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Article

Feeding behavior of ram lambs in the feedlot receiving diets without roughage in different amounts

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Abstract

This study aimed to evaluate the feeding behavior of Santa Inês ram lambs in the feedlot receiving diets without roughage in different amounts. Ten castrated Santa Inês male sheep with an average body weight of 20 kg and an average age of four months were used in the experiment. The following treatments were tested: T1 - animals receiving a diet *ad libitum* (FS100); T2 - animals receiving 95% of the amount of feed supplied in T1 (FS95); T3 - animals receiving 90% of the amount supplied in T1 (FS90); T4 - animals receiving 85% of the amount supplied in T1 (FS85); and T5 - animals receiving 80% of the amount supplied in T1 (FS80). A Latin square (5 × 5) design was adopted, using two simultaneous squares. The times spent feeding, ruminating, performing other activities; the total chewing time; and the number of periods spent feeding and on other activities changed with the reduction in the amount of feed supplied ($P<0.05$). Number of rumination chews per cud, time per cud, chewing speed, and time per rumination chew did not differ with the reduction of feed supply ($P>0.05$). Reducing the amount of feed provided to ram lambs consuming diets without roughage changes their feeding behavior.

Keywords: concentrate, sheep, intensive production, ruminants

Introduction

Sheep farming in Brazil is mostly performed in extensive systems, in which animals feed on degraded pastures, under conditions that provide extremely low weight gains, delaying their body development. As a result, sheep are slaughtered at advance ages (over six months) and with low carcass dressing values.

One of the possibilities to reduce the slaughter age is rearing lambs in the feedlot. However, feeding accounts for one of the factors that most elevate the costs of a production system (Pompeu et al., 2012), especially in the feedlot. Roughage production is one of the greatest hindrances to the dissemination of this technique, as it requires a cultivation area as well as excellent planning.

Because of the high production costs of roughages, feedlot systems with high-concentrate diets or diets without roughage have emerged as a new strategy. Few studies correlating the effect of these diets with the feeding and rumination characteristics are available in the literature, though. Knowing the feeding behavior of animals based on the consumed diet is of great importance for the evaluation of their productive performance (Missio et al., 2010), since it has been utilized to guide and underpin several discussions related to the intake, and, most importantly, the performance of animals (Pereira et., 2007;

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Confortin et al., 2010; Pereira et al., 2011; Pinheiro et al., 2011; Santana Júnior et al., 2013).

When fed *ad libitum*, feedlot ram lambs consuming diets without roughages or high-concentrate diets tend to select the feed, which causes an imbalance in the formulated diet, leading to a deficit of nutrients for the expected gain. One of the alternatives to reduce this selection of ingredients could be reducing the amount of feed supplied, which would consequently cause the animal to consume the entire amount provided, maintaining the balance of the diet formulation and possibly maintaining or decreasing weight gain.

In a pessimistic scenario, in which the animal loses weight, the benefit-cost ratio could be maximized by the decrease in the feed cost, which has a high impact on the total production cost. Addressing this matter, the evaluation of the feeding behavior has become crucial to better understanding this type and level of daily supply of the diet.

The aim of this study was to evaluate the feeding behavior of Santa Inês ram lambs in the feedlot receiving diets without roughage in different amounts.

Materials and methods

The experiment was conducted in the Laboratory of Animal Nutrition Trials (*Laboratório de Ensaios Nutricionais em Animais*, LENA), at the Center for Teaching and Research on Animal Nutrition (*Centro de Ensino e Pesquisa em Nutrição Animal*, CEPENA) located on the *Dep. Jesualdo Cavalcanti de Barros* campus, at the State University of Piauí, in Corrente-PI, Brazil. Ten castrated Santa Inês ram lambs with an average body weight of 20 kg and four months of age were used in the experiment. All animals were dewormed and evaluated for their health conditions at the time of selection to be included in the trial.

The following treatments were tested: T1 - animals receiving the diet *ad libitum* (FS100); T2 - animals receiving 95% of the amount of feed supplied in T1 (FS95); T3 - animals receiving 90% of the amount supplied in T1 (FS90); T4 - animals receiving 85% of the amount supplied in T1 (FS85); and T5 - animals receiving 80% of the amount supplied in T1 (FS80). The treatment with *ad libitum* supply (FS100) was meant to provide approximately 10% as orts to ensure maximum consumption. A Latin square (5 × 5) design was employed, using two simultaneous squares. The experiment lasted 50 days, with five 10-day periods, consisting of six days for adaptation to the change in the amount supplied only, and four for data collection.

The diet was supplied daily at 07h30 and 15h45; animals were identified by numbered plastic earrings, and later allocated to individual 1.0 × 1.0 m stalls containing individual troughs and bucket-type drinkers. The diet was composed of concentrate feedstuffs, including ground corn (55.76%), cottonseed cake (37.17%), and a buffered vitamin-mineral premix (7.07%); the diet was balanced for maintenance and a weight gain of 325 g/day (NRC, 2007) in the *ad libitum* treatment (FS100).

For four days, from the 7th to the 10th day of each period, feed intake (Table 1) was quantified by subtracting the orts from the total feed supplied, always in the morning of the next days, before the feed was supplied on those days. Fecal production was determined from the 7th to the 9th day of each period via total feces collection. The apparent digestibility estimates were calculated from intake and fecal production. Feces were collected using a polyethylene screen placed below the slatted floor, free of any contaminations. Samples of feces were weighed in the morning, and approximately 10% of the total were collected. A composite sample was formed from the daily collections from the three days of fecal collection. The apparent digestibility coefficients were estimated from intake and fecal production data.

The chemical composition of the feed supplied, orts, and feces was evaluated by drying these components in a forced-air oven at 55 °C for 72 h and later estimating the dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), and acid detergent fiber (ADF) contents according to methodologies described by Detmann et al. (2012). Non-fiber carbohydrates (NFC) were calculated by the following equation: NFC = 100 – (%CP + %EE +

%NDFap + %Ash). The total digestible nutrients (TDN) were calculated according to Weiss (1999), as follows: TDN (%) = DCP + DNDFap + DNFC + 2.25 × DEE, where: D = digestibility of each component. The diet contained 914 g DM/kg fresh matter and (per kg DM) 152 g CP, 194 g NDFap, 100 g EE, 92 g ash, 432 g NFC, and 650 g TDN in its composition.

Table 1. Daily intake, in grams per day, of ram lambs fed different amounts of a diet without roughage

Item	Amount of feed supplied					CV[1]
	FS100	FS95	FS90	FS85	FS80	
DM[2]	917.5	872.0	825.7	778.0	734.0	12.81
OM[3]	833.3	792.0	750.0	706.6	666.7	12.81
CP[4]	139.9	133.0	125.9	118.7	112.0	12.81
NDFap[5]	178.4	169.5	160.5	151.3	142.7	12.81
NFC[6]	396.6	376.9	356.9	336.3	317.3	12.81
EE[7]	118.4	112.5	106.6	100.4	94.7	12.81
TDN[8]	589.9	560.6	531.6	500.8	472.4	16.92

1Coefficient of variation; 2Dry matter; 3Organic matter; 4Crude protein; 5Neutral detergent fiber corrected for ash and protein; 6Non-fiber carbohydrates; 7Ether extract; 8Total digestible nutrients.

Feeding behavior was evaluated on the 10th day of each experimental period, with observations made every five minutes, according to the methodology of Carvalho et al. (2011), for 24 h, aiming to identify the times spent feeding, ruminating, and performing other activities. Animals were evaluated visually by two trained observers who switched shifts every four hours. Digital watches were used to determine the time spent on each activity.

The behavioral variables studied were feeding time, rumination time, and time spent performing other activities. The behavioral variables were considered mutually exclusive.

Feeding time was considered the time taken by the animal to consume the diet. Rumination time corresponded to the processes of regurgitation, re-chewing, re-salivation, and re-swallowing. Lastly, the time on other activities was considered rest, water intake, interactions, etc.

Total chewing time (TCT) was determined by the following equation: TCT = FT + RT, where: FT (min) = feeding time and RT (min) = rumination time. The discretization of time series was performed directly on the data collection spreadsheets, counting the discrete periods of feeding, rumination, and other activities. The average duration of each one of the discrete periods was obtained by dividing the daily time spent on each one of the activities by the number of discrete periods of that activity.

Feed efficiency, in grams of DM, NDF, TDN, NFC, and CP per minute; and rumination efficiency, in DM and NDF, were calculated by dividing the intake of each of these chemical components by the total feeding time (feed efficiency) or by the rumination time (rumination efficiency).

Three observations were made in each period to determine the number of rumination chews per cud (RChC) and the time spent on the rumination of each cud (TRC). The variables number of cuds ruminated per day (CRD), chewing speed (ChS), time per rumination chew (ChT), and number of rumination chews per day (RChD) were calculated by the following equations:

CRD = RT/TRC, where: CRD (n/day); RT (s/day); TRC (s);

ChS = RChC/TRC, where: ChS (s/chew); RChC (n/cud); TRC (s);

ChT = TRC/RChC, where: ChT (s); TRC (s); RChC (n/cud); and

RChD = CRD × RChC, where: RChD (n/day); CRD (n/day); RChC (n/cud).

Results were analyzed statistically by variance and regression analyses at 0.05 probability level using SAS software (version 9.1).

Results and Discussion

The times spent feeding, ruminating, performing other activities, and the total chewing time differed with the reduction of feed supply ($P<0.05$) (Table 2). The feeding time decreased linearly as the amount of feed supplied was reduced, consequently decreasing the time required to consume the diet by 14.1 min per unit of reduction in feed supply.

Table 2. Feeding behavior, in minutes, of ram lambs fed different amounts of a diet without roughage

Item	Amount of feed supplied					CV[1]	RE	R²
	FS100	FS95	FS90	FS85	FS80			
Feeding	127	98	58	73	69	64.13	[3]	0.65
Rumination	244	241	206	225	175	29.74	[4]	0.73
Other activities	1071	1102	1176	1142	1197	8.52	[5]	0.80
TCT[2]	370	339	264	298	244	32.65	[6]	0.79

[1]Coefficient of variation; 2Total chewing time; 3Ŷ = 127.3 – 14.1x; 4Ŷ = 2,464.4 – 15.4x; 5Ŷ = 1,050 + 29.2x; 6Ŷ = 390.9 – 29.3x.

According to Van Soest (1994), the fiber content and the physical form of the diet are the main factors affecting the rumination time. Agreeing with this statement, the rumination time decreased linearly because of the reduction of both the amount of feed supplied and of the neutral detergent fiber intake, resulting in less time necessary to reduce the feed particles. As the feeding-behavior activities are mutually exclusive, the time spent on other activities increased linearly.

The total chewing time (TCT) changed with the alteration in the amount of feed supplied (P<0.05). Because TCT is the sum of the feeding and rumination times, and because these variables decreased linearly, TCT potentiated this effect, presenting a variation of 29.3 min per unit.

The reduction in the amount of feed supplied led to a decrease in the number of feeding periods (NFP) and of periods on other activities (NOP) (P<0.05) (Table 3). This effect was due to the decline in the times spent feeding and on other activities, respectively, because the periods, within their normality, for whatever activity, have a maximum and minimum time range. The maximum, in the case of feeding, is a result of the physical filling caused by the action of the dietary fiber or the energy availability via metabolizable energy. The minimum is associated with feeding restriction, sanitation problems, and/or management faults.

Table 3. Discrete periods of the feeding behavior of ram lambs fed different amounts of a diet without roughage

Item	Amount of feed supplied					CV[1]	RE	R²
	FS100	FS95	FS90	FS85	FS80			
NFP[2]	12.4	9.4	5.8	6.3	5.7	80.50	[8]	0.79
NRP[3]	19.7	20.4	21.4	17.8	17.7	25.07	Ŷ = 19.2	---
NOP[4]	31.3	29.0	26.8	23.5	23.2	27.46	[9]	0.96
TFP[5] (min)	11.4	13.6	14.9	14.5	14.6	42.65	Ŷ = 13.9	---
TRP[6] (min)	12.6	12.0	9.7	10.6	9.8	22.07	[10]	0.72
TOP[7] (min)	37.6	40.4	48.1	53.7	58.0	33.03	[11]	0.98

[1]Coefficient of variation; [2]Number of feeding periods; [3] Number of rumination periods; [4] Number of periods on other activities; [5]Time per feeding period; [6] Time per rumination period; [7] Time per period on other activities; [8]Ŷ = 12.87 – 1.65x; [9]Ŷ = 33.27 – 2.17; [10]Ŷ = 13.04 – 0.7x; [11]Ŷ = 31.33 + 5.41x.

The number of rumination periods (NRP) and the time per feeding period (TFP) did not differ with the alteration in the feed supply (P>0.05). The NRP increases according to the dietary fiber content, which reflects the need for processing the rumen digesta to elevate digestive efficiency.

The fact that the diets supplied to the animals on all treatments were similar and that they had a low fiber content (194 g NDFap/kg DM) gives rise to the hypothesis that the reduction in feed supply did not provide a significant change in the amount of fiber ingested, but mostly changed the timer per rumination period (TRP), which decreased linearly (P<0.05) by 0.7 period per percentage unit of decrease in the amount of feed supplied.

Rather than TRP, the times per period on other activities increased linearly, because a reduction in the time per period on any activity is only possible by the compensation of the time on another activity.

The number of rumination chews per cud (RChC), the time per ruminated cud (TRC), the chewing speed (ChS), and time per chew (ChT) did dot differ with the reduction in the amount of feed supplied (P>0.05) (Table 4). The number of rumination chews (RChD) and the number of ruminated cuds (CRD), both per expressed day, decreased as the feed restriction was increased

(P<0.05). The effects on the variables RChC, TRC, ChS, and ChT are similar to those discussed previously for number of rumination periods. From this discussion, it can be inferred that RChD and CRD only varied because of the time considered for the variables (24 h), because despite being part of the formula for the calculation of RChD and CRD, variables with a shorter evaluation time, in minutes or seconds, did not change with the alteration of treatments.

Table 4. Rumination-related aspects of the feeding behavior of ram lambs fed different amounts of a diet without roughage

Item	Amount of feed supplied					CV[1]	RE	R²
	FS100	FS95	FS90	FS85	FS80			
RChC[2] (n)	57.3	61.1	54.9	58.1	57.1	13.72	Ŷ = 57.7	---
TRC[3] (s)	48.9	51.0	46.7	47.5	50.1	17.35	Ŷ = 48.8	---
ChS[4] (n/s)	1.19	1.22	1.20	1.24	1.15	16.16	Ŷ = 1.20	---
ChT[5] (s)	0.86	0.85	0.86	0.82	0.88	16.78	Ŷ = 0.85	---
RChD[6] (n)	17523	17738	14578	16813	12308	34.98	8	0.60
CRD[7] (n)	310	286	265	288	217	30.87	9	0.68

[1]Coefficient of variation; [2]Number of rumination chews per cud; [3]Time per ruminated cud; [4]Chewing speed; [5]Time per chew; [6]Rumination chews per day; [7]Number of cuds ruminated per day; [8]Ŷ = 19,199 – 1,135x; [9]Ŷ = 328.76 – 18.472x.

Carvalho et al. (2008) evaluated feedlot Santa Inês sheep consuming a diet containing roughage and levels of inclusion of cocoa meal, and obtained a maximum value of 882 cuds (14.76% cocoa meal), which was highly discrepant from the 328.76 cuds ruminated per day in the diet without roughage. This effect can be explained by the lack of roughage in the diet, which leads to a marked reduction in the dietary fiber content.

The feed and rumination efficiencies did not change with the reduction in feed supply (P>0.05) (Table 5). Because efficiency is the result of the division of intake by the time on the feeding activity, the reduction of 14.1 and 15.3 min with the decrease of a percentage unit of the diet, respectively, associated with the linear decrease in intake that was the goal of this study, indicates a proportionality of effects, causing a lack of changes in the feeding-behavior efficiency variables.

Table 5. Feeding behavior efficiencies of ram lambs fed different amounts of a diet without roughage

Item	Amount of feed supplied					CV[1]	RE	R²
	FS100	FS95	FS90	FS85	FS80			
Feed efficiency								
DM[2]	8.90	18.42	17.28	14.18	15.78	80.83	Ŷ = 15.6	---
NDFap[3]	1.73	3.58	3.36	2.76	3.07	80.83	Ŷ = 3.0	---
NFC[4]	3.85	7.96	7.47	6.13	6.82	80.83	Ŷ = 6.7	---
CP[5]	1.36	2.81	2.64	2.16	2.41	80.83	Ŷ = 2.4	---
Rumination efficiency								
DM	3.87	3.80	4.37	3.83	4.69	31.96	Ŷ = 4.1	---
NDFap	0.75	0.74	0.85	0.75	0.91	31.96	Ŷ = 0.8	---

[1]Coefficient of variation; [2]Dry matter; [3]Neutral detergent fiber corrected for ash and protein [4]Non-fiber carbohydrates; [5]Crude protein.

According to Zanine et al. (2006), the increase in feed intake tends to reduce the rumination time per gram of feed, which did not occur in the present study.

The decrease in the amount of feed supplied to ram lambs consuming diets without roughage changes their feeding behavior. No alteration in the feeding behavior of the animals was observed in an attempt to increase feed efficiency, but only as a direct response to the reduction of the amount of feed supplied.

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