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Nutritional value and chemical composition of pastures of peanut forage or red clover

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ABSTRACT. With this study, we aimed at evaluating the nutritional value and chemical composition of forage legume intercropping with elephant grass (EG) + spontaneous growth species (SGS) + annual ryegrass (AR) + peanut forage (PF), as treatment T1; and EG + SGS + AR + red clover (RD), as T2. The EG was planted in 4-m spaced rows. The annual ryegrass was planted between the EG rows during the cool season; the RC was sowed and the PF was preserved. The experiment was performed between October 2009 and April 2010, with six grazing cycles. Samples of forage legume was collected, under simulated the grazing, to determine the levels of organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), organic matter *in situ* digestibility (OMISD), total phenols (TF), total tannins (TT), and condensed tannins (CT). The mean values of OM, CP, NDF, OMISD, TF, TT and TC were 90.8, 20.96, 48.38, 86.68, 1.92, 1.42 and 1.39%; and 91.84, 21.41, 41.36, 85.18, 1.90, 1.31 and 0.17% for peanut forage and red clover, respectively. Higher values ($p \leq 0.05$) were observed in the level of CT of peanut forage.

Keywords: *Arachis pintoi*, crude protein, digestibility, neutral detergent fiber, phenolic compounds, *Trifolium pratense*.

Valor nutritivo e composição química de pastagens de amendoim forrageiro ou trevo vermelho

RESUMO. Com esta pesquisa, objetivou-se avaliar o valor nutritivo e a composição química da forragem de leguminosas consorciadas com o capim elefante (CE) + espécies de crescimento espontâneo (ECE) + azevém anual (AZ) + amendoim forrageiro (AF), como tratamento T1; e CE + ECE + AZ + trevo vermelho (TV), como T2. O CE foi estabelecido em linhas afastadas a cada 4 m. O azevém anual foi estabelecido entre as linhas do CE durante o período hibernal; o TV foi semeado e o AF foi preservado. O experimento foi realizado entre outubro de 2009 e abril de 2010, sendo realizados seis pastejos. Foram coletadas amostras de forragem das leguminosas, simulando o pastejo, para determinação dos teores de matéria orgânica (MO), proteína bruta (PB), fibra em detergente neutro (FDN), digestibilidade *in situ* da matéria orgânica (DISMO), fenóis totais (FT), taninos totais (TT) e taninos concentrados (TC). Os valores médios de MO, PB, FDN, DISMO, FT, TT e TC foram de 90,8; 20,96; 48,38; 86,68; 1,92; 1,42 e 1,39%; e de 91,84; 21,41; 41,36; 85,18; 1,90; 1,31 e 0,17% para o amendoim forrageiro e trevo vermelho, respectivamente. Valores superiores ($p \leq 0,05$) foram observados no teor de TC da forragem do amendoim forrageiro.

Palavras-chave: *Arachis pintoi*, proteína bruta, digestibilidade, fibra em detergente neutro, compostos fenólicos, *Trifolium pratense.*

Introduction

Milk production is one of the most predominant and important activities in the state of Rio Grande do Sul, especially in small and medium properties. In most of them, pastures are the main source of forage for cattle, consisting especially of grasses. In this strategy, the elephant grass has been a key alternative as a forage supply for animals in different regions of the country (SILVA et al., 2002).

The majority of studies evaluate the elephant grass mainly during the warm season, frequently including the production peak, between late spring and summer, and few references analyze this forage during the crop year (OLIVO et al., 2007).

In the properties, the elephant grass is planted in a singular way, with few studies evaluating this crop associated with other species, aiming the establishment of forage systems (SOBCZAK et al., 2005), for the use of the pasture throughout the crop year, with greater balance between production and quality of the forage.

In this way, researches have being undertaken to increase the yield of these systems by introducing legumes with cool season, such as the red clover (PAIM, 1994) or with warm season, like the peanut forage (MACHADO et al., 2005), characterized by a high nutritional value (OLIVO et al., 2009), by

contributing to the reduction of chemical fertilization (SANTOS et al., 2002) and preventing the sward degradation (AROEIRA et al., 2005). Despite having this forage potential, they also have antinutritional factors, highlighting the tannins with variable levels in the legumes (LASCANO, 1994), which can influence the animal performance. The tannins and phenols are phenolic compounds from the secondary metabolism of the plants (BUTLER et al., 1984; SOUZA et al., 2007), but can play a great influence on the forage nutritional value. However, there is a scarcity of studies evaluating the nutritional values and the chemical composition of intercropped forage legumes and under grazing conditions, remarkably as for tannin levels.

Thus, this study evaluated the nutritional value and chemical composition of legumes (peanut forage and red clover) subjected to intercropping with grasses and grazed by dairy cows.

Material and methods

The study was conducted in an experimental area belonging to the Department of Zootechny of the UFSM, located in the Central Depression (Santa Maria, Rio Grande do Sul State), at 29º43'45.41" latitude and 53º42'03.62" longitude. The average temperature and rainfall were 19.31ºC and 2,368 mm. For the temperature, the values were similar to the regular ones. But, during the warm season, the rainfall surpassed the historical average, except for the late February and mid-March, with a rainfall deficit. The climate in the region is humid subtropical, according to the classification of Köppen, and the soil is classified as red eutrophic argisol (EMBRAPA, 2006).

The treatments were made up by the legumes peanut forage and red clover, intercropped with two forage systems, with the common components: elephant grass, the spontaneous growth species, and annual ryegrass.

The experimental area used had 0.52 ha., (subdivided into four paddocks of 0.13 ha each), with the forage elephant grass (*Pennisetum purpureum* Schum.), cv. Merckeron Pinda, planted since 2004 in 4-m spaced rows. Between the rows, in two paddocks, the peanut forage was planted since 2004 (*Arachis pintoi* Krap. And Greg. cv. Amarillo). On May 11st, 2009 the anual ryegrass (*Lolium multiflorum* Lam.), cv. Comum, was sowed throughout the area between the rows formed by clumps of elephant grass, at the rate of 30 kg ha^{-1}, by scarifying the soil. In two paddocks it was also sowed the red clover (*Trifolium pratense* L.), cv. Estanzoela 116, at the rate of 3 kg ha^{-1}. The areas were planted and managed without herbicides, allowing the development of spontaneous growth species.

The area was fertilized using 300 kg ha^{-1} N-P_2O_5-K_2O (5-20-20) and 13 kg ha^{-1} KCl, according to soil analysis and recommendations for perennial legumes (SBCS, 2004). As topdressing, it was applied urea, corresponding to 13.5 kg ha^{-1} nitrogen. The study was performed between October 2009 and April 2010, corresponding to the production cycle of the peanut forage. The occupation of each paddock lasted from one to two days.

For the assessment, it was used Holstein dairy cows, 565.24 ± 33.52 kg in average live weight, and average milk production of 21.5 ± 6.1 kg day^{-1}. The animals were submitted to milking at 7h and at 16h. After this, the cows received dietary supplement according to milk production. On average, a level of 5 kg concentrate day^{-1} was supplied. The cows stayed on the pastures from 9 to 15h 30 min. and from 18 to 6h 30 min.

Before the entry of the animals, the forage mass was estimated using double sampling technique (WILM et al., 1944). On the elephant grass, the cuts were made at 50 cm above the ground, and between the rows, to the ground level. The samples were weighed and homogenized; a subsample was withdrawn for the estimative of the botanical composition of the pasture, and structural composition of the elephant grass, being later oven dried to determine the partial dry matter.

To determine the chemical composition of the forage, samples were taken from each paddock, under simulated grazing (EUCLIDES et al., 1992), being dried and milled with a Willey-type mill, stored and analyzed afterwards.

The levels of dry matter were determined for all samples, by oven drying at 105ºC for 8 hours, and ash levels in muffle furnace at 600ºC for 3 hours. The level of organic matter was calculated as OM = dry matter (DM) - ash. The nitrogen level was determined by the Kjeldahl method (AOAC, 1995). The level of neutral detergent fiber was verified according to Silva and Queiroz (2002), adapted for using autoclave (SENGER et al., 2008). For the *in situ* digestibility, the technique of Mehrez and Orskov (1977) was applied, which evaluates the degradation of foods using porous bags under actual conditions of the rumen environment.

To determine the phenolic compounds of the legume forage, the samples of peanut forage and red clover were partially dried, milled and stored for further analysis, as described by Makkar (2000).

The experimental design was completely randomized with two treatments (legumes), two repetitions of area (paddocks) and plots subdivided

over time (grazing cycles). The data were subjected to analysis of variance, being the mean values compared by the F-test at 5% significance level, and correlation, by Pearson Coefficient. The analyses were made using the SAS, (1997) statistical package (Statistical Analysis System, version 9.2).

The statistical model relative to the analysis of the pasture variables was represented by:

$$Y_{ijk} = m + T_i + R_j(T_i) + C_k + (TC)_{ik} + \varepsilon_{ijk}$$

where:

Y_{ijk} represents the dependent variables, i, index of treatments (forage systems, for the assessment of botanical composition, and legume systems, for the analysis of the nutritional value and chemical composition); j, index of repetitions (paddocks); k, index of grazing; m is the mean value of all observations; T_i is the effect of the treatments; $R_j(T_i)$ is the effect of the repetition within the treatments (error a); C_k is the effect of the grazing cycles; $(TC)_{ik}$ is the interaction between the treatments and grazing; ε_{ijk} is the residual experimental error (error b).

Results and discussion

Along the experimental period, 212 days, six grazing cycles were performed, with an average time of rest of 35 days between each grazing. Short periods of occupation, as in the present study, are associated with the quality of forage provided to the animals (SOARES et al., 2004) and with the performance of dairy cows (DERESZ, 2001).

The values of pre-grazing forage mass were, on average, 3.97 and 4.05 t ha^{-1} DM for the systems formed by peanut forage and red clover. For the participation of the major pasture components (Table 1) some differences were observed. For the elephant grass and annual ryegrass, the values were similar. For *Paspalum* and other species with spontaneous growth, significant differences were detected ($p \leq 0.05$) due to the presence of legumes. The highest participation of the legumes is related to the decrease of spontaneous growth species, evidenced by the inverse correlation with the red clover ($r = -0.90$; $p = 0.03$).

Variations were observed for the legumes, due to the different development cycles of each. The peanut forage had a small contribution, initially, in the grazing performed in October, but high and continuous in the other evaluations.

Table 1. Percentage of the botanical components in two forage systems involving the legumes (LEG) peanut forage (PF) and red clover (RC).

Variables	LEG	Grazing periods						Mean	CV (%)
		Oct.	Dec.	Dec.	Jan.	Feb.	Apr.		
		2009			2010				
EG	PF	5.27	42.89	39.92	33.92	41.09	39.38	33.74	8.86
	RC	7.01	31.31	41.51	31.64	50.53	36.07	33.01	
AR	PF	44.43	-	-	-	-	-	44.43	8.33
	RC	36.72	-	-	-	-	-	36.72	
LEG	PF	9.99[b]	22.20	22.50	24.54[a]	25.82	25.33	21.73	4.28
	RC	23.68[a]	19.23	15.93	12.91[b]	-	-	17.94	
PAS	PF	-	5.58	11.28	14.90	10.18	15.74[b]	11.53	12.16
	RC	-	11.28	12.06	19.41	16.81	31.32[a]	18.17	
SGS	PF	17.56[a]	5.03	13.57	16.20[b]	13.47	11.09	12.82	16.96
	RC	11.39[b]	14.31	18.81	26.15[a]	19.81	21.08	18.59	
TDM	PF	22.74	24.28	12.71	10.42	9.43	8.44	14.67	11.18
	RC	21.19	23.87	11.69	9.89	12.84	11.52	15.16	

'a b' means followed by different letters in the column are significantly different by the F-test ($p \leq 0.05$). [1]PF = elephant grass (EG) + anual ryegrass (AR) + spontaneous growth species (SGS) + PF; RC= EG + AR + SGS+ RC (control treatment); PAS = *Paspalum* spp.; TDM = total dead material.

For the red clover, a greater variability was verified for its participation, however its presence was not detected from February, partially due to the cumulative effect of heat and water deficit in the period, corroborating Paim (1994), which stated that this forage is sensitive to these conditions.

In relation to the red clover organic matter (Table 2), a typical trend was registered, with the lowest level at the end of the development cycle.

Table 2. Percentage of mineral matter (MM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), organic matter *in situ* digestibility (OMISD), total phenols (TF), total tannins (TT), and condensed tannins (CT) of the forage of the legumes (LEG) peanut forage (PF) and red clover (RC).

Variables	LEG	Períodos de Pastejo						Mean	CV (%)
		Oct.	Dec.	Dec.	Jan.	Feb.	Apr.		
		2009			2010				
MM	PF	8.23	8.74	9.13[a]	10.38	9.22	9.47	9.20	2.90
	RC	8.60	8.35	7.79[b]	7.90	-	-	8.16	
OM	PF	91.77	91.26	90.86[b]	89.62	90.78	90.53	90.80	0.28
	RC	91.39	91.64	92.20[a]	92.10	-	-	91.84	
CP	PF	22.17[b]	21.60	22.64[a]	18.67	20.51	20.17	20.96	4.43
	RC	30.10[a]	21.42	18.54[b]	15.57	-	-	21.41	
NDF	PF	47.66	47.85	45.53[a]	52.54	50.32	43.36	48.38	1.60
	RC	36.29	39.94	37.73[b]	51.47	-	-	41.36	
OMISD	PF	92.14[b]	90.23	89.32	81.81	82.75	83.83	86.68	1.55
	RC	94.92[a]	85.37	85.53	74.91	-	-	85.18	
TF	PF	2.43[a]	2.20	2.18	1.90	1.72	1.87	1.92	7.72
	RC	2.07[b]	2.41	1.90	1.23	-	-	1.90	
TT	PF	1.74[a]	1.55	1.59	1.43	1.29	1.38	1.42	9.14
	RC	1.37[b]	1.70	1.34	0.83	-	-	1.31	
CT	PF	1.44[a]	1.26[a]	1.48[a]	1.56[a]	1.18	1.35	1.39	12.25
	RC	0.08[b]	0.19[b]	0.20[b]	0.21[b]	-	-	0.17	

'a b' means followed by different letters in the column are significantly different by the F-test ($p \leq 0.05$); Samples of simulated grazing.

For the peanut forage, the levels have indicated a lower variability in the organic matter.

The highest value ($p \leq 0.05$) of crude protein was observed with the red clover in the grazing in October. Drawing a comparison, also this fraction had the highest variability for the peanut forage. The values observed are within the expected. According to Paim (1994), the crude protein levels of the red clover

vary from 28% in the vegetative period to 16% in the period of seed formation. The mean value of crude protein of red clover is higher than reported by Lopez et al. (2001) who found for the red clover hay, values of 14.8%, with hay of the whole plant.

The mean level of crude protein for the peanut forage was close to 20%, higher than 13%, for the dry season, and similar to 19%, for the rainy season, obtained by Carulla et al. (1991) with leaves of *A. pintoi* CIAT 17434, highlighting that the samples of simulated grazing in the present study was primarily made up by this plant structure. The mean value obtained is similar to that verified by Silva et al. (2009), with the same cultivar of peanut, and cuts performed between 60 and 90 days, from January to March.

Considering the neutral detergent fiber, for the red clover the values were close to expected, increasing at the final development period of this forage. In the period when the levels of neutral detergent fiber were greater, around 50%, the red clover was forming seeds. The mean level observed for the red clover was similar to 40.1% obtained by Rocha et al. (2007), examining whole plants. For the peanut forage, the values were higher and more stable between the grazing cycles. A superior result was found by Olivo et al. (2010), with a mean level 55.93% in samples of simulated grazing for the peanut forage. A similar value (46.6%) was recorded for the same cultivar by Silva et al. (2009), with samples obtained by cutting the pasture.

Usual negative correlations between the levels of crude protein and neutral detergent fiber were expected and observed both for peanut forage ($r = -0.81$; $p = 0.0014$) and for red clover ($r = -0.70$; $p = 0.0500$). A positive association between crude protein and participation (%) of the legume in the pasture was verified for the red clover ($r = 0.86$; $p = 0.005$). This relationship was not observed for peanut forage, especially because of its participation more stable and regular (Table 1), and also due to the lower variability in its protein composition, also confirmed by Carulla et al. (1991).

A difference ($p \leq 0.05$) was detected for organic matter *in situ* digestibility in October (Table 2), with the highest value observed for the red clover, which also presented the highest variability in the levels compared to the peanut forage. For both legumes, the mean values were high, above those reported by Lenzi et al. (2009), with digestibility values of 68 and 70% for the whole plant of peanut forage for the dry and rainy season, respectively. Besides that, it was registered correlations between the levels of *in situ* digestibility with neutral detergent fiber ($r = -0.66$; $p = 0.0181$, for the peanut; $r = -0.88$; $p = 0.0037$, for the clover) and with crude protein ($r = 0.85$; $p = 0.0004$, for the peanut; $r = 0.92$; $p = 0.0014$, for the clover).

In relation to the total phenols, a significant difference ($p \leq 0.05$) was identified, with the highest value for the peanut forage in October (Table 2). The regression analysis models kept a similarity between the legumes, but with higher variability in the levels of the red clover.

The highest level of total tannins ($p \leq 0.05$) was observed for the peanut forage in October. The regression models obtained were distinct, being decreasing linear for the peanut forage and cubic with initial ascendent for the red clover (Figure 1). Mean concentrations between 1 and 2% of total tannins, as observed for the evaluated legumes, seem to cause no effect on the protein digestion in the rumen (PONCET; RÉMOND, 2002). When supplied at high concentrations (6-12% DM), it may cause a decrease in the voluntary intake and in the efficiency of digestion process and animal productivity (FRUTOS et al., 2002).

Regarding the levels of condensed tannins, the values of the peanut forage were higher in all evaluations (Table 2). Also, there was a greater variability for the red clover, with a linear increase in the condensed tannins according to the plant development (Figure 1). The mean level of condensed tannins is lower than observed by Lascano (1994), of 2.5%, for *A. pintoi* CIAT 17434. Tannins can be beneficial or harmful, depending on the amount consumed, structural components, molecular weight, and animal physiology (HAGERMAN; BUTLER, 1981).

The tannin levels of peanut forage were relatively low, pointing out the partial protection that this component may provide to the protein degradability in the rumen (LASCANO, 1994). This assertion was evidenced in studies with alfalfa in comparison with *Arachis glabrata* cv. Florigraze, in which the protein degradability rates were similar between these forages (ROMERO et al., 1987).

According to Otero and Hidalgo (2004), it is recommended levels of 2-4% of condensed tannins in the dry matter, so that there is no decrease in the intake and digestibility, with a consequent increase in the amount of non-degraded proteins in the rumen, improving thus the use of essential amino acids in the small intestine. For Animut et al. (2008), condensed tannin concentrations between 3 and 4% decrease the waste of ammonia, prevent the tympanism, increase the absorption of amino acids from the diet in the small intestine, and reduce the methane production in the rumen.

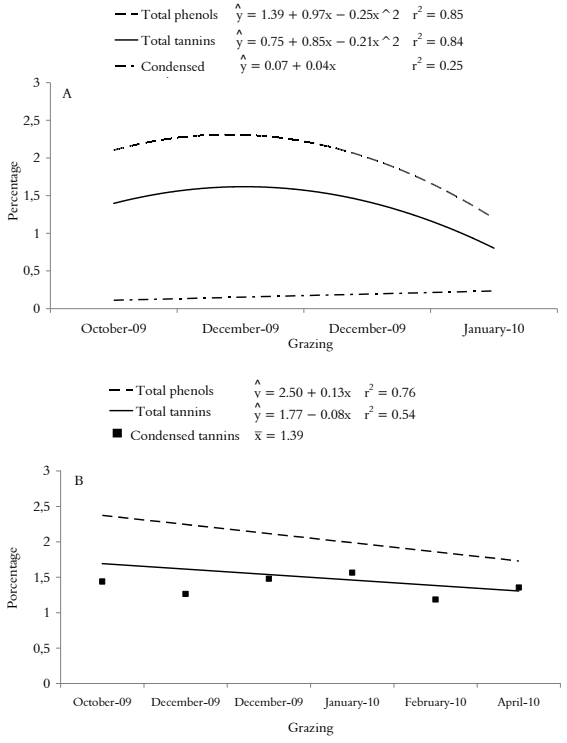

Figura 1. Percentage of total phenols, total and condensed tannins of the red clover (A) and peanut forage (B).

Conclusion

In summary, the red clover and the peanut forage have similar nutritional value. The peanut forage has higher levels of condensed tannins. Comparatively, the participation of the peanut forage in the pasture is more regular, with lower variability in the nutritional components and in the phenolic compounds of the forage.

References

ANIMUT, G.; PUCHULA, R.; GOETSCH, A. L.; PATRA, A. K.; SAHLU, T.; VAREL, V. H.; WELLS, J. Methane emission by goats consuming different sources of condensed tannins. **Animal Feed Science and Technology**, v. 144, n. 3/4, p. 228-241, 2008.

AROEIRA, L. J. M.; PACIULLO, D. S. C.; LOPES, F. C. F.; MORENZ, M. J. F.; SALIBA, E. S.; SILVA, J. J.; DUCATTI, C. Disponibilidade, composição bromatológica e consumo de matéria seca em pastagem consorciada de *Brachiaria decumbens* com *Stylosanthes guianensis*. **Pesquisa Agropecuária Brasileira**, v. 40, n. 4, p. 413-418, 2005.

AOAC-Association of Official Analytical Chemists. **Official methods of analysis**. 12th ed. Washington, D.C.: AOAC, 1995.

BUTLER, L. G.; RIEDL, D. J.; LEBRYK, D. G.; BLYTT, H. J. Interaction of proteins with sorghum tannin: mechanism, specificity and significance. **Journal of the American Oil Chemistry Society**, v. 61, n. 5, p. 916-920, 1984.

CARULLA, J.; LASCANO, C. E.; WARD, J. K. Selectivity of residente and oesophageal fistulated steers grazing *Arachis pintoi* and *Brachiaria dictyoneura* in the Llanos of Colombia. **Tropical Grasslands**, v. 25, n. 4, p. 315-324, 1991.

DERESZ, F. Influência do período de descanso da pastagem de capim elefante na produção de leite de vacas mestiças Holandês x Zebu. **Revista Brasileira de Zootecnia**, v. 30, n. 2, p. 461-469, 2001.

EMBRAPA-Centro Nacional de Pesquisa Agropecuária. **Sistema brasileiro de classificação de solos**. 2. ed. Rio de Janeiro: Embrapa Solos, 2006.

EUCLIDES, V. P. B.; MACEDO, M. C. M.; OLIVEIRA, M. P. Avaliação de diferentes métodos de amostragens sob pastejo. **Revista Brasileira de Zootecnia**, v. 21, n. 4, p. 691-702, 1992.

FRUTOS, P.; HERVÁS, G.; RAMOS, G.; GIRÁLDEZ, F. J.; MANTECÓN, A. R. Condensed tannin content of several shrub species from a mountain area in northern Spain, and its relationship to various indicators of nutritive value. **Animal Feed Science and Technology**, v. 95, n. 3/4, p. 215-226, 2002.

HAGERMAN, A. E.; BUTLER, L. G. The specificity of proantho cyaniding-protein interactions. **Journal of Biological Chemistry**, v. 256, n. 9, p. 4494-4497, 1981.

LASCANO, C. E. Nutritive value and animal production of forage *Arachis*. In: KERRIDGE, P. C.; HARDY, B. (Ed.). **Biology and agronomy of forage *Arachis***. Colômbia: CIAT, 1994. cap. 10. p. 109-121.

LENZI, A.; CECATO, U.; MACHADO FILHO, L. C. P.; GASPARINO, E.; ROMA, C. F. C.; BARBERO, L. M.; LIMÃO, V. A. Produção e qualidade do pasto de *coastcross* consorciado ou não com amendoim forrageiro com ou sem aplicação de nitrogênio. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 61, n. 4, p. 918-926, 2009.

LOPEZ, V. A.; MORALES, S.; CABRERA, C. R.; ARIAS, M. Ingestión y digestibilidad aparente de forrajes por la llama (*Lama glama*). II. heno de trébol rosado (*Trifolium pratense*), heno de ballica (*Lolium multiflorum*), paja de poroto (*Phaseolus vulgaris*) y paja de avena (*Avena sativa*). **Archivos de Medicina Veterinaria**, v. 33, n. 2, p. 145-152, 2001.

MACHADO, A. N.; SIEWERDT, L.; VAHL, L. C.; FERREIRA, O. G. L. Estabelecimento e produção de amendoim-forrageiro em campo natural de planossolo, sob diferentes níveis de fósforo e potássio. **Revista Brasileira de Agrociência**, v. 11, n. 4, p. 461-466, 2005.

MAKKAR, H. P. S. **Quantification of tannins in tree foliage**. Vienna: FAO/IAEA, 2000. p. 38.

MEHREZ, A. Z.; ORSKOV, E. R. A study of the artificial fibre bag technique for determining the digestibility of feed in the rumen. **Journal of Agricultural Science**, v. 88, n. 3, p. 645-650, 1977.

OLIVO, C. J.; CHARÃO, P. S.; PEREIRA, L. E. T.; ZIECH, M. F.; MEINERZ, G. R.; TYSKA, D. Produtividade e valor nutritivo de pasto de capim elefante manejado sob princípios agroecológicos. **Revista Brasileira de Zootecnia**, v. 36, n. 6, p. 1729-1735, 2007.

OLIVO, C. J.; ZIECH, M. F.; BOTH, J. F.; MEINERZ, G. R.; TYSKA, D.; VENDRAME, T. Produção de forragem e carga animal em pastagens de capim elefante consorciadas com azevém, espécies de crescimento espontâneo e trevo-branco ou amendoim forrageiro. **Revista Brasileira de Zootecnia**, v. 38, n. 1, p. 27-33, 2009.

OLIVO, C. J.; STEINWANDTER, E.; AGNOLIN, C. A.; MEINERZ, G. R.; SANTOS, J. C.; BEM, C. M.; AGUIRRE, P. F.; MACHADO, P. R.; ARAÚJO, T. L. R. Contribuição dos componentes e composição química de pastagens em sistemas forrageiros constituídos por diferentes leguminosas. **Ciência Rural**, v. 40, n. 12, p. 2534-2540, 2010.

OTERO, M. J.; HIDALGO L. G. Taninos condensados en especies forrajeras de clima templado: efectos sobre la productividad de rumiantes afectados por parasitoses gastrointestinales (una revisión). **Livestock Research for Rural Development**, v. 16, n. 2, p. 1-9, 2004.

PAIM, N. R. Melhoramento genético de leguminosas forrageiras. In: PEIXOTO, A. M.; MOURA, J. C.; FARIA, V. P. (Ed.). **Pastagens**: fundamentos da exploração racional. 2. ed. Piracicaba: Fealq, 1994. p. 893-908. (Série atualização em Zootecnia, 10).

PONCET, C.; RÉMOND, D. Rumen digestion and intestinal nutrient flows in sheep consuming pea seeds: the effect of extrusion or chestnut tannin addition. **Animal Research**, v. 51, n. 3, p. 201-216, 2002.

ROCHA, M. G.; QUADROS, F. L. F.; GLIENKE, C. L.; CONFORTIN, A. C. C.; COSTA, V. G.; ROSSI, G. E. Avaliação de espécies forrageiras de inverno na Depressão Central do Rio Grande do Sul. **Revista Brasileira de Zootecnia**, v. 36, n. 6, p. 1990-1999, 2007. (Suplemento).

ROMERO, F.; VAN HORN, H. H.; PRINE, G. M.; FRENCH, E. C. Effect of cutting interval upon yield, composition and digestibility of Florida 77, Alfafa and Florigraze Rhizoma peanut. **Journal of Animal Science**, v. 65, n. 3, p. 786-796, 1987.

SANTOS, H. P.; FONTANELI, R. S.; BAIER, A. C. **Principais forrageiras para integração lavoura-pecuária, sob plantio direto, nas Regiões Planalto e Missões do Rio Grande do Sul**. Passo Fundo: Embrapa Trigo, 2002.

SAS-Statistical Analysis System. **User's guide**: statistics. Version 6.11. Cary: SAS Institute, 1997.

SBCS-Sociedade Brasileira de Ciência e Solo. **Manual de adubação e de calagem para os Estados do Rio Grande do Sul e Santa Catarina**. Comissão de Fertilidade e Química do Solo. Porto Alegre: Sociedade Brasileira de Ciência do Solo, 2004.

SENGER, C. C. D.; KOZLOSKI, G. V.; SANCHEZ, L. M. B.; MESQUITA, F. R.; ALVES, T. P.; CASTAGNINO, D. S. Evaluation of autoclave procedures for fibre analysis in forage and concentrate feedstuffs. **Animal Feed Science and Technology**, v. 146, n. 1/2, p. 169-174, 2008.

SILVA, D. J.; QUEIROZ, A. C. **Análise de alimentos**: métodos químicos e biológicos. 3. ed. Viçosa: UFV, 2002. p. 235.

SILVA, M. M. P.; VASQUEZ, H. M.; SILVA, J. F. C.; BRESSAN-SMITH, R. E.; ERBESDOBLER, D.; SOARES, C. S. Composição bromatológica, disponibilidade de forragem e índice de área foliar de 17 genótipos de capim elefante (*Pennisetum purpureum* Schum.) sob pastejo, em Campos de Goytacazes, R.J. **Revista Brasileira de Zootecnia**, v. 31, n. 1, p. 313-320, 2002. (Suplemento).

SILVA, V. P.; ALMEIDA, F. Q.; MORGADO, E. S.; FRANÇA, A. B.; VENTURA, H. T.; RODRIGUES, L. M. Digestibilidade dos nutrientes de alimentos volumosos determinada pela técnica dos sacos móveis em equinos. **Revista Brasileira de Zootecnia**, v. 38, n. 1, p. 82-89, 2009.

SOARES, J. P. G.; BERCHIELLI, T. T.; AROEIRA, L. J. M.; DERESZ, F.; VERNEQUE, R. S. Estimativas de consumo do capim elefante (*Pennisetum purpureum* Schum.), fornecido picado para vacas lactantes utilizando a técnica do óxido crômico. **Revista Brasileira de Zootecnia**, v. 33, n. 3, p. 811-820, 2004.

SOBCZAK, M. F.; OLIVO, C. J.; GABBI, A. M.; CHARÃO, P. S.; HEIMERDINGER, A.; SILVA, J. H. S.; PEREIRA, L. E. T.; ZIECH, M. F.; ROSSAROLLA, G. Evaluation of an elephantgrass pasture mixed with black oat managed under agro ecological principles in winter period. **Livestock Research for Rural Development**, v. 17, n. 6, p. 1-3, 2005.

SOUZA, C. M. M.; SILVA, H. R.; VIEIRA-JÚNIOR, G. M.; AYRES, M. C. C.; COSTA, C. L. S.; ARAÚJO, D. S.; CAVALCANTE, L. C. D.; BARROS, E. D. S.; ARAÚJO, P. B. M.; BRANDÃO, M. S.; CHAVES, M. H. Fenóis totais e atividade antioxidante de cinco plantas medicinais. **Química Nova**, v. 30, n. 2, p 351-355, 2007.

WILM, H. G.; COSTELLO, D. F.; KLIPPLE, G. E. Estimating forage yield by the double-sampling methods. **Journal of the American Society of Agronomy**, v. 36, p. 194-203, 1944.

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