

Effects of Early Feed Restriction on Breast and Leg Meat Composition and Plasma Lipid Concentration in Unsexed Broiler Chickens Reared in Cages

U. Santoso*

Department of Animal Science, Faculty of Agriculture, Bengkulu University
Jl. Raya Kandang Limun, Bengkulu 38371 A, Indonesia

ABSTRACT : The study was conducted to evaluate the effect of early feed restriction on growth, fat accumulation and meat composition in unsexed broiler chickens. In experiment 1, three hundred and fifty one-day-old broiler chicks were divided into 7 groups. Each treatment group was represented by five replicates of ten broilers each. One group was fed *ad libitum* as the control group and the other six groups were fed 25% *ad libitum* (25% multiplied by amount of feed intake of *ad libitum* chicks at the previous day) for 4 or 6 days, 50% *ad libitum* for 4 or 6 days, and 75% *ad libitum* for 4 or 6 days. In experiment 2, five hundred broiler chicks were divided into 10 groups. Each treatment group was represented by five replicates of ten broilers each. One group was fed *ad libitum* as the control group. Three initial age at which broilers were restricted (2, 4 or 6 days of age) and three type of feed restriction (physical restriction, meal feeding and diet dilution) (3×3) were examined. They were restricted feeding for 6 days. Experimental results showed that broilers fed 25% *ad libitum* for 4-6 days tended to reduce leg meat fat with lower abdominal fat ($p<0.05$) (experiment 1). Breast meat fat was significantly higher in restricted broilers ($p<0.01$). Plasma triglyceride was higher in broilers fed 75% *ad libitum* for 4-6 days. In experiment 2, abdominal fat was lower in restricted broilers ($p<0.05$). Breast meat fat was significantly higher ($p<0.01$), whereas leg meat fat was significantly lower ($p<0.05$) in restricted broilers. Plasma triglyceride was significantly higher in physical feed restriction for 4 days, meal feeding for 4 days and diet dilution for 6 days ($p<0.05$). In conclusion, to reduce fat accumulation in abdomen and leg meat, broilers should be fed 25% *ad libitum* for 6 days started at 4 days, or subjected to meal feeding (6 hours per day for 6 days) started at 6 days. (*Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 10 : 1475-1481*)

Key Words : Early Feed Restriction, Breast Meat, Leg Meat, Plasma Lipid, Unsexed Broilers

INTRODUCTION

Many investigators have shown that early feed restriction could reduce fat accumulation in the abdomen (Plavnik and Hurwitz, 1985, 1988, 1989; Santoso et al., 1993a,b, 1995a,b; Santoso, 2001a), in carcass and plasma (Santoso et al., 1993a,b, 1995a,b; Santoso, 2001a,b,c, 2002a,b), and in meat (Santoso, 2001a). Some suggestion have been made to explain this phenomenon. Rosebrough et al. (1986) found that the reduction of fat accumulation might partly be explained by reduction of hepatic lipogenesis. Santoso et al. (1993a,b, 1995a,b) also found that reduction of fat accumulation was accompanied by lower activity of acetyl-CoA carboxylase, the rate limiting enzyme for lipogenesis. However, most published studies of early feed restriction used separated sexes, and therefore it had no practical meaning.

In addition, it was known that broilers reared on-floor had different responses to nutritional planes as compared with those reared in cages (Anderson and Adams, 1994), and they also contained different fat accumulation (Santoso, unpublished results). Therefore, it is possible that different rearing (cages vs floor) may result in different responses to

early feed restriction. Santoso (2001a) found that broilers reared on-floor had lower meat fat, abdominal fat and plasma triglyceride when they were feed-restricted. In addition, leg meat had higher fat than breast meat, and therefore, it is more useful if early feed restriction could reduce fat content of leg meat more than that of breast meat. In some areas, consumers would prefer higher fat content of breast meat. Unfortunately, no there are published investigations of early feed restriction on breast and leg meat composition in unsexed broilers. Therefore, the present study was conducted to evaluate effect of early feed restriction on abdominal fat, plasma triglyceride and cholesterol concentration, and leg and breast composition in unsexed broilers.

MATERIALS AND METHODS

Experiment 1

Three hundred and fifty one-day-old broiler chicks (strain Arbor Acres CP 707) obtained from a commercial hatchery (PT Charoen Phokphand, Indonesia) were used in this study. From 1 to 14 day of age, supplemental heat was provided with a hanging heat lamp. Temperature was maintained at 32.5°C in the first week and gradually decreased at the second week. The broiler chicks were maintained on the cage in a house under continuous fluorescent lighting with feed and water available *ad libitum*

* Corresponding Author : U. Santoso, Tel: +62-736-21170, Fax: +62-736-28616.

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during the early dry season. At 7 days of age, broiler chicks were divided into 7 groups. Each treatment group was represented by five replicates of ten broilers each. One group was fed *ad libitum* as the control group and other six groups were fed 25% *ad libitum* (25% multiplied by amount of feed intake of *ad libitum* chicks at the previous day) for 4 or 6 days, 50% *ad libitum* for 4 or 6 days, and 75% *ad libitum* for 4 or 6 days. Thereafter, they were fed *ad libitum* to 56 days of age. Water was provided *ad libitum* and recommended husbandry practices were followed in this experiment. Broilers were fed commercial starter diet from 1 to 28 days of age, and commercial finisher diet from 29 to 56 days of age. The nutrient composition of commercial feed was published elsewhere (Santoso, 2001a).

At 56 day of age, 6 broilers (male:female=1:1) were obtained in control and restricted groups, and blood was taken from the wing vein with a heparinized syringe and then centrifuged at 600×g for 10 min. Plasma obtained was stored and frozen at -30°C until analysis of lipid fraction concentration. Thereafter, broilers were slaughtered by decapitation, and abdominal fat and liver were immediately removed and weighed.

Breast and leg meats were then removed and ground through a 5 mm screen. The ground meat was passed through the mincer five times to obtain uniform mixing. Fat, moisture and protein of meat were determined by the methods of AOAC (1980). Ash content was calculated using the following equation: 100%-(% crude protein+% moisture +% fat). The plasma were analyzed for their total cholesterol and triglyceride concentrations using commercial kits (Bio Systems SA, Spain).

All data were statistically analyzed using analysis of variance (Shinjo, 1990). Significant difference between treatments was determined by orthogonal contrasts. Factorial design (2×3) was used to evaluate the effect of duration and level of feed restriction and its interaction. Significant difference was determined by Duncan's Multiple Range Test (Duncan, 1955).

Experiment 2

Five hundred one-day-old broiler chicks (strain Arbor Acres CP 707) obtained from a commercial hatchery (PT Charoen Phokphand, Indonesia) were used in this study. Husbandry practices were similar to experiment 1.

At 7 days of age, broiler chicks were divided into 10 groups. Each treatment group was represented by five replicates of ten broilers each. One group was fed *ad libitum* as the control group. Three initial ages at which broilers were begun to be restricted (2, 4 or 6 days of age) and three types of feed restriction (physical restriction, meal feeding and diet dilution) (3×3) were examined. Physical restriction was conducted by feeding broilers chicks at 25% *ad libitum* (the best result in experiment 1); meal feeding

was conducted by feeding broiler chicks for 6 hours started at 08:00 to 14:00 and; diet dilution was conducted by feeding broiler chicks with diet diluted with sawdust (25:75). They were feed restricted for 6 days. Thereafter, they were fed *ad libitum* to 56 days of age. Water was provided *ad libitum* and recommended husbandry practices were followed in this experiment. Broilers were fed a commercial starter diet from 1 to 28 days of age, and commercial finisher diet from 29 to 56 days of age. The procedure of collecting samples and variables measured were similar to experiment 1.

All data were statistically analyzed using analysis of variance (Shinjo, 1990). Significant difference between treatments was determined by single d.f. orthogonal contrasts. Factorial design (3×3) was used to evaluate the effect of initial age and type of feed restriction and its interaction. Significant difference was determined by Duncan's Multiple Range Test.

RESULTS

Experiment 1

Table 1 shows the effect of early feed restriction on abdominal fat, liver composition, and plasma triglyceride and cholesterol in unsexed broilers. Abdominal fat was significantly lower in broilers fed 25% *ad libitum* for 4 or 6 days ($p<0.05$) as compared with the control. Breast and leg meats were not significantly different in their weights. The contents of liver moisture, protein and fat were not significantly different, whereas liver ash was significantly higher in restricted broilers ($p<0.01$) as compared with the control group except for broilers fed 50% *ad libitum* for 6 days. Broilers fed 75% *ad libitum* for 4 or 6 days had significantly higher plasma triglyceride ($p<0.05$) as compared with the control, whereas plasma cholesterol was not significantly different.

Table 2 shows the effect of early feed restriction on breast and leg meat composition in unsexed broilers. In comparison with the control group, fat content of breast meat was significantly higher in broilers fed 25% *ad libitum* for 4-6 days, 50-75% *ad libitum* for 6 days, whereas ash content was higher in broilers fed 50% *ad libitum* for 4 and 75% *ad libitum* for 6 days ($p<0.05$). Moisture and protein of breast meat were not significantly different. Fat content of leg meat was not significantly different. However, broilers fed 25% *ad libitum* for 4 or 6 days tended to have lower fat by 9.6% and 20.6%, respectively. Ash contents of leg meats were significantly higher in broilers fed 75% *ad libitum* for 4 days, 25% or 50% *ad libitum* for 6 days ($p<0.05$) as compared with the control.

Table 3 shows the effect of duration and level of feed restriction on abdominal fat, liver composition, plasma

Table 1. Effect of early feed restriction on abdominal fat, liver composition, and plasma triglyceride and cholesterol in unsexed broilers¹ (Experiment 1)

Variables	Control	4 days of restriction			6 days of restriction			SD
		25%	50%	75%	25%	50%	75%	
Abdominal fat, %BW	2.83	1.82*	2.66	2.52	2.03*	2.63	2.60	0.51
Leg meat, % BW	16.6	16.4	16.4	16.5	16.1	16.6	16.7	0.73
Breast meat, % BW	10.1	9.4	10.3	11.0	9.8	9.8	9.5	0.62
Liver composition, %								
Moisture	72.0	69.4	70.7	71.5	70.0	71.5	70.7	0.29
Protein	19.7	20.4	19.7	19.0	19.7	19.8	19.3	0.16
Fat	5.6	5.8	5.4	5.7	5.6	5.6	5.4	0.57
Ash	2.8	4.4**	4.2**	3.8**	4.8**	3.1	4.6**	0.27
Plasma (mg/dL)								
Triglyceride	61.5	62.8	66.8	86.3*	53.8	74.5	80.0*	12.6
Cholesterol	150.5	131.3	140.5	126.5	153.3	149.0	151.2	18.4

¹ Values reported represent means for 6 broilers (male:female=1:1).* or ** Significantly different from the control group at level $p < 0.05$ or $p < 0.01$, respectively.**Table 2.** Effect of early feed restriction on breast and leg meat composition in unsexed broilers¹ (Experiment 1)

Variables	Control	4 days of restriction			6 days of restriction			SD
		25%	50%	75%	25%	50%	75%	
Breast composition, %								
Moisture	71.2	71.2	70.3	71.0	70.7	71.0	70.3	0.64
Protein	24.2	23.9	24.2	24.1	24.3	23.6	23.9	0.21
Fat	2.2	3.0*	2.6	2.8	3.0*	3.3*	3.2*	0.40
Ash	2.1	1.8	2.9*	2.2	2.3	1.9	2.6*	0.20
Leg composition, %								
Moisture	61.5	61.1	61.6	59.3	62.0	59.8	61.1	1.51
Protein	21.0	21.0	20.8	21.0	21.1	20.9	20.8	0.21
Fat	14.6	13.2	13.4	14.5	11.6	13.7	13.7	1.27
Ash	4.0	4.6	4.2	5.2*	5.3*	5.9*	4.3	1.0

¹ Values reported represent means for 6 broilers (male:female=1:1).* or ** Significantly different from the control group at level $p < 0.05$ or $p < 0.01$, respectively.**Table 3.** Effect of duration and level of feed restriction on abdominal fat, liver composition, plasma triglyceride and serum cholesterol in broiler chickens at 56 days of age¹ (Experiment 1)

Variables	Duration of restriction		Level of restriction			SD	ANOVA		
	4 d	6 d	25%	50%	75%		D	L	D×L
Abdominal fat, % BW	2.33	2.49	2.02 ^a	2.64 ^b	2.56 ^b	0.50	NS	<0.05	NS
Liver composition, %									
Moisture	70.5	70.7	69.7	71.1	71.1	0.31	NS	NS	NS
Protein	19.7	19.6	20.0	19.7	19.1	0.87	NS	NS	NS
Fat	5.6	5.5	5.7	5.5	5.5	0.36	NS	NS	NS
Ash	4.1	4.2	4.6 ^b	3.6 ^a	4.2 ^b	0.28	NS	<0.05	NS
Plasma (mg/dl)									
Triglyceride	72.0	70.1	59.3 ^a	70.6 ^{ab}	83.1 ^b	11.6	NS	<0.05	NS
Cholesterol	132.8	151.2	142.3	144.7	138.0	17.4	NS	NS	NS

¹ Values reported represent means for 6 broilers (male:female=1:1).

D=Duration of restriction. L=Level of restriction. D×L=Interaction.

Means within a row not followed by the same superscripts are significantly different.

triglyceride and cholesterol in broilers. Duration of feed restriction had no effect on abdominal fat, whereas level of restriction had a significant effect ($p < 0.05$). Broilers fed 25% *ad libitum* had lower abdominal fat ($p < 0.05$) than other levels of restriction. Duration of restriction had no effect on abdominal fat, liver composition and plasma triglyceride and cholesterol, whereas level of restriction

significantly affected plasma triglyceride. Broilers fed 75% *ad libitum* had significantly higher plasma triglyceride ($p < 0.05$) than those fed 25% *ad libitum*. Broilers fed 50% *ad libitum* had lower liver ash as compared with 25 or 75% *ad libitum* ($p < 0.05$).

Table 4 shows the effect of duration and level of feed restriction on breast and leg meat composition in broilers.

Table 4. Effect of duration and level of feed restriction on breast and leg meat composition in broiler chickens at 56 days of age¹ (Experiment 1)

Variables	Duration of restriction		Level of restriction			SD	ANOVA		
	4 d	6 d	25%	50%	75%		D	L	D×L
Breast composition, %									
Moisture	70.8	70.7	71.0	70.7	70.7	0.63	NS	NS	NS
Protein	24.1	23.9	24.1	23.9	24.0	0.21	NS	NS	NS
Fat	2.8	3.2	3.0	2.9	3.0	0.55	NS	NS	NS
Ash	2.3	2.3	2.0	2.4	2.4	0.30	NS	NS	NS
Leg composition, %									
Moisture	60.7	61.0	61.5	60.7	60.2	1.49	NS	NS	NS
Protein	20.9	20.9	21.0	20.8	20.9	0.22	NS	NS	NS
Fat	13.7	13.0	12.4 ^a	13.6 ^{ab}	14.1 ^b	1.27	NS	<0.05	NS
Ash	4.6	5.2	4.9	5.0	4.7	0.6	NS	NS	NS

¹ Values reported represent means for 6 broilers (male:female=1:1).

D=Duration of restriction. L=Level of restriction. D×L=Interaction.

Means within a row not followed by the same superscripts are significantly different.

Duration and level of feed restriction had no effect on breast composition. Level of feed restriction significantly affected fat content of leg meat ($p<0.05$). Broilers fed 75% *ad libitum* had higher fat content of leg meat as compared with those fed 25% *ad libitum*.

Experiment 2

Table 5 shows the effect of early feed restriction on abdominal fat, liver composition and plasma triglyceride and cholesterol in broilers. Abdominal fat was significantly lower in restricted broilers ($p<0.05$) as compared with the control. Breast or leg meat was not significantly different. Liver composition was not significantly different. Ash in liver was significantly higher in broilers subjected to physical restriction started at 2 or 4 days, and with meal feeding started at 2 or 6 days ($p<0.05$).

Plasma triglyceride was significantly higher in broilers subjected to physical restriction started at 4 days of age, meal feeding started at 4 days of age ($p<0.05$), diet dilution started at 6 days of age ($p<0.01$). Plasma cholesterol was not significantly different (Table 5).

Table 6 shows the effect of early feed restriction on the

composition of breast and leg meats. Fat content of breast meat was significantly higher ($p<0.01$) with no change in moisture, protein and ash content. Fat content of leg meat was significantly lower in broilers subjected to physical restriction started at 4 days of age, meal feeding started at 6 days of age, diet dilution started at 2 or 4 days of age ($p<0.05$), with no change in moisture, protein and ash content.

Table 7 shows the effect of initial age and types of restriction on abdominal fat, liver composition, and plasma triglyceride and cholesterol in broilers. Initial age and type of restriction had no effect on abdominal, liver composition, plasma triglyceride and cholesterol.

Table 8 shows the effect of initial age and types of restriction on breast and leg meat composition in broilers. Initial age and type of restriction had no effect on breast composition, but they significantly affected the content of leg fat. Meal feeding or diet dilution had lower leg fat as compared with physical restriction ($p<0.05$). Feed restriction started at 4 days of age significantly lowered fat content of leg meat as compared with 2 and 6 days ($p<0.05$).

Table 5. Effect of early feed restriction on abdominal fat, liver composition, plasma triglyceride and cholesterol¹ (Experiment 2)

Variables	Control	Physical feed restriction			Meal feeding			Diet dilution			SD
		2 d	4 d	6 d	2 d	4 d	6 d	2 d	4 d	6 d	
Abdominal fat, % BW	3.20	2.56*	2.57*	2.37*	2.12*	2.35*	2.37*	2.35*	2.60*	2.21*	0.62
Leg meat, % BW	13.8	14.7	12.6	14.1	14.4	13.9	13.6	14.1	15.2	12.5	0.61
Breast meat, % BW	10.6	10.8	9.8	10.5	11.9	9.2	10.4	10.7	10.9	11.3	0.54
Liver composition, %											
Moisture	71.1	70.2	70.5	71.2	71.0	70.7	70.4	70.8	71.1	71.2	0.28
Protein	19.5	19.6	19.7	19.5	19.4	19.8	19.6	19.6	19.6	19.4	0.44
Fat	6.7	6.8	6.6	6.5	6.5	6.6	6.7	6.7	6.3	6.3	0.50
Ash	2.7	3.4*	3.2*	2.8	3.2*	2.9	3.3*	2.9	3.0	3.1	0.27
Plasma (mg/dL)											
Triglyceride	76.0	82.2	112.7*	101.3	100.2	118.7*	90.5	100.7	100.7	129.0**	20.5
Cholesterol	125.7	129.5	94.5	116.5	120.7	102.0	128.7	105.5	118.5	128.0	10.2

¹ Values reported represent means for 6 broilers (male:female=1:1).

* or ** Significantly different from the control group at level $p<0.05$ or $p<0.01$, respectively.

Table 6. Effect of early feed restriction on breast and leg composition¹ (Experiment 2)

Variables	Control	Physical feed restriction			Meal feeding			Diet dilution			SD
		2 d	4 d	6 d	2 d	4 d	6 d	2 d	4 d	6 d	
Breast composition, %											
Moisture	73.3	73.9	73.4	73.8	72.0	73.0	72.6	73.6	73.4	73.4	0.63
Protein	24.6	23.5	23.8	23.1	25.0	24.1	24.7	23.7	24.0	23.7	0.21
Fat	0.9	1.6**	1.6**	1.9**	1.9**	1.7**	1.6**	1.4**	1.4**	1.7**	0.04
Ash	1.2	1.1	1.2	1.2	1.2	1.2	1.1	1.3	1.3	1.2	0.12
Leg composition, %											
Moisture	71.8	71.8	73.5	71.4	71.7	73.6	73.7	74.2	73.3	73.1	0.91
Protein	18.0	18.0	19.6	18.8	19.9	18.1	19.4	19.1	18.7	18.4	0.32
Fat	8.9	8.8	5.6*	8.4	7.3	7.0	5.6*	5.4*	6.7*	7.0	0.65
Ash	1.3	1.4	1.3	1.5	1.1	1.4	1.4	1.3	1.3	1.5	0.10

¹ Values reported represent means for 6 broilers (male:female=1:1).* or ** Significantly different from the control group at level $p < 0.05$ or $p < 0.01$, respectively.**Table 7.** Effect of initial age and type of restriction on abdominal fat, liver composition, plasma triglyceride and cholesterol in broilers¹ (Experiment 2)

Variable	Initial age			Type of restriction			SD	ANOVA			
	2	4	6	Physical	Meal	Dilution		IA	TR	IA×TR	
Abdominal fat, % BW	2.34	2.51	2.35	2.50	2.31	2.39	0.65	NS	NS	NS	
Liver composition, %											
Moisture	70.7	70.8	70.9	70.6	70.7	71.0	0.31	NS	NS	NS	
Protein	19.5	19.7	19.5	19.6	19.6	19.5	0.45	NS	NS	NS	
Fat	6.7	6.5	6.5	6.6	6.6	6.4	0.51	NS	NS	NS	
Ash	3.2	3.0	3.1	3.1	3.1	3.0	0.25	NS	NS	NS	
Plasma (mg/dL)											
Triglyceride	94.4	110.7	106.9	98.7	103.1	110.1	18.5	NS	NS	NS	
Cholesterol	118.6	105.0	124.4	113.5	117.2	117.3	14.2	NS	NS	NS	

¹ Values reported represent means for 6 broilers (male:female=1:1).

IA=Initial Age, TR=Type of restriction, IA×TR=Interaction.

Means within a row not followed by the same superscripts are significantly different.

Table 8. Effect of initial age and type of restriction on breast and leg meat composition in broilers¹ (Experiment 2)

Variable	Initial age			Type of restriction			SD	ANOVA			
	2	4	6	Physical	Meal	Dilution		IA	TR	IA×TR	
Breast composition, %											
Moisture	73.2	73.3	73.3	73.7	72.3	73.5	0.66	NS	NS	NS	
Protein	24.0	24.0	23.8	23.5	24.6	23.8	0.23	NS	NS	NS	
Fat	1.6	1.6	1.7	1.7	1.8	1.5	0.05	NS	NS	NS	
Ash	1.2	1.2	1.1	1.2	1.1	1.2	0.11	NS	NS	NS	
Leg composition, %											
Moisture	72.6	73.5	72.7	72.2	73.0	73.5	0.91	NS	NS	NS	
Protein	19.0	18.8	18.9	18.8	19.1	18.8	0.22	NS	NS	NS	
Fat	7.2 ^b	6.4 ^a	7.0 ^b	7.6 ^b	6.6 ^a	6.3 ^a	0.65	<0.05	<0.05	NS	
Ash	1.3	1.3	1.4	1.4	1.3	1.4	0.08	NS	NS	NS	

¹ Values reported represent means for 6 broilers (male : female = 1:1).

IA=Initial Age, TR=Type of restriction, IA×TR=Interaction.

Means within a row not followed by the same superscripts are significantly different ($p < 0.05$).

DISCUSSION

The present study shows that unsexed broilers had positive responses to early feed restriction as indicated by lower abdominal fat (both experiments) and lower fat content of leg meat (Experiment 2). From these results it could be justified that unsexed broilers also responded to

early feed restriction as well as sexed broilers. Santoso (2001a) also found that early feed restriction at a given level reduced abdominal fat, plasma triglyceride and meat fat in unsexed broilers. It appeared that the severity of early feed restriction may affect fat accumulation in unsexed broilers. Santoso et al. (1993a) also found similar results in sexed broilers.

Restricted feeding of broilers reared in cages showed lower abdominal fat content. It is difficult from the present results to discuss the mechanism, since plasma triglyceride concentration remained unchanged. The reduction of abdominal fat was confirmed in experiment 2. However, this reduction was accompanied by higher triglyceride concentration in plasma. From these two experiments, the reduction of abdominal fat might not be caused by lower triglyceride concentration in plasma as suggested by Hasegawa et al. (1994). Our prediction was confirmed by the results of experiment 2 which showed the inversion correlation between abdominal fat and plasma triglyceride ($r=-0.65$). It was known that nutritional planes influenced triglyceride concentration. Santoso (2001a) also found that triglyceride concentration was not the sole factor influencing abdominal fat content. It appears that abdominal fat was influenced by the ability of fat cell to uptake triglyceride from the circulation. McMurtry et al. (1988) found that the reduction of abdominal fat was accompanied by the reduction of the number of adipocytes present in abdominal fat pad tissue in broilers. Jones and Farrell (1992) found that restricting the feed intake of broilers to provide only 3.1 kJ/kg BW^{0.67}/day during the period 7-13 days of age resulted in lower fat cell number, and as a consequence decreased abdominal fat content.

It was found that broilers reared in cages and fed 25% *ad libitum* had lower abdominal fat than those fed 50% or 75% *ad libitum*. This did not agree with the observation of Santoso (2001a) who found that broilers reared on-floor and fed 75% *ad libitum* had lower abdominal fat than those fed 25% or 50% *ad libitum*. This difference might result from the difference of rearing types, since those experiments were conducted in the same house, management and season of the same year.

Santoso (1992) found that sexed broilers fed 25% *ad libitum* had lower abdominal fat content as compared with those fed 50% or 75% *ad libitum* at 56 days of age. This observation was confirmed by the present study. The present study agreed with the observation of Ballay et al. (1992) who found that the age when the restriction was started (1, 7 or 13 days of age) had no effect on abdominal fat of sexed broilers. Our results (Experiment 1) also agreed with the observation of Santoso et al. (1995b) who found that duration of restriction did not affect abdominal fat in sexed broilers.

Liver fat was not affected by early feed restriction in both experiments. Fontaka et al. (1993) also found that early feed restriction did not affect fat deposition in the liver. They postulated that since lipogenesis in poultry occurs primarily in the liver, with unused fatty acids stored as triglyceride in adipose tissue, lipid content in the liver would not be expected to be different in broilers exposed to different feeding treatments. However, this postulation was

not wholly true, since Santoso et al. (1993a, 1995b) found that early feed restriction changed hepatic triglyceride content.

It is of interest to note that in general, early feed restriction increased fat content of breast meat, but it tended to reduce that of leg meat (Experiment 1). This was confirmed by experiment 2. The mechanism of this phenomenon is unknown. It is possible that early feed restriction caused a shift in fat distribution among organs. There was positive correlation between plasma triglyceride and breast fat in experiment 2 ($r=0.53$), but this correlation was not confirmed by experiment 1 leading to hypothesis that plasma triglyceride concentration could not be a good tool for estimating breast fat.

Fat content of leg meat was lower in broilers fed 25% *ad libitum* than those fed 75% *ad libitum*. Santoso et al. (1993a) found that broilers subjected to severity of feed restriction had lower activity of hepatic acetyl-CoA carboxylase, a rate limiting enzyme for lipogenesis. Therefore, the reduction of fat content of leg meat might result from the reduction of lipogenesis in the liver. This assumption was supported by the present study which showed lower plasma triglyceride content in broilers fed 25% *ad libitum* as compared with those fed 75% *ad libitum*.

The present study also showed that types of restriction influenced fat content in leg meat. Diet dilution and meal feeding resulted in lower fat in leg meat than physical restriction. Fat accumulation in these groups might be lower during restriction period, and this accumulation might not be recovered during refeeding. Diet dilution applied here used sawdust at level 75%, which contained high crude fiber. Crude fiber was known to reduce fat accumulation in poultry (Deuchi et al., 1994). This lower leg fat was accompanied by higher plasma triglyceride concentration.

The present study showed that early feed restriction increased ash content of meat and liver. These results were in agreement with the observation of Santoso (2001a). It was hypothesized that early feed restriction improved mineralization (Santoso, 2001a). However, it was shown that this effect was not consistent, since this program did not affect ash content of breast and leg meat in Experiment 2.

Plasma triglyceride of restricted broilers was higher or tended to be higher. Muiruri et al. (1975) found that the rate of fatty acid synthesis and plasma triglyceride concentration were greater in meal feeding than in the *ad libitum* fed broilers during refeeding. However Nir et al. (1973) found that refeeding was not accompanied by an increase in plasma triglyceride. Santoso (2001a) found that feed restriction resulted in lower plasma triglyceride in broilers aged 56 days. The reason of this inconsistent result was unknown.

The present study showed that early feed restriction in unsexed broilers resulted in higher plasma triglyceride as

compared with the *ad libitum* group. This was contrary to the observation of Santoso (2001a) who found that early feed restriction in unsexed broilers reduced plasma triglyceride. This difference may result from the difference of rearing types, since both experiments were conducted in the same house, management and season of the same year.

It was shown that to achieve lower abdominal fat and leg meat fat with comparable plasma triglyceride and cholesterol as compared with the control, unsexed broilers reared in cages should be fed 25% *ad libitum* for 6 days (Experiment 1). In addition, they could be subjected to physical restriction started at 4 days, or they could be subjected to meal feeding started at 6 days of age. Although diet dilution resulted in lower fat accumulation, this program (at least in the present study) could not be applied, because it caused lower body weight (Santoso, 2002c). It appears that rearing types affected the response of unsexed broilers to early feed restriction.

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