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Performance and digestibility in feedlot lambs fed hay based diets

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ABSTRACT. This study aimed to evaluate the performance of feedlot lambs fed diets formulated with hay of different genotypes of *Cynodon* spp. and to compare the dry matter digestibility of diets using different evaluation methods (total fecal collection and chromium oxide). Suffolk crossbred neutered male lambs (n=30), with an average age of 90 days and average body weight of 21.5 kg ± 1.6. Diets were formulated using a standard concentrate and hay of the following genotypes of *Cynodon dactylon*: Jiggs, Vaquero, Tifton 68, Coast-Cross, Tifton 85 and Russell, in a 60:40 forage concentrate ratio, composing the treatments distributed in a randomized block design in a factorial 5 x 2 arrangement of 5 diets and 2 digestibility evaluation methods. Animals receiving Vaquero hay showed dry matter intake of 18.3; 16.9; 25.6; 20.7 and 24.2% higher than those fed hay of Jiggs, Tifton 68, Coast Cross, Tifton 85 and Russell, respectively. There was no difference between diets for digestibility using total fecal collection, chromium oxide and final weight of animals. Jiggs hay based diets allowed greater daily weight gain and better feed conversion.

Keywords: *Cynodon*, sheep, chromic oxide, intensive animal production, finished

Desempenho e digestibilidade em cordeiros confinados recebendo dietas a base de feno

RESUMO. Este estudo foi realizado para avaliar o desempenho de cordeiros em confinamento recebendo dietas formuladas com fenos de diferentes genótipos de *Cynodon* spp. Ainda, comparar a digestibilidade da matéria seca das dietas usando diferentes métodos de avaliação (coleta total de fezes e óxido crômico). Foram utilizados 30 cordeiros, machos, não castrados, mestiços Suffolk, com média de idade de 90 dias e peso corporal médio de 21,5 kg ± 1,6. As dietas foram formuladas utilizando um concentrado padrão e feno dos seguintes genótipos de *Cynodon dactylon*: Jiggs, Vaquero, Tifton 68, Coast-Cross, Tifton 85 e Russel, em uma razão volumoso concentrado de 60:40, constituindo os tratamentos, distribuídos em delineamento em blocos casualizados em esquema fatorial 5 x 2, sendo 5 dietas e 2 métodos de avaliação de digestibilidade. Os animais que receberam feno do Vaquero apresentaram ingestão de matéria seca de 18,3; 16,9; 25,6; 20,7 e 24,2% superior aos animais alimentados com feno de Jiggs, Tifton 68, Coast Cross, Tifton 85 e Russel, respectivamente. Não foi verificada diferença entre as dietas para digestibilidade usando coleta total de fezes e óxido de cromo e peso final dos animais. As dietas a base de feno de Jiggs possibilitaram maior ganho de peso diário e melhor conversão alimentar.

Palavras-chave: *Cynodon*, ovinos, óxido crômico, produção animal intensiva, terminação

Introduction

In 2013, the Brazilian sheep flock exceeded the number of 17.3 million head; the Central-West region of the country had the greatest growth, in the same year, the state of Mato Grosso do Sul had the largest effective flock of this region (over 500 thousand heads) (ANUALPEC, 2015). Unlike beef where approximately 20% of production is destined for the foreign market (Food and Agricultural Policy Research Institute [FAPRI], 2015). Production of sheep meat is not able to meet the domestic demand, which implies the need to improve animal performance indices in addition to adopting management strategies, such as feedlot (Oliveira et al., 2016).

Among the main factors of low production of sheep meat, there is a reduction in the nutritional value of forage, represented by tropical grasses, during the dry season, resulting in low indices of milk and meat yield in Brazil (Moreira, & Prado, 2010; Moreira, Prado, Cecato, Wada, & Mizubuti, 2004). This situation requires the storage of high nutritional value forage to feed the animals at this

time of year. In this sense, studies have sought forage species showing high dry matter production, with high leaf/stem ratio and high nutritional value (Miranda, Pereira, Rodriguez, Neto, & Arruda, 2008; Oliveira et al., 2014).

The use of forage conserved as hay is an alternative to mitigate the problems arising from the seasonality of forage production. In order to maintain animal performance and the supply of nutrients to the animal during the period of greater food shortages it is essential to manage high quality forages for production of hay with high nutritional value (Oliveira, Monção, Gabriel, Lempp, & Moura, 2014). *Cynodon* grasses are potentially recommended for animal production, given their capacity for dry matter production throughout the year and high nutritional value, besides the possibility of using for grazing or as forage conserved as silage or hay (Oliveira et al., 2014). Among these are: Tifton 68 (*Cynodon nlemfuensis* Vanderyst.), and Tifton 85, Russel, Jiggs, Coast cross and Vaqueiro (*Cynodon dactylon* cv.), given the rapid soil cover, hardiness and resistance to adverse weather conditions. These grasses have been an interesting alternative not only because of those features, but also considering their high forage production.

However, the forage potential can be investigated through evaluations of intake, performance and feed digestibility. Cherney, Patterson and Johnson (1990) stated that the voluntary feed intake depends on its digestibility and chemical, physical and morphological characteristics. According to Van Soest (1994) and Zeoula, et al. (2006), digestibility measurements have contributed significantly to the development of systems to estimate the nutritional value of food. This author points out that the morphology of plants can affect the intake/digestibility ratio, as at levels of *ad libitum* or restricted intake, selection opportunity can decrease or increase the differences between forages.

Based on the above, this study evaluated the performance of feedlot lambs fed diets formulated with hay of different genotypes of *Cynodon* spp. and to compare the dry matter digestibility of diets using different evaluation methods (total fecal collection and chromium oxide).

Material and methods

The work was conducted in accordance with ethical standards and approved by the ethics and biosafety committee of the institution, University of Grande Dourados, protocol number 223/07. The experiment was conducted in the facilities of the Animal Science Sector, Faculty of Agrarian Sciences (FCA), Federal University of Grande Dourados (UFGD), Dourados, state of Mato Grosso do Sul, latitude: 22014'S; longitude: 54049'W, altitude: 450 m. The climate, according to the classification of Köppen and Geiger (1928) is Cwa (mesothermal humid), with rainy summers and dry winters and an average annual temperature of 22ºC. The soil is classified as Latossolo Vermelho Distroférrico (Empressa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2006). The genotypes of the genus *Cynodon* studied were: Jiggs, Vaquero, Tifton 68, Coast-cross, Tifton 85 and Russell. From the standardization cut, at 5 cm from the ground, it was broadcast 100 kg nitrogen ha^{-1}, and then forage was made into hay at 52 regrowth days. The cutting was carried out with the aid of a motorized backpack brush cutter; forage was exposed to sun and wind in the field, and turned the hay carefully over 2 to 3 times a day, using rakes and forks, providing a uniform dehydration until the optimum, with moisture between 15 to 18%. Rectangular bales were made using a mechanical baler coupled to a tractor. The entire curing of hay took between 48 to 60 hours. Bales were stored in roofed barns on wooden pallet until use, crushed to particles between 1 and 2 cm, with the aid of a shredder coupled to a tractor. After hay production, the experiment began. Animals were housed in shed previously washed with soap and water and disinfected with quicklime. The study used 30 male lambs, neutered, Suffolk crossbred (½ Santa Inês vs. ½ Sulfolk), ear tagged, with average age of 90 days and average body weight of 21.5 kg ± 1.61. The animals were randomly distributed in five randomized blocks in a 5 x 2 factorial arrangement of five genotypes of *Cynodon* and two digestibility evaluation methods. Animals were housed in individual pens (1.20 x 1.0 m), with concrete floor covered with wood shavings, equipped with individual feeder and drinker. Endoparasite control was done with ivermectin, 1 mL per 50 kg body weight, during the entire stay of animals in the feedlot strategically using the test of counting the eggs per gram of feces (OPG). Adaptation to diet and facilities lasted 14 days and the trial period lasted 84 days. Diet contained 60% forage and 40% commercial concentrate (Table 1), on a dry matter basis. The variable between the treatments were the genotypes of hay belonging to the genus *Cynodon*. Feeding was carried out at 7 AM, offering 60% of the daily amount, and at 2 PM, with the remaining 40%, and water provided *ad libitum*. The adjustment of intake was made daily to allow leftovers of at least 10%. Diets were formulated as recommended by National Research Council

[NRC] (2007). The chemical composition of different genotypes of *Cynodon* is presented in Table 2.

Cr_2O_3 was administered orally at a single dose of 5 g per day, wrapped in paper towel. Samples of feces and leftovers were placed in plastic bags and stored at -10°C. At the end of the trial, the samples were thawed at room temperature and then pre-dried in a forced ventilation oven at 55°C for 72 hours, ground in a Wiley knife through a 1 mm-sieve and sent for laboratory analysis. Chemical composition of food, leftovers and feces of the animals was determined. Analyses of dry matter (DM) (934.01), nitrogen compounds (N) (978.04), organic matter (OM) (estimate) and ash (942.05) were performed according to procedures described by Association Official Analytical Chemist [AOAC] (2005). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (72% sulfuric acid) were analyzed according to the sequential method according to Robertson and Van Soest (1981).

Table 1. Proximate composition of the commercial concentrate.

Ingredients	Percentage in the concentrate, %
Soybean meal	25.00
Ground corn	43.00
Corn germ	25.40
Degummed oil	2.00
Sugar cane yeast	0.25
Dicalcium phosphate	1.50
Sodium Chloride	1.50
Calcium carbonate	1.20
Mineral premix	0.15

Table 2. Chemical composition of the different genotypes of the genus *Cynodon*.

Nutrients	Hay					
	Jiggs	Vaquero	Tifton 68	Coast-Cross	Tifton 85	Russel
DM	92.65	92.86	92.56	92.88	92.43	92.58
DP [1]	12.63	10.98	12.3	10.36	11.91	11.47
NDF [1]	55.23	55.91	54.68	57.98	56.09	56.20
ADF [1]	23.68	21.60	24.15	25.03	23.69	23.94
Lig[1]	3.97	4.08	4.37	4.65	4.34	4.43
TDN [1]	70.46	72.08	70.09	69.40	70.46	70.26
MM [1]	6.36	6.07	6.21	5.92	5.78	6.12

[1]DM basis; TDN estimated according to Patterson et al., (2000); DM: dry matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; Lig: lignin; TDN: total digestible nutrients; MM: mineral matter.

Total dry matter digestibility (DTMS) was determined by an external marker (DMS) of diets using chromium ide and calculated as follows:
DTMS (%) = 100 *(kg nutrient ingested – kg nutrient in feces) / kg nutrient ingested

DMS (%) = 100 – (100 *(% chromium in the feed/% chromium in feces) *(% nutrient in feces / % nutrient in the feed))

Data were subjected to analysis of variance using SAS (2004). When significant, mean values of treatments were compared by *F*-test, considering the 5% significance level.

Results and discussion

Intake of dry matter (IDM) of the diet, in kg animal^{-1} day^{-1}, was significantly different ($p < 0.05$) between treatments (Table 3). Animals receiving Vaquero hay presented IDM 18.3; 16.9; 25.6; 20.7 and 24.2% higher than animals fed hay of Jiggs, Tifton 68, Coast Cross, Tifton 85 and Russel, respectively.

A similar behavior was also observed for ICP, INDF, IADF and ITDN, where animals fed Vaquero hay had higher ($p < 0.05$) intake. The increase in CMS of feedlot finished lambs may result in better performance because it is from the CMS that the animal is consuming a greater or lesser amount of nutrients (Brochier & Carvalho, 2008). This increased intake of diets made with Vaquero hay probably occurred by the variation in components of the cell wall and content quantified by the chemical composition (Table 2). Animals that received Vaquero hay consumed diets with lower ADF content and lignin (Table 2). When free in the cell wall, lignin probably does not interfere or interferes little with IDM. However, when lignin form ester bonds with hemicellulose, it limits the IDM through rumen fill (Mertens, 1994; Van Soest, 1994), and causes metabolic effects of dietary energy and protein, which trigger the satiety center in animals and reduce the dry matter intake (Allen, 2000).

Table 3. Intake of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and total digestible nutrients (TDN) in feedlot lambs fed diets formulated with hay of grasses of the genus *Cynodon* spp.

Treatments	Intake (kg animal^{-1} day^{-1})				
	DM	CP	NDF	ADF	TDN
Jiggs	0.938 B	0.117 B	0.528 B	0.230 B	0.635 B
Vaquero	1.148 A	0.139 A	0.604 A	0.265 A	0.767 A
Tifton 68	0.954 B	0.101 B	0.518 B	0.200 B	0.670 B
Coast-Cross	0.854 B	0.107 B	0.501 B	0.214 B	0.632 B
Tifton 85	0.910 B	0.109 B	0.490 B	0.221 B	0.614 B
Russel	0.870 B	0.103 B	0.504 B	0.217 B	0.634 B
SEM	0.05	0.00	0.02	0.01	0.03
P > Fc	0.01	0.05	0.05	0.05	0.05
CV(%)	12.74	17.75	11.03	11.13	10.95

Mean values followed by different letters in the same column are significantly different by F-test at 5% probability. SEM- Standard error of the mean; p > Fc- Probability; CV- Coefficient of Variation.

However, the average IDM (0.95 kg animal^{-1} day^{-1}) between treatments is close to that recommended by NRC (2007), which set values of 1 kg DM animal^{-1} day^{-1} as a requirement for daily weight gain of up to 200 g animal^{-1} in lambs weighing between 20 and 30 kg body weight.

Net protein requirements for maintenance, according to NRC (2007) for lambs with body weight ranging from 20 to 35 kg body weight are from 9 to 12 grams per kilogram of dry matter (DM). In this study, ICP ranged from 101 to 139 grams animal^{-1} day^{-1}, that is, animals ingested sufficient amounts for maintenance.

Recommendation of NRC (2007) for ICP in lambs with body weight ranging from 20 to 40 kg and daily weight gain of 200 g animal^{-1} day^{-1} is from 120.6 to 149.6 grams day^{-1}, respectively. In this way, only the lambs ingesting Vaquero hay based diets reached the recommended protein intake with average of 139 grams animal^{-} day^{-1} for daily weight gain of 200 grams day^{-1}, which may be the result of the lowest IDM. Nevertheless, TDN intake was below the recommended in all treatments.

NRC (2007) recommends intake of 0.8 kg NDT per day for finishing lambs. The higher ($p < 0.05$) ITDN was observed in the treatment of Vaquero hay diet, which averaged 0.767 kg day^{-1}. Cunha, Carvalho, Véras and Batista (2008) registered ITDN of 0.757 kg day^{-1} in feedlot lambs fed Tifton 85 hay. According to the authors, these values are close to the recommended by NRC (2007), for a growing animal with moderate weight gain.

The digestibility coefficients of dry matter, calculated by the total fecal collection (DMTD) technique and using an external marker (chromium oxide) showed no significant difference between the diets for feedlot finished lambs (Table 4).

Table 4. Total dry matter digestibility coefficient of diets for feedlot finished lambs using total fecal collection (DMTD) and chromium oxide as an external marker.

Treatments	DMTD, %	Chromium oxide, %
Jiggs	70.50 Aa	63.81 Aa
Vaquero	69.62 Aa	65.47 Aa
Tifton 68	68.26 Aa	63.32 Aa
Coast-Cross	71.48 Aa	64.79 Aa
Tifton 85	72.97 Aa	68.31 Aa
Russel	69.22 Aa	68.76 Aa
SEM	2.79	2.73
p > Fc	0.52	0.62
CV (%)	6.07	9.31

Mean values followed by different uppercase letters in the same column, or lowercase letters in the same row, are significantly different by F-test at 5% probability. SEM- Standard error of the mean; CV- Coefficient of Variation

Coefficients of diets are close between the different techniques, indicating precision and accuracy of the data. Mean values of diets for DMTD and for the external marker were 70.3% and 65.7%, respectively. Oliveira et al. (2014) evaluated the ruminal degradability of DM (*in situ* technique) of diets formulated using the same genotypes in this study, and verified mean value of 58.4%, indicating fluctuations in the results, but similar values. These variations are inherent to each technique. Cunha et al. (2008) analyzed diets for lambs containing Tifton 85 hay and increasing levels of cottonseed, and found DMTD of 69.43% in the control diet, corroborating the results obtained herein for the same genotypes.

There was no effect ($p < 0.05$) of diets on the final weight (FW) at slaughter, with an average of 33.7 kg animal^{-1} (Table 5). However, the animals that received Jiggs hay showed higher average daily gain (ADG), total daily gain (TDG) and better feed conversion (FC).

The best ADG of animals receiving Jiggs hay is probably related to chemical composition (Table 2), the rate of degradation and passage of nutrients through the rumen, resulting in better utilization of nutrients in relation to other treatments (Oliveira et al., 2014). These results allow us to infer that even with lower IDM (Table 3), the intake of energy and protein of Jiggs hay diet was not limited to performance, resulting in GPD close to that recommended by NRC (2007). Thus, high NDF levels in diets are not always infer that allows lower animal performance, but the structural arrangement of the cell wall components, especially hemicellulose and lignin, can affect ruminal degradation of fiber. This is because lignin causes intoxication to ruminal microflora, due to the presence of ferulic and *p*-coumaric acids in its molecular structure (Jung & Vogel, 1986) and reduces animal weight gain.

Table 5. Mean values of initial weight (IW), final weight (FW), daily weight gain (ADG), feed efficiency (FE), feed conversion (FC) of feedlot lambs fed *Cynodon* hay based diets.

Treatments	PI (kg)	PF (kg)	GPD (kg)	GPT (kg)	CA
Jiggs	21.36 A	36.14 A	0.180 A	14.78 A	5.21 A
Vaquero	21.42 A	33.90 A	0.152 B	12.48 B	7.55 B
Tifton 68	21.58 A	33.88 A	0.149 B	12.30 B	6.40 B
Coast-Cross	21.44 A	32.16 A	0.130 B	10.72 B	6.56 B
Tifton 85	21.46 A	33.14 A	0.142 B	11.68 B	6.40 B
Russel	21.68 A	32.84 A	0.136 B	11.16 B	6.39B
SEM	0.22	0.89	0.01	0.02	0.20
p > Fc	0.92	0.07	0.04	0.00	0.00
CV, %	2.33	5.94	15.46	15.46	7.14

Mean values followed by different letters in the same column are significantly different by F-test at 5% probability. SEM- Standard error of the mean; CV - Coefficient of Variation

Papi, Mostafa-Tehrani, Amanlou and Memarian (2011) examined different forage: concentrate ratios in the diet and observed higher daily gain for treatments with 50 and 70% hay with average daily gain weight of 0.27 kg and 0.28 kg, respectively. According to the authors, this is due to lower dry matter intake of treatment with 10% hay, since the animals usually consume food to meet their energy requirement. Parente et al. (2009) worked with Santa Inês crossbred sheep, male, non-neutered, receiving diet with Tifton 85 and obtained a GPD of

0.20 kg. Considering the forage: concentrate ratio of 42.75: 57.25, this result is higher than those observed herein, probably the explanation is related to higher proportion of concentrate used in the diet.

On different breeds (Santa Inês ½ Dorper-Santa Inês and ½ White Dorper-Santa Inês) of feedlot lambs receiving the same diet consisting of pelleted feed containing 20% Coast-cross grass hay, Amaral et al. (2011) found, respectively, weight gain of 237 g day^{-1}, 311 g day^{-1} and 317 g day^{-1}. These results are superior to the treatment supplemented with Coast-Cross hay and others. This is probably related to the higher proportion of concentrate, and because feed was pelleted, which provides greater uptake of nutrients by the animals, but this technology generates an additional cost.

Regarding FC, the animals that consumed Jiggs hay based diets showed better feed conversion, which was 31.0; 18.6; 20.6; 18.6 and 18.5% better than the other treatments. This indicates that animals with high IDM, as noted in Jiggs (Table3), tend to present inferiority in FC, probably due to the higher requirements for maintenance and the increased cost in depositing fat in relation to muscle, for each kg body weight gain, which is important when seeking to identify the body weight at slaughter.

According to our findings and also observed by Papi et al. (2011), slaughtering lambs weighing more than 30-35 kg can make fattening activity less profitable or even unprofitable, in view of the high cost of feed for feedlot animals. The authors confined Chall lambs with initial weight of 38 kg, slaughtered them with 60.02 kg and verified mean FC of treatments of 8.2 kg DM kg^{-1} weight gain. Also, they obtained lower quality carcasses due to higher accumulation of fat cover, which made unprofitable the finishing of the animals under those conditions.

Conclusion

Cynodon dactylon grasses have the potential to compose nutritional diets for finishing lambs. The use of diets based on concentrate and Jiggs hay results in higher daily weight gain and better feed conversion. Both the total fecal collection and the use of external marker, chromium oxide, are effective in evaluating diet digestibility.

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