THE EFFECT OF GENOTYPE ON RESPONSE IN BODY COMPOSITION TO VARIATION IN DIETARY PROTEIN : ENERGY RATIOS

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ABSTRACT

An experiment with 480 day-old chicks of four commercial strains was conducted to study the effect of genotype on response in body composition to variation in dietary protein: energy ratios. The chicks were randomly allocated into 4x2x4 factorial and fed on a commercial starter diet (250 g CP and 12.5 MJ of ME /kg) from hatching to 5 d of age and divided into two groups with three replications each of 16 birds and given either the such starter diet (S) or a finisher diet (F) containing 190 g CP and 13.0 MJ of ME /kg. The birds were reared in strain-and sex-intermingled groups in brooders and follow-on cages until they reached the target body weight of 600-650 g (females) or 650-700 g (males) and transferred to single cages and fed S or F diet until 1200-1300 g (females) or 1300-1400 g (males). The lighting program was 23 h light for the first two days, and reduced to 18 h/d for the remainder of the experiment. There were considerable variations in relative growth performance, FCR, carcass fat and abdominal fat due to genotypes and dietary regimen. Although birds tend to response in similar way when dealing with the excesses and insufficient supply, the nutrient requirements in relation to the protein: energy ratios should be designed according to genetic background.The accumulation of fat during the growing period was primarily due to the genetic variation whereas beyond this age, variation in abdominal fat was due principally to dietary effects.

Keywords: growth, starter, finisher, strain, broiler

INTRODUCTION

Genetic variation contributes approximately 40% to the differences between genotypes in weight gain: feed ratio. Differences in body weight do not necessarily reflect differences in feed efficiency (Wasburn *et al*., 1975). This was because of different capacities to deposit fat and different capacities to metabolize energy intake (Jórgensen *et al*., 1990). Differences between strains in dietary protein utilization are responsible for different amino acid requirements (Leclercq, 1983). However, much of the work in determining nutrient allowance for broilers (eg. ARC, 1975; NRC, 1987; 1994) has assumed that genotype differences are small.

Although it is generally accepted that growth and body composition of broilers are influenced by the dietary protein and energy ratios (Summers *et al.*, l992; Corzo *et al.*, 2005; Sadeghi and Tabiedian, 2005; Sterling *et al.*, 2003; 2006; Rahimi and Hassanzadeh, 2007), the response of broilers to diets varying in energy: protein ratio is also dependent on the genotypes (Gous *et al*., l990; Morel *et al*., 2002; Corzo *et al*., 2005; Sterling *et al.*, 2006*)*. Smith *et al*. (l998) reported on the effect of genotype and protein level on body composition in a study with two strains. The degree of response varied between the two strains; increasing dietary protein improved performance more for one strain than the other.

The conventional feeding practise applied in commercial broiler production with change from high–protein starter to lower protein grower and finisher diets normally two to three times during the growing period may not necessarily optimise performance. In studies of the effect of the time of change from starter to grower and grower to finisher diets showed a substantial effect of the time at which the finisher diets commenced. Body weight was significantly depressed while abdominal fat increased by 0.3 g/kg for each additional day the finisher diet was fed (Saleh *et*

al., 1997a; Saleh *et al.*, 1997b). Insufficient supply of amino acids in the finisher diet was considered to be an important contributing factor to be the lower performance. This could be a major cause of observed differences in growth performance and of differences in body composition in commercial broiler production practise. Therefore, the present study is desirable to identify the response of different genotypes to variation in dietary protein: energy and to evaluate how dietary manipulation should be implemented at appropriate levels to allow the birds to perform to its genetic potential.

MATERIALS AND METHODS

Animal and management

A total of 480 day-old chicks commercial broilers (Steggels = A; Cobb=B; Ingham= C and Barter=D) were obtained on the same day and sexed (n = 120 per genotype). They were wing-banded and kept in strain-and sex-intermingled groups in a hot brooder room with the ambient temperature reduced from 31ºC by 0.5º C per day until it reached 25ºC at 12 days after which it was held at this level. The birds were fed on a commercial starter diet (S) containing 250 g crude protein (CP) and 12.5 MJ of ME/kg from hatching to five d of age when they were divided into two groups of experimental diets until reached the target body weight (600 to 650 g for females or 650 to 700 g for males).

They were then transferred to single cages measuring 200 mm wide and 400 mm deep x 400 mm high with individual feeders in a fan-ventilated and temperature controlled room. Feed and water were provided *ad libitum*. The lighting program was 23 h light for the first two days, and reduced to 18 h/d for the remainder of the experiment.

Experimental design

Experiment was a factorial design. Four genotypes, two initial and two final feeding treatments and two sexes were imposed in this study. At 5 d of age, the birds were divided into two groups with three replications each 16 birds (96 birds/ genotype) and fed either the starter diet or a commercial broiler finisher (F) containing 190 g CP and 13.0 MJ of ME/kg until achieved the target body weight.

As each strain x sex x feeding treatment reached the nominated target body weight, 16 birds were transferred to individual growing cages and given the starter or finisher diet *ad libitum.* In these individual cages, the birds were grown until they reached approximately 1200-1300 g for females and 1300-1400 g for males (double weight). The experimental treatments were four genotypes x sexes x two initial and two final feeding and 8 individual bird replicates. This target body weight was considered to be adequate for them to express differences in terms of both growth and body composition to dietary manipulation. Birds which reached the target body weight, feed was weighed and body weight gain (BWG) and feed conversion ratio (FCR) calculated.

After being fasted overnight, the birds were killed by cervical dislocation. Abdominal fat was removed and weighted. Abdominal fat was defined as the adipose tissue present around the vent, the bursa, and the adjacent abdominal muscles, as described by Smith (1993). The carcass was stored at -20ºC and analysed using Soxlet extraction method. In determining the effects of the starter treatment on body composition, two birds per sample were taken when they were transferred to the single cages.

The determined crude protein and amino acid concentrations for both starter and finisher diets are shown in Table 1.

Data analysis

Data were analysed by the GLM procedure of SAS software (Version 6.12, 1996). The major independent variables were strain, sex and diet. Least Significant Difference (LSD) multiple range tests (probability $P<0.05$) identified all results showing a significant difference (Kaps and Lamberson, 2004)

RESULTS AND DISCUSSION

Results of the present study are given in Table 2 to 4. The response of the four strains to dietary level of crude protein and energy revealed that a significant difference due to genotype was evident. Growth rate during the starter phase was significantly higher in the birds receiving the starter diet (250 g/kg CP) than in their counterparts given the finisher diet (190 g/kg CP). There was also an indication that growth rate was more depressed in strain Ingham from 24.0 to 18.7 g/d than Steggels, Barter and Cobb from 23.5 to 19.0, 22.4 to 18.4 and 23 to 19.4 g/d, respectively when they were fed on the starter diet than on finisher diet (Table 2). In other words,

Table 1. Analysis of Experimental Diets Used

Nutrient	Starter	Finisher
Crude Protein	230	190
Lysine	16.83	8.58
Methionine	6.76	4.25
Methionine plus cystine	10.54	6.9
Isoleucine	9.95	5.43
Leucine	20.67	12.59
Threonine	10.65	5.8
Tryptophan	4.33	2.63
Histidine	7.54	4.32
Valine	10.42	6.93

Expressed as g/kg on as is basic (approx. 900 g/kg Dry Matter)

Cobb was less responsive in low amino acid provided by the finisher diet. This finding may indicate that one genotype required more supply amino acids which are critical for muscle development than one other during their growing period. In agreement with Sterling *et al*. (2006), two genotypes responded differently and required different amino acids particularly lysine. Data provided by these authors showed that Cobb grew faster and higher feed consumption and had a better FCR than Ross 308. The lower FCR and higher BWG at the lowest lysine levels suggested that Cobb required less lysine.

Data obtained by Vieira *et al.* (2004) revealed the concept of ideal protein for growing broilers of different genotypes. Ross 308 should be provided 0.76% TDF SAA (True Digestible Faecal Sulfur Amino Acid) at adequate dietary protein level (205 g/kg) or 1.06% TDF SAA with the high protein diet (260 g/kg). However, as differences at placement and the beginning of the experiment, Vieira *et al*. (2004) limited the estimation of differences due to genotypes. Regardless of this, they have established optimum amino acid level and dietary protein level.

When considering the commercial diets used in the present study with nutrient composition as presented in Table 1, and compared to NRC (1994) recommendation for starter period (7-21 d) and growing period (21-42 d) reported by Sadeghi and Tabiedian (2005), it is necessary to revaluate the amino acid content in this commercial diets in relation to dietary protein. As a comparison, lysine content in the starter and finisher diets used in this study was 16.8 g/kg with 250 CP/kg and 8.58 g/kg with 190 g CP/kg, respectively, which was higher in the starter but lower in the finisher diets than NRC (12.2 g/kg lysine with 211 g CP/kg and 10.4 g/kg lysine with 18.18 g CP/kg). Although this present study is not exclusively intended to evaluate the commercial diets, understanding the differences in genotypes and use a simple approach through feeding strategies would minimise low performance if this exist. Thus, Corzo *et al*. (2005) studied the effect of dietary amino acid density on growth and carcass of three different broilers genotypes (two multipurpose strains and one high yield strain). High amino acid density diets improved body weight and FCR consistently measured at 14, 28, 42 and 52 d of age compared to the low amino acid density diet. However, not all strains responded similarly. High yield strain had lower BW and higher FCR in all periods than the two strains. Strain results for live performance were

Table 2. The Influence of the Starter or Finisher Diet during the Starter Phase from 5 Days to 600-650 g (Females) and 6 50-700 g (Males) on Growth Rate (g/d) and Carcass Fat (g/kg) of the Four Commercial Strains.

Strain	Growth Rate* Diet			Carcass Fat* Diet		
	Starter	Finisher	Mean	Starter	Finisher	Mean
Steggels	23.5^{ab}	19	21.3	97^{a}	95^{b}	96.0^{ab}
Cobb	23.0^{ab}	19.4	21.2	105^{a}	112^{a}	108.5^{a}
Ingham	24.0^{a}	18.7	21.4	70^{b}	114^{a}	92.0^{b}
Barter	22.4^{b}	18.4	20.4	99^{a}	109^{ab}	104.0^{ab}
LSD 0.05	1.2		1.0	19		13.5

* Sex average values for each dietary treatment

Means followed by different letters in the column are significantly different ($P<0.05$).

influenced, to some extent, by sex and diet type, but mostly at early ages. Observed interaction at 14 and 28 d of age were not repeated at later ages. It means that growth rate during early age is critical for birds to express their genetic potential which depends on dietary amino acid level and ultimately determine the subsequent production performance .

Growth rate during the grower and combined phase (5 d to 1250- 1350 g) (Table 4) was influenced by sex and diet, not strain whereas FCR was affected by strain and diet, but abdominal fat was responsive to all independent variables. Birds receiving the SF diets did not achieve the performance level as observed for the FS. The growth rate and FCR of FS feeding regimen considerably improved, showing 1.8 and 1.7 higher for growth rate and FCR or, almost double of the SF as the opposite combination (Table 3 and 4) but at the expense of the body composition. These revealed on how birds tried to compensate the poor growth rate under limit condition and demonstrate growth variation due to dietary regimen. These results are similar to the observations of Koch *et al*. (2002) who found birds with the 100%-starter diets and 120%-grower diet did not perform the 120% starter and 100% grower and a high performance potential genotype needs optimal diets which referred to ideal protein concepts. Amino acid supply particularly during the early life affects the subsequent performance and can not be compensated in the later phases.

In attempt to offer an idea the length of rearing period due to different dietary treatments with resulted in substantial growth rate, age at termination or at slaughter weight was 30±2.2; 35,5±2.7; 36,6±2.9 and 38.6±2.3 d of age for SS, SF, FS and FF. Whilst rearing period due to genotype was 37.8±2.3, 37.3±2.8, 37.1±2.4 and 38.7±2.8 d of age for Steggels, Cobb, Ingham and Barter respectively. Combining the relative growth variation as shown in Table 3 with some consequences on other performance, in relation to differences in age at termination, the different growth responses were due to differences in voluntary feed intake (Baker, 2004). In low dietary protein, feed intake was affected by amino acid balance (Swatson *et al.*, 2002) and unbalanced amino acid pattern in low protein diet stimulates gluconeogenesis pathway and as a consequence, fat was deposit as a result of extra calorie (Baker, 2004; Sadeghi and Tabiedian, 2005). Significant interaction strain and diet were observed of growth rate during the grower phase (Table 4), indicating the sensitiveness of growth rate due to changes in dietary crude protein : energy ratios and due to the genotype.

When considering the low FCR over the grower phase in the FS group which also demonstrated relatively high abdominal fatness (Table 4) is contrary to expectations based on the high energetic cost of depositing fatty tissues (Pym and Farrell, 1977). The apparent abnormality can be explained by the much higher growth rate during this phase of the chicks than those given the SF as a standard feeding regimen. The higher growth rate and hence much reduced maintenance cost, more than compensated for the increase in fat deposition.

In regard to the effect of dietary protein on fat accumulation, this study observed a significant reduction in abdominal fat deposition performed by birds on the SS or SF diets and an increase in birds on the FS or FF in all strains although the degree of response varied between strains (Figure 1 and Table 4). Abdominal fat of Ingham was only 62%, 73% and 67 % respectively of Cobb, Steggels and Barter during the grower phase. However, Ingham was fatter when given the finisher diet (114 g/kg) than given the starter (70 g/kg) during the starter period (Table 2). This shows that responses of broilers of different genetic backgrounds to a range of dietary energy: protein ratios were dependent on the age at which such diet was introduced. Feeding behaviour in response to dietary nutrient composition determined the ultimate outcome in terms of effects on growth, efficiency or carcass composition as modified by genotype (Sizemore and Siegel, l993). In other words, both genetic strain and feeding treatment affected how the

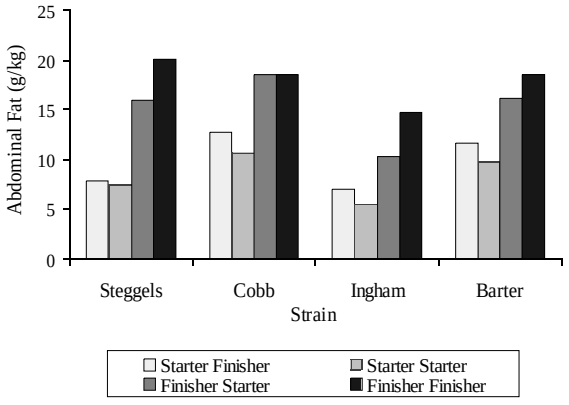

Figure 1. Effect of Dietary Regimen on Abdominal Fat (g/kg) of the Four Strains at 1200 -1300 g (Female) and 1300-1400 g (Males)

Table 3. Body Weight (g), Growth Rate (g/d) and Rearing Period (d) of the Four Commercial Strains at Target Body Weight* of Four Commercial Strains at different feeding regimen

		Male				Female		
Strain	Diet	Body Weight		Growth Rate	Age at Termination**	Body Weight		Growth Rate
		Starter	Finisher			Starter	Finisher	
A	SS	666±28	1322±12	49.2±4.4	30.2±3.2	619±24	1208±31	49.1±3.0
	SF	675±16	1350±84	30.4±4.0	39.0±2.9	611±11	1217±55	36.2±4.3
	FS	687±39	1384±33	61.7±6.3	37.0±0.8	622±0.7	1303±65	62.0±1.9
	FF	679±15	1338±28	51.5±4.2	37.8±0.9	634±62	1240±32	43.0±7.9
B	SS	663±25	1306±23	48.0±3.5	32.6±2.6	600±10	1307±24	47.1±9.7
	SF	653±41	1326±15	36.9±3.7	36.2±3.2	622±23	1326±15	37.3±6.3
	FS	691±68	1360±41	64.3±14.3	37.2±4.0	612±16	1360±41	58.6±7.0
	FF	701±35	1330±26	47.4±8.7	37.8±1.9	655±34	1330±26	43.2±3.5
C	SS	650±14	1312±27	53.5±9.0	28.2±2.0	627±24	1259±24	49.8±5.6
	SF	671±22	1331±27	37.9±6.7	33.8±3.3	635±24	1241±70	34.3±3.3
	FS	657±22	1359±47	68.0±7.9	36.0±3.7	668±48	1268±68	63.1±4.0
	FF	707±36	1354±27	46.8±2.9	39.5±2.1	635±27	1277±51	34.1±1.7
D	SS	661±29	1367±59	59.1±3.8	29.3±2.8	636±31	1243±64	50.8±4.1
	SF	651±15	1390±24	38.0±0.5	36.7±0.5	625±7.0	1237±49	35.0±3.8
	FS	685±30	1355±36	65.1±11.8	36.6±1.1	611±31	1310±64	56.9±2.9
	FF	683±28	1367±53	45.4±4.2	41.7±1.8	652±52	1241±60	42.2±2.3

* Target Body Weight = approximately 600-650 g (during starter) and 1200-1300 g (during finisher) for females; Target body weight approximately 650-700 g (during starter) and 1300-1400 g (during finisher) for males;
** Age termination = age at slaughtering when birds on target body weight
A= Steggels; B=Cobb; C=Ingham; D= Barter
SF = Starter-Finisher; FS = Finisher-Starter; SS = Starter-Starter; FF = Finisher-Finisher

birds came into production and had some influence on carcass fleshing traits (Renema *et al.*, 2006).

This is in agreement with results of Barragán (2005) who suggested that fat deposition could be reduced significantly by feeding the starter diet for a greater proportion of the growing period. Nutrition can significantly affect fat-free body composition at a certain fat-free body weight in modern meat-type animals (Eits *et al*., 2002) and profile amino acids can affect on weight gain and feed conversion (Koch *et al*., 2002; Araújo *et al.***,** 2004) as well as carcass protein and fat deposition (Furlan *et al*., 2004**)**.

The considerably greater relative propensity for Ingham in comparison with Cobb, Steggels and Barter to deposit fat in response to a reduction in dietary protein during the starter phase, would appear to be reflective of differences in selection approaches. It is significant that Ingham had been selected on feed efficiency which was shown by the low body fatness on the higher protein starter diet but moderate to high fatness on the low protein finisher diet (Table 2 and 4). Selection for low FCR whilst improving the net efficiency of utilisation of protein (Tomas *et al*., 1988) also increases the dietary protein requirement for growth and FCR (Leenstra and Pym, 1995; Pym, 2005). Other consequences of this selection were response to inadequate dietary protein in this genotype is to increase the deposition of body fat. No direct relationship between weight gain and fat deposition was evident (Table 2).

Griffiths *et al.* (l978) reported on considerable variation in the amount of abdominal fat deposited by commercial broiler strains at 4 and 8 wk of age. The accumulation of fat at 4 wk was primarily due to genetic variation whereas beyond this age, variation in abdominal fat was due principally to dietary effects. Whilst genetic factors had a major effect on body fatness at the conclusion of the starter and grower phases in the present study, the effect of diet was much greater at the earlier age. This is in agreement with Barragán (2005) who prolonged feeding starter or finisher feeds in broilers.

This study clearly demonstrates that the effect genotype do exist, and birds with low

Table 4. The Influence of Four Dietary Regimens on Growth Rate (g/d), during the Grower and Combined Starter and Grower Phase and FCR and Abdominal Fat (g/kg) of the Four Commercial Strains during the Grower Phase

Variable	Growth rate		FCR	Abdominal Fat
	Grower	Combined S + G1		
Sex				
Male	38.6[a]	42.0[a]	1.95	10.6[b]
Female	36.2[b]	39.6[b]	1.99	14.2[a]
LSD 0.05	1.4	1.25	0.09	1.47
Strain				
Steggels	52.2	36.1	1.965[ab]	12.76[b]
Cobb	52.8	35.4	1.936[b]	15.14[a]
Ingham	54.4	37.5	1.904b	9.33[c]
Barter	52	35.3	1.977[ab]	13.84[ab]
LSD 0.05	2.4	3.4	0.16	2.180
Dietary regimen				
SF	36.2d	33.7[c]	2.540[a]	9.59[c]
SS	53.8[b]	40.3[a]	1.701c	7.87[c]
FS	67.9[a]	35.0[b]	1.474d	15.27[b]
FF	48.3[c]	31.7d	2.098[b]	17.81[a]
LSD 0.05	2	1	0.14	2.53
Source				
Sex	**	**	NS	**
Strain	NS	NS	**	**
Diet	**	**	**	**
Interaction				
Strain x Diet	*	NS	NS	NS
Strain x Sex	NS	NS	NS	NS
Sex x Diet	NS	NS	NS	NS

a-d: Values within comparison with different superscripts is differ ((P<0.05)
S= Starter; G= Grower; 1 Combined S + G = Starter and Grower phase (5 d to 1250 -1350g)
SF = Starter-Finisher; FS = Finisher-Starter; SS = Starter-Starter; FF = Finisher-Finisher
* (P<0.05) ; **(P<0.01; NS = Not Significant (P>0.05)

CONCLUSION

performance which indicated by high FCR and high abdominal fat during the growing observed in all genotypes showed insufficient supply of amino acids as required. In other words, birds tend to response in similar way when dealing with the excesses and insufficient supply. Therefore, the nutrient requirements dealing with the protein: energy ratios should be designed according to genetic background. And a standard feeding regimen that commonly applied in broiler production should also be revaluated and modified.

The results obtained in this study allow concluding that the genetic lines do have differences in performance. Birds tend to response in similar way when dealing with the excesses and insufficient supply. The nutrient requirements dealing with the protein: energy ratios should be designed according to genetic background. The accumulation of fat during the growing period was primarily due to genetic variation whereas beyond this age, variation in abdominal fat was due principally to dietary effects. Protein and energy ratios significantly effects on growth performance and abdominal fat, depending on the

production performance when a diet was introduced.

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