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Diets Formulated on Total or Digestible Amino Acid Basis with Different Energy Levels and Physical form on Broiler Performance

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ABSTRACT

We studied the effects of two different systems of expressing amino acid requirements (total – TAA or digestible – DAA), two energy levels (2,900 or 3,200 kcal of ME/kg) and two physical forms (mash or pellet) on the performance of male broilers from 21 to 42 d of age. Diets formulated on DAA basis improved feed conversion ($p<0.001$) and the conversion of consumed ME into body weight gain ($p<0.001$). Birds fed 3,200 kcal ME/kg presented better feed conversion ($p<0.001$), higher abdominal fat deposition ($p<0.001$) and worse conversion of consumed ME into body weight gain ($p<0.001$) as compared to birds fed 2,900 kcal ME/kg. Birds fed pelleted feed had higher feed intake ($p<0.001$), higher weight gain ($p<0.001$), better feed conversion ($p<0.001$), better conversion of consumed ME into body weight gain ($p<0.001$) and higher abdominal fat deposition ($p<0.001$). The results obtained in the present study suggest that feed formulation based on DAA is required when diets contain protein sources which amino acid digestibility is unreliable. Besides, pelleted feed improves performance parameters of broilers.

INTRODUCTION

Recent studies show the importance of diet formulation based on digestible amino acids (DAA), as well as amino acid balance, on optimal performance and reduction of environment contamination due to better use of diet protein and lower nitrogen levels in the excreta (Baker & Han, 1994; Rostagno *et al.*, 1995). The wide variation in the composition and amount of protein and/or amino acids present in animal byproducts is of great concern when using these raw materials. Protein and amino acid digestibility in animal byproducts primarily depend on processing temperature, cooking time and drying process, which vary according to the processing system that is used.

The excess of energy consumed by birds is deposited as fat (Rosebrough & Steele, 1985). Excessive energy intake is related to the calorie:protein (C:P) ratio in the diet, and consequently, to carcass composition. Isocaloric diets with decreasing protein levels show increasing C:P ratio, which result in carcasses with higher fat percentage (Donaldson, 1985; Rosebrough & Steele, 1985).

Pelleted feeds may especially favor the intake of birds, as birds might have difficulty picking up food if finely ground diets are provided. Several other benefits in terms of broiler performance are also attributed to pelleting, such as the improvement in the digestibility of some nutrients (Moran, 1987).

This study aimed at evaluating the live performance and carcass composition of broilers fed diets formulated on total (TAA) or digestible amino acid (DAA) basis, two energy levels (2,900 or 3,200 kcal/kg) and two physical forms (mash or pellet).

MATERIALS AND METHODS

Four hundred Ross male chicks (21 to 42 days old) were used in the experiment. 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 NRC (1994). Feed and water were supplied *ad libitum*. At 18 days of age, birds were individually weighed, selected by weight and transferred to a room equipped with metabolic cages, measuring 80 x 35 cm. The broilers were submitted to a 3-day period of acclimation to the new environment because they have been transferred from a house with wood-shavings as litter material to wired-floor cages. Water and feed were also supplied *ad libitum*. Light was provided continuously throughout the experimental period.

It was evaluated two systems of expressing amino acid requirements (TAA and DAA) in the ratio recommended by Baker & Han (1994) for ideal protein for broilers, two energy levels (2,900 or 3,200 kcal ME/kg of diet) and two physical forms (mash or pellet). Amino acid levels in the ingredients were obtained by high-pressure liquid chromatography. TAA levels were then multiplied by their respective digestibility coefficients to determine digestibility, as suggested by Heartland Lysine (1995). Therefore, the following treatments were applied:

- T1- Diet formulation based on TAA, with 2,900 kcal of ME/kg (mash).
- T2- Diet formulation based on DAA, with 2,900 kcal of ME/kg (mash).
- T3- Diet formulation based on TAA, with 2,900 kcal of ME/kg (pellet).
- T4- Diet formulation based on DAA, with 2,900 kcal of ME/kg (pellet).
- T5- Diet formulation based on TAA, with 3,200 kcal of ME/kg (mash).
- T6 - Diet formulation based on DAA, with 3,200 kcal of ME/kg (mash).
- T7- Diet formulation based on TAA, with 3,200 kcal of ME/kg (pellet).
- T8- Diet formulation based on DAA, with 3,200 kcal of ME/kg (pellet).

Diets were formulated based on corn, soybean meal, meat meal, wheat bran and feather meal (Table 1).

During the experimental period, feed intake, weight gain, feed conversion and efficiency of utilization of ME (ME intake (kcal)/weight gain (g)) were measured. Carcass quality was evaluated at the end of the experimental period (42 days of age) in 2 birds per repetition. These birds were weighed, killed, defeathered, eviscerated, and parts were weighed to obtain carcass weight (including head and feet) and abdominal fat weight. Carcass yield was determined as the carcass weight relative to body weight and expressed as percentage of body weight. Abdominal fat was expressed as percentage of carcass weight."

Table 1 - Composition and calculated analysis of diets.

Ingredients (%)	T1/T3	T2/T4	T5/T7	T6/T8
Yellow corn	61.61	61.61	61.61	61.61
Soybean meal 44	15.29	15.29	15.29	15.29
Meat meal	5.00	5.00	5.00	5.00
Wheat bran	6.50	6.50	6.50	6.50
Feather meal	5.00	5.00	5.00	5.00
Soybean oil	1.44	1.44	4.85	4.85
Oyster meal	0.56	0.56	0.56	0.56
Mineral mix and Vitamin premix*	0.13	0.13	0.13	0.13
NaCl	0.24	0.24	0.24	0.24
L-Threonine	0.00	0.04	0.00	0.04
L-Lysine (HCl)	0.32	0.35	0.32	0.35
DL-Methionine	0.05	0.09	0.05	0.09
Sand	3.86	3.75	0,45	0,34
Calculated analysis				
Crude protein (%)	20.00	20.00	20.00	20.00
Metabolic energy 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 sulfur amino acids (%)	0.80	0.84	0.80	0.84
Digestible sulfur amino acids (%)	0.63	0.67	0.63	0.67
Lysine total (%)	1.06	1.09	1.06	1.09
Lysine digestible (%)	0.86	0.89	0.86	0.89
Threonine total (%)	0.74	0.78	0.74	0.78
Threonine digestible (%)	0..58	0.62	0.58	0.62
Na (%)	0.18	0.18	0.18	0.18

*Provides per kg of diet: Vitamin A (7,000 IU); Vitamin D_3 (1,400 IU); Vitamin E (16.65 mg); Vitamin K (1.5 mg); Vitamin B_1 (0.6 mg); Vitamin B_2 (2.36 mg); Vitamin B_6 (0.6 mg); Vitamin B_{12} (1.320 mcg); 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).

A completely randomized experimental design was used, in a factorial arrangement (2 x 2 x 2). The experimental unit consisted of a cage with 10 birds, there were 5 replicates per treatment and a total of 40 cages. Data were submitted to analysis of variance and Scheffé's test to determine contrasts among treatments.

RESULTS AND DISCUSSION

The diets formulated on DAA basis, as well as the high-energy diets (3,200 kcal/kg), resulted in better feed conversion ($p<0.001$), although no differences were seen for feed intake and weight gain (Table 2). The improvement in feed conversion shows that formulation on DAA basis is required for the diets formulated with protein sources that contain amino acids with low digestibility. 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 ingredients. According to Parsons (1992), diet formulation based on total amino acid is equal to diet formulation based on crude energy requirements. Formulation based on DAA is needed in those diets containing protein sources that are not reliable in terms of amino acid digestibility (Maiorka *et al.*, 2004).

The process of pelleting (Table 2) promoted a significant increase in feed intake, weight gain, and feed conversion (p<0.001). Such improvements caused by pelleting may be attributed to the combined effects of heat, pressure, and feed humidity. A certain degree of gelatinization occurs, which allows a better use of the nutrients by the birds. The temperature acts on carbohydrates, breaking down amylose and amylopectin granules, and also changes the natural tertiary structure of proteins, improving their digestibility (Moran, 1987). Jensen *et al.* (1962) reported that the increase in feed density promoted by pelleting resulted in increased growth rate of broilers. These authors observed that birds fed mash diet consumed the same amount of feed three times slower than birds fed pelleted diet.

Table 2 - Feed intake, weight gain, feed conversion and metabolizable energy intake of broilers fed diets formulated based on TAA or DAA, with different ME levels (2,900 or 3,200 kcal/kg) and different physical form (pellet or mash) from 21 to 42 days of age.

	Feed intake (g)	Weight gain (g)	Feed conversion (g/g)
TAA	3,335	1,392	2.406
DAA	3,293	1,424	2.317
2,900 kcal ME/kg	3,315	1,384	2.406
3,200 kcal ME/kg	3,313	1,431	2.318
Mash	3,098	1,288	2.411
Pellet	3,530	1,527	2.312
	Probability		
AA	0.393	0.212	0.001
Energy	0.959	0.067	0.001
Physical form	0.001	0.001	0.001
AA * Energy	0.803	0.422	0.069
AA * Physical form	0.279	0.158	0.226
Energy * Physical form	0.077	0.076	0.212
AA * Energy * Physical form	0.814	0.906	0.416

Feed formulation based on DAA did not change weight gain when feed was pelleted. This finding suggests three possibilities. Firstly, feed intake was much higher when pelleted feed was used, and thus the birds ingested the amount of digestible amino acids required for the expression of optimal performance. Secondly, pelleting may have resulted in higher amino acid digestibility due to the action of heat and pressure on protein tertiary structure, enhancing the action of acids and enzymes responsible for their digestion, and therefore increasing amino acid availability (Moran, 1982). Finally, the increase in ME intake promoted by pelleting may have improved the use of ingested amino acids in the protein synthesis possibly due to minimization of the use in energy production.

Animals fed low-energy diets try to obtain adequate energy intake by increasing feed consumption (Rosebrough & Steele, 1985). In the present study, feed intake was not influenced by dietary energy level. The intake was not higher in birds fed low-energy mash diets probably because the feed geometrical mean diameter (550 mm) was too small. Since birds have difficulty picking up finely ground diets, feed intake was decreased.

The beak size plays an important role in feed intake regulation, since the birds have difficulty picking up and ingesting particles that are much smaller or much larger than the beak (Moran, 1982). Besides, the saliva in birds is produced in low quantities and has high viscosity, which also contributes to a lower intake of diets with small particle size (Turk, 1982). Thus, a thick paste is formed and adheres to the beak, impairing saliva secretion, picking up of food and swallowing. However, these difficulties were partially compensated when the pelleted diet was fed.

The efficiency of ME utilization (Table 4) was significantly better when birds were fed pelleted diets (p<0.001) formulated on DAA basis (p<0.001) and containing 2,900 kcal ME/kg (p<0.001).

Carcass yield was not significantly influenced by energy level, physical form and diet formulation based on DAA or TAA.

Diets formulated with the higher energy level (3,200 kcal ME/kg) and pelleted diets increased abdominal fat deposition (p<0.001).

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

Contrasts	Feed intake (g)	Weight gain (g)	Feed conversion (g/g)
2,900 Pellet x 3,200 Mash	3,576 x 3,142	1,529 x 1,338	2.340 x 2.325
DAA, 3,200 Pellet x TAA, 3,200 Pellet	3,435 x 3,531	1,514 x 1,536	2.268 x 2.299
DAA, 3,200 Mash x TAA, 3,200 Mash	3,160 x 3,124	1,360 x 1,315	2.325 x 2.377
DAA, 2,900 Mash x TAA, 2,900 Mash	3,048 x 3,061	1,284 x 1,194	2.377 x 2.566
DAA, 2,900 Pellet x TAA, 2,900 Pellet	3,527 x 3,625	1,536 x 1,523	2.298 x 2.382
Probability			
2,900 Pellet x 3,200 Mash	0.001	0.001	0.761
DAA, 3,200 Pellet x TAA, 3,200 Pellet	0.336	0.667	0.542
DAA, 3,200 Mash x TAA, 3,200 Mash	0.720	0.378	0.312
DAA, 2,900 Mash x TAA, 2,900 Mash	0.900	0.077	0.001
DAA, 2,900 Pellet x TAA, 2,900 Pellet	0.329	0.796	0.103

Table 4 - Efficiency of ME utilization, carcass yield and abdominal fat deposition of broilers fed diets formulated based on TAA or DAA, with different ME levels (2,900 or 3,200 kcal/kg) and different physical form (pellet or mash) from 21 to 42 days of age.

	Efficiency of ME utilization (ME/body weight gain)	Carcass yield (%)	Abdominal Fat (%)
TAA	7.33	85.99	2.25
DAA	7.06	85.87	2.14
2,900 kcal ME/kg	6.98	85.57	1.83
3,200 kcal ME/kg	7.74	86.29	2.57
Mash	7.34	86.09	1.88
Pellet	7.05	85.77	2.53
Probability			
AA	0.001	0.872	0.552
Energy	0.001	0.340	0.001
Physical form	0.001	0.665	0.001
AA * Energy	0.094	0.588	0.779
AA * Physical form	0.235	0.243	0.519
Energy * Physical form	0.292	0.642	0.359
AA * Energy * Physical form	0.447	0.139	0.143

Table 5 - Contrasts for efficiency of ME utilization, carcass yield and abdominal fat deposition.

Contrasts	Efficiency of ME utilization (ME/body weight gain)	Carcass yield (%)	Abdominal fat (%)
2,900 Pellet x 3,200 Mash	6.79 x 7.52	85.58 x 86.66	2.24 x 2.28
DAA, 3,200 Pellet x TAA, 3,200 Pellet	7.26 x 7.36	86.22 x 85.69	2.97 x 2.64
DAA, 3,200 Mash x TAA, 3,200 Mash	7.44 x 7.61	86.66 x 86.12	2.10 x 2.55
DAA, 2,900 Mash x TAA, 2,900 Mash	6.89 x 7.44	86.30 x 84.81	1.42 x 1.43
DAA, 2,900 Pellet x TAA, 2,900 Pellet	6.66 x 6.91	85.30 x 85.86	2.08 x 2.40
Probability			
2,900 Pellet x 3,200 Mash	0.001	0.327	0.738
DAA, 3,200 Pellet x TAA, 3,200 Pellet	0.674	0.726	0.368
DAA, 3,200 Mash x TAA, 3,200 Mash	0.502	0.975	0.226
DAA, 2,900 Mash x TAA, 2,900 Mash	0.095	0.329	0.982
DAA, 2,900 Pellet x TAA, 2,900 Pellet	0.387	0.959	0.499

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