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Nutritional evaluation of sorghums grown with different organic fertilizers for slow-growing broilers[1]

Avaliação nutricional do sorgo cultivado com diferentes adubos orgânicos para frangos de crescimento lento

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Abstract

The aim of this study was to evaluate the effects of sorghums grown with different organic fertilizers on the chemical composition, energy values, and nutrient metabolizability coefficients, as well as their use for feeding slow-growing broilers. Two trials were performed. In the first experiment, 200 21-day-old broilers were distributed in a completely randomized design (CRD), with five treatments and four replicates of 10 birds per experimental unit. The treatments consisted of a control diet and four test diets (sorghum fertilized with crotalaria, sorghum fertilized with millet, sorghum fertilized with humus, and sorghum without fertilization), including sorghum at 30% in the control diet. The apparent metabolizable energy (AME), apparent metabolizable energy corrected for nitrogen balance (AME_n), metabolizability coefficients of dry matter, crude protein, and gross energy were evaluated. In trial 2, 200 1-day-old chicks were used in a CRD with five treatments (T1 – control diet with commercial corn, T2 – sorghum fertilized with crotalaria, T3 – sorghum fertilized with millet, T4 – sorghum fertilized with humus, and T5 – sorghum without fertilization) and four replicates of 10 birds per experimental unit. Weight gain, feed intake, feed conversion, and final weight at 28 days were evaluated. The values of AME and AME_n of sorghums fertilized with crotalaria, millet, humus, and sorghum without fertilization were 2894 Kcal kg^{-1} and 2881 Kcal kg^{-1}; 2736 Kcal kg^{-1} and 2675 Kcal kg^{-1}; 2727 Kcal kg^{-1} and 2694 Kcal kg^{-1}; and 2994 Kcal kg^{-1} and 2959 Kcal kg^{-1}, respectively. The metabolizable coefficients of dry matter, crude protein, and gross energy were 76.04%, 42.01%, and 75.25% for sorghum fertilized with crotalaria; 77.50%, 50.77%, and 75.95% for sorghum fertilized with millet; 77.62%, 46.39%, and 75.54% for sorghum fertilized with humus; and 75.83%, 39.53%, and 74.71% for sorghum cultivated without fertilization, respectively. The dietary use of sorghum cultivated with different fertilizers did not affect ($P>0.05$) weight gain, feed intake, feed conversion, and final weight. Green manures with crotalaria, millet, and

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humus (bovine manure) are alternatives that can be used on sorghum crops because they resulted in grains with adequate nutritional composition, energy values, and metabolizable coefficients for slow-growing broilers from 1 to 28 days of age.
Key words: Alternative poultry farming. Productive performance. Metabolizable energy.

Resumo

Objetivou-se no presente trabalho avaliar o sorgo cultivado com diferentes adubos orgânicos sobre a composição química, valores energéticos, coeficientes de metabolizabilidade dos nutrientes e sua utilização na alimentação de frangos de crescimento lento. Foram realizados dois experimentos, no primeiro foram utilizadas 200 aves de 21 dias de idade, distribuídas em delineamento inteiramente casualizado (DIC), com cinco tratamentos e quatro repetições de 10 aves por unidade experimental. Os tratamentos consistiram de uma dieta referência e quatro dietas testes (sorgo adubado com crotalária, sorgo adubado com milheto, sorgo adubado com húmus e sorgo sem adubação), na qual os sorgos substituíram 30% da dieta referência. Foram avaliados a energia metabolizável aparente (EMA), energia metabolizável aparente corrigida para o balanço de nitrogênio (EMAn), os coeficientes de metabolizabilidade da matéria seca, proteína bruta e energia bruta. No ensaio de desempenho, foram utilizados 200 pintos de 1 dia de idade, distribuídos em delineamento experimental inteiramente casualizado, com cinco tratamentos (T1 - ração referência com milho comercial, T2 – ração com sorgo adubado com crotalária, T3 – ração com sorgo adubado com milheto, T4 – ração com sorgo adubado com húmus e T5 – ração com sorgo sem adubação) e quatro repetições de 10 aves por unidade experimental. Foram avaliados o ganho de peso, consumo de ração, conversão alimentar e o peso final aos 28 dias. Os valores determinados de EMA e EMAn dos sorgos adubados com crotalária, milheto, húmus e o sorgo sem adubação foram de 2894 Kcal kg^{-1} e 2881 Kcal kg^{-1}; 2736 Kcal kg^{-1} e 2675 Kcal kg^{-1}; 2727 Kcal kg^{-1} e 2694 Kcal kg^{-1}; 2994 Kcal kg^{-1} e 2959 Kcal kg^{-1}, respectivamente, e os coeficientes de metabolizabilidade da MS, PB e EB foram: 76,04%, 42,01% e 75,25% para o sorgo adubado com crotalária; 77,50%, 50,77% e 75,95% para o sorgo adubado com milheto; 77,62%, 46,39% e 75,54% para o sorgo adubado com húmus e 75,83%, 39,53% e 74,71% para o sorgo cultivado sem adubação, respectivamente. Observou-se que a utilização dos sorgos cultivados com diferentes adubações não afetou (P>0,05) o ganho de peso, consumo de ração, conversão alimentar e peso final. A adubação verde com crotalaria e milheto, e o uso de húmus de esterco bovino são alternativas que podem ser utilizadas no cultivo do sorgo, pois propiciaram grãos com composição nutricional, valores energéticos e coeficientes de metabolizabilidade adequados ao desempenho de frangos de crescimento lento de 1 a 28 dias de idade.
Palavras-chave: Avicultura alternativa. Aesempenho produtivo. Energia metabolizável.

Introduction

The current model of intensive agriculture has been the focus of discussions by all sectors of society because of the growing concern about environment preservation and food contamination. These discussions consider sustainable food production, so-called agroecological farming, which aims to preserve the natural environment and biodiversity (ALENCAR et al., 2013).

Researchers have proposed the adoption of practices that favor several biological processes in agroecosystems, such as biological nitrogen fixation and nutrient recycling, aiming at maintaining and improving soil quality through minimum soil disturbance and increased organic matter content and biological activity (DELARMELINDA et al., 2010; KARMAKAR et al., 2016).

In this perspective, green manuring is a practice capable of contributing to the sustainability of agriculture by improving the physical, chemical, and biological characteristics of soil, as well as allowing the control of invasive plants. According to Malavolta (1981), organic fertilizers are characterized by high levels of organic matter and total nutrients, including nitrogen, water content, and C/N ratio. The use of different fertilizers changes soil constituents, with a consequent effect on nutritional and energy values of food, depending on the soil type, climatic conditions, and interaction between fertilization and these factors (GALLO et al., 1976).

Among the different fertilizers, low-tannin sorghum stands out due to its nutritional characteristics and satisfactory yield per unit area. Thus, sorghum is a suitable substitute for corn in broiler diets. Some studies have shown the feasibility of using sorghum in broiler diets even in the initial phase, without restrictions in later stages (FAGUNDES et al., 2017; PIMENTEL et al., 2007; ROCHA et al., 2008; TORRES et al., 2013). Raising backyard poultry is an important alternative for small farmers because of the growing interest of consumers in food security and sustainability. This bird is known as Caipira (Southeast), Colonial (Southern region), or Capoeira (Northeast region), and its meat has different sensorial characteristics compared to that of birds raised under commercial confinement (TAKAHASHI et al., 2006).

The increasing demand for quality food allows pointing out the importance of studies on the effects of types of fertilization on nutritional and energetic values of food as well as on animal performance. However, few studies in recent years have focused on broilers in agroecological farming systems. In this context, the aim of the present study was to evaluate the effects of sorghums grown with different organic fertilizers on the chemical composition, energetic values, metabolizability coefficients of dry matter (AMCDM), crude protein, energy, and performance of slow-growing broilers.

Material and Methods

Two trials were conducted at the Poultry Research Center of the School of Veterinary Medicine and Animal Science, Federal University of Tocantins, Araguaína, TO. The first trial was carried out from August 2 to August 9, 2015, and the second during the period from August 17 to September 15, 2015. The study was conducted in accordance with the rules of the Ethics in Animal Use Committee, Federal University of Tocantins (CEUA-UFT), under protocol no. 23101.003578/2016-51.

The average annual air temperature and precipitation ranged from 28° C and 1800 mm, respectively. The climate is classified as Aw (hot and humid) according to Köppen classification. The sorghum experimental area has a typical eutrophic brown soil and is in the fourth productive year.

Soil preparation for sorghum cultivation

The establishment of the system began with soil correction with dolomitic limestone at 400 kg ha^{-1} and division into four plots of 840 m^2 each. Soil preparation was done with subsoil tillage to 30 cm depth. Three plots received one type of fertilization (millet, crotalaria, and humus), and one plot did not receive fertilization (control). Millet and *Crotalaria juncea* sowing were carried out in rows spaced 1.0 m apart. At the early stages of inflorescence (82 days after sowing), the two cultures were cut and later incorporated into the soil using a disk plow. Humus (cow manure vermicompost) was distributed (250 kg) by hand.

After a resting period of 10 days (chopped material), natural rock phosphate was applied at 50 kg ha^{-1} of P_2O_5. Subsequently, the IPA 1011 sorghum cultivar was sown in shallow pits spaced 20 cm apart and 80 cm apart between rows. Sorghum was harvested at physiological maturity, when the grains were dry. After harvesting the panicles, the grains were removed, cleaned, and stored in bags identified according to the treatment to prepare the experimental diets. Corn used in the control diet was cultivated following conventional methods.

Trial I: Chemical composition (DM, CP, MM, GE, and CF), energy values (AME and AME_n), and metabolizability coefficients (DM, CP, and GE) of sorghums cultivated with different organic fertilizers

A total of 200 slow-growing (Red Naked Neck) broilers of both sexes and 21 days of age were used to determine the metabolizable energy (AME), metabolizable energy corrected for nitrogen balance (AME_n), AMCDM, crude protein (AMCCP), and gross energy (AMCGE) of sorghums grown with different fertilizers using the traditional method of total excreta collection (ALBINO et al., 1992; SIBBALD, 1976; SIBBALD; SLINGER, 1963). Broilers were housed in experimental cages (1.00 x 1.00 x 0.40 m) equipped with trough-type feeders and drinkers, a heating system for chicks until the 14^{th} day of life, and metal trays immediately below the cages to remove excreta. On the 21^{st} day, birds with a mean weight of 294 g ± 12.3 g were randomly distributed in experimental cages in a completely randomized design (CRD) with five treatments, four replicates, and 10 birds per experimental unit, with the following treatments:

T1: Control diet based on corn and soybean meal formulated to meet the nutritional requirements of semi-heavy chickens in the growing phase, corrected for the average temperature in Araguaína, according to Rostagno et al. (2011) (Table 1).

Table 1. Centesimal and calculated composition of reference diet (base in natural matter).

Ingredients	(%)
Corn	61.813
Soybean meal (45%)	32.559
Soybean oil	1.787
Dicalcium phosphate	1.697
Limestone	0.853
Salt	0.474
DL-methionine	0.218
L-lysine HCl	0.181
Choline chloride (60%)	0.125
Premix[1]	0.250
L-threonine	0.033
BHT	0.010
Calculated nutritional composition	
ME (kcal kg^{-1})	3000
Crude protein (%)	20.17
Calcium (%)	0.840
Available phosphorus (%)	0.422
Chlorine (%)	0.330
Potassium (%)	0.769
Sodium (%)	0.207
Digestible lysine (%)	1.096
Digestible methionine (%)	0.491
Digestible methionine + cysteine (%)	0.852
Digestible threonine (%)	0.722

[1]Composition/ton: folic acid: 150.00 mg; cobalt: 178.00 mg; copper: 2,675.00 mg; choline: 120.00 g; iron: 11.00 g; iodine: 535.00 mg; manganese: 31.00 g; mineral matter: 350.00 g; niacin: 7,200.00 mg; calcium pantothenate: 2,400.00 mg; selenium: 60.00 mg; vitamin A: 1,920,000.00 IU; vitamin B1: 300.00 mg; vitamin B12: 3,600.00 mg; vitamin B2: 1,200.00 mg; vitamin B6: 450.00 mg; vitamin D3: 360,000.00 IU; vitamin E: 3,600.00 IU; vitamin H: 18.00 mg; vitamin K: 480.00 mg; zinc: 22.00 g.

T2: 70% control diet + 30% test ingredient (sorghum fertilized with crotalaria)

T3: 70% control diet + 30% test ingredient (sorghum fertilized with millet)

T4: 70% control diet + 30% test ingredient (sorghum fertilized with humus)

T5: 70% control diet + 30% test ingredient (sorghum without fertilization).

The experimental period lasted seven days. The broilers went through a period of adaptation to the experimental diets for four days, and the total excreta collection was carried out during the three subsequent days (RODRIGUES et al., 2005). During the sampling period, the cage floor was covered with plastic to avoid contamination and any loss of excreta. Samples were collected twice a day (8 a.m. and 4 p.m.) to prevent fermentation. After each sampling, excreta were packed in plastic bags, properly identified, and frozen for further analysis. At the end of the experimental period, the total amounts of feed consumed and excreta produced were determined according to the methodology proposed by Sakomura and Rostagno (2007).

For analysis, 400 g of excreta from each treatment was defrosted at room temperature and homogenized. Subsequently, the samples were partially dried in a forced ventilation oven at 55° C for 72 hours to determine the oven-dry sample weight. Subsequently, the samples were processed in a mill with a 1 mm sieve and transported to the laboratory.

Experimental diets and excreta samples were sent to the laboratory of Tropical Animal Science at the Federal University of Tocantins to determine the dry matter (DM), crude protein (CP), and gross energy (GE) of the feed, experimental diets, and excreta, following the procedures described by Silva and Queiroz (2009). Sorghum samples were sent to the laboratory of Bonasa Alimentos S.A, Tocantinópolis, to determine tannin values. After laboratory analysis, the AME and AME_n were determined using the equations proposed by Matterson et al. (1965).

$$\text{Dietary AME (kcal kg}^{-1}) = \frac{(GE_{int} - GE_{exc})}{DM_{int}}$$

$$\text{Dietary AME}_n\text{ (kcal kg}^{-1}) = \frac{GE_{int} - (GE_{exc} \pm 8.22 \times NB)}{DM_{int}} \times 100$$

In which AME = apparent metabolizable energy (kcal kg^{-1}); AME_n = apparent metabolizable energy corrected for nitrogen balance (kcal kg^{-1}); GE_{int} = gross energy intake (kcal); GE_{exc} = gross energy excreted (kcal); NB = nitrogen balance ([DM intake x dietary N] – [DM excreted x N excreted]); and DM_{int} = dry matter intake (kg).

The AMCDM, crude protein (AMCCP), and gross energy (AMCGE) of sorghums grown with different fertilizers were determined according to the equation described by Sakomura and Rostagno (2007):

$$\text{AMC (\%)} = \frac{\text{(g of the ingested nutrient} - \text{g of the excreted nutrient)}}{\text{g of the ingested nutrient}} \times 100$$

Data of energetic value, AMCDM, crude protein, and gross energy of sorghums grown with different fertilizers were subjected to tests for normality (Cramer Von Mises) and homoscedasticity (Levene). Variables for which these assumptions were met were subjected to analysis of variance. Means were compared by the Student Newman Keuls (SNK) test at 5% significance. Statistical analyses were performed using SAS 9.0 Software (2002).

Trial II: Effect of different organic fertilizers in sorghum cultivation on performance of slow-growing broilers

A total of 200 slow-growing chicks one-day-old (Red Naked Neck) with an average initial weight of 37.53 g ± 3.88 g were used. The broilers were housed in experimental cages (1.00 x 1.00 x 0.40 m) located inside the experimental shed with a concrete floor, covered with Babassu straw, and equipped with adjustable side curtains according to temperature and animal behavior. The experimental cages were equipped with trough-type feeders and cup-type drinkers, which were cleaned and refilled twice a day to ensure free access to water and feed throughout the experimental period.

The broilers were distributed in a CRD with five treatments (T1 – control diet with commercial corn, T2 – sorghum fertilized with crotalaria, T3 – sorghum fertilized with millet, T4 – sorghum fertilized with humus, and T5 – sorghum without fertilization) and four replicates of 10 birds per experimental unit. Experimental diets were formulated to meet the nutritional requirements of semi-heavy chickens in the growing phase, corrected for the average temperature in Araguaína, according to Rostagno et al. (2011) (Table 2). In treatments T2 to T5, corn was completely replaced by sorghum in the rations formulations. Until 14 days old, the broilers were heated artificially, using incandescent lamps (60 W) located inside the cages.

Table 2. Composition of experimental diets with sorghums grown with different organic fertilizers for slow-growing broilers from 1 to 28 days of age.

Ingredients	Treatments				
	Control diet	Sorghum crot[1]	Sorghum mill[2]	Sorghum hum[3]	Sorghum test[4]
Corn	59.870	0.000	0.000	0.000	0.000
Sorghum	0.000	61.000	61.000	61.000	61.000
Soybean meal (45%)	33.760	31.330	31.330	31.330	31.330
Soybean oil	2.450	3.800	3.800	3.800	3.800
Dicalcium phosphate	1.800	1.800	1.800	1.800	1.800
Limestone	0.920	0.800	0.800	0.800	0.800
Salt	0.491	0.450	0.450	0.450	0.450
DL-methionine	0.200	0.200	0.200	0.200	0.200
L-lysine HCl	0.109	0.170	0.170	0.170	0.170
L-threonine	0.000	0.050	0.050	0.050	0.050
Mineral supplement[2]	0.200	0.200	0.200	0.200	0.200
Vitamin supplement[2]	0.200	0.200	0.200	0.200	0.200
Total	100.00	100.00	100.00	100.00	100.00
Calculated nutritional composition					
ME (kcal kg^{-1})	3001	2985	2985	2985	2985
Crude protein (%)	20.20	19.94	19.94	19.94	19.94
Calcium (%)	0.887	0.836	0.836	0.836	0.836
Available phosphorus (%)	0.443	0.451	0.451	0.451	0.451
Digestible lysine (%)	1.069	1.036	1.036	1.036	1.036
Digestible methionine + cysteine (%)	0.769	0.709	0.709	0.709	0.709
Digestible methionine (%)	0.477	0.448	0.448	0.448	0.448
Digestible threonine (%)	0.704	0.693	0.693	0.693	0.693
Sodium (%)	0.214	0.197	0.197	0.197	0.197
Potassium (%)	0.791	0.781	0.781	0.781	0.781

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Crude fiber (%)	2.859	3.095	3.095	3.095	3.095
Neutral detergent fiber (%)	11.798	10.439	10.439	10.439	10.439
Acid detergent fiber (%)	4.748	6.127	6.127	6.127	6.127

[1]Sorghum crot: sorghum fertilized with crotalaria; [2]Sorghum mill: sorghum fertilized with millet; [3]Sorghum hum: sorghum fertilized with humus; [4]Sorgo test: sorghum without fertilization.

[2]Composition/ton: folic acid: 150.00 mg; cobalt: 178.00 mg; copper: 2,675.00 mg; choline: 120.00 g; iron: 11.00 g; iodine: 535.00 mg; manganese: 31.00 g; mineral matter: 350.00 g; niacin: 7,200.00 mg; calcium pantothenate: 2,400.00 mg; selenium: 60.00 mg; vitamin A: 1,920,000.00 IU; vitamin B1: 300.00 mg; vitamin B12: 3,600.00 mg; vitamin B2: 1,200.00 mg; vitamin B6: 450.00 mg; vitamin D3: 360,000.00 IU; vitamin E: 3,600.00 IU; vitamin H: 18.00 mg; vitamin K: 480.00 mg; zinc: 22.00 g.

The performance variables evaluated were feed intake, weight gain, feed conversion, and weight at 28 days. Feed intake was based on the amount of feed supplied and that remaining in the feeders, corrected for mortality; weight gain was measured by the difference between the final weight at the end of the trial and the initial weight. Feed conversion was the ratio of feed intake to weight gain.

Data were subjected to tests for normality (Cramer Von Mises) and homoscedasticity (Levene). Variables for which these assumptions were met were subjected to analysis of variance. Means were compared by the SNK test at 5% significance. Statistical analyses were performed using SAS 9.0 Software (2002).

Results and Discussion

Chemical composition, energy values, and metabolizable coefficients of sorghums grown with different organic fertilizers

The average nutritional values of sorghums fertilized with crotalaria, millet, humus, without fertilization, and commercial corn were lower than those reported by Rostagno et al. (2011) for dry matter (85.61 vs 87.90%) and gross energy (3726.15 vs 3912 Kcal kg^{-1}) but higher for crude protein (12.52 vs 8.97%), mineral matter (3.28 vs 1.41%), and crude fiber (2.53 vs 2.30%) (Table 3). Dry matter values ranged from 84.48 to 87.06%, lower than those reported by Queiroz et al. (2015) for four-grain sorghum samples (89.85 to 90.45%), Etuk et al. (2012) for sorghum hybrids (88.94 to 93.31%), and Vieira et al. (2014) (88.34%). On the other hand, Santos et al. (2013), Gomes et al. (2010), and Rostagno et al. (2011) found similar DM values of 86.44%, 86.95%, and 87.90%, respectively.

The average of 3726.15 Kcal kg^{-1} gross energy was similar to those found by Nunes et al. (2008) of 3741 Kcal kg^{-1} and by Mello et al. (2009) of 3757 Kcal kg^{-1}, and lower than those reported by Vieira et al. (2014), Santos et al. (2015), and Etuk et al. (2012) of 3890 Kcal kg^{-1}, 4234 Kcal kg^{-1}, and 4120 Kcal kg^{-1}, respectively. The average of 12.51% crude protein ranged from 11.66% to 13.36%. These values are within the range reported by Queiroz et al. (2015) for grain sorghum samples (9.07 to 13.67%) and by Etuk et al. (2012) (8.9 to 14.89%). Amal et al. (2015) reported similar CP values to sorghum fertilized with millet as green manure (13.70 vs 13.36%).

The different fertilizations used in the study probably influenced the nutritional values of the sorghum. Organic fertilizers have a different chemical composition and mineralization rate, and they are influenced by climatic conditions. Therefore, the loss of nutrients by volatilization affects the availability of nutrients for crop production, which consequently impacts feed chemical composition (SILVA et al., 2015).

Table 3. Nutritional composition of sorghums grown with different fertilizers[1].

Sorghum	DM[2] (%)	CP[3] (%)	MM[4] (%)	GE[5] (kcal kg^{-1})	CF[6] (%)	Tannin (%)
Fertilized with crotalaria	85.12	12.82	2.85	3691.25	2.67	0.50
Fertilized with millet	84.48	13.36	3.66	3643.06	2.69	0.60
Fertilized with humus	85.79	11.66	3.46	3762.17	2.38	0.50
Without fertilization	87.06	12.22	3.15	3808.12	2.38	0.50
Mean	85.61	12.52	3.28	3726.15	2.53	0.53
Maximum value	87.06	13.36	3.66	3808.12	2.69	0.60
Minimum value	84.48	11.66	2.85	3643.06	2.38	0.50
CV[7](%)	1.29	5.88	10.81	1.97	6.84	9.52

[1]Values expressed on the basis of natural matter.
[2]DM=dry matter; [3]CP= crude protein; [4]MM= mineral matter; [5]GE = gross energy; [6]CF= crude fiber
[7]Coefficient of variation (%).

The use of grasses as cover crops in early years of establishment may lead to greater nitrogen immobilization, impairing crop performance (FONTANÉTTI et al., 2007). Nonetheless, in the medium and long term, nitrogen can be made available for the subsequent crop due to biomass accumulation (PADOVAN et al., 2013), which may have occurred in the present study conducted in the fourth year of sorghum planting. Since legumes fix atmospheric nitrogen and have a low C/N ratio, they immobilize less N by soil microbiota and make it available for subsequent cultivation (CRUZ et al., 2017). Humus, in turn, may vary N availability for sorghum crops due to the stability condition of the organic compound in the soil (KUMADA, 1987).

Relative to the soil without fertilization, since the experiment was in the fourth year of production, there was a biomass accumulation of previous sorghum planting, and in the medium and long term, the nutrients were made available for the subsequent cultivation. This helps to explain the results obtained for the treatment without fertilization. There was no effect ($P>0.05$) of AMCDM, crude protein, and gross energy of sorghums grown with different fertilizations (Table 4).

Table 4. Mean (± standard error) of metabolizable coefficients of dry matter (AMCDM), crude protein (AMCCP), and gross energy (AMCGE) of sorghums grown with different fertilizers.

Treatments	Variables		
	AMCDM	AMCCP	AMCGE
Sorghum fertilized with crotalaria	76.03±2.77	42.01±6.24	75.25±1.91
Sorghum fertilized with millet	77.50±1.97	50.77±1.65	75.95±1.33
Sorghum fertilized with humus	77.62±1.01	46.39±3.82	75.54±0.58
Sorghum without fertilization	75.83±1.25	39.53±1.47	74.71±0.75
CV[1](%)	4.9	13.48	4.43
P > F[2]	0.8578	0.1036	0.9600

[1]Coefficient of variation (%)
[2]ANOVA F-test.

The metabolizable coefficients of crude protein were considerably lower than the value reported by Rostagno et al. (2011) of 88%. This result is associated with intrinsic factors in sorghum grains, especially the texture of endosperm that impairs protein digestion as well as the presence of anti-nutritional factors, which would affect the availability of nutrients for poultry (ANTUNES et al., 2006; ETUK et al., 2012). However, tannin analysis in sorghums grown with different fertilizations showed no possibility of compromising protein metabolism because tannin values were within the quality standard (Table 3).

AME_n values were significantly different ($P<0.05$) in sorghums. Sorghum without fertilization differed from millet- and humus-fertilized sorghums, but was similar to sorghum fertilized with crotalaria (Table 5). Possibly, since the experiment was conducted in the fourth year of production and faced accumulated biomass from previous crops in the plot, the nutrients for the crop in succession were provided in the medium and long term.

Table 5. Mean (± standard error) of apparent metabolizable energy (AME) and apparent metabolizable energy corrected (AME_n) of sorghums grown with different fertilizers[1].

Treatments	Variables	
	AME ($Kcal\ kg^{-1}$)[2]	AME_n ($Kcal\ kg^{-1}$)[2]
Sorghum fertilized with crotalaria	2894±100[a]	2881±87[ab]
Sorghum fertilized with millet	2775±69[a]	2636±66[b]
Sorghum fertilized with humus	2727±30[a]	2694±12[b]
Sorghum without fertilization	2994±40[a]	2959±40[a]
CV[3] (%)	4.63	4.16
P > F[4]	0.0375	0.0112

[1]Values expressed on the basis of natural matter
[2]Means followed by the same letters in the column did not differ by the SNK test (P>0.05).
[3]Coefficient of variation (%)
[4]ANOVA F-test.

The mean values of AME and AME_n of sorghums grown with different fertilizers were 2847.5 Kcal and 2792.5 Kcal, respectively. These values were lower than those found by Bueno et al. (2012), analyzing sorghum hybrids (3386 Kcal and 3250 Kcal), and Rostagno et al. (2011), with 3189 Kcal for AME. However, the values were similar to those found by Santos et al. (2013) evaluating the same sorghum cultivar used in this study (IPA 1011) for broilers at 14 days of age (2908 Kcal for AME and 2766 Kcal for AME_n).

Performance of slow-growing broilers fed sorghums grown with different organic fertilizers

The use of sorghums grown with different organic fertilizers in poultry feeding did not affect feed intake, weight gain, feed conversion, and weight at 28 days in slow-growing broilers at the initial stage (1 to 28 days) (Table 6). The results can be attributed to the nutritional similarity between corn and sorghum (ROSTAGNO et al., 2011), which makes it possible to formulate diets with comparable values mainly for metabolizable energy and crude protein. Recent studies demonstrate the possibility to use sorghum in broiler diets even in the initial stage, at levels up to 100% of corn, without restrictions in later stages (FAGUNDES et al., 2017; PIMENTEL et al., 2007; ROCHA et al., 2008; TORRES et al., 2013). However, Tandiang et al. (2014) and Batonon-Alavo et al. (2015) observed that high levels of substitution may decrease the performance of broilers, which was not observed in the present experiment.

Table 6. Average feed intake (FI), weight gain (WG), feed conversion (FCR), and weight at 28 days (W28d) in slow-growing broilers fed sorghum grown with different fertilizers.

Treatments	Variables			
	FI (g)	WG (g)	FC (g g^{-1})	W28d (g)
Control diet	938.13	501.93	1.87	538.83
Sorghum without fertilization	886.37	464.25	1.91	501.2
Sorghum fertilized with humus	964.99	504.55	1.91	541.7
Sorghum fertilized with millet	887	462.98	1.92	499.83
Sorghum fertilized with crotalaria	939.48	505.23	1.86	543.43
CV[1](%)	6.00	5.79	2.42	5.46
P > F[2]	0.2266	0.0918	0.3311	0.0919

[1]Coefficient of variation (%)
[2]ANOVA F-test.

Performance is directly affected by nutrient digestibility, mainly dry matter digestibility, which was not reported in the digestion trial. This demonstrates the nutritional similarity between sorghums grown with different fertilizers. Sorghum grown with different fertilizers had potential to be used for feeding slow-growing broilers in the initial phase, not differing from the commercial diet but with the advantage of not using chemical fertilizers. However, more research is necessary on the utilization of grains grown with different fertilizers for feeding backyard poultry in all breeding phases.

Conclusion

Green manures with crotalaria, millet, and humus (bovine manure) are alternatives that can be used on sorghum crops because they resulted in grains with adequate nutritional composition, energy values, and metabolizable coefficients for slow-growing broilers from 1 to 28 days of age.

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