THE EFFECT OF DIETARY NUTRIENT DENSITY UPON GROWTH, NUTRITIONAL ANATOMY AND PHYSIOLOGICAL IN FOUR DIFFERENT LINES OF SELECTED CHICKENS

Sofjan Iskandar[1] and R.A.E. Pym[2]

ABSTRACT

The study consisted of two experiments of similar design (2 diets x 4 lines x 2 sexes x 4 birds per subcell), which were undertaken consecutively with the same parameters were measured. The four lines selected for tweleve generation for increased bodyweight (line W), increased food consumption (line F), decreased food consumption ratio (line E) or at random (line C) were subjected to two different dietary nutrient densities (13.0 MJ ME/kg, with 230 g protein/kg, and 9.5 MJ ME/kg with 190 g protein/kg). Each experimental bird was kept in an individual cage provided with automatic drinkers and individual feed trough. The experiment was ceased until the bird reached the age of 63 days. There were significant ($P<.05$) interaction between line and diet for both liveweight gain and food intake in each experiment. There was change in ranking of lines in liveweight gain for the high to the low nutrient density diet. On the high diet, liveweight gain was the greatest in line W followed by the F, E then line C. On the low diet in Experiment I, the ranking of the F and E males were reversed and in Experiment II, liveweight gain in the E and C lines were similar. However liveweight gain as expected, was the greatest in line W (1160 g/bird) and least in line C (759 g/bird). Food intake was the greatest in line F (3591 g/bird) and least in line C and E (2800 g/bird) as a consequence food conversion ratio was highest in line F (3.95) lowest in line E (3.44). Metabolizable energy and nitrogen retention were highest in line E (11.08 MJ ME /kg and 19.13 g N/kg) and lowest in line F (10.78 MJ ME /kg and 14.93 g N/kg). Birds given the high diet retained more nitrogen than those given the low diet. Body fat was highest in F line (14.86 %) and lowest in E line (7.39 %). Body protein was uneffected by line, diet and sex. Expressed as a proportion of liveweight, the E line had the heaviest proventiculus (3.6 g/kgW), gizzard (27.8 g/kgW) and intestine (16.8 g/kgW), whilst the F line had the smallest proventiculus (3.1 g/kgW), gizzard (21.6 g/kgW), but largest liver (21.8 g/kg W) and about four times more abdominal fat than the E line.

Key words: Chicken-lines, Nutrient-density, Growth, Anatomy, Physiology

INTRODUCTION

The economic and scientific significance of growth rate in today's broiler chickens, as a result of intense selection for juvenile growth rate over thirty generations was well recognized (Marks, 1979; Chamber *et. al.*, 1981 and Liu *et al.*, 1994), yet there still much to learn about the effect of such selection upon the birds biology.

The increasing cost of feedstuff ingredients and recognition of the very significant increase in appetite as a correlated response to selection for increase growth rate (see McCarthy and Siegel, 1983) has led the industry to reappraise past selection practices

---

[1] Research Institute for Animal Production, P.O. Box 221, Bogor 16002.

[2] Departement of Animal Medicine and Production University of Queensland, St. Lucia Qld. 4067 Australia.

prior to any major alteration to selection criteria, however, it would be appropriate to study such alternative selection strategies in their effect upon the complex relationship between growth and appetite. An understanding of the physiological factors which contribute to this relationship is likely to assist the industry in determining an appropriate course of action.

Evidence is presently accumulating that selection for growth rate has resulted in "genetic lesions" (see McCarthy and Siegel, 1983) of the hypothalamus involving a suppresion of the satiety mechanism. Burkhart *et al.* (1983) demostrated that a line of broiler chickens selected for increased growth rate did not increase food intake following electrolytic lesioning of their hypothalamus (assuming the destruction of the satiety centre) whereas their low growth-selected counterparts displayed the hyperphagia following the operation. The high weight line thus tended to consume food at a rate close to the capacity of their gut. It has further been shown that the energostatic theory of control of food-intake regulation in which the animal eats to meet its body energy requirements, as seen in mamals (see Forbes, 1986), also occurs in chickens (Fisher and Wilson, 1974; Sykes and Beh, 1985).

This paper presents the results of a study of the effect of dietary nutrient density upon food intake, growth rate, body composition and aspects of nutritional anatomy and physiology in four lines of chickens selected for either increased growth, appetite, food efficiency or at random (Pym and Nichols, 1979). The information

Table 1. Ingredient and nutrient composition of diets (g/kg) used in Experiment I and II

Ingredient	Diet	
	High	Low
Wheat	308	200
Sorghum	306	196
Meat meal	80	52
Fish meal	30	26
Vegetable oil	30	26
Ground rice hull (180-300 microns)	-	350
Salt	2.5	1.7
Vitamin premix[1]	1.5	1
Mineral premix[2]	1.5	1
dl-Methionine	2	1.3
Diatomeaceous earth	7.5	4.9
Coccidiostat	1	1
Total	100	100
Calculated:		
ME, MJ/kg	13.0	9.5
Protein, g/kg	230	150
Calcium, g/kg	9.1	5.9
Phosporus, g/kg	7.6	4.9
Lysine, g/kg	9.2	6.0
Methionine, g/kg	4.6	3.0
Protein : ME ratio	17.9	17.6

[1] Each gram of vitamin premix contained: Vit.A 8000 i.u., Vit.D3 2000 i.u., Vit.B2 6.5 mg, Vit.B6, Vit.B12, Vit.E, Vit.K3 Biotin, Folic acid, Ca-pantothenate, Niacin, Antioxidant.

[2] Each gram of mineral premix contained: Co 0.4 mg, I 0.6 mg, Mo 0.6 mg, Fe2+ 30 mg, Mn 60 mg, Zn 50 mg, Cu 4 mg, Se 0.05 mg, F 0.1 mg.

presented in this paper is hopefully giving basic ideas, which lead to proper direction of action in improving indigenous chickens industry in Indonesia, which recently prioritized program of improving native chickens is in operation at the Research Institute for Animal Prodction of Bogor .

MATERIALS AND METHODS

Experiment I

The four selection lines (Pym and Nicholls, 1979) selected for 12- week increased bodyweight (line W), for 12-week increased food intake (line F), 12-week decreased feed conversion ratio (line E) and the control population (line C). Eight males and eight females from each line were trasfered into individual cages from the brooder when they were 35 days of age. The two dietary treatments used and shown in Table 1 were formulated to vary in nutrient density but to contain all other nutrients in the same proportion to metabolizable energy (ME). The low density diet (diet L) was obtained by diluting the high density diet (diet H), which contained 230 g protein and 13.0 MJ ME/kg, with 350 g finely ground (180-300 microns) rice hull per kg. The other nutrients in diet H were formulated to comply with requirements suggested by NRC (1977). The experimental design was 2 diets x 4 lines x 2 sexes x 4 birds per sub-cell.

Birds were individually weighed at 35 and 63 days of age and food consumption over the period was recorded. A sub-sample of excreta was collected once a week from each bird and stored frozen. The four excreta collections from each bird were pooled and dried in a force-draft oven at 60-70 °C for about 48 hours or in freeze-drying machine. Feed and excreta were analysed for gross energy, nitrogen and acid-insoluble ash, for determination of ME and nitrogen retention. At 63 days of age, male birds were starved overnight and on the following day were killed by cervical dislocation. Bodies were stored frozen at -20 °C. The frozen bodies were subsequently chopped and the pieces put through a mincer with 5-mm die. Each carcass was minced three times for thorough mixing. The mincer was cleaned between carcasses. A representative sample (about 400 g) of minced was placed in an aluminium container, weighed to nearest 0.1 g and dried in a force draft oven at 60-70 °C for 72 hours. The dried samples were subsequently ground in a hammer mill (C & N Laboratory Mill) and again stored in plastic bags at –20 °C. Chemical analysis for body composition was subsequently carried out.

Experiment II

A second experiment identical in design to Experiment I was undertaken to study the effects of variation in dietary nutrient density upon body composition and digestive-organ size. The experiment commenced seven days earlier than in Experiment I when the birds were 28 days of age and terminated at 63 days of age.

The digestive organs were disected and removed from the body, cleaned of mesenteric fat and the remaining digesta were removed mechanically before components were replaced and the bodies were stored frozen at -20 °C. Body-chemical analysis as described in Experiment I was then carried out. Data of both experiments were analyzed by analysis of variance using the balanced factorial (BALF) computer programme of Beattie (1982). Treatment means were compared using the Least Significant Difference (LSD) test (Steel and Torrie, 1980).

Results and Discussion

Effect of dietary nutrient density upon growth rate, food intake, ME and nitrogen retention (NR) in the four lines are shown in Table 2.

Results in the performance traits were similar in the two experiments, although liveweight gain and food intake were higher in Experiment II, which was due to the longer test period in that experiment. Liveweight gain was the greatest in line W and least in line C, food intake was greatest in line F and least in lines C and E and as a consequence food conversion ratio was highest in line F and lowest in line E. Birds given the high density diet grew faster, ate less and were more efficient in converting food into

Table 2. Liveweight gain (LWG), food intake (FI), food conversion ratio (FCR), in chicken from the four selected lines (W,F,E,C) given diets varying in nutrient density in Experiment I and II.

Paramenters/	LWG (g/bird)		FI (g/bird)		FCR (feed/gain)		ME (MJ/kg)	
Exp.	I	II	I	II	I	II	I	II
Line (L):								
W[1]	807^{d}[2]	1160^{d}	2793^{b}	3591^{b}	3.67^{a}	3.30^{a}	10.90^{a}	17.51^{b}
F	730^{c}	997^{c}	3053^{c}	3643^{b}	4.45^{b}	3.95^{b}	10.78^{a}	14.93^{a}
E	633^{b}	861^{b}	2028^{a}	2730^{a}	3.38^{a}	3.44^{a}	11.08^{a}	19.13^{c}
C	520^{a}	759^{a}	1955^{a}	2803^{a}	3.91^{b}	3.91^{b}	10.97^{a}	17.70^{b}
LSD (5%)	69	59	183	250	.30	.31	.32	1.82
Diet (D):								
H[3]	803^{b}	1152^{b}	2337^{a}	3048^{a}	2.92^{a}	2.71^{a}	12.84^{b}	20.37^{b}
L	541^{a}	737^{a}	2578^{b}	3335^{b}	4.79^{b}	4.59^{b}	10.62^{a}	14.37^{a}
LSD (5%)	49	42	129	176	.21	.22	.22	1.29
Sex (S):								
Male	738^{b}	1057^{b}	2656^{b}	3356^{b}	3.38^{a}	3.47^{a}	10.93^{a}	17.68^{a}
Female	606^{a}	831^{a}	2258^{a}	3027^{a}	3.87^{b}	3.83^{b}	10.93^{a}	16.96^{a}
LSD (5%)	49	42	129	176	.21	.22	.22	1.29
Interactions								
L x D	**	**	**	**	ns	ns	ns	ns
L x S	ns	ns	ns	ns	ns	ns	ns	ns
D x S	**	**	*	ns	ns	ns	ns	ns

[1] Line W, selected for increased 5-9 week high liveweight gain; Line F, selected for increased 5-9 week high food consumption; Line E, selected for decreased 5-9 week feed conversion ratio; Line C, selected at random

[2] Values with the same supersript in the same colom in the same parameter are not significantly (P>.05) different, *=p<.05, ** =P<.01, ns not significantly different (P>.05)

[3] H diet contained 230 g protein with 13 MJ ME/kg; L diet contained 150 g protein with 9.5 MJ ME/kg.

liveweight gain than those on the low density diet, whilst males grew faster, ate more and had a lower FCR than females. ME and NR were highest in line E and lowest in line F. Birds given the high density diet retained more nitrogen than those given the low density diet. There were significant (P<.05) interactions between line and diet for both liveweight gain and food intake in each experiment. Because of the significant (P<.05) difference between males and females for liveweight gain and food intake, the data were presented with the difference separately for males and females (Table 3).

There was a change in ranking of the lines in liveweight gain from the high to the low nutrient density diet. On the high diet, liveweight gain in both males and females was greatest in the W line followed by the F, E then C lines. On the low diet in Experiment I, the ranking of the F and E males were reversed and in Experiment II, live weight gain in the E and C lines were similar. There was a substantially higher intake of line E and C, whereas the F line showed a marked decreased in intake of the low density diet in both experiments. The males of the W line showed a slight increase in food intake of the low density diet in Experiment I, but a decrease in Experiment II. Females of the E and C lines in both experiments followed the same pattern as the males. Females of the W

Table 3. The line-mean effect of line, sex and dietary nutrient density upon liveweight gain and food intake in Experiments I and II

	Liveweight gain (g/bird)						Food intake (g/bird)					
	Experiment I			Experiment II			Experiment I			Experiment II		
	H[1]	L	L-H	H	L	L-H	H	L	L-H	H	L	L-H
Male:												
W[2]	1125^{e}	650^{cd}	-475	1520^{f}	950^{c}	-570	3000^{e}	3375^{f}	+375	3800^{d}	3550^{cd}	-250
F	1700^{f}	476^{b}	-1225	1450^{e}	800^{b}	-650	3650^{g}	2800^{d}	-850	3750^{d}	3625^{cd}	-125
E	700^{d}	600^{b}	-100	1200^{d}	700^{a}	-500	1800^{a}	2500^{c}	-700	2800^{ab}	3060^{b}	+260
C	660^{cd}	450^{a}	-210	1000^{c}	700^{a}	-300	1900^{a}	2225^{b}	-325	2600^{a}	3400^{c}	+800
LSD(5%)		69			58			180			251	
Female:												
W[2]	725^{d}	650^{c}	-75	1175^{f}	850^{c}	-325	2250^{c}	2800^{de}	+550	3100^{c}	3700^{f}	+600
F	725^{d}	525^{b}	-200	1050^{e}	700^{b}	-350	2700^{d}	2900^{e}	+200	3500^{de}	3350^{d}	+50
E	675^{c}	425^{a}	-200	925^{d}	600^{a}	-325	1600^{a}	2000^{b}	+400	2250^{a}	2700^{b}	+450
C	500^{b}	400^{a}	-100	725^{b}	600^{a}	-125	1575^{a}	1950^{b}	+375	2150^{a}	3000^{c}	+250
LSD(5%)		70			58			175			249	

[1,2] See footnotes in Table 2

line also ate more of the low density diet. Females of the F line in Experiment I ate slightly more of the low density diet, but in Experiment II there was no difference in their intake of the two diets. There were significant interaction ($P<.05$) between sex and diet for liveweight gain and food intake in both experiments due to much larger sex differences on the high diet than on the low diet.

Growth rate, food intake and food utilization efficiency of the four selection lines was generally consistent with those previously reported (Pym, 1985) in the lines after twelve generations of selection. However slight differences in the relative performance of the lines in these experiments were possibly due to line x dietary nutrient density interaction. Food intake of the C and E lines were in all cases quite simillar although there was a difference in response to variation in dietary nutrient density, indicating that selection for improved food efficiency does not result in an increase in appetite but rather moderate increase in growth rate. As might be expected, birds grew faster, ate less and were more efficient in converting food to gain on the high nutrient density diet than on the low density diet. Food intake is a response of homeostatic mechanism of the bird to maintain growth capacity. Thus liveweight gain and food conversion ratio are determined by the amount of ingested nutrients and specific capacity for converting these nutrients into liveweight gain.

The reduction in liveweight gain as nutrient density decreased in the F line was greater than the other three selection lines. This was due to an inability of the F line to consume more food on the low nutrient density diet. This finding was in contrast to the well accepted proposition that chicken eat to meet their energy requirements (Fisher and Wilson, 1974; Sykes and Beh, 1985). The result, however, supports the findings of Burkhart *et al.* (1983), which showed that, unlike slow-growing and layer-type birds (Lepkovsky and Yasuda, 1966), broiler selected for high growth rate did not increase their food intake when the satiety centre in the hypothalamus was electrostatically lesioned. The responses in the E and C lines are in keeping with expectations that chickens that have not been subjected to intense selection for increase appetite have an ability to eat to meet their energy requirements over a reasonable dietary energy range. It is thus possible that the sensitivity of the satiety centre of the F line was reduced as a consequence of selection for increase appetite

Table 4. Body-chemical composition in the four selection lines of chickens (W,F,E,C) given diet varying in nutrient density in Experiment I and II

	Body fat (%)		Body protein (%)		Body ash (%)		Body water (%)	
	I#	II	I	II	I	II	I	II
Line (L)								
W^{1}	11.80^{c2}	11.98^{c}	19.25^{a}	20.18^{a}	3.17^{a}	3.14^{a}	64.0^{a}	63.1^{b}
F	12.45^{d}	14.86^{d}	20.17^{a}	19.98^{a}	3.49^{b}	3.39^{b}	63.6^{a}	59.9^{a}
E	7.71^{a}	7.39^{a}	19.93^{a}	20.55^{a}	3.05^{a}	3.41^{b}	67.2^{b}	66.7^{c}
C	9.25^{b}	10.24^{b}	20.12^{a}	20.66^{a}	3.53^{b}	3.41^{b}	65.2^{ab}	63.5^{b}
LSD (5%)	2.22	1.47	0.95	0.80	0.22	0.18	2.1	1.4
Diet (D)								
H^{3}	10.88^{b}	13.93^{b}	19.61^{a}	20.06^{a}	3.20^{a}	3.16^{a}	64.1^{a}	61.0^{a}
L	8.74^{a}	8.30^{a}	20.13^{a}	20.62^{a}	3.42^{b}	3.52^{b}	65.9^{b}	65.6^{b}
LSD (5%)	1.57	1.04	0.67	0.58	0.15	0.13	1.5	1.0
Sex (S)								
Male	10.00^{a}		20.65^{a}		3.49^{b}		64.3^{b}	
Female	12.23^{b}		20.03^{a}		3.19^{a}		62.3^{a}	
LSD (5%)	1.04		0.57		0.13		1.0	
Interactions								
L x D	ns	**	ns	ns	ns	*	ns	**
S x D		*		ns		ns		ns
L x S		ns		ns		ns		ns

1,2 and 3, See footnotes in Table 2.
Values in Experiment I were taken from male birds only.

and this line was eating to gut capacity.

The determined ME of the high nutrient density diets was slightly lower than the calculated values, whilst for the low nutrient density diet, the determined ME was higher than calculated. Such differences are to be expected since the ME values of the ingredients used was not determined prior to formulation. Mollah *et al.* (1983) reported abnormally low ME in certain wheats using broiler chickens, as a result of reduced starch digestibility. Wheat was included to provide at least one-third of the energy in all diets in the present study. The higher determined ME of the low density diet was probably due to the addition of oil which contributed at least 10 percent of total calculated ME. In fact a similar result was reported long time ago by Rand *et al.*(1958) who demonstrated that the inclusion of meize oil in the diet resulted in improvement in growth and efficiency of protein and energy utilization. Horani and Sell (1977) suggested that there may be an interrelationship between dietary carbohydrate and fat with regard to energy utilization of diets.

The higher nitrogen retention in the E line, whilst in keeping with expectations, was not reflected in higher body-protein levels. The result does, however, agree with the findings of Tomas *et al.* (1988) in these lines that protein breakdown rate, using 3-methyl histidine excretion as the measure, was significantly lower in the E line than in the C and F lines, with the W line intermediate. In proportioal term breakdown rate in the F line was about 30 percent greater than in E line. Thus the improved net efficiency of protein utilization in the E line as indicated by its higher nitrogen retention in this study was achieved by a reduction in the rate of protein breakdown.

Body composition in the four lines is shown in Table 4. Body fat was highest in the F line and lowest in E line ($P<.05$). Birds on the high density diet were fatter ($P<.05$) than those on the low density diet and females were fatter than males. Body protein was uneffected by line, diet and sex. The W line in both experiments showed the lowest body ash. Birds given the low density diet had a lower body ash than those given the high density diet. Males had more body ash than females. The E line showed the highest body water and the F line the lowest. Males had more body water than females.

Although the significant interaction between line and diet only appeared in Experiment II (see Table 5), it is interesting to note that the effect of low density diet resulted in the different way of responce of the lines, which had a different genetic background. The reduction in body fat in the W, F, E and C lines given the low compared to the high density diet was 6, 10, 3 and 3 percent respectively. Increases in body water and body ash from the high to the low density diet in the W, F, E and C lines were 5, 9, 3 and 2 percent for body water and 0.5, 0.6, 0.1 and 0.3 percent for body ash respectively. The relatively decrease in the amount of fat deposited in the abdominal fat from the high to the low density diet was greatest in the F line (32 %) followed by the amount of fat pad deposited in the abdominal fat pad of the W, E and C lines (20, 11 and 7 % respectively).

The difference in body fatness between birds given high and low density diets was greater in the F line than in the three other selection lines. There were consequently greater effects of diet upon body water and body ash in the F line than in other lines. These effects on body composition were caused by the low intake reducing the surplus energy available for fat deposition.

The effect of line, dietary nutrient density and sex upon digestive-organ size are shown in Table 6. Expressed as a proportion of liveweight, the E line also had the heaviest provinticulus, gizzard and intestine, whilst the F line had the smallest proventiculus and gizzard but the largest liver and about four times more abdominal fat than the E line. The weights of the crop, proventiculus, gizzard and small intestine of the birds given the high density diet were significantly lighter ($P<.05$) than those of birds given the low density diet. The small intestine was significantly ($P<.05$) longer in birds given the high than in those given the low density diet. The abdominal fat pad was larger in birds given the high density than in those given the low density diet. Males had relatively heavier crop but a lighter proventiculus and gizzard and less fat than females.

The data showed that the birds given the low nutrient density diets compensated by eating more, voiding more undigested matter, reducing the length and diameter of the intestine, and enlarging the gizzard in comparison with their counterparts on the high density diets.

The study is exercising the fact that choosing the selection traits for the long-term

Table 5. The combined effects of lines and diet upon body fat, body water, body ash and fat pad size in the four selection lines of chickens (W,F,E,C) given diet varying in nutrient density in Experiment II

	Body fat (%)			Body water (%)			Body ash (%)			Fat Pad (%)		
	H[1]	L	L-H	H	L	L-H	H	L	L-H	H	L	L-H
Line :												
W[2]	15.09^{d3}	8.88^{b}	-6.21	60.79^{b}	65.47^{d}	+4.68	2.91^{a}	3.38^{c}	+0.47	32.71^{e}	12.74^{bc}	-19.97
F	19.90^{e}	9.82^{bc}	-10.08	55.61^{a}	64.17^{cd}	+8.56	3.08^{ab}	3.71^{d}	+0.63	53.50^{f}	21.05^{d}	-32.45
E	9.08^{b}	5.70^{a}	-3.38	65.11^{cd}	68.35^{e}	+3.24	3.36^{c}	3.46^{cd}	+0.10	15.30^{bcd}	4.58^{a}	-10.72
C	11.67^{c}	8.80^{b}	-2.87	62.61^{bc}	64.36^{c}	+1.75	3.28^{bc}	3.53^{cd}	+0.25	18.85^{cd}	1.77^{b}	-7.08
LSD(5%)		2.08			1.93			0.25			6.25	

1,2,3 See footnotes in Table 2

Table 6. Digestive-organ and fat-pad size in the four selection lines of chickens (W,F,E,C) given diets varying in nutrient density in Experiment II

	Crop weight (g/kgW)	Proventiculus weight (g/kgW)	Gizzard weight (g/kgW)	Intestine		Liver weight (g/kgW)	Fat pad weight (g/kgW)
				weight (g/kgW)	length (cm)		
Line (L)							
W[1]	5.0^{a}[2]	3.4^{ab}	22.6^{ab}	14.9^{a}	144^{a}	18.7^{a}	22.7^{c}
F	5.1^{a}	3.1^{a}	21.6^{a}	15.9^{ab}	135^{a}	21.8^{b}	37.3^{d}
E	5.0^{a}	3.6^{b}	27.8^{c}	16.8^{b}	148^{b}	18.7^{a}	9.9^{a}
C	5.1^{a}	3.6^{b}	24.5^{b}	15.6^{ab}	144^{ab}	20.8^{b}	15.3^{b}
LSD(5%)	0.5	0.4	2.5	1.2	12	1.9	4.4
Diet (D)							
H[3]	4.4^{a}	3.2^{a}	18.2^{a}	14.6^{a}	149^{b}	20.2^{a}	30.1^{b}
L	5.6^{b}	3.7^{b}	30.1^{b}	17.1^{b}	137^{a}	19.8^{a}	12.5^{a}
LSD(5%)	0.4	0.3	1.8	0.9	8	1.3	3
Sex (S)							
Male	5.1^{b}	3.3^{a}	23.2^{a}	15.8^{a}	145^{a}	20.0^{a}	17.9^{a}
Female	4.9^{a}	3.6^{b}	25.1^{b}	16.0^{a}	141^{a}	20.0^{a}	24.7^{b}
LSD(5%)	0.4	0.3	1.8	0.9	8	1.3	3
Interactions							
L x D	ns	ns	ns	ns	ns	ns	**
L x S	ns	ns	ns	ns	ns	ns	ns
D x S	ns	ns	ns	ns	ns	ns	ns
L x S x D	ns	ns	ns	ns	ns	ns	ns

[1,2,3] See footnotes in Table 2.

has to be accurately considered accordingto the future demands of poultry products, which at the mean time, the market weight is still the end target of selection. However, meat quality should come up as one and feed utilization efficiency is another that should carefully set up. Research Institute for Animal Production of Bogor has recently crossed two local lines of chickens without prior to selection on any selection trait in order to keep the meat quality as much as preffered by the consumers.

REFERENCES

Beattie, A.W., 1982. *BALF, a computer programme for use in the Faculty of Veterinery Science at The University of Queensland.* The University of Queensland.

Burkhart, C.A., Cherry, J.A., Van Krey H.P. and Siegel, P.B., 1983. Genetic selection for growth rate alters hypothalamic satiety mechanism in chickens. *Behaviour Genetics,* (13):295-300.

Chambers, J.R., Gavora, J.S and Fortin, A., 1981. Genetic changes in meat-type chickens in the last twenty years. *Can. J. Anim. Sci.,* (61):555-563

Fisher, C. and Wilson, B.J., 1974. Response to dietary energy concentration by broiler chickens. In *Energy Requirements of Poultry* (T.R. Morris and B.M. Freemen, Eds.) Edinburgh, British Poultry Science Ltd., pp. 154-184.

Forbes, J.M., 1986. *The Voluntary Food Intake of Farm Animals.* Butterworths, London.

Horani, F. and Sell, J.L., 1977. Effect of feed grade animal fat on laying hen performance and metabolizable energy of rations. *Poult. Sci.*, (56):1972-1980.

Lepkovsky, S. and Yasuda, M., 1966. Hypothalamic lesions, growth and body composition of male chickens. *Poult. Sci.*, (45):582-588.

Liu, G., Dunnington, E.A. and Siegel, P.B., 1994. Response to long-term divergent selection for eight-week body weight in chickens. *Poult. Sci.*, (73):1642-1650.

Marks, H.L., 1979. Growth and feed intake of selected and non selected broilers. *Growth*, (43):80-90.

McCarthy, J.C. and Siegel, P.B., 1983. A review of genetical and physiological effects of selection in meat-type poultry. *Animal Breeding Abstracts*, (51):87-94.

Mollah, Y., Bryden, W.L., Wallis, I.R., Balnave, D. and Annison, E.F., 1983. Studies on low metabolizable energy wheats for poultry using conventional and rapid assay procedures and the effects of processing. *British Poult. Sci.*, (24):81-89.

N.R.C., 1977. *Nutrient Requirements of Poultry*. National Academic of Science.

Pym, R.A.E., 1985. Direct and correlated responses to selection for improved food efficiency. *Poultry Genetics and Breeding* (W.G. Hill, J.M. Manson and D. Hewitt, Eds.) British Poultry Science Ltd., pp. 97-111.

Pym, R.A.E. and Nicholls, P.J., 1979. Selection for food conversion in broilers: Direct and correlated responses to selection for body-weight gain, food consumption, and food conversion ratio . *British Poult. Sci.*, (20):99-107.

Rand, N.T., Scott, H.M. and Kummerow, F.A., 1958. Dietary fat in the nutrition of the growing chicks. *Poult. Sci.*, (37):1075-1085.

Steel, R.G.D. and Torrie, J.H., 1980. *Principles and Procedures of Statistics*. A Biometrical Approach, 3rd ed. McGraw-Hill Book Co., New York, NY.

Sykes, A.H. and Beh, B.L., 1985. Food intake of the laying hen following crop load of meize oil and other nutrients. *British Poult. Sci.*, (26):207-216.

Tomas, F.M., Jones, L.M. and Pym, R.A.E., 1988. Rates of muscle protein breakdown in chickens selected for increased growth rate, food consumption or efficiency of food utilization as assessed by NT-methylhistidine excretion. *British Poultry Science*, (29):359-370.