0.34±0.10[a]
C20:2ω6	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
C20:3ω6	1.14±0.50[a]	0.88±0.24[ab]	0.90±0.07[ab]	0.79±0.23[ab]	0.90±0.14[ab]	0.75±0.17[ab]	0.66±0.28[b]
C20:4ω6	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
C20:5ω3	0.99±0.26[d]	2.09±0.27[bc]	2.28±0.70[b]	3.45±0.53[a]	1.58±0.52[cd]	2.16±0.17[bc]	2.04±0.20[bc]
C22:6ω3	4.29±0.60[c]	6.37±1.21[b]	8.75±0.50[a]	8.60±0.67[a]	5.67±1.84[bc]	8.31±0.63[a]	9.75±2.29[a]
C24:0	1.03±0.19	0.97±0.22	1.57±0.45	1.28±0.34	1.02±0.36	1.51±0.48	1.30±0.35

[a, b, c] 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), C18:1ω9 (oleic acid), C18:2ω6 (linoleic acid), C18:3ω3 (linolenic acid), C20:1ω9 (eicosenoic acid), C20:2ω6 (eicosadienoic acid), C20:3ω6 (eicosatrienoic acid), C20:4ω6 (eicosatetraenoic acid), C20:5ω3 (eicosapentaenoic acid), C22:6ω3 (docosahexenoic acid), C24:0 (lignoceric acid).

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[b]	0.98±0.12[ab]	0.91±0.05[b]	0.97±0.11[ab]	1.19±0.15[a]	0.99±0.10[ab]	0.91±0.18[b]
C16:0	23.77±3.16[a]	21.43±0.37[ab]	22.82±1.53[a]	21.92±0.81[ab]	20.24±0.46[b]	22.16±1.95[ab]	22.33±1.47[ab]
C16:1	6.78±1.00[a]	4.40±0.48[c]	5.44±0.90[ab]	5.85±0.29[ab]	5.21±0.12[bc]	5.21±0.52[bc]	4.98±0.45[bc]
C18:0	6.95±0.26[abc]	7.88±0.87[a]	7.15±0.80[abc]	6.68±0.32[bc]	6.37±0.16[c]	7.08±0.16[abc]	7.57±0.55[ab]
C18:1ω9	40.40±1.00[a]	38.05±1.30[b]	39.16±0.61[ab]	39.69±1.54[ab]	39.98±0.31[ab]	39.86±1.24[ab]	39.52±0.56[ab]
C18:2ω6	16.23±2.58[c]	19.66±1.36[ab]	17.02±0.47[bc]	17.07±0.86[bc]	20.49±0.68[a]	17.78±1.01[abc]	17.80±2.65[abc]
C18:3ω3	0.68±0.10[c]	1.13±0.21[b]	0.99±0.06b[c]	1.09±0.13[b]	1.43±0.12[a]	1.06±0.13[b]	0.94±0.25[bc]
C18:4ω3	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
C20:1ω9	0.46±0.13[b]	0.69±0.12[ab]	0.84±0.32[a]	0.75±0.30[ab]	0.56±0.01[ab]	0.54±0.04[ab]	0.54±0.03[ab]
C20:2ω6	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
C20:3ω6	0.40±0.03[ab]	0.44±0.20[ab]	0.38±0.04[ab]	0.37±0.06[ab]	0.26±0.05[b]	0.34±0.05[ab]	0.50±0.20[ab]
C20:4ω6	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
C20:5ω3	0.18±0.02[b]	0.31±0.14[ab]	0.33±0.02[ab]	0.45±0.11[a]	0.34±0.05[a]	0.30±0.08[ab]	0.35±0.08[a]
C22:6ω3	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

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

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 arteriosclerosis. According to the recent researches, one of the factors affecting content of cholesterol in blood was fiber content in the feed. Balmer and Zilversmit (1974) suggested that cellulose as an indigestible material controlled the cholesterol metabolism and affected concentration of cholesterol in blood and cholesterol turnover rate. In this study, content of LDL-cholesterol was not significantly different among treatments although that of DLF-fed group was higher than that of control due to lower cellulose content of DLF.

Meat cholesterol concentrations of broilers fed diets containing DLF at different levels are shown in Table 7. Meat cholesterol concentrations of broilers fed diets containing 10 and 20% DLF were higher than that of control without significant differences (p>0.05).

Fatty acid in blood and meat

Plasma fatty acids of broilers fed diets containing DLF at different levels are shown in Table 8. Blood fatty acids compositions are listed in the order of palmitic acid, linoleic acid, oleic acid and stearic acid. Feeding DLF to broilers tended to increase linolenic acid, eicosenoic acid and 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 10. Effects of feeding DLF on the economic efficacy of broiler

Item	Control	DLF 10%	DLF 20%	DLF 30%	AP5+ DLF 10%	AP10+ DLF 20%	AP15+ DLF 30%
Starter							
Feed cost (won/kg)	250.56	241.52	233.57	225.50	248.26	249.29	250.24
Feed intake (kg)	1.02	1.01	1.03	0.97	0.92	1.02	1.10
Total feed cost (won)	256.32	243.94	239.64	218.06	227.90	255.02	274.01
Total body weight gain (kg)	0.64	0.62	0.59	0.47	0.53	0.61	0.58
Feed cost per kg body weight gain (won)	398.02	391.55	404.80	463.95	431.63	417.39	470.81
Index	100.00	98.38	101.70	116.57	108.45	104.87	118.29
Finisher							
Feed cost (won/kg)	217.97	209.76	202.89	195.57	217.14	217.90	217.56
Feed intake (kg)	2.27	2.47	2.47	2.39	2.40	2.62	2.80
Total feed cost (won)	495.23	518.74	500.73	468.00	520.05	570.46	608.52
Total body weight gain (kg)	1.02	1.00	0.91	1.11	1.12	0.96	1.01
Feed cost per kg body weight gain (won)	486.47	519.78	550.86	421.62	463.09	593.00	600.71
Index	100.00	106.85	113.24	86.67	95.19	121.90	123.48
Overall							
Total feed cost (won)	751.55	762.67	740.38	686.06	747.95	825.49	882.53
Total body weight gain (kg)	1.66	1.62	1.50	1.58	1.65	1.57	1.60
Feed cost per kg body weight gain (won)	452.20	470.49	493.25	434.21	453.03	524.78	553.31
Index	100.00	104.05	109.08	96.02	100.18	116.05	122.36

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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REFERENCES

AOAC. 1990. Official methods of analysis. 15th Ed. Association of official analytical chemists. Washington, DC.

Balmer, J. and D. B. Zilversmit. 1974. Effects of dietary roughage on cholesterol absorption, cholesterol turnover and steroid excretion in the rat. J. Nutr. 104:1319-1328.

Brunnekreeft, J. W., G. J. Boerma and B. Leijnse. 1983. Direct determination of total serum cholesterol by column gas liquid chromatographic analysis without previous derivatisation compared with WHO-CDC reference method. Ann. Clin. Biochem. Nov. 20(pt 6):360-363.

Burstein, S., H. L. Kimball and M. Gut. 1970. Transformation of labeled cholesterol, 20 alpha-hydroxycholesterol, dried preparations from guinea pigs, cattle and man. II. Kinetic studies. Steroids. Jun, 15(6):809-857.

Deaton, J. W., L. F. Kubena, T. C. Chen and F. N. Reece. 1974. Factors influencing the quantity of abdominal fat in broilers. II. Cage versus floor rearing. Poult. Sci. 53:574-576.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometric. 11:1.

Dyerberg, J., H. O. Bang and N. Hjorne. 1975. Fatty acid composition of the plsma lipids in greenland eskimos. Am. J. Clin. Nutr. 28:958.

Dyerberg, J. and H. O. Bang. 1978. Eicosapentaenoic acid and prevention of thrombosis and atherosclerosis. Lancet. 117:119.

Dyerberg, J. 1986. Linolenate-derived polyunsaturated fatty acid and prevention of atherosclerosis. Nutr. Rev. 44:125.

Goldstein, J. L. and M. S. Brown. 1977. The low density lipoprotein pathway and its relation to atherosclerosis. Ann. Rev. Biochem. 46:897-902.

Hoshii, H. and M. Yoshida. 1981. Variation of chemical composition and nutritive value of dried sample of garbage. Japan. Poult. Sci. 18(3):145-150.

Kim, C. H., Y. H. Song, B. J. Chae and Y. C. Rhee. 2001. Effects of feeding extruded swine manure and food waste mixture diets on growth performance, body composition and feeding behaviour of broilers. J. Anim. Sci. Technol. Kor. 43(1):91-100.

Lee, K. H. and S. K. Lee. 1998. Biological feed value of dried food waste meals for poultry. Kor. J. Anim. Nutr. Feed. 22(2):95-102.

Lipstein, B. 1984. Evaluation of the nutritional value of treated kitchen waste in broiler diet. Proc. of the 17th World Poultry Science Congress. Helsinki. pp. 372-374.

Lipstein, B. 1985. The nutritional value of treated Kitchen waste in layer diets. Nutr. Rep. Int. 32:693-698.

Miller, G. J. and N. E. Miller. 1975. Plasma high density lipoprotein concentration and development of ischaemic disease. Lancet. 1:16-19.

Ministry of Environment. 1996. Environmental Protection in Korea.

Ministry of Environment. 1997. The Trend of Food Waste Management Technology. Monthly Publication Wastes. 7:144-152.

Myer, R. O., J. H. Brendemuhl and D. Johnson. 1999. Evaluation of dehydrated restaurant food waste products and feedstuffs for finishing pig. J. Anim. Sci. 77:685-692.

SAS. 1995. SAS User's Guide Statistics. Statistical Analysis System. Inst.

Savory, C. J. and M. J. Gentle. 1976a. Effects of dietary dilution with fibre on the food intake and gut dimensions of Japaness quail. Br. Poult. Sci. 17(6):561-570.

Savory, C. J. and M. J. Gentle. 1976b. Changes in food intake and gut size in Japaness quail in response to manipulation of dietary fibre content. Br. Poult. Sci. 17(6):571-580.

Sim, J. K. 1998. Background and policy direction of a master plan for food refuse as a resources. Symposium for food waste as a feed. pp. 13-29.

Soliman, A. A., S. Hamdy, A. A. Khaleel, M. A. Abaza, A. R. Akkada and K. Shazly. 1978. The use of restaurant food waste in poultry nutrition. 1. Effects on growing chicks. Alex. J. Agric. Res. 26(3):489-499.

Whitehead, C. C. 1986. Nutritional factors influence fat in poultry. Feedstuff. Jan. 20:31.

Yang, S. Y., H. Y. Park, C. W. Kim and K. K. Park. 2001. Isolation of halotolerant lactic acid bacteria for fermentation of food wastes. J. L. H. E. Kor. 7(2):137-140.