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Values of Metabolizable Energy and Metabolization of Nutrients for Slow- and Fast-growing Birds at Different Ages

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ABSTRACT

Two trials were performed to determine apparent metabolizable energy (AME) and AME corrected for zero nitrogen balance (AMEn) values and coefficients of apparent metabolizability of nitrogen (CAMN) and of ether extract (CAMEE) of slow- and fast-growing broilers (Isa label and Cobb, respectively) fed four different diets between 10 to 17 days or 28 to 35 days of age. The method of total excreta collection was applied. The tested feedstuffs were corn, whole corn germ (WCG), sorghum, and soybean meal (SBM). A randomized block experimental design was applied, with two treatments (breeds) and four replicates of ten animals each in the first trial, and four replicates of six animals each in the second trial. No differences in CAMN values were observed between the breeds; however, Isa Label birds presented higher CAMEE for all tested feedstuffs. The AME and AMEn values obtained in Isa Label chickens fed the corn diet were 5.75 and 3.44% higher relative tothe Cobb birds, respectively. Breed did not influence AME and AMEn values of the other tested feedstuffs. Independently of breed, age influenced the AME and AMEn values of WCG, sorghum and SBM, suggesting that birds become utilize feed more efficiently as they age.

INTRODUCTION

In order to formulate economically viable feeds, it is important to know the nutritional value of feedstuffs, which requires determining their chemical composition, nutrient availability, and energy content and utilization by a given species (Generoso *et al.*, 2008). Although feedstuffs are often evaluated for fast-growing chickens, few studies have been performed to determine feed nutrient utilization by slow-growing chicken strains reared in alternative animal production systems.

Additional studies are required to elucidate nutrient utilization of protein- and energy-rich feeds used in slow-growing broilers, particularly because bird age, which is associated with the development of the gastrointestinal tract, may interfere with the nutritional evaluation of feeds, as mentioned by Calderano *et al.* (2012).

According to Mendonça *et al.* (2008), slow-growing broilers show increased energy metabolization capacity as they age. Therefore, the use of values of apparent metabolizable energy (AME) corrected for zero nitrogen balance (AMEn) derived from published tables to assess feeds may overestimate energy utilization by those birds during the early stages of life and underestimate it at older ages.

Considering that the growth rate of Isa Label chickens is slower than that of fast-growing broiler strains, their rates of digestive tract growth and enzyme production may be different from those of broilers selected to fast growth. This difference in gastrointestinal development may influence nutrient utilization, which has implications for the formulation of feeds for slow-growing chickens, which feeds are commonly formulated based on nutritional data derived from fast-growing breeds.

The current study was performed to determine the chemical composition, coefficients nutrient metabolization, and levels of apparent metabolizable energy and apparent metabolizable energy corrected for nitrogen of selected feedstuffs included in the diets of slow- and fast-growing broiler chickens at different ages.

MATERIALS AND METHODS

Two metabolism assays were performed in the poultry sector of the Federal Institute Goiano (Instituto Federal Goiano),Rio Verde campus, state of Goiás, Brazil. This project was approved by our institutional ethics committee for animal research under the protocol number 012/2012.

Experimental Design, Animals, Housing and Diets

The assays evaluated a broiler strain selected for slow growth rate (Isa Label) and one selected for high growth rate (Cobb) during the periods of 10 to 17 days and 28 to 35 days of age.

Energy values and coefficients of apparent metabolizability of nutrients were determined for each evaluated feedstuff. A randomized block design was applied, in which each cage represented one block with two treatments (breeds). During the first trial, there were four replicates of 10 birds each, and during the second trial, four replicates of six birds each. Data were submitted to joint analysis of variance to verify the effect of bird age on the evaluated variables.

In order to determine the coefficients digestibility and metabolizable energy levels, a reference diet was formulated, and the four test feeds were obtained by substituting 40% of the reference feed by the tested feedstuffs. Corn, sorghum, soybean meal (SBM) and whole corn germ (WCG) were evaluated. Nutrient utilization was determined in four groups of 10 birds of each breed that were fed the reference diet. The ingredient composition and calculated nutritional values of the reference diet are presented in Table 1.

Birds were housed in galvanized-wire cages measuring 0.90 m x 0.60 m x 0.45 m. In the first experiment (10 to 17 days of age), 200 male broiler chickens from each breed, with initial average bodyweights of 130.33 ± 6.51 gand202.69 ± 10.13 g for the Isa Label and Cobb breeds, respectively, were evaluated. In the second experiment (28 to 35 days of age), 120 chickens from each breed, with initial average body weights of 632.0 ± 31.58 g and 1055.0 ± 50.26 g for the Isa Label and Cobb breeds, respectively, were used.

Cages were equipped with trough feeders and nipple drinkers. Water and feed were provided *ad libitum* for the entire experimental period. The feeders were refilled twice a day to avoid waste.

Table 1 – Ingredient composition (%) and calculated nutritional levels of the reference feed

Ingredient	% of Natural Matter	Calculated Levels	
Corn grain	57.57	AME (kcal/kg)	3.050
Soybean meal45%	34.66	Crude Protein, %	21.14
Soybean oil	3.03	Digestible Lys, %	1.19
Dicalcium phosphate	1.77	Digestible Met+Cys, %	0.85
Limestone	0.86	Digestible Thr, %	0.72
Regular salt	0.44	Calcium, %	0.89
DL-Methionine	0.28	Available phosphorus, %	0.44
L-Lysine	0.25	Sodium, %	0.22
Avilamycin, 10%	0.01		
Mineral Premix[1]	0.04		
Vitamin Premix[2]	0.04		
BHT Antioxidant	0.01		
Inert material[3]	1.00		
Total	100.00		

[1]Compostion per kg of the product: manganese - 75,000 mg; iron - 20,000 mg; zinc -50,000 mg; copper – 4,000 mg; cobalt - 200 mg; iodine – 1,500 mg and carrier q.s.p. -1,000 g.

[2]Composition per kg of the product: Folic acid – 1,600 mg/kg; Pantothenic acid – 29 g/kg; BHT – 5,000 mg/kg; Biotin – 60 mg/kg; Niacin – 87 g/kg; Vitamin A – 20,000.000 IU/kg; Vitamin B1 – 3,000 mg/kg; Vitamin B12 – 28,000 mcg/kg; Vitamin B2 – 12 g/kg; Vitamin B6 – 6,000 mg/kg; Vitamin D3 – 5,000,000 IU/kg; Vitamin E – 40,500 IU/kg; Vitamin K3 – 4,800 IU/kg and carrier q.s.p. -1,000 g.

[3]Washed sand

Experimental Procedure and Chemical Analysis

Energy values and coefficients of apparent metabolizability of nitrogen (CAMN) and of ether extract (CAMEE) were determined using the method of total excreta collection (Sakomura & Rostagno, 2007). Birds were submitted to four-day adaptation period of to the cages and to the experimental diets before the period of four days of excreta collection, performed daily at 8:00 am and 3:00 pm. An aluminum tray lined with a plastic sheet was placed under each cage for excreta collection.

Excreta samples, tested feedstuffs, and experimental feeds were analyzed in the laboratory of Animal Nutrition of the Federal Institute Goiano to determine dry matter (DM), nitrogen (N), and gross energy (GE) contents. Tested feedstuffs were also analyzed for crude fiber (CF), ether extract (EE) crude protein (CP), ash (A), and nitrogen-free extract (NFE) contents according to the protocol of Silva & Queiroz (2002). Total amino acid levels of the feedstuffs were analyzed by high-performance liquid chromatography (HPLC) at ADISSEO, a company that provides technical animal nutrition support.

Calculation of Variables

The variables AME and AMEn were calculated using the equations described by Matterson *et al.* (1965).The following equations were applied to calculate CAMN and CAMEE:

$$\text{CAM of a nutrient (\%)} = \frac{\text{Nutrient intake - Nutrient excretion}}{\text{Nutrient intake}} \times 100$$

The AME, AMEn, CAMN, and CAMEE values of the experimental diets were evaluated for each rearing period.

Statistical analyses

To verify the effect of bird age on the coefficients of nutrient metabolizability, and AME and AMEn values were assessed by conjunct analysis of variance using the Sisvar software (System for Analysis of Variance, version 5.3, Ferreira *et al.*, 2011). The differences between breeds and age means were determined by the Tukey's test at 5% probability level.

RESULTS AND DISCUSSION

Small variations were observed in the energy content of the tested feedstuffs (Table 2) relative to literature reports (Brito *et al.*, 2005; Generoso *et al.*, 2008; Mello *et al.*, 2009). Total amino acids content of the tested feedstuffs (Table 3) were consistent with those observed by Freitas *et al.* (2005) and Rostagno *et al.* (2011).

Table 2 – Chemical composition and gross energy values of the tested feedstuffs.

	Corn	Whole corn germ	Sorghum	Soybean meal
DM (%)	89.62	88.98	90.22	88.50
EE (%)	4.64	10.03	3.15	3.24
CP (%)	8.41	10.96	9.32	47.70
CF (%)	1.93	2.61	2.72	3.71
A (%)	1.20	2.74	1.53	6.51
NFE (%)	73.44	58.88	72.53	31.15
GE (kcal/kg)	3.947	4.234	3.899	4.267

DM: dry matter, EE: ether extract, CP: crude protein, CF: crude fiber, A: ash, NFE: nitrogen-free extract, GE: gross energy

Table 3 – Total amino acid content of the tested feedstuffs.

Amino acid	Corn	Whole corn germ	Sorghum	Soybean meal
Lysine	0.22	0.40	0.17	2.90
Methionine	0.15	0.17	0.14	0.63
Cysteine	0.14	0.16	0.13	0.64
Arginine	0.42	0.76	0.44	3.39
Threonine	0.27	0.50	0.31	1.80
Glycine	0.28	0.50	0.31	2.04
Serine	0.40	0.53	0.48	2.48
Valine	0.26	0.38	0.34	2.04
Isoleucine	0.17	0.32	0.26	1.87
Histidine	0.22	0.30	0.21	1.52
Phenylalanine	0.32	0.43	0.44	2.13
Tyrosine	0.24	0.40	0.29	1.80
Aspartic Acid	0.48	0.78	0.69	4.30
Glutamine	1.50	1.35	2.15	7.70
Alanine	0.47	0.58	0.72	1.86
Proline	0.81	0.80	0.89	2.14

According to Calderano *et al.*, (2010), variations in the chemical and energy composition of feedstuffs may occur for several reasons, such as differences in cultivar, as well as growth, soil, and weather conditions and processing to which the source material is exposed.

The CAMN of the feedstuffs was not influenced by broiler breed or age, except for WCG. Isa Label birds presented CAMEE values11.74%, 18.76% and 46.54% greater than those obtained Cobb broilers for corn, WCG, and SBM, respectively (Table 4).

Table 4 – Coefficient of apparent metabolizability of nitrogen (CAMN, %) and ether extract (CAMEE, %) of the tested feedstuffs fed to slow-growing (Isa Label) and fast-growing (Cobb) broilers.

Feed	Age (days)	CAMN, (%) Breed		Mean	CAMEE, (%) Breed		Mean
		Isa Label	Cobb		Isa Label	Cobb	
Corn	10 to 17	88.19	90.08	89.13a	92.29	81.87	87.08a
	28 to 35	92.69	85.48	89.09a	94.34	85.16	89.75a
	Mean	90.44A	87.78A		93.32A	83.51B	
	CV, (%)[1]	6.62			9.65		
Whole corn germ	10 to 17	76.35	76.02	76.18b	80.74	57.34	69.04b
	28 to 35	85.99	87.13	86.56a	86.25	83.28	84.77a
	Mean	81.17A	81.58A		83.50A	70.31B	
	CV, (%)[1]	6.48			12.73		
Sorghum	10 to 17	92.53	90.39	91.46a	87.3	74.58	80.94a
	28 to 35	90.29	84.24	87.27a	90.85	84.37	87.61a
	Mean	91.41A	87.31A		89.07A	79.48A	
	CV, (%)[1]	6.02			13.22		
Soybean meal	10 to 17	46.74	46.11	46.43a	71.45	51.55	61.50a
	28 to 35	50.41	46.64	48.53a	80.32	52.38	66.35a
	Mean	48.58A	46.38A		75.89A	51.96B	
	CV, (%)[1]	13.19			14.77		

Means followed by different lowercase letters in the same column and uppercase letters in the same row differ byTukey's test at 5% significance level. [1]Coefficient of variation.

Chickens fed WCG between 28 and 35 days of age presented with 13.63% and 22.78% higher CAMN and CAMEE values, respectively, when compared with chickens fed with the same feedstuffs between 10 and 17 days of age (Table 4). According to Brumano *et al.*, (2006), young broilers present lower nutrient digestion and absorption capacity compared with older broilers because their digestive system is still under development. On the other hand, older broilers have a fully developed digestive system, with a larger digestive tract and higher enzyme production and gastric secretions, resulting in better feed utilization.

The effect of age on nutrient utilization was most obvious in the birds fed WCG. As show in Table 2, WCG presented the highest ether extract content (10.03%), and excessive availability of lipids can be a limiting factor for the digestion of WCG during the first days of the broiler's life (Maiorka *et al.*, 2004).

Significant differences in ether extract metabolizability were observed between breeds, except for sorghum. According to Bertechini (2006), several factors related to the chemical composition of a given molecule and the digestive maturity of the bird can influence lipid absorption.

We did not observe any significant interactions between breed and age for any of the tested feedstuffs in relation to energy utilization (Table 5). As the birds aged, AME (kcal/kg) and AMEn (kcal/kg) of WCG, sorghum, and SBM values increased, except for corn, which values were not affected by age.

Based on studies on other feedstuffs, we expected an age-dependent increase in corn energy metabolization in the studied breeds. However, Mello *et al.* (2009) observed that age-dependent changes in AME content were not observed in corn, wheat bran, or poultry by product meal despite an age-dependent increase in AME and AMEn values detected in other feedstuffs (sorghum, soybean meal, and blood plasma). These results suggest that the energy use of birds of different ages changes according to how feedstuffs are processed by the digestive enzymes at the different stages of the bird's life.

When fed the corn diet, Isa Label chickens presented AME and AMEn values 5.75% (177.98 kcal/kg) and 3.44% (105.94 kcal/kg) higher than those determined in Cobb birds, respectively. The AME and AMEn values of the other tested feedstuffs were not influenced by breed (Table 5). Energy utilization of WCG, sorghum, and particularly SBM was not statistically different between breeds, however, slow-growing birds presented higher corn energy utilization. Isa Label birds tended to show higher AME values (71.6, 42.57, and 85.10 kcal/kg) than Cobb birds, which accounted for increases of 2.56, 1.39, and 3.85% for WCG, sorghum and SBM, respectively.

Santos *et al.* (2005) reported that there is large difference in the maximum growth rate between Cobb and Isa Label breeds. The authors verified that the inflection point of the growth curve corresponding

Table 5 – Apparent metabolizable energy (AME) and apparent metabolizable energy corrected for nitrogen balance (AMEn) values of the tested feedstuffs fed to slow-growing (Isa Label) and fast-growing (Cobb) broilers.

Feed	Age	AME, (kcal/kg)		Mean	AMEn, (kcal/kg)		Mean
	(days)	Breed			Breed		
		Isa Label	Cobb		Isa Label	Cobb	
Corn	10 to 17	3240.7	3046.7	3158.7a	3156.9	3036.1	3096.5a
	28 to 35	3305.5	3143.5	3200.3a	3221.3	3130.3	3175.8a
	Mean	3273.1A	3095.1B		3189.1A	3083.18B	
	CV, (%)[1]	3.47			3.50		
Whole corn germ	10 to 17	2762.6	2633.1	2697.8b	2686.5	2633.8	2661.7b
	28 to 35	2978.2	2964.9	2971.3a	2896.8	2951.1	2923.9a
	Mean	2870.4A	2798.8A		2791.6A	2792.5A	
	CV, (%)[1]	5.08			5.11		
Sorghum	10 to 17	3276.2	3214.3	3245.1b	2984.5	2961.6	2973.1b
	28 to 35	3473.9	3484.2	3479.1a	3222.0	3159.8	3190.9a
	Mean	3375.0A	3349.3A		3103.3A	3060.7A	
	CV, (%)[1]	5.95			5.86		
Soybean meal	10 to 17	2363.4	2226.6	2295.0b	2261.9	2140.3	2201.1a
	28 to 35	2393.8	2346.4	2370.1a	2325.1	2275.9	2300.5b
	CV, (%)[1]	4.79			4.76		
	Mean	2378.6A	2286.5A		2293.5A	2208.1A	

Means followed by different lowercase letters in the same column and uppercase letters in the same row differ by Tukey's test at 5% significance level. [1]Coefficient of variation.

to the moment at which growth decelerates and leads to a decrease in the metabolic rate of the bird occurs at 37 days of age in male Cobb birds and at 52 days of age in Isa Label. Considering the growth rate of Cobb chickens, we assumed that the higher positive nitrogen balance values obtained by Cobb breed broilers at 10 to 17 and 28 to 35 days of age resulted in a smaller AMEn difference between Cobb and Isa Label, which emphasizes the importance of considering growth rate when formulating feeds (Table 5).

The trend of the smaller difference in WCG and sorghum AMEn values between breeds observed in this study may be explained by the correction for nitrogen balance (body nitrogen gain or loss), which standardizes and reduces the variation in energy values of the feedstuffs measured under different conditions (Sakomura & Rostagno, 2007). According to those authors, when organic molecules are oxidized, energy is utilized in the metabolic processes and produces heat increment. Therefore, energy availability represents the sum of the energy increments during the digestion of protein, starch, and lipids. In the present study, differences between breeds regarding nitrogen metabolization were not analyzed because carbohydrate utilization was not quantified. However, the greater lipid digestibility may have contributed for the greater energy availability (AME and AMEn) of the corn for the slow-growing birds.

According to Rougiere *et al.*, (2009) and Verdal *et al.* (2010), birds with larger gastric compartments (proventriculus and gizzard) tend to present more effective nutrient utilization compared with birds that show greater development of the small intestine. Thus, the higher energy use of slow-growing birds can be attributed to the peculiarities of the digestive organs of Isa Label broilers because they present with higher proventriculus and gizzard relative weight compared with Cobb broilers, as observed by Santos *et al.* (2005). Similarly to our study, Rougiere *et al.* (2009) also analyzed broiler breeds with different digestion efficiencies at 21 days of age and determined AMEn values and nutrient digestibility of grain-based pelleted feeds. The authors verified that the birds with larger gastric compartments presented 3.5, 5.6, 5.8 and 0.5% higher AMEn and lipid, protein and starch digestion, respectively, compared with breeds with smaller proventriculus and gizzard and larger small intestine. These studies suggest that the high proventriculus and gizzard relative weights of Isa Label birds may contribute to better gastric processing of the feeds, optimizing intestinal function, and consequently, improving nutrient utilization.

There are few studies evaluating feed energy utilization by slow-growing broilers. However, the AMEn values determined for both breeds and ages in the present studies are consistent with literature findings (Generoso *et al.*, 2008; Calderano *et al.*, 2010; Rostagno *et al.*, 2011).

Energy utilization values determined in the present study were age-dependent, but no considerable differences were observed between slow- and fast-growing broilers. Therefore, future studies analyzing metabolizable energy values of the feedstuffs used in the formulation of feeds for broilers with slow growth rates should be conducted to update the energy values in the published nutritional tables according to age. Such information is essential for the optimization of feed formulation for slow-growing birds. In particular, these birds are marketed relatively older than fast-growing chickens, and therefore, may present different nutrient utilization.

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