Replacement of alfalfa hay for tropical legumes in goats diets

Substituição do feno de alfafa pelo de leguminosas tropicais em dietas de caprinos

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ABSTRACT
The aim of this study was to evaluate the effect of alfalfa hay replacement by tropical legume hay on goat diets. Four diets were formulated using: 1) perennial soybean hay; 2) tropical kudzu; 3) macrotiloma and 4) alfalfa, in a roughage/concentrate ratio of 25/75. Eight castrated crossbred (Boer x Saanen) animals, with a mean weight of 17.8 kg (4 months of age), were arranged in a 4 x 4 double Latin Square Design. Intake of dry matter (DM), organic matter (OM), crude protein (CP), total carbohydrates (TC), ether extract (EE), non-fibrous carbohydrates (NFC) and total digestible nutrients (TDN) were not affected by the legume species. On the other hand, the intake of acid detergent fiber (ADF) was lower in the diet formulated with alfalfa, compared to the other legumes ($P<0.05$), since this presented lower levels in this diet. The digestibility of DM, OM, CP, ADF, TC and NFC did not differ among the four treatments ($P>0.05$). However, EE digestibility was lower in the diet with alfalfa compared to ration with tropical kudzu and perennial soybeans. The digestibility of this constituent between the diet formulated with tropical kudzu and those formulated with macrotiloma and perennial soybean ($P < 0.05$), and the digestibility of the NDF of the ration prepared with perennial soybean was higher than the other legumes. There was no difference for the nitrogen balance between the different diets, indicating that these legumes are options for replacement of alfalfa hay in goat diets.

Keywords: Digestibility, Intake, Macrotyloma, Perennial Soybean, Tropical Kudzu.

RESUMO
Objetivou-se neste estudo avaliar o efeito da substituição do feno de alfafa pelo feno de leguminosas tropicais em dietas de caprinos. Para isto, foram formuladas quatro rações utilizando feno de soja perene, kudzu tropical, macrotiloma e alfafa, numa relação volumoso: concentrado de 25:75. Foram utilizados oito animais mestiços (Boer x Saanen) castrados, com peso médio de 17,8 kg (4 meses de idade), dispostos em um delineamento em quadrado latino 4 x 4 duplo. O consumo dos constituintes matéria seca (MS), matéria orgânica (MO), proteína bruta (PB), carboidratos totais (CT), extrato etéreo (EE), carboidratos não fibrosos (CNF), fibra em detergente neutro (FDN) e nutrientes digestíveis totais (NDT) não foi afetado pela espécie de leguminosa. Já o consumo de fibra em detergente ácido (FDA) foi menor na ração preparada com alfafa, frente às

demais leguminosas (P<0,05) uma vez que esta se apresentava em menores teores nesta ração. A digestibilidade da MS, MO, PB, FDA, CT e CNF não diferiu entre os quatro tratamentos (P>0,05). No entanto, a digestibilidade do EE foi menor na dieta com alfafa em comparação a ração com kudzu tropical e soja perene. A digestibilidade deste constituinte entre a dieta formulada com kudzu tropical e a formulada com macrotiloma e soja perene (P <0,05), e a digestibilidade do FDN da ração preparada com soja perene foram superiores às demais leguminosas. Não houve diferença para o balanço de nitrogênio entre as diferentes dietas, indicando que essas leguminosas são opções para a substituição ao feno de alfafa em dietas de caprinos.

Palavras-Chave: Consumo, Kudzu Tropical, Macrotiloma, Recuperação De Nitrogênio, Soja Perene.

1 INTRODUCTION

Goat production is a common activity in several tropical regions, and its intensification has the challenge of roughage high nutritional value production, especially during the climate unfavorable season as the Brazilian winter (KANANI et al., 2006). The critical periods results on seasonality of forage production, which determines the need for supplementation in the different production systems. Roughage supplementation can be carried out through a protein bank with legumes, pasture, silage or hay.

Hay process demands a gradual dehydration, by natural or artificial processes of forage plants with minimum loss of nutritional values (ANDRADE, 1999). The phenotype stands out in forages that present characteristics that allow quick dehydration in a uniform way, high forage potential, high water loss capacity and high crude protein content (SILVA et al., 2013; SÁ et al., 2017).

The phenological process is generally carried out in grasses that present high mass production and high water loss capacity, but in forage legumes it is a little disseminated practice in national livestock (CALIXTO Jr. et al., 2012, SILVA et al. al., 2015). The adoption of legumes for this process is restricted to the massive use of alfalfa (*Medicago sativa*), which originates from the temperate climate, since this climatic factor makes it difficult to cultivate this species in the most of Brazilian territory (SILVA et al., 1995; NERES et al., 2010).

As an alternative, there is research being developed to study forage legumes adapted to the tropical climate for animal feed (SÁ et al., 2017). Among the many alternatives, legume kudzu tropical (*Pueraria phaseoloides*), macrotyloma (*Macrotyloma axillare*) and perennial soybean (*Neonotonia wightii*) can be highlighted, which have proved to be good alternatives. However, the inclusion of these legumes in animal feed

needs further studies on nutritional quality, intake and digestibility, which are determinants of animal performance (SILVA et al., 2009).

The hypothesis of the present study was that alfafa hay can be replaced by hay from tropical species on goats diet. The aim of this study was to evaluate the effects of alfalfa hay replacement by tropical kudzu hay, macrotiloma and perennial soybean in goat diets.

2 MATERIAL AND METHODS

The present study was carried out in the Goats Production Section and in the Animal Nutrition Laboratory of the Universidade Federal Rural do Rio de Janeiro (UFRRJ), located in Seropédica - Rio de Janeiro, Brazil, at 22º46 'South and 43º41' West and 33 meters of altitude. The climate of the region is classified as Aw, according to Köppen, with a dry season from April to September and a warm and rainy season from October to March, with annual average rainfall of 1354 mm and average monthly temperature of 23.5ºC.

Eighteen crossbred (Boer x Saanen), weaned, castrated, with an average weight of 17.8 kg (mean age 4 months) were used. The animals were kept in metabolic cages with apparatus for total collection of feces and urine. Each experimental period had a duration of 15 days, being 10 days of adaptation to the diet, 5 days for collection of leftover food and feces, and 3 days for the collection of urine (13th to 15th day), to determine the balance of nitrogen. The kids were weighed at the beginning and end of the trial period. All procedures followed the guidelines of the Animal Care and Ethics Committee of Universidade Federal Rural do Rio de Janeiro.

Experimental rations were prepared with ground legume hay: 1) alfalfa; 2) tropical kudzu; 3) macrotyloma and 4) perennial soybean. The milled hay was mixed with the concentrate to obtain an isoproteic, isoenergetic mixture of homogeneous granulometry. The roughage/concentrate ratio was 25/75. The chemical composition of hay of each legume, centesimal composition and chemical composition of each diet are exhibited on tables 1, and 2, respectively.

Table 1. Chemical composition of legume hays: alfalfa, tropical kudzu, macrotyloma and perennial soybean.

	Roughage			
	Alfafa	Tropical Kudzu	Macrotyloma	P. soybean
DM (%)	83.00	82.00	81.00	83.00
CP (%)	17.99	15.59	15.89	14.50
DE (Kcal/Kg)	2382.40	1936.80	1911.30	2098.30
TDN (%)	54.03	43.93	43.35	47.59
NDF (%)	48.71	62.54	59.48	55.96
ADF (%)	31.90	42.05	42.63	38.38
Ca (%)	1.29	1.00	1.00	1.34
P (%)	0.23	0.20	0.20	0.21

Dry matter (DM), crude protein (CP), digestible energy (DE), total digestible nutrients (TDN), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

Table 2. Composition of experimental diets (treatments) with legume hays: alfalfa, tropical kudzu, macrotyloma and perennial soybean

	Treatments			
	1	2	3	4
Ingredients (%)				
Soybean meal	2.50	4.86	3.96	4.52
Corn	51.00	60.40	59.27	55.60
Wheat bran	19.23	7.41	9.63	12.64
Alfafa hay	25.00	-	-	-
Tropical kudzu hay	-	25.00	-	-
Macrotyloma hay	-	-	25.00	-
Perennial soybean hay	-	-	-	25.00
Urea	0.17	0.36	0.39	0.36
Calcareous	0.60	0.47	0.46	0.40
Mineral mixed[1]	1.10	1.10	0.90	1.08
NaCl	0.40	0.40	0.40	0.40
Chemical composition				
DM (%)	89.08	86.35	85.78	87.56
CP (%)	14.04	14.02	14.00	14.01
DE (Kcal/Kg)	2936.4	2929.5	2909.9	2925.6
TDN (%)	66.60	66.45	66.00	66.36
NDF (%)	28.19	28.07	28.00	28.02
ADF (%)	12.90	14.46	14.77	14.02
Ca (%)	0.68	0.55	0.54	0.61
P (%)	0.39	0.30	0.32	0.34
Mg (%)	0.17	0.13	0.14	0.15

[1]Mineral mixed. Dry matter (DM), crude protein (CP), digestible energy (DE), total digestible nutrients (TDN), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

It was supplied the amount of 3.89% of body weight (BW) on dry matter (DM) basis, 30% higher than that recommended by NRC (2007) for gain of 100 grams/day. The diets were supplied twice a day at 8:00 a.m. and 2:30 p.m. Nutritional values, diet digestibility and body weight gain of growing goats were evaluated.

The apparent digestibility of DM, crude protein (CP), organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), total carbohydrates were estimated by total collection of feces. The equation adopted was (Equation 1):

$$\text{Apparent digestibility} = \frac{\text{intake-excretion}}{\text{intake}} \text{ x } 100 \quad [1]$$

Total feces collection was performed using trays fixed below the grid floor of each cage. The feces were weighed, and an aliquot of 20% of the total sample was used to compose the representative composite sample of each animal in each experimental period.

The urine was collected in plastic buckets placed under the tray of each cage, in which 100 mL of 50% HCl were added to fix the nitrogen, and they were equipped with impurities retention screens. After collection, the urine was weighed and sampled in 10% of its daily volume for compound composition of each experimental period, which were conditioned in glass bottles and frozen at -20ºC for subsequent determination of urinary nitrogen.

Samples were dried in a forced ventilation oven (55±5°C for 72 hours), milled in a Willey mill with 1 mm sieves and packed in plastic bags duly identified by animal, treatment and period. Analysis of DM, OM, CP and EE were performed according to the methodology described by AOAC (1990). The analyzes of neutral detergent fiber (NDF), acid detergent fiber (ADF) and neutral detergent insoluble nitrogen (NDIN) were performed according to Van Soest et al. (1991). Total digestible nutrient were estimated according to Sniffen et al. (1992).

The percentage of total carbohydrates (TC) was obtained by equation 2, and non-fibrous carbohydrates (NFC) by the equation 3, according to Sniffen et al. (1992):

$$TC = 100 - (\%CP + \%EE + \%MM) \quad [2]$$

$$NFC = 100 - \left(\%CP + \%EE + \%NDF_{\text{corrected for ash and protein}} + \%MM\right) \quad [3]$$

FDNcp was analyzed according to Van Soest et al. (1991), where by boiling the samples in a neutral detergent solution, the NDF residue was obtained and the latter was then brought to the muffle at 600ºC for 1 hour to determine the mineral insoluble matter content of the neutral detergent. Correction for the protein was performed by determining the value of the neutral detergent insoluble nitrogen (NDIN), which is multiplied by 6.25.

The experimental design was in a 4 x 4 double Latin Square. The results were evaluated through analysis of variance and the means tested by the SNK test, at 5% of probability, using the SAEG statistical package (UFV, 2000).

3 RESULTS

There were no differences on DM and nutrients intake (P>0,05). Average daily weight gain (ADG) did not differ between treatments (P> 0.05; table 3).

Table 3. Intake of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), total carbohydrates (TC), non-fibrous carbohydrates (NFC), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrients, and average daily gain (ADG) by crossbred (Boer x Saanen) male goats receiving diets with roughage sources.

	Roughage			
	Alfafa	T. Kudzu	Macrotyloma	P. soybean
DM intake (Kg/d)	0.93	0.96	0.93	0.96
DM intake (% do PC)	4.31	4.34	4.32	4.42
OM intake (Kg/d)	0.87	0.90	0.89	0.90
CP intake (Kg/d)	0.14	0.14	0.13	0.14
EE intake (Kg/d)	0.03	0.03	0.03	0.03
TC intake (Kg/ d)	0.82	0.87	0.83	0.86
NFC intake (Kg/d)	0.50	0.54	0.47	0.47
NDF intake (Kg/d)	0.32	0.33	0.36	0.39
ADF intake (kg/d)	0.12c	0.13b	0.17a	0.14b
TDN intake (Kg/d)	0.80	0.88	0.80	0.86
ADG (kg/d)	0.13	0.13	0.15	0.10

Means followed by the same letter in the same line do not differ by SNK test (α=0,05).

The digestibility of the constituents DM, OM, CP, TC, NFC and ADF did not differ (P> 0.05; table 4).

Table 4. Digestibility of dry matter (DM), organic matter (OM), crude protein (CP), total carbohydrates (TC), non-fibrous carbohydrates (NFC), ether extract (EE), neutral detergent fiber (NDF), and acid detergent fiber (ADF) by crossbred (Boer x Saanen) male goats receiving diets with roughage sources.

	Roughage			
	Alfafa	T. Kudzu	Macrotyloma	P. soybean
DM (%)	77.13	79.63	77.07	79.19
OM (%)	78.24	80.79	78.00	80.34
CP (%)	76.96	78.77	76.33	77.21

TC (%)	77.18	79.99	77.22	79.44
NFC (%)	85.43	87.54	87.00	85.54
EE (%)	80.27c	87.97a	82.05bc	84.17b
NDF (%)	64.27b	67.93b	64.47b	72.13a
ADF (%)	49.75	52.48	56.37	52.54

Means followed by the same letter in the same line do not differ by SNK test (α=0,05).

Nitrogen losses from feces and urine were not influenced by legume species added to diets (P> 0.05). The animal was able to retain 13.5; 14.6; 13.2 and 13.9 g / day of N for diets containing alfalfa, tropical kudzu, macrotiloma and perennial soybean, respectively (table 5).

Table 5. Nitrogen balance by crossbred (Boer x Saanen) male goats receiving diets with roughage sources.

	Roughage			
	Alfafa	T. Kudzu	Macrotiyloma	P. soybean
N intake (g/day)	22.89	22.79	20.77	22.58
N-total feces (g/day)	5.08	4.55	4.69	4.84
N-total urine (g/day)	4.29	3.64	2.87	3.79
Balanço de N (g/dia)	13.52	14.60	13.22	13.95

Fecal and urinary nitrogen losses corresponded to 40.9; 35.9; 36.4 and 38.2% of the nitrogen ingested for alfalfa, tropical kudzu, macrotiloma and perennial soybean rations, respectively, indicating that the animal used 59.1; 64.1; 63.6 and 61.8% of the ingested nitrogen.

4 DISCUSSION

Small ruminants have the ability to adapt to the different types of management and feeding, thus regulating their consumption to meet their nutritional requirements (SILVA et al., 2006). The ADF intake differed (P <0.05), and was lower for diet formulated with alfalfa in relation to other legumes. This dissimilarity is explained by the difference in the ADF content in the diets, in which the feed formulated with alfalfa had a lower content of this constituent than the other diets (P <0.05).

Evaluating the association or not of legume hay with concentrate in goat diets Anglo-Nubiano, Câmara et al. (2015) observed that the intake of DM, NDF, ADF and TDN did not differ. The authors associated this response with the fiber content of legumes used, styles and leucine, which are forages with higher fiber content.

Studying the intake of different protein sources for Alpine and Anglo-Nubian goats, Santos et al. (2014) reported that DM intake did not differ between treatments

(soybean meal, cotton cake, cassava leaf hay and leucine hay), and data reported corroborate with the present study, with DM intake (% PC) between 4.0-4.5. Santos et al. (2014), based on the literature, have stated that the substitution of traditional protein foods for alternative foods does not affect consumption, as long as NDF levels are at levels that do not restrict consumption, and also when diets are isonitrogen.

Average daily weight gain (ADG) did not differ between treatments (P> 0.05). This is due to the fact that the diets are formulated to guarantee ADG of 100g/day, and the highest weight observed relative to the excess intake of the feed supplied, which in the experimental conditions was to guarantee a leftover of 30%.

In a study using isoproteic and isoenergetic diets with inclusion of tifton 85 hay and maniçoba for feeding goats of the Moxotó breed, Lima Júnior et al. (2015) observed that there was lower intake before the prediction of the NRC (2007) for the categories and weights studied, resulting in lower weight gain and even loss. The authors attributed this result to the insufficient adaptation of the animals to the diet; the advanced age of the animals (> 20 months) at the beginning of the confinement and the extensive system that were created before confinement.

In the present study, the results of intake and weight gain were consistent with the prediction of NRC (2007). This is attributed to several factors that were controlled during the conduction of the experiment as: experimental ration with the same proportion of roughage/concentrate; less roughage, which could interfere the intake, due to the high NDF content when compared to concentrated diets; homogeneous mixture in terms of granulometry, protein content and energy.

The apparent digestibility of the nutrients is associated with the chemical composition. Increased amounts of lignified and sclerenchyma vascular tissues also provide lower digestibility rates (WILSON; HATFIELD, 1997).

Temperate legumes present higher digestibility in relation to tropical legumes, but in the present study, the rations presented similar digestibility to those composed by alfalfa.

Nitrogen balance is an important tool to determine the efficiency of ruminant protein utilization and its losses to the environment (GENTIL et al., 2007). In this study, nitrogen balance was positive in all evaluated diets, an expected result, since the goats were growing. The positive balance occurs when the ingested nitrogen is higher than excreted, occurring in animals that are synthesizing new tissue such as growth, gestation or recovery from injury and disease (CASE et al., 1998).

5 CONCLUSIONS

The inclusion of tropical legume hays studied presented nutritional values and animal performance similar to alfalfa, which allows their replacement in the diets of growing goats without adverse effects.

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