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Mesquite pod meal in diets for Santa Inês sheep: ingestive behavior

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ABSTRACT. This study aimed to evaluate the ingestive behavior of sheep fed increasing levels of mesquite pod meal (0, 15, 30 and 45% in total dry matter diet), replacing grass silage elephant. Eight non-castrated Santa Inês sheep with average weight of 32 kg were divided into two 4 x 4 Latin squares, each lasting 15 days. The sheep were submitted to visual observation every ten minutes, for 24 hours, in the 13^{th} day of each experimental period. There was no significant regression ($p > 0.05$) relative to the time spent on feeding, rumination and resting, depending on the levels of substitution of mesquite pod meal. The average time spent on feeding, rumination and resting was 5.64, 10.88 and 8.8h day^{-1}, respectively. There was a positive linear effect ($p < 0.05$) regarding the levels of replacement of elephant grass silage by mesquite pod meal on dry matter intake (DMI), neutral detergent fiber intake (NDFI), feeding efficiency of DM, rumination efficiency of DM, rumination efficiency of NDF. The use of observation intervals of up to 30 minutes does not alter the assessment of time spent on feeding, rumination and resting.

Keywords: ethology, elephant grass silage, feeding efficiency, *Prosopis juliflora*.

Farelo de algaroba em dietas para ovinos Santa Inês: comportamento ingestivo

RESUMO. Objetivou-se avaliar o comportamento ingestivo de ovinos alimentados com níveis de farelo da vagem de algaroba (FVA) (0, 15, 30 e 45% na matéria seca total da dieta), em substituição à silagem de capim-elefante. Foram utilizados oito ovinos da raça Santa Inês, machos, não-castrados, com peso médio de 32 kg, distribuídos em dois quadrados latinos 4 x 4, com duração de 15 dias cada período experimental. Os carneiros foram submetidos à observação visual a cada 10 min., durante 24h, ao 13^{o} dia de cada período experimental. Não foi observada regressão significativa ($p > 0,05$) para os tempos despendidos com alimentação, ruminação e ócio em função dos níveis de substituição do FVA. Ocorreu efeito linear positivo ($p < 0,05$) dos níveis de substituição da silagem pelo FVA sobre os consumos de MS, FDN, eficiência de alimentação da MS, eficiência de ruminação da MS, eficiência de ruminação de FDN. O FVA não aumenta o tempo disponível para alimentação e ruminação, mas eleva o consumo de MS de dietas baseadas em silagem de capim-elefante. A utilização de intervalos de observação de até 30 min., não altera a avaliação dos tempos despendidos com alimentação, ruminação e ócio.

Palavra-chave: etologia, silagem de capim-elefante, eficiência de alimentação, *Prosopis juliflora*.

Introduction

Food shortage during dry periods is the main problem of low zootechnical indices of sheep-raising in Northeastern Brazil. For mesquite pod meal is largely available in the region and has an excellent nutritional value, it is a nutritional alternative for sheep this time of the year; in addition, the use of tropical legumes in the diet of animals has aroused the interest of researchers over the last years, especially because these foods contribute substantially to reduce costs of production.

Mesquite [*Prosopis juliflora* (SW) D. C.] was introduced in Brazil - mainly in the Northeastern region - over 50 years ago and can live in dry environments and produce large amounts of pods with excellent palatability and good digestibility (SILVA et al., 2001).

The study of ingestive behavior can elucidate problems related to the decrease in consumption during critical periods, associated with the effects of management practices, sizing of facilities, quality and quantity of the diet. The assessment of short-term behavioral parameters has received increasing attention from researchers in the fields of animal nutrition and production (CARVALHO et al., 2006, 2008; FISCHER et al., 1997, 1998; MORAIS et al., 2006; POMPEU et al., 2009).

The behavioral patterns constitute one of the most effective means by which animals adapt to various environmental factors and can therefore indicate potential methods of improving animal productivity through the use of different management systems. Yet, the correct understanding of a phenomenon depends on the study and the evaluation methodology. However, the choice for scale in most studies on feeding behavior is usually performed arbitrarily and that can affect the viewer's perception on the heterogeneity of the system, since inadequate use may affect the results.

Thus, the aim of this work was to evaluate parameters the ingestive behavior and to compare the ranges of 10, 20 and 30 minutes for 24 hours to determine the time spent eating, ruminating and resting sheep fed with meal of mesquite pods to replace elephant grass silage in the proportions of 0, 15, 30 and 45.0%) on the basis of total dry matter of diet.

Material and methods

The experiment was conducted at the Department of Nutritional Tests of Sheep and Goats of the Experimental Unit of Goats and Sheep - State University of Bahia (UESB), Itapetinga, Bahia, State.

We used eight Santa Inês sheep, non-castrated males, mean age of five months and mean weight at the beginning of the experiment from 32.0 ± 1.0 kg were divided into two Latin squares balanced 4 x 4 in four experimental periods of 15 days each, the first ten days of adaptation and five days of data collection.

Four levels of replacement of elephant grass silage by mesquite pod meal (0.0, 15.0, 30.0 and 45.0%) in the total dry matter content were tested.

The animals were kept in metabolic cages (0.8 m^2) equipped with salt-box, drinking and feeding troughs, where they were fed *ad libitum* twice a day, to allow 5-10% of scraps as a safety margin. The diets and leftovers of all animals were daily weighted to estimate daily consumption. During the collection period of each experimental period, samples of feed supplied and leftovers of each animal were collected daily, placed in plastic bags and stored at -20°C for later laboratory analysis.

Samples of forage, concentrate and leftovers of each animal were dried in an oven with forced ventilation, at 60°C, and processed in a shredding mill (with a 1 mm mesh sieve) for subsequent chemical analysis.

Analyses of dry matter (DM), organic matter (OM), mineral matter (MM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose , hemicellulose and lignin 72% (w w^{-1}) H_2SO_4 were made following the procedures described by Silva and Queiroz (2002). The content of neutral detergent fiber corrected for ash and protein was performed according to the recommendations of Licitra et al. (1996) and Mertens (2002).

The concentration of total carbohydrates (TC) was estimated following the procedures proposed by Sniffen et al. (1992):

$$TC = 100 - (\%CP + \%EE + \%MM)$$

The concentration of non-fibrous carbohydrates corrected for ash and protein (NFCcp) were calculated as proposed by Hall (2003), as follows:

$$NFCcp(\%DM) = (100 - \%NDF - \%CP - \%EE - \%ash)$$

Table 1 shows the bromatologic compositions of mesquite pod meal (MPM) and elephant grass silage.

Table 1. Bromatologic composition of MPM and elephant grass silage.

Nutrient (% DM)	Forage	
	MPM	Elephant grass silage
DM	88.90	30.14
OM	97.94	97.10
MM	2.05	2.54
CP	12.01	6.47
NDF	31.34	77.70
ADF	27.51	70.96
EE	1.16	2.81
NFC	58.99	13.83
TC	84.78	88.18
NFCcp	53.44	10.48

On the 13^{th} day of each experimental period, ingestive behavior was evaluated by measuring the time intervals spent on feeding, rumination and resting; visual observations were performed every 10 minutes during 24 hours (JOHNSON; COMBS, 1991) and artificial lighting was used during nighttime observations.

On the 14^{th} day, every animal was observed in three different periods of the day (10 - 12 a.m., 2 - 4 p.m. and 6 a.m. - 8 p.m.). The number of chews per ruminal bolus (no/bolus) was assessed and the time spent on rumination was recorded (sec/bolus). This procedure was performed using stopwatches handled by four observers strategically placed so as not to disturb the animals.

The number of boluses ruminated each day was obtained as follows: total rumination time (min) divided by the average time spent on the rumination of a bolus. The content of DM and NDF in each ruminated bolus (g) was obtained by dividing the amount of DM and NDF consumed (g day^{-1}) in 24 hours by the number of boluses ruminated each day.

Feeding and rumination efficiency was obtained as follows:

$$FEDM = DMI / FT;$$
$$FENDF = NDFI / FT;$$

where:

FEDM (DM consumed g h^{-1}); FENDF (consumed NDF g h^{-1}) = feeding efficiency; DMI (g) = daily intake of dry matter, NDFI (g) = daily intake of NDF; FT = time daily spent on feeding.

$$RUEDM = DMI / RUT;$$
$$RUENDF = NDFI / RUT;$$

where:

RUEDM (ruminated DM g h^{-1}); RUENDF (ruminated NDF g h^{-1}) = rumination efficiency and RUT (h day^{-1}) = rumination time. The ingestive behavior and its variables were conducted as described by (BÜRGER et al., 2000).

Data were subjected to analysis of variance and regression using the software SAEG (RIBEIRO JUNIOR, 2001), at a 5% probability of error. The evaluation of observation intervals was conducted independently from the fixed effects of the treatment; the intervals between observations (10, 20 and 30 minutes) where considered as treatments and that of 10 minutes was used as reference (control). Analysis of variance and Dunnett's test were then performed using 0.05 as a critical level of probability.

Results and discussion

DM intake in kg day^{-1} has linearly increased ($p < 0.05$) as the levels of replacement of elephant grass silage by MPM have increased (Table 2), probability due to reducing the physical filling caused by high NDF content of elephant grass silage may have contributed to the increased intake of DM.

A similar result was observed for the consumption of NDF, which was linearly and positively ($p < 0.05$) associated with the replacement levels of elephant grass silage by mesquite pod meal (Table 2). Yet, that has occurred due to the higher intake of dry matter and the possible additive effect of mesquite pod meal.

The time spent on feeding, rumination and resting was not influenced ($p > 0.05$) by the levels of replacement of elephant grass silage by mesquite pod meal; the following averages were observed: 5.64; 10.08; 8.27h day^{-1}, respectively, regardless of the level of replacement (Table 2). The results of this study are consistent with those observed by Alves et al. (2010) evaluated the addition of urea (0.0, 0.5, 1.0 and 1.5% of dry matter) in mesquite meal diets for sheep and also found no change in times spent on feeding (5.28h day^{-1}), rumination (7.81h day^{-1}) and resting (10.90h day^{-1}).

Table 2. Mean values of dry matter intake (DMI) and neutral detergent fiber intake (NDFI), time spent on feeding, rumination, resting, number of ruminated boluses (RB), chewing time per bolus (CT/bolus) and coefficients of variation (CV), probability (P) on Linear (L) and quadratic (Q) effects and regression equations on the basis of the replacement levels of elephant grass silage by mesquite pod meal (MPM).

Parameter	Level of MPM (% DM)				CV	P	
	0	15	30	45		L	Q
DMI (kg day^{-1})	0.599	0.729	0.887	1.034	7.5	0. 001[1]	n.s.
NDFI (kg day^{-1})	0.421	0.463	0.502	0.526	7.9	0.026[2]	n.s.
Feeding (h day^{-1})	5.9	5.3	5.4	5.9	12.0	n.s.	n.s.
Rumination (h day^{-1})	10.1	9.9	9.9	10.3	10.8	n.s.	n.s.
Resting (h day^{-1})	7.9	8.7	8.6	7.8	13.8	n.s.	n.s.
RB (no day^{-1})	761.2	702.3	749,3	761.2	17.6	n.s.	n.s.
CT/bolus(sec)	48.2	53.1	49.3	49.2	17.2	n.s.	n.s

[1]$\hat{Y}$ = 0, 5931 + 0, 9756*X (r^2 = 0, 99); [2]$\hat{Y}$ =0, 4252 + 0, 2372*X (r^2 = 0.98); n.s.: not significant at 5% probability.

According to Mertens (1997), increasing the amount of fiber in the diets stimulates chewing activity, although in this experiment had observed high consumption of NDF, it was not evident. The similarity in the times spent on feeding, rumination and resting probably results from the size of particles of mesquite pod meal. Thus, after ingestion, rumen microorganisms could possibly colonize and degrade with the same constancy of that observed for lower NDF intake from silage only.

In a study assessing the levels of inclusion of urea in diets with mesquite pod meal concentrate (30% of MPM in the diet), Alves et al. (2010) has observed an average feeding time (5.28h day^{-1}) similar to that found in this study, whereas time spent on rumination (7.81h day^{-1}) was lower and resting time (10.90h day^{-1}) was higher. The above mentioned authors have found consumption of DM and NDF of 1.25 and 0.53 kg day^{-1}, respectively, similar to that of the diet with 45% of MPM. The lowest time spent on rumination observed may be due to the small particle size used in this study.

The source of NDF from the forage was replaced by a non-roughage source in the total diet, but no change was observed in the number of ruminated boluses and chewing time per bolus, which in turn may have contributed to the similarity of time spent on rumination (Table 2). Besides, the similarities concerning these parameters may have resulted from the similar levels of NDF and the size of particles. According to Van Soest (1994), the time spent on rumination is a variable directly and proportionately associated with NDF content and particle size and processing of the diet.

The influence of treatments ($p < 0.05$) feeding efficiency (g DM hour^{-1}), rumination efficiency (g DM hour^{-1} and g NDF hour^{-1}) was observed. On the other hand, the feeding efficiency of NDF (g NDF hour^{-1}) was not significant and the lowest numerical value was observed for the diet containing only elephant grass silage (Table 3).

Table 3. Feeding and rumination efficiency (DM and DNF/hour), cud chewing, coefficients of variation (CV), probability (P) on Linear (L) and quadratic (Q) effects and regression equations on the basis of the replacement levels of elephant grass silage by mesquite pod meal (MPM).

Parameter	Level of MPM (%DM)				CV (%)	P	
	0	15	30	45		L	Q
Feeding efficiency							
DM (g hour^{-1})	104.2	152.9	167.9	179.9	11.3	0.003[1]	n.s.
DNF (g hour^{-1})	73.4	99.5	96.4	91.9	13.6	n.s.	n.s.
Rumination efficiency							
DM (g hour^{-1})	59.7	73.5	89.7	103.1	15.3	0.001[2]	n.s.
DNF (g hour^{-1})	42.0	46.4	50.9	53.0	14.1	0.001[3]	n.s.
Cud chewing							
Hours day^{-1}	16.0	15.4	15.3	16.2	7.3	n.s.	n.s.
No bolus^{-1}	77.5	84.3	80.5	79.6	17.0	n.s.	n.s.
No day^{-1}	58348.9	57283.4	59350.8	59797.6	12.3	n.s.	n.s.

[1]$\hat{Y}$ =114,8630 + 1, 6156*X (r^2 = 0,97); [2]$\hat{Y}$ =59,5114 + 0,9767*X (r^2 = 0,98); [3]$\hat{Y}$ =42,4690 + 0,2501*X; (r^2 = 0,97). n.s.: not significant at 5% probability.

This linear positive behavior can be explained by the increased consumption of dry matter and accordingly the intake of NDF. Despite MPM shows high concentrations of NDF, it has half that fraction and is more digestible than the NDF of elephant grass silage; thus, it has a minor limiting effect on DMI.

The rumination efficiency of NDF has probably increased due to the increased intake of NDF as the levels of MPM were raised. Carvalho et al. (2004) have reported that rumination is a physiological feature usually activated as the feeding time decreases, for the best use of food, thus making it possible to reduce the filling effect. This fact does not apply in this study, since the time available to both feeding and rumination has not changed. In this study, the physical regulation by reticulum-rumen distention in the diet containing only elephant grass silage may have been the factor that affected the intake of dry matter, given that the time required for chewing did not change depending on the type of diet (ALLEN, 2000).

Moreover, it is noteworthy that mesquite meal due to its higher content of NDF compared to concentrates, used as an energy source, changes the parameters of feeding and rumination and that fiber with low physical effectiveness increases the rate of passage, with impaired NDF digestibility. It was shown by Almeida et al. (2011), the supplement consisting of mesquite meal as an energy source reduced feeding and rumination efficiencies of dry matter obtaining similar values to the control (no supplementary concentrate), causing substitutive effect of 20% on the intake of forage (ALMEIDA et al., 2012).

Thus when the mesquite meal is used as a concentrated food may reduce the efficiency of feeding and rumination when the forage fiber has higher nutritional quality, in contrast to the roughage that presents physically effective fiber with low digestibility, the use of mesquite meal promote increase in efficiency of feed and rumination as can be observed in this study.

Cud-chewing expressed in hours day^{-1}, No/bolus and No/day have not changed (Table 3); these results are similar to those obtained by Carvalho et al. (2007b) studying the behavior of confined sheep fed ammoniated elephant grass with 5% urea, plus 40% of cocoa meal or palm cake, and Bürger et al. (2000), who tested the different levels of concentrate 30, 45, 60, 75 and 90% (constituted of soybean meal and corn ground grain) in the diets of five Holstein calves.

The values of the average daily time spent on feeding, rumination and resting (h day^{-1}) at the different intervals tested are shown in Table 4. The replacement of the elephant grass for mesquite pod meal has not influenced ($p > 0.05$) the ingestive behavior of animals in any of the time scales studied; then, data regarding the different treatments were analyzed together.

Table 4. Average time spent on feeding, rumination and resting (h day^{-1}) at different observation intervals (10, 20 and 30 minutes) and coefficients of variation (CV) regarding sheep fed mesquite pod meal to replace elephant grass silage.

Item (h day^{-1})	Time of observation (minutes)			Average	CV (%)
	10	20	30		
Feeding	5.64	5.63	5.50	5.59	22.59
Rumination	10.09	10.13	10.22	10.14	13.29
Resting	8.27	8.24	8.28	8.26	20.31

Not significant at 5% probability by Dunnett's test.

The average daily time spent on feeding, rumination and resting did not differ ($p > 0.05$) in the ranges of 10, 20 and 30 minutes, in any of the experimental periods. The results of this study are consistent with those found by Carvalho et al. (2007b), who tested ranges of 5, 10, 15, 20, 25 and 30 minutes for registration of continuous observation of Santa Inês sheep fed ammoniated elephant grass and regional byproducts and found that the time spent on the observed activities was similar at all scales, hence indicating that the animals could have been observed at intervals of up to 30 minutes.

Silva et al. (2006) have evaluated the feeding behavior of Holstein calves during suckling period and also recommended ranges of up to 30 minutes for daily assessment of behavior parameters.

The literature shows results that differ from those found in this study, such as that obtained by Silva et al. (2004) with heifers and Fischer et al. (2000) with sheep, indicating a range of 5 minutes. On the other hand, Carvalho et al. (2007a) have recommended intervals of up to 20 minutes in a study involving lactating sheep, thereby reinforcing the need for an analysis for the optimal range before its application in the field. Yet, the choice for the range of observation in most researches intended to assess behavioral aspects was observed to be performed in a random way, without prior criteria, and that may result in observation losses and consequently in decreased accuracy of results. Still, studies should be conducted in order to validate which scale should be used for discretization of behavioral parameters without data loss.

Conclusion

The inclusion of mesquite pod meal of up to 45% of the dry matter content of diets with a high concentration and low fiber quality improves the efficiency of feeding and rumination, without changing the time spent on feeding, rumination and resting by Santa Inês sheep. Hence, an observation interval of 30 minutes is recommended for the assessment of time spent on the above mentioned activities, without significant changes in the results.

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