EFFECTS OF EARLY FEED RESTRICTION ON GROWTH PERFORMANCE AND BODY COMPOSITION IN BROILERS

U. Santoso, K. Tanaka[1], S. Ohtani and B. S. Youn

Department of Animal Science and Technology, Faculty of Agriculture
Gifu University, Gifu 501-11, Japan

Summary

Day-old male and female broilers obtained from commercial strain (Hubbard) were used in this study. At 7 days of age, all chicks were weighed individually (female 0.11 kg and male 0.12 kg in average) and divided into 5 group of 45 birds each group with no replicate in each treatment group as follows: 1. fed *ad libitum*; 2. fed 75% *ad libitum*; 3. fed 65% *ad libitum*; 4. fed 55% *ad libitum*; 5. fed 45% *ad libitum*. Chicks were restricted for 10 days (d 7 through 17) of a 56-day trial. Chicks were fed a commercial starter diet (crude protein (CP) 23.8% and metabolizable energy (ME) 3,070 kcal/kg) for 21 days, and commercial finisher diet (CP 20% and ME 3,160 kcal/kg) from 22 to 56 days of age. When chicks were feed-restricted at an early age, compensatory growth did not immediately occur following refeeding. Body weights of restricted chicks were not equal to the *ad libitum* chicks before 49 days of age. At 56 days of age, body weights of restricted chicks were heavier ($p < 0.01$). Abdominal fat values of female chicks fed *ad libitum* was not significantly different from those fed 45% to 75% *ad libitum*. Carcass fat values of restricted female chicks were lower than those of control chicks when female chicks were fed either 55% or 45% *ad libitum*. Furthermore, feed efficiencies of restricted chicks were better. The response of chicks to early feed restriction might depend on the degree of feed restriction, and sex. Factors contributing carcass fat included energy loss, fat protein ratio of carcass, fatty acid synthesis in the liver and triglyceride content of the liver. The heavier body weights in the restricted chicks might be correlated with the lower growth rate during period of feed restriction.

(**Key Words** : Compensatory Growth, Feed Restriction, Carcass Fat)

Introduction

Ad libitum feeding is an artificial condition, an outcome of modern management, and restriction feeding brings the animals back to their natural conditions (Ballay et al., 1992). Furthermore, food scarcity or abundance is accompanied by adaptive mechanisms. Selection for body weight is accompanied by an increase body fat and abdominal fat. Nutrient restriction during the early life of chicks was investigated for reducing abdominal fat and body fat at market age without loss in general performance characteristic (Plavnik and Hurwitz, 1985, 1988, 1990; McMurtry et al., 1988). However, in the majority of cases fat deposition increases resulted from compensatory growth (Summers et al., 1992). These methods also depend on compensatory growth to correct for earlier growth depression, a phenomenon that remains controversial in terms of poultry production (Reid and White, 1977).

Several proposals were made to explain the role of feed restriction in reducing body and abdominal fat without reducing body weight at market age. Some of them are lower lipogenesis (Rosebrough et al., 1986), the delay of hyperplasia, hypertrophy of adipocytes, or both (March and Hansen, 1977; Plavnik and Hurwitz, 1985; Plavnik et al., 1986), and low energy balance (Plavnik and Hurwitz, 1985).

Other effects of feed restriction include lower mortality and abnormality (Hester et al., 1990), and improving feed efficiency (Plavnik and Hurwitz, 1985, 1988; Plavnik et al., 1986).

In view of the inconsistance reported above, this experiment was conducted to evaluate effects of early feed restriction on broiler performance and body composition. Furthermore, there was a little investigation in the effect of long period of feed restriction on lipid metabolism. Therefore,

[1]Address reprint requests to Dr. K. Tanaka, Department of Animal Science and Technology, Faculty of Agriculture, Gifu University, Gifu 501-11, Japan.

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lipogenic enzyme activities and various lipid fractions in the liver were also measured.

Materials and Methods

Animal and diets

Day-old male and female broilers obtained from commercial strain (Hubbard) were used in this study. They were raised on floor pens. Feed and water were made available at all times. At 7 days of age, all chicks were weighed individually and divided into 5 groups of 45 birds each as follows: 1. fed *ad libitum*; 2. fed 75% *ad libitum* (75% multiplied by amount of feed intake of *ad libitum* chicks at the previous day); 3. 65% *ad libitum*; 4. fed 55% *ad libitum*; 5. fed 45% *ad libitum*. Chicks were restricted for 10 days (d 7 through 17) of a 56-day trial. Each treatment group was represented by one replicate floor pen.

Chicks were fed a commercial starter diet (crude protein: 23.8%, crude fat: 5.8%, crude fiber: 2.5%, crude ash: 5.3%, and Metabolizable Energy (ME): 3,070 kcal/kg) for 21 days, and commercial finisher diet (crude protein: 20%, crude fat: 6.8%, crude fiber: 2.6%, crude ash: 5.0%, and ME: 3,160 kcal/kg) from 22 to 56 days of age. Body weight was obtained weekly and at the end of feed restriction period, and feed intake was weighed daily.

General procedure

At 21 and 56 days of age, 8 chicks were obtained in each group, and abdominal fat was removed and weighed. One part of livers of female chicks were placed in an ice-cold saline to measure the activities of lipogenic enzymes and another part of those livers were frozen and stored prior to various lipid fractions analysis. The various lipid fractions were separated by thin layer chromatography on silica gel chromarod using hexane/diethyl ether/formic acid (85 : 15 : 0.15) as developing solvents, and quantitated by IATROSCAN with hidrogen as gas flow (Tanaka et al., 1979). At 56 days of age, carcasses of both sexes (the body without blood, feces and feathers) were also obtained. After the body was cut, each body including abdominal fat was frozen and stored in a sealed plastic bag at −30℃ prior to subsequent analysis. The frozen bodies were again cut into small pieces with a knife and ground through a 5 mm screen. The ground bodies were passed through the mincer on four further occasion to obtain uniform mixing. Fat, moisture and protein contents of carcasses were determind by the method of AOAC (1980).

Preparation of liver homogenates

Livers were homogenized in 0.25 M sucrose solution containing 1 mM ethylenediaminetetra acetate−2Na (EDTA-2Na), after which the homogenates were centrifuged at 600xg at 4℃ for 15 minutes. The supernatants were recentrifuged at 105,000xg at 4℃ for 60 minutes and the resulting clear supernatants (cytosolic fraction) was used for assaying lipogenic enzymes.

Enzyme assay

Acetyl-CoA carboxylase was assayed by $H^{14}CO_3$-fixation method (Qureshi et al., 1980). Fatty acid synthetase was assayed by 1-^{14}C-CoA incorporation method (Hsu et al., 1965). The protein content of solutions used for enzyme assay was determined by the method of Lowry et al. (1951) using albumin as the standard. Enzymes activities are expressed as nanomole of substrate converted to product per minute per mg protein at 37℃.

Statistical analyses

All data were statistically analyzed using the one-way or two-way analysis of variance (Yoshida, 1975). Significant differences between treatments were determined by Duncan's multiple range test (Duncan, 1955).

Results and Discussion

The purpose of this experiment was to determine the extent of compensatory growth after periods of feed restriction at an early age. Effects of feed restriction early in life on performance and body weight gains of male and female broilers are shown in table 1, table 2 and figure 1. The body weight was lower in the restricted birds than in control during a short period after the end of restriction. However, starting at the 35 days of age, weight gains of the restricted birds were higher than those of control birds. At 49 days of age, the body weight of the restricted broilers were similar to those of control. Furthermore, at 56 days of age, body weight was heavier in restricted birds than in control. The

TABLE 1. EFFECT OF EARLY FEED RESTRICTION ON BODY WEIGHT OF BROILERS

Age (day)	Female[1] *Ad lib.*	Female[1] 75%	Female[1] 65%	Female[1] 55%	Female[1] 45%	Male[1] *Ad lib.*	Male[1] 75%	Male[1] 65%	Male[1] 55%	Male[1] 45%	Pooled SE	Prob[3] R	Prob[3] S	Prob[3] R × S
	(kg/bird)													
7	0.11[2]	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.001	NS	NS	NS
14	0.34^{e}	0.24^{d}	0.21^{c}	0.20^{b}	0.18^{a}	0.37^{e}	0.26^{d}	0.25^{c}	0.22^{b}	0.19^{a}	0.004	<0.01	<0.01	<0.01
17	0.48^{e}	0.30^{d}	0.25^{c}	0.24^{b}	0.21^{a}	0.54^{e}	0.32^{d}	0.31^{c}	0.26^{b}	0.22^{a}	0.004	<0.01	<0.01	<0.01
21	0.67^{d}	0.55^{c}	0.53^{c}	0.50^{b}	0.41^{a}	0.76^{e}	0.65^{d}	0.60^{c}	0.56^{b}	0.52^{a}	0.006	<0.01	<0.01	<0.01
28	1.08^{d}	0.98^{c}	0.94^{bc}	0.92^{b}	0.85^{a}	1.31^{d}	1.19^{c}	1.13^{b}	1.09^{b}	1.01^{a}	0.009	<0.01	<0.01	NS
35	1.52^{c}	1.41^{b}	1.40^{ab}	1.39^{ab}	1.33^{a}	1.88^{d}	1.80^{c}	1.70^{b}	1.68^{b}	1.60^{a}	0.01	<0.01	<0.01	<0.05
42	1.87^{b}	1.79^{ab}	1.78^{ab}	1.80^{ab}	1.72^{a}	2.33^{c}	2.27^{bc}	2.20^{ab}	2.16^{a}	2.15^{a}	0.01	<0.01	<0.01	<0.05
49	2.17	2.16	2.20	2.19	2.14	2.74	2.78	2.54	2.73	2.69	0.01	NS	<0.01	<0.05
56	2.45^{a}	2.49^{ab}	2.58^{bc}	2.56^{abc}	2.63^{c}	3.00^{ab}	3.15^{bc}	2.93^{a}	3.25^{c}	3.20^{c}	0.02	<0.01	<0.01	<0.01

[1] *Each treatment group was represented by one replicate floor pens per group.*

[2] Values reported represent means for 45 birds (7 d to 21 d) or for 37 birds (22 d to 56 d). Means within a row not followed by the same superscripts are significantly different.

[3] Probability of a significant treatment effect; R = restriction, S = sex, and R × S = interaction between R and S.

TABLE 2. EFFECT OF EARLY FEED RESTRICTION ON FEED INTAKE, FEED CONVERSION RATIO AND MORTALITY OF BROILERS

Age (days)	Female* *Ad lib.*	Female* 75%	Female* 65%	Female* 55%	Female* 45%	Male* *Ad lib.*	Male* 75%	Male* 65%	Male* 55%	Male* 45%
Feed intake (kg/bird)										
7-17	0.46	0.30	0.26	0.22	0.18	0.51	0.35	0.30	0.26	0.21
18-56	4.56	4.80	4.87	4.90	4.72	5.68	5.95	5.52	5.86	5.73
7-56	5.02	5.10	5.13	5.12	4.90	6.19	6.30	5.82	6.12	5.94
Feed conversion ratio (feed/gain)										
7-56	2.15	2.14	2.08	2.10	1.95	2.15	2.08	2.07	1.95	1.93
Mortality (bird)										
7-56	6	0	1	1	0	6	2	4	3	2

* Each treatment group was represented by one replicate floor pen of 45 birds (7 d to 21 d) or 37 birds (22 d to 56 d).

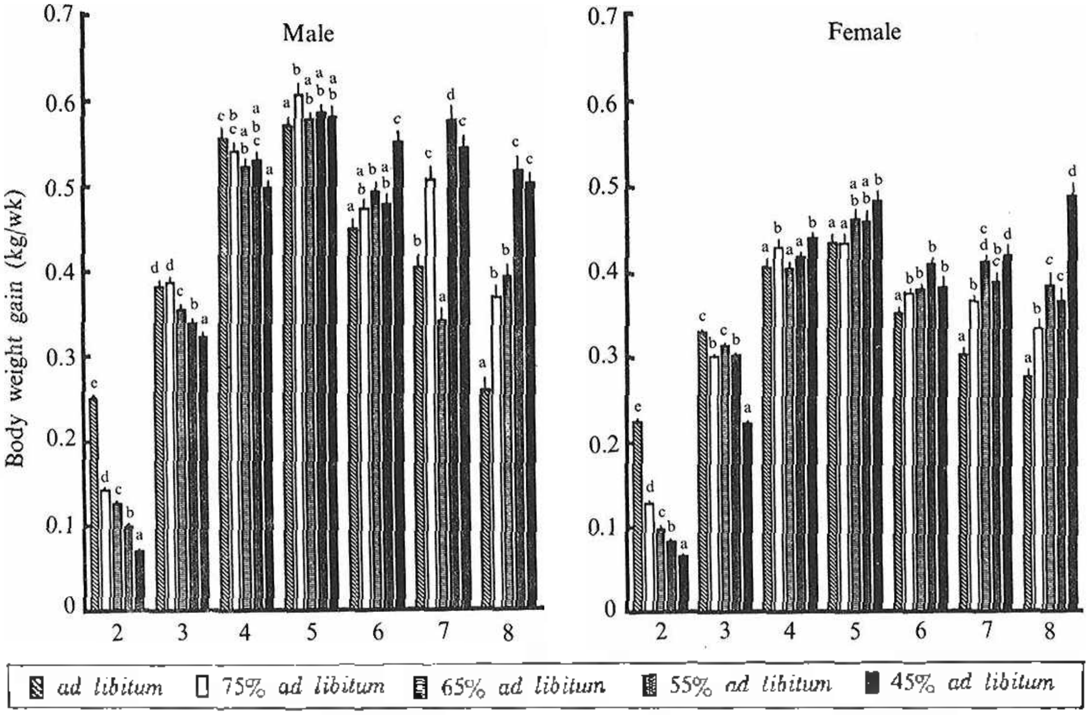

Figure 1. Effect of early feed restriction on body weight gain of broilers.

results were in agreement with observation of Plavnik and Hurwitz (1990). Some researchers (Washburn and Bondari, 1978; Yu et al., 1990) did not observe compensatory growth but this might be caused by the excessive period of food restriction and/or the use of a food restriction regime that was not sufficiently severe. Plavnik et al. (1986) pointed out that compensatory growth was obtained after short periods of restriction, whereas longer periods diminish recovery and may result in delay in achieving normal weight or in a permanent stunting of the animal. Mosier (1986) explained that compensatory growth occurred because the body has a set point for body size appropriate for age. It is unknown, however, how restricted birds exceed the body weight as shown in the present results. It is likely that early feed restriction resulted in change the growth pattern. Metabolic and hormonal alteration during and after the feed restriction should also be considered. Newcombe et al. (1992) found that plasma triiodothyronine (T_3) were elevated in restricted birds which coincided with a period of compensatory growth. Plasma concentration of T_3 appears to be positively related to growth rate (Decuypere and Buyse, 1988; McGuinness and Cogburn, 1990). In the present study, body weights at market age were heavier for birds in which the body weight during restriction period was lower. This finding suggests that the body weight during feed restriction period might have an important role on the occurrence of compensatory growth (Jones and Farrell, 1992). If it is the case, its severity, duration of feed restriction, the degree of feed restriction, initiated age of feed restriction applied, and sexes should be considered when researchers designed feed restriction in order to keep lower growth rate or body weight stasis during period of feed restriction.

During the period of feed restriction, feed intakes of female chicks were 462, 304, 264, 223 and 184 g for *ad libitum*, 75%, 65%, 55% and 45% *ad libitum* treatment groups, respectively. Those of male chicks were 512, 346, 301, 258, 208 g for *ad libitum*, 75%, 65%, 55% and 45% *ad libitum* treatment groups, respectively. Total feed intake throughout the experimental period (7-56 days) of both males and females were lower in 45% *ad libitum* fed birds than that of control birds. Body weight gains of female chicks from 18 to 56 days of age were 1.97, 2.19, 2.33, 2.32 and 2.42 kg for *ad libitum*, 75%, 65%, 55% and

45% *ad libitum* treatment groups, respectively, and those of male chicks were 2.46, 2.83, 2.62, 2.99 and 2.98 kg for *ad libitum*, 75%, 65%, 55% and 45% *ad libitum* treatment group, respectively. This compensatory growth was accompanied by hyperphagia, except for chicks fed 45% *ad libitum* treatment group which also appear to be able to use feed more effective (table 2). Hyperphagia during refeeding might partly contribute compensatory growth. Ashworth (1969) stated that compensatory growth was associated with hyperphagia in children. It is likely that a certain degree of hyperphagia is needed to induce compensatory growth. In the present study, there was an apparent sex influence on the birds ability to undergo complete compensatory growth as noted by Plavnik et al. (1986).

In the present study, early feed restriction resulted in an improved feed efficiency. This was in agreement with observations of Plavnik and Hurwitz (1985, 1988, 1990) and McMurtry et al. (1988). Because this improvement in some cases could have been due to reduced body weights, the system would not be of any practical importance unless broilers could reach market weight with an improved feed efficiency (Plavnik and Hurwitz, 1985). This was tested by plotting the cumulative feed efficiency against the body weight rather than against age as suggested by Plavnik and Hurwitz (1985). In the present study, the plots for male and female broilers are given in figure 2. Within control birds, cumulative feed efficiency was better in younger birds. This phenomenon could be explained by the principle of diminishing increments and food consumption during growth (Brody, 1964). As the animal grows larger, its maintenance cost in comparison to weight gain increases and, therefore, the energetic efficiency of growth decreases. Furthermore, as the broilers grow, beyond some point, it deposits increasing proportions of fat relative to protein and water (Santoso et al., unpublished results). Consequently, the energy density of gain increases which causes the increasing inefficiency of gain. In the present study, cumulative feed efficiency in the refed groups, which initially has been lower than in the control, exceeded that of the latter when body weights exceeded 2,500 g (females) or 3,000 g (males). The calculated improvement in cumulative feed efficiency was 1%, 1% and 4% for females fed 65%, 55% and 45% *ad libitum*, respectively, and 1%, 1%, 4% and 5% for

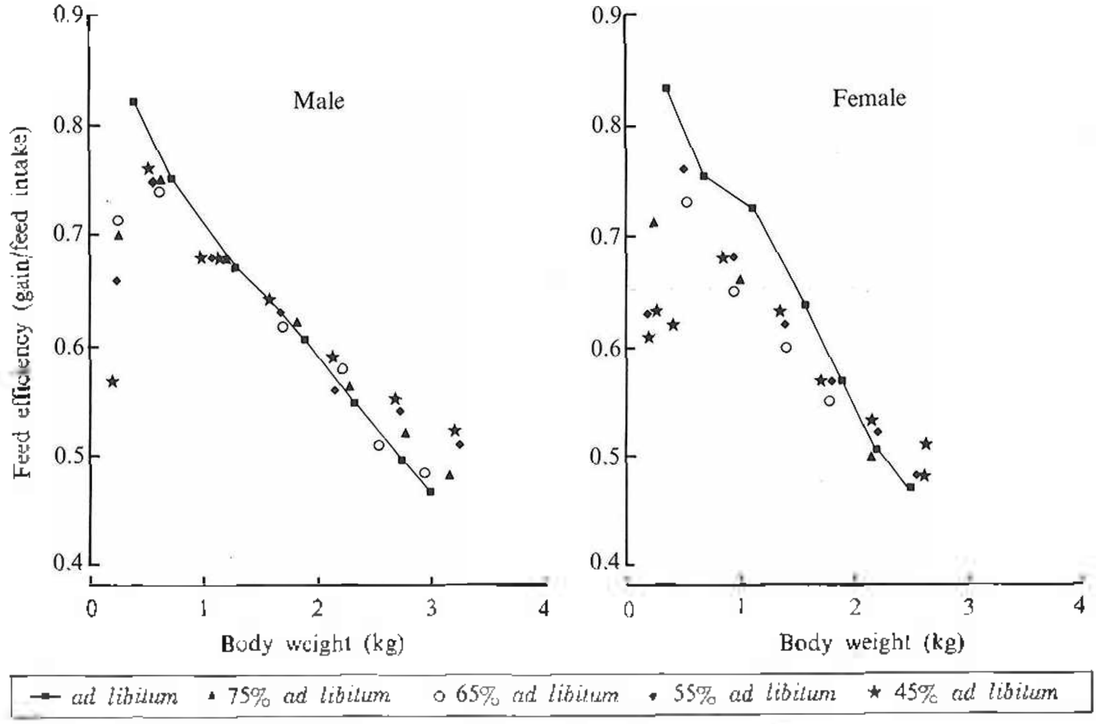

Figure 2. The relationship between body weight and feed efficiency in broilers.

males fed 75%, 65%, 55% and 45% *ad libitum*, respectively. It is possible that males were more responsive to restriction in an early life in improving feed efficiency. The improved cumulative feed efficiency during refeeding is explainable by the more concave growth pattern exhibited by the restricted chicks (tabel 1). It can be estimated that a more concave growth pattern results in a reduction in the area under the body weight vs. time curve (Plavnik and Hurwitz, 1985).

As pointed out by Ballay et al. (1992) *ad libitum* feeding of broilers may be detrimental because of higher mortality rate and lower feed efficiency. Results of the present study confirm that observation. It has been hypothesized that food restriction decreases mortality possibly by decreased formation of toxins and/or carcinogens, and/or decreased accumulation of waste products (Holloszy, 1992).

Plavnik and Hurwitz (1985, 1989), Plavnik et al. (1986) demonstrated that restricting feed intake of broilers at an early age exerts a negative effect on subsequent lipid deposition and positive effect on lean tissue growth. The present study demonstrated that early feed restriction increased protein contents (for chicks fed 75%, 55% or 45% *ad libitum*), and decreased fat contents - although it was not statistically different (for 65%, 55% or 45% *ad libitum*) - in male chicks; however, there was evident that early feed restriction decreased both body fat contents and protein contents in female chicks (table 3). There was an apparent sex influence on the chicks ability to undergo complete body composition recovery. Protein efficiencies (carcass protein/ protein intake) of female chicks were 37.0%, 36.1%, 34.5%, 35.8% and 40.1% for *ad libitum*, 75%, 65%, 55% and 45% treatment group, respectively, and those of male chicks were 36.6%, 39.2%, 38.2%, 41.7% and 44.3% for *ad libitum*, 75%, 65%, 55% and 45% treatment group, respectively during experimental period. Thus, differences in protein utilization between females and

TABLE 3. EFFECT OF EARLY FEED RESTRICTION ON BODY COMPOSITION AND ABDOMINAL FAT WEIGHT OF BROILERS AT 56 DAYS OF AGE

	Female[1]					Male[1]					Pooled	Prob[3]		
	Ad lib.	75%	65%	55%	45%	*Ad lib.*	75%	65%	55%	45%	SE	R	S	R × S
	(%)													
Moisture	55.9[2a]	56.4[a]	59.3[b]	60.8[b]	59.9[b]	60.7	60.1	60.3	60.9	61.7	0.3	<0.05	<0.01	<0.05
Fat	25.6[b]	25.4[b]	24.2[b]	21.9[a]	20.9[a]	20.3	20.8	18.7	18.0	19.0	0.5	<0.01	<0.01	NS
Protein	15.6[b]	15.1[b]	14.0[a]	14.6[ab]	15.2[b]	15.5[a]	16.0[b]	15.5[a]	16.0[b]	16.7[b]	0.1	<0.05	<0.01	NS
Abdominal fat (g/100 BW)	3.73[ab]	3.99[b]	4.67[b]	3.13[a]	3.26[a]	3.37	3.82	3.19	3.38	3.30	0.09	<0.05	<0.01	NS

[1] Each treatment group was represented by one replicate floor pen of 46 birds (7 d to 21 d) or 37 birds (22 d to 56 d) per pen.

[2] Values reported represent means for 8 birds. Means within a row not followed by the same superscripts are significantly different.

[3] Probability of a significant treatment effect; R = restriction, S = sex, and R × S = interaction between R and S.

males through out the experimental period might partly explain differences in protein contents between females and males. Other factors such as protein synthesis and degradation should also be considered, since Hayashi et al. (1990) found that protein synthesis and degradation were altered by starvation-refeeding program. At 56 days of age, abdominal fat weights of restricted female chicks were not significantly different from those of control chicks (table 3). Abdominal fat weights of male chicks were not significantly different. It appears rather unlikely that the reduced carcass fat in the restricted and refed birds is the direct effect of a low energy balance of the body during refeeding (Plavnik and Hurwitz, 1985). In the present study, greater energy loss might partly contribute lower body fat in female chicks (table 4). The increased energy loss (may be during refeeding period) in these groups may be a consequence of the bird having no adequate adipocyte mass available for storing excess dietary energy (Jones and Farrell, 1992).

TABLE 4. EFFECT OF EARLY FEED RESTRICTION ON ENERGY INTAKE, CARCASS ENERGY, ENERGY LOSS, AND FAT PROTEIN RATIO OF BROILERS AT 56 DAYS OF AGE

	Female[1]					Male[1]	
	Ad lib.	75%	65%	55%	45%	*Ad lib.*	75%
	(kcal/bird)						
Energy intake[2]	15,783	16,066	16,169	16,138	15,435	19,486	19,832
Carcass energy[4]	7,896	8,295	7,944	7,357	7,176	8,300	9,036
Energy loss	8,156	8,041	7,761	9,050	8,528	11,429	11,039
Energy efficiency[5]	50	52	49	46	47	43	46
Fat protein ratio	1.61	1.68	1.75	1.51	1.37	1.31	1.30

	Male[1]			Pooled	Prob[6]		
	65%	55%	45%	SE	R	S	R × S
	(kcal/bird)						
Energy intake[2]	18,322	19,273	18,717				
Carcass energy[4]	7,543	8,292	8,699	175	NS	NS	NS
Energy loss	11,022	11,223	10,260				
Energy efficiency[5]	41	43	47				
Fat protein ratio	1.21	1.13	1.15	0.03	NS	NS	NS

[1] Each treatment group was represented by one replicate floor pen of 45 birds (7 d to 21 d) or 37 birds (22 d to 56 d).
[2] Energy intake = feed intake × metabolizable energy of feed.
[3] Values reported represent means for 8 birds. Means within a row not followed by the same superscripts are significantly different.
[4] Carcass energy = fat weight of carcass × 9.129 kcal + protein weight of carcass × 5.5209 kcal (Hakansson and Svensson, 1984).
[5] Energy efficiency was expressed as percentage (%)
[6] Probability of a significant treatment effect; R = restriction, S = sex, and R × S = interaction between R and S.

There was positive relationship between abdominal fat and body fat in the present study (females: $Y = 19.13 + 1.15\ X$, $r = 0.48$, $p < 0.05$ and males: $Y = 12.01 + 2.13\ X$, $r = 0.53$, $p < 0.01$; where Y = body fat and X = abdominal fat weight). These results were in agreement with the observation of Plavnik and Hurwitz (1985, 1988, 1991). No relationship between carcass fat or abdominal fat weight with feed conversion ratio was observed. This result suggested that in selection programs involving feed conversion ratio and carcass fat or abdominal fat weight, the advantageous relationship between improved feed conversion ratio and decreased carcass fat or abdominal fat weight might be altered by using a restricted plane.

Although body fatness can be affected by diet, conventional wisdom is that genetic factors are more important determinants of body composition than are dietary factors (Donaldson, 1985). Among these genetic factors would be the lipogenic enzyme capacity of chick liver since O'Hea and Leveille (1969) have shown that 90-95% of total fatty acid synthesis in chicks occur in liver. Fatty acid was used to synthesize triglyceride and phospholipid (Mayes, 1988). Therefore effects of early feed restriction on hepatic lipogenic enzyme activities of females were also determined and are shown in table 5. At 21 days of age, acetyl-CoA carboxylase activity (ACC) was significantly decreased in females fed 55% *ad libitum*. At 56 days of age, ACC activities were decreased by 12.5% and 25% for female chicks fed 65% and 55% *ad libitum*, respectively, although it was statistically not different from *ad libitum* female chicks. At 21 days of age, fatty acid synthetase (FAS) activity of females tended to be decreased, although it was statistically not significant different. At 56 days of age, FAS activities of female chicks were decreased 4.5%, 18.2% and 13.6% for 75%, 55% and 45% *ad libitum*, respectively.

The effect of early feed restriction on the content of various lipid fractions of the female chick livers are shown in table 6. At 21 days of age, free cholesterol and phospholipid contents of the liver were significantly decreased in female chicks fed 55% *ad libitum* ($p < 0.01$). At 56 days of age, phospholipid contents of the female chick livers were increased ($p < 0.01$). Cholesterol contents of female chicks fed 45% *ad libitum* were lower than those of *ad libitum* female chicks although it was statistically not significant difference. At 56 days of age, triglyceride content of females was significantly increased in the 45% *ad libitum* treatment group ($p < 0.01$).

From data of lipogenic enzyme activity it appears that lower fatty acid synthesis might also contribute lower body fat in restricted female chicks. There was negative relationship between triglyceride content in the liver and body fat content in the present study ($r = 0.71$, $p < 0.05$). Chicks fed 45% *ad libitum* exhibited fatty acid synthesis similar to *ad libitum* chicks, but triglyceride content in the liver was increased.

TABLE 5. EFFECT OF EARLY FEED RESTRICTION ON ACETYL-COA CARBOXYLASE (ACC) AND FATTY ACID SYNTHETASE (FAS) ACTIVITIES OF FEMALE BROILERS

Age (day)	Feeding *Ad lib.*	75%	65%	55%	45%	Pooled SE	Prob[2]
	(nmol/min/mg protein)[3]						
Acetyl CoA carboxylase							
21	2.60^{ab}	3.50^{c}	3.00^{bc}	1.60^{a}	2.60^{b}	0.18	<0.05
56	0.80	0.80	0.70	0.60	0.80	0.08	NS
Fatty acid synthetase							
21	9.00	8.10	8.10	8.70	8.70	0.19	NS
56	6.60	6.30	6.90	5.40	5.70	0.25	NS

[1] Values reported represent means for eight birds. Means within a row not followed by the same superscripts are significantly different.

[2] Probability of a significant treatment effect.

[3] Enzyme activities are expressed as nanomole of substrate converted to product per minute per mg protein at 37℃.

This phenomenon could be explained by decreased transport of triglycerides from the liver into the blood, and might partly contribute a decreased body fat content, since Griffin et al. (1982) found that there is positive correlation between plasma triglyceride concentration and body fat content. The present study showed that factors contributing body fat included energy loss, fat protein ratio of carcass, fatty acid synthesis in the liver and triglyceride content of the liver.

TABLE 6. EFFECT OF EARLY FEED RESTRICTION ON VARIOUS LIPID FRACTIONS CONTENTS IN THE LIVER OF FEMALE BROILERS

Age (day)	Feeding *Ad lib.*	75%	65%	55%	45%	Pooled SE	Prob[2]
	(mg/g liver)						
21							
Cholesterol ester	0.42[1]	0.40	0.35	0.37	0.41	0.02	NS
Triglyceride	10.56	12.46	9.88	12.14	9.55	0.65	NS
Free cholesterol	3.26[bc]	3.55[c]	2.40[abc]	1.68[ab]	1.37[a]	0.27	<0.05
Phospholipid	31.15[b]	37.38[b]	34.20[b]	22.09[a]	32.06[b]	1.15	<0.01
56							
Cholesterol ester	0.52[ab]	0.60[b]	0.5[ab]	0.46[a]	0.54[ab]	0.02	<0.05
Triglyceride	79.00[a]	93.25[a]	98.33[a]	88.67[a]	119.40[b]	8.96	<0.01
Free cholesterol	3.30	3.27	4.27	3.80	2.55	0.34	NS
Phospholipid	22.29[a]	26.00[a]	28.51[b]	27.15[ab]	31.26[b]	1.61	<0.01

[1] Values reported represent means for eigth birds. Means within a row not followed by the same superscripts are significantly different.

[2] Probability of a significant treatment effect.

It is concluded that broilers can withstand early feed restriction without loss general performance characteristic with better feed efficiency. Furthermore, early feed restriction program can be used to reduce body fat in female broilers. The response of chicks to early feed restriction might be depend on the degree of feed restriction and sex.

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