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 (Jørgensen 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., 1992; Corzo et al., 2005; Sadeghi and Tabedian, 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., 1990; Morel et al., 2002; Corzo et al., 2005; Sterling et al., 2006). Smith et al. (1998) 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., 1990).

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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 practice. 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 31°C by 0.5°C per day until it reached 25°C 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 days 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 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).

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,
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).

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 | 10.54   | 6.9      |
| Cystine         | 9.95    | 5.43     |
| Isoleucine      | 20.67   | 12.59    |
| Leucine         | 10.65   | 5.8      |
| Threonine       | 4.33    | 2.63     |
| Tryptophan      | 7.54    | 4.32     |
| Histidine       | 10.42   | 6.93     |

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

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

| Strain    | Growth Rate* | Carcass Fat* |
|-----------|--------------|--------------|
|           | Starter Diet | Finisher Diet | Mean | Starter Diet | Finisher Diet | Mean |
| Steggels  | 23.5ab       | 21.3         | 97a  | 95b          | 96.0ab        |
| Cobb      | 23.0ab       | 21.2         | 105a | 112a         | 108.5a        |
| Ingham    | 24.0d        | 21.4         | 70b  | 114a         | 92.0b         |
| Barter    | 22.4b        | 20.4         | 99a  | 109ab        | 104.0ab       |
| 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, 1993). In other words, both genetic strain and feeding treatment affected how the
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. (1978) 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

| Strain | Diet | Male | Female |
|--------|------|------|--------|
|        |      | Body Weight | Growth Rate | Age at Termination** | Body Weight | Growth Rate |
| 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±27.9 | 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

**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
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<sup>a</sup> | 42.0<sup>a</sup> | 1.95  | 10.6<sup>b</sup> |
|                   | Female          | 36.2<sup>b</sup> | 39.6<sup>b</sup> | 1.99  | 14.2<sup>a</sup> |
|                   | LSD 0.05        | 1.4   | 1.25          | 0.09  | 1.47           |
| Strain            | Steggels        | 52.2  | 36.1          | 1.965<sup>ab</sup> | 12.76<sup>b</sup> |
|                   | Cobb            | 52.8  | 35.4          | 1.936<sup>b</sup> | 15.14<sup>a</sup> |
|                   | Ingham          | 54.4  | 37.5          | 1.904<sup>b</sup> | 9.33<sup>c</sup> |
|                   | Barter          | 52    | 35.3          | 1.977<sup>ab</sup> | 13.84<sup>ab</sup> |
|                   | LSD 0.05        | 2.4   | 3.4           | 0.16  | 2.180          |
| Dietary regimen   | SF              | 36.2d | 33.7<sup>c</sup> | 2.540<sup>a</sup> | 9.59<sup>c</sup> |
|                   | SS              | 53.8<sup>b</sup> | 40.3<sup>a</sup> | 1.701<sup>c</sup> | 7.87<sup>c</sup> |
|                   | FS              | 67.9<sup>a</sup> | 35.0<sup>b</sup> | 1.474<sup>d</sup> | 15.27<sup>b</sup> |
|                   | FF              | 48.3<sup>c</sup> | 31.7d         | 2.098<sup>b</sup> | 17.81<sup>a</sup> |
|                   | LSD 0.05        | 2     | 1             | 0.14  | 2.53           |
| Source            | Sex             | **    | **            | NS    | **            |
|                   | Strain          | NS    | 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 superscript 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)

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

**CONCLUSION**
production performance when a diet was introduced.

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