



Effect of Energy Levels of Diets Formulated on Total or Digestible Amino Acid Basis on Broiler Performance

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ABSTRACT

This study was conducted to evaluate the performance and carcass and breast yields of broilers fed two different energy levels (3,200 or 2,900 kcal ME/kg) and two ways of expressing amino acid requirements (total – TAA or digestible – DAA) between 21 and 42 days of age. The results showed that broilers fed the diet containing 3,200 kcal ME/kg had higher weight gain ($P=0.015$), better feed conversion ($P=0.001$), and higher abdominal fat deposition ($P=0.001$) as compared to those fed the diet containing 2,900 kcal ME/kg. Diets formulated on DAA basis promoted higher weight gain ($P=0.043$), better feed conversion ($P=0.010$) and better conversion of ME intake into weight gain ($P=0.007$) as compared to those formulated on TAA basis. The results of this study suggest that formulation based on DAA is necessary if the diets contain protein sources that are not reliable in terms of amino acid digestibility. The response to formulation based on DAA was minimized when birds received the low energy level diet (2,900 kcal ME/kg).

INTRODUCTION

In the past, poultry diets were formulated to meet crude protein requirements. However, the growth of the synthetic amino acid industry permitted the reduction of crude protein levels in diets and nutritionists were then able to formulate diets considering the specific requirements of essential amino acids. Recent studies show the importance of formulation based on digestible amino acids (DAA), as well as of amino acid balance, for optimal performance and reduction of environmental contamination due to better use of the protein of the diet and lower amount of nitrogen in the excreta (Baker & Han, 1994; Rostagno *et al.*, 1995; Dari & Penz, 1996).

The wide variation in the composition and the amount of protein and/or amino acids present in animal byproducts is of great concern when using these raw materials. Protein quality and amino acid digestibility of these byproducts depend primarily on processing temperature, cooking time and drying process, which vary according to the processing system.

The excess of energy intake is related to the calorie:protein (C:P) ratio in the diet, and consequently, to carcass composition. In isocaloric diets, if crude protein level is decreased, there is an increase in C:P ratio, which result in fatter carcasses (Summers *et al.*, 1965; Griffiths *et al.*, 1977; Rosebrough & Steele, 1985).

This study was conducted to evaluate the live performance and carcass composition of broilers fed diets with two energy levels (3,200 or 2,900 kcal ME/kg) and two ways to express amino acid requirements, either as total amino acid (TAA) or digestible amino acid (DAA).



MATERIALS AND METHODS

A total of 200 male Ross chicks was used. During the starter phase (1 to 18 days of age), chicks were housed in a commercial broiler house and fed according to the requirements proposed by the National Research Council (NRC, 1994). At 18 days of age, birds were individually weighed, selected by weight and transferred to a room equipped with cages, measuring 80 x 35 cm. Broilers were submitted to a 3-day period of adaptation to the new environment, since housing was changed from a poultry-house with wood shavings litter to wired-floor cages. Water and feed were also supplied *ad libitum*. The lighting regimen was continuous, with 24 hours of light daily, throughout the experimental periods.

It was used two energy levels (2,900 and 3,200 kcal ME/kg of diet) and two forms of expressing amino acid requirements (TAA and DAA), in the ratio recommended by researchers of the University of Illinois, USA, for ideal protein for broilers. The total amino acid values of the ingredients were assayed by high-pressure liquid chromatography analysis. In order to determine

digestibility, the levels of TAA determined in the analysis were multiplied by their respective digestibility coefficients, as determined by Heartland Lysine (1995). Therefore, the following treatments were applied: diet with 2,900 kcal ME/kg, formulation based on TAA; diet with 2,900 kcal ME/kg, formulation based on DAA; diet with 3,200 kcal ME/kg, formulation based on TAA; diet with 3,200 kcal ME/kg, formulation based on DAA.

Diets were formulated based on corn and soybean meal, in which amino acids are highly digestible, and on meat meal, wheat middling, and feather meal, in which amino acids have low digestibility. Diets are shown on Table 1. Diets were fed in mash form with mean geometric diameter of 850µm.

During the experimental period, feed intake, metabolizable energy intake, weight gain and feed conversion were measured. In order to evaluate carcass quality, at the end of the experimental period (42 days of age), 2 birds with body weights as close as possible to the average body weight of the experimental unit were slaughtered per repetition. These birds were weighed, defeathered, eviscerated, and weighed again to obtain carcass weight (including head and feet),

Table 1 - Composition and calculated analysis of diets.

Ingredient (%)	2,900 kcal ME/kg, TAA	2,900 kcal ME/kg, DAA	3,200 kcal ME/kg, TAA	3,200 kcal ME/kg, DAA
Yellow corn	62.36	62.36	62.36	62.36
Soybean meal 44	14.72	14.72	14.72	14.72
Meat and bone meal	5.00	5.00	5.00	5.00
Wheat bran	5.00	5.00	5.00	5.00
Feather meal	5.00	5.00	5.00	5.00
Soybean oil	2.17	2.17	5.57	5.57
Oyster shell	0.86	0.86	0.86	0.86
Mineral and vitamin mix ¹	0.26	0.26	0.26	0.26
Salt	0.24	0.24	0.24	0.24
Dicalcium Phosphate	0.12	0.12	0.12	0.12
L-Threonine	0.00	0.04	0.00	0.04
L-Lysine-HCl	0.21	0.23	0.21	0.23
DL-Methionine	0.06	0.10	0.06	0.10
Kaolin	4.00	3.90	0.60	0.50
Calculated Analysis				
Crude protein (%)	20.0	20.0	20.0	20.0
ME (kcal/kg)	2,900	2,900	3,200	3,200
Calcium (%)	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.35	0.35	0.35	0.35
Total sulphur amino acids (%)	0.81	-	0.81	-
Digestible sulphur amino acids (%)	-	0.67	-	0.67
Total lysine (%)	1.07	-	1.07	-
Digestible lysine (%)	-	0.89	-	0.89
Total threonine (%)	0.74	-	0.74	-
Digestible threonine (%)	-	0.64	-	0.64
Na (%)	0.18	0.18	0.18	0.18

¹ - Provides per kg of diet: vitamin A (7,000 IU); vitamin D₃ (1,400 IU); vitamin E (16.65 mg); vitamin K (1.5 mg); vitamin B₁ (0.6 mg); vitamin B₂ (2.36 mg); vitamin B₆ (0.6 mg); vitamin B₁₂ (0.013 mg); biotin (0.15 mg); choline (1.54 g); pantothenic acid (9.32 mg); niacin (30.12 mg); folic acid (1.42 mg); selenium (0.65 mg); iodine (0.35 mg); iron (57.72 mg); copper (12.30 mg); zinc (141.48 mg); manganese (173 mg).



breast weight and abdominal fat weight. Carcass yield was determined as the carcass weight in relation to body weight, and expressed as percentage of body weight (%), whereas breast yield (with bone) and abdominal fat were expressed as percentages of the carcass weight.

A completely randomized experimental design was used, in a factorial scheme (2 x 2). The experimental unit consisted of a cage with 10 birds, with 5 replicates per treatment, with a total of 20 cages. Data were submitted to analysis of variance and Scheffé's test to determine contrasts among treatments using the General Linear Model (GLM) procedure of SAS (1998).

RESULTS AND DISCUSSION

Feed intake was not significantly influenced by the way amino acid requirements were expressed, which is consistent with previously published results from experiments comparing diets based on alternative ingredients with low amino acid digestibility to diets based on ingredients with high amino acid digestibility (corn and soybean meal), and to diets with low digestibility ingredients supplemented with synthetic amino acids (Rostagno *et al.*, 1995; Dari & Penz, 1996). The formulation based on total or digestible amino acids

did not influence metabolizable energy intake. In addition, feed intake was not influenced by dietary energy level. However, metabolizable energy intake was higher in birds fed diets containing 3,200 kcal ME/kg ($P=0.001$). This may be explained by the fact that the diet with 3,200 kcal ME/kg merely promoted a trend to reduce feed intake ($P=0.101$). Therefore, if feed intake was similar in both diets, it was expected that diets with higher metabolizable energy would result in higher energy intake during the experimental period (Table 2).

Diet formulation based on DAA resulted in better weight gain and feed conversion, which agrees with results published by Fernandes *et al.* (1985), Rostagno *et al.* (1995) and Dari & Penz, 1996. Diets with higher metabolizable energy level (3,200 kcal ME/kg) also promoted higher weight gain and better feed conversion; these results agree with those published by Sizemore & Siegel (1993) and Leeson *et al.* (1996).

The evaluation of the contrasts showed that the effects of the formulation based on DAA were significant only when diets contained the high energy level. The diet with 3,200 kcal ME/kg and DAA promoted higher weight gain as compared to the diet with 3,200 kcal ME/kg and TAA. When low energy diets were considered, the result of the formulation based on DAA was not different from that obtained with the

Table 2 - Feed intake, body weight gain, feed conversion and metabolizable energy intake.

Aminoacid (AA)	ME (kcal/kg diet)	Feed intake (g)	Body weight gain (g)	Feed conversion (g/g)	ME intake (kcal)
Total	2,900	3,278	1,462	2,244	9,506
Digestible	2,900	3,247	1,472	2,208	9,416
Total	3,200	3,222	1,486	2,166	10,310
Digestible	3,200	3,168	1,596	1,986	10,138
Main effects					
Total AA		3,250	1,474	2,205	9,908
Digestible AA		3,208	1,534	2,097	9,777
2,900 kcal ME/kg		3,262	1,467	2,226	9,416
3,200 kcal ME/kg		3,195	1,541	2,076	10,224
Probability					
AA		0.292	0.043	0.010	0.285
Energy		0.101	0.015	0.001	0.001
AA*Energy		0.775	0.090	0.071	0.734

Table 3 - Contrasts for feed intake, body weight gain and feed conversion.

Contrasts	Feed intake (g)	Body weight gain (g)	Feed conversion (g/g)
2,900 DAA x 2,900 TAA	3,247 x 3,278	1,472 x 1,462	2,208 x 2,244
3,200 DAA x 3,200 TAA	3,168 x 3,222	1,596 x 1,486	1,986 x 2,166
2,900 DAA x 3,200 TAA	3,247 x 3,222	1,472 x 1,486	2,208 x 2,166
Probability			
2,900 DAA x 2,900 TAA	0.580	0.787	0.503
3,200 DAA x 3,200 TAA	0.343	0.012	0.003
2,900 DAA x 3,200 TAA	0.652	0.722	0.436



formulation based on TAA (Table 3). These results suggest that, in the combination of low energy and DAA, energy was not sufficient to allow the expression of DAA-based formulation into growth with the same intensity as the combination of high energy and DAA. It was also found that there were no differences in weight gain among the low-energy diet based on DAA and the high-energy diet based on TAA (Table 2).

Contrasts showed that feed conversion was similar for the low-energy diet based on DAA and the low-energy diet based on TAA. However, feed conversion promoted by the high-energy diet formulated on DAA basis was significantly different from that promoted by the high-energy diet formulated on TAA basis (Table 3). This indicates that the combination high energy and DAA resulted in higher efficiency of feed use, that is, broilers fed this diet had higher weight gain with lower feed intake as compared to those fed lower energy level and DAA. It is possible that there was a lack of energy for tissue accretion, which led to higher intake in birds fed the lower energy diet in order to obtain the same calorie intake, resulting in worse feed conversion.

Diet formulations based on DAA resulted in better conversion of ME intake into weight gain (Table 2). This shows the higher efficiency of these diets as they allow a better transformation of ME intake into tissue synthesis and accretion. This is possibly related to a higher amino acid availability to use the available energy to synthesize muscle. Diets formulated with lower energy level (2,900 kcal ME/kg) promoted a trend to a better conversion of ME intake into body weight. This suggests that the excess of ME intake caused by the diet with 3,200 kcal ME/kg was deposited as fat, which is metabolically less efficient than lean tissue accretion. Indeed, when abdominal fat deposition was evaluated, higher fat deposition was observed in birds fed diets

with 3,200 kcal ME/kg (Table 4). It was also verified that the low-energy diet formulated on DAA basis promoted better conversion of ME into weight gain. The combination DAA and low energy possibly led to less ME available for fat deposition.

Formulation based on DAA did not influence carcass and breast yields, independent of the dietary energy level (Table 4). These results are consistent with Rostagno *et al.* (1995) and Dari & Penz (1996), who found no differences in carcass yield.

Dietary energy levels had no influence on carcass and breast yield parameters. These data corroborate the results found by Nobre *et al.* (1994), who evaluated four energy levels and reported no significant differences in carcass yield.

When contrasts were evaluated, a significant difference was found for broilers fed a diet formulated on DAA (Table 4). Thus, the same hypothesis mentioned in the discussion on weight gain is also considered in this situation. The lower DAA level may have been compensated by the higher feed intake, and thus higher amino acid intake, in birds fed the low energy diet and DAA, that causes a deficiency of energy to synthesize tissues.

Diets formulated on DAA did not significantly influence abdominal fat deposition (Table 4). Dietary energy level significantly influenced abdominal fat percentage. High-energy diets resulted in higher abdominal fat deposition. This increase in abdominal fat percentage is probably related to the significant increase in metabolizable energy intake.

CONCLUSIONS

The formulation based on DAA is needed for diets containing protein sources that are not reliable in terms of amino acid digestibility.

Table 4 - Carcass and breast yield, abdominal fat deposition and efficiency of ME utilization (ME/body weight gain).

Aminoacid (AA)	ME (kcal/kg)	Carcass (%)	Breast (%)	Abdominal fat (%)	Efficiency of ME utilization
Total	2,900	83.68	18.67	2.05	6.509
Digestible	2,900	84.85	18.58	2.23	6.405
Total	3,200	84.24	18.63	2.75	6.939
Digestible	3,200	84.41	19.83	2.68	6.359
Main effects					
Total AA		83.96	18.65	2.40	6.724
Digestible AA		84.63	19.20	2.45	6.382
2,900 kcal EM/kg		84.26	18.62	2.72	6.457
3,200 kcal EM/kg		84.33	19.23	2.14	6.649
Probability					
AA		0.231	0.100	0.727	0.007
Energy		0.906	0.072	0.0001	0.103
AA*Energy		0.372	0.057	0.409	0.047



Broilers fed low energy diets apparently obtain the adequate amount of energy by a higher feed intake. However, this is not sufficient to achieve optimal performance. On the other hand, when high-energy diets are fed, feed intake seems to be regulated by amino acid requirements, as birds have an apparent excessive metabolizable energy intake, which results in fatter carcasses. The interaction between digestible amino acids and higher energy level allows the full expression of the genetic potential for growth in broilers.

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