

Behavior of sheep fed different sequences of ingredients in a spineless cactus (*Nopalea cochenillifera* Salm-Dyck) based-diet

Comportamento de ovinos alimentados com diferentes seqüências de ingredientes em dieta a base de palma forrageira ("Nopalea cochenillifera Salm-Dyck")

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SUMMARY

The purpose of this experiment was to evaluate the ingestive behavior of sheep fed diets containing different sequences of ingredients of a spineless cactus based diet because of the paucity of available information regarding the best method of feeding, especially in relation to the use of spineless cactus. The observed variables were daily time of eating, ruminating and idling. Five sheep were distributed into a 5 × 5 Latin Square with five treatments, five animals and five periods, the treatments 1 – (TMR, total mixed ration) at 7:00 and 15:00h; 2 – (C, concentrate) at 7:00h, (SC, spineless cactus) at 8:00 h, (C) at 15:00h and (TGH, tifton grass hay) at 16:00h; 3 – (C) at 7:00h, (TGH) at 8:00h, (C) at 15:00h and (SC) at 16:00h; 4 – (SC) at 7:00h, (C) at 8:00h, (TGH) at 15:00 and (C) at 16:00h and 5 – (TGH) at 7:00h, (C) at 8:00h, (SC) at 15:00h and (C) at 16:00h. No treatment effect on feeding activities (hour/day) in time total daily, but when activities were divided into periods, the sheep in sequence 3: concentrate/hay/ concentrate/spineless cactus spent a longer time eating within the period from 7:00 to 11:00h than the sheep in sequences 1: total mixed ration (TMR) and 2: concentrate/ spineless cactus/ concentrate /hay. The digestibility of dry matter and matter organic was greater for concentrate/ spineless cactus/ concentrate/ hay and spineless cactus/ concentrate/ hay/ concentrate being recommended the use of the same as feeding strategy.

Keywords: feeding, non-fiber carbohydrates, rumination, total mixed ration

RESUMO

Objetivou-se com este estudo avaliar o comportamento ingestivo de ovinos alimentados com dietas contendo diferentes seqüências de ingredientes a base de palma forrageira, devido à escassez de informações disponíveis sobre o melhor método de alimentação, especialmente ao uso da palma forrageira. As variáveis observadas foram tempo diário de ingestão, ruminação e ócio. Cinco ovinos foram distribuídos em um quadrado latino 5 × 5, com cinco tratamentos, cinco animais e cinco períodos, sendo os tratamentos: 1 – (ração totalmente misturada- TMR) às 7:00 e às 15:00h; 2 – (concentrado- C) às 7:00h, (palma forrageira- PF) às 8:00h, (C) às 15:00h e (feno de capim tifton- FCT) às 16:00h; 3 – (C) às 7:00h, (FCT) às 8:00h, (C) às 15:00h e (PF) às 16:00h; 4 – (PF) às 7:00h, (C) às 8:00h, (FCT) às 15:00 e (C) às 16:00h e 5 – (FCT) às 7:00h, (C) às 8:00h, (PF) às 15:00h e (C) às 16:00h. Não houve efeito de tratamento sobre as atividades de alimentação (horas/dia) no total de tempo diário. Porém quando as atividades foram divididas em períodos, os ovinos na seqüência 3: concentrado/ feno/ concentrado/ palma passaram um tempo de ingestão maior no período de 7:00-11:00 h comparados aos da seqüência 1: ração total misturada e 2: concentrado/ palma/ concentrado/ feno. A digestibilidade da matéria seca e da matéria orgânica foi maior para concentrado/ palma/ concentrado/ feno e palma/concentrado/feno/concentrado sendo recomendado o uso dos mesmos como estratégia alimentar.

Palavras-chave: alimentação, carboidratos não fibrosos, ruminação, ração totalmente misturada

INTRODUCTION

The typical sheep management practice in northeast Brazil is to offer forage cactus in the morning after a feeding of concentrate. On most farms, there is a lack of skilled labor and equipment to provide this as a TMR. However, when this forage is supplied separate of fibrous sources, abrupt changes in the rumen environment may occur, leading to the onset of digestive disorders as a result of excessive non-fibrous carbohydrate (NFC) ingestion (NOCEK, 1997). More uniform rumen fermentation and better utilization of nutrients is observed when ingredients are consumed through TMR rather than separated feedings.

According to Shekarchian (2012) the TMR may be recommended mainly when concentrate is associated to high quality roughages. Therefore, fiber source must be initially supplied when feed is offered separately to provide appropriate fermentation and thus a stable rumen environment (NRC, 2007). Thus, the feeding behavior is important in assessing diets because it enables post adjustment for feed management to obtain better productive and reproductive performance (FRANÇA et al., 2009).

The objective of this study was to evaluate the effect of feeding systems (concentrated separately vs TMR) on feeding behavior due to selection and reduced food waste, especially in relation to the use of spineless cactus.

MATERIAL AND METHODS

The research was conducted in the Department of Animal Science of the Federal Rural University of

Pernambuco-UFRPE, located in the city of Recife in the state of Pernambuco, northeast Brazil. The study made use of five sheep of nondescript breeding, averaging 38.5kg, gifted with rumen cannule. The diet consisted of 31% hay (Tifton grass 85, *Cynodon spp.*), 40.0% spineless cactus (*Nopalea cochenillifera* Salm-Dyck), 29.0% concentrate (55.7% soybean meal, *Glycine Max*; 37.2% corn, *Zea mays*) and 4.88% mineral mix. The treatments consisted of five feeding sequences as follows: 1 – (TMR, total mixed ration) at 7:00 and 15:00h; 2 – (C, concentrate) at 7:00h, (SC, Spineless cactus) at 8:00h, (C) at 15:00h and (TGH, Tifton grass hay) at 16:00h; 3 – (C) at 7:00h, (TGH) at 8:00h, (C) at 15:00h and (SC) at 16:00h; 4 – (SC) at 7:00h, (C) at 8:00h, (TGH) at 15:00 and (C) at 16:00h and 5 – (TGH) at 7:00h, (C) at 8:00h, (SC) at 15:00h and (C) at 16:00h (Table 1).

The diets were offered allowing 10% of leftover of the previous day consumption. The amount of each dietary component fed and the amount refused were recorded each day. Ingestive behavior parameters were recorded at 10min intervals for 24 hours per day to each animal, according to the procedures of Martin & Bateson (2007), and were classified into three main activities: eating time (ET), ruminating time (RT) and idling time (IT). Ruminal content samples (\pm 400mL) were collected for six days at every zero hour; (immediately prior to feeding) and at 2; 4; 6; 8 and 10h after the first feeding. The apparent nutrient digestibility were determined following methodology described by Coelho da Silva & Leão (1979), the contents of dry matter (DM) and neutral fiber detergent (NDF) by Silva & Queiroz (2002).

The experimental design was 5 x 5 Latin Square with five treatments, five animals and five periods. The SNK test was used for comparisons between

means, with the level of significance set at 5%, using the SAEG program (UFV, 2007).

Table 1. Chemical composition of ingredients and experimental diet

Item	Diet	Spineless cactus	Tifton hay	Soybean meal	Ground corn
Dry matter (g/Kg NM)	334.3	171.0	917.6	901.1	891.4
Organic matter (g/Kg NM)	910.8	894.7	936.8	933.9	984.0
Crude protein (g/Kg NM)	128.1	29.1	51.9	530.5	89.2
Ether extract (g/Kg NM)	21.0	13.3	22.7	40.2	25.0
Neutral detergent fiber (g/Kg NM)	377.6	201.4	782	285.2	119.9
Acid detergent fiber (g/Kg NM)	145.5	95.2	318.4	54.7	22.6
Total carbohydrates (g/Kg NM)	761.7	852.3	862.1	378.6	852.3
Non-fiber carbohydrates (g/Kg NM)	384.1	650.9	80.1	90.1	734.4

NM = natural matter.

RESULTS AND DISCUSSION

The overall time (eating) behavioral variables of sheep fed different diet sequences are shown (Table 2). No treatment effect ($P > 0.05$) was observed on the ingestive traits. In this study, the same values of neutral detergent fiber intake and dry matter ($P > 0.05$), led to a lack of selection, only the sequence was

changed, which indicates an adjustment over the course of the day with respect to the intake of diet ingredients. It is common to find differences between the parameters ingestive mainly in rumination time when diets vary in their fiber content (BEAUCHEMIN et al., 2003; CARVALHO et al., 2006; COSTA et al., 2012), but this was not observed this study.

Table 2. Dry matter and neutral detergent fiber intakes, apparent digestibility of dry and organic matter, and total rumination time, idle and ingestion of sheep fed in different sequences of food

Item	Treatments					P	SEM ¹
	1	2	3	4	5		
	Intake						
Dry matter (kg/day)	1.26	1.29	1.18	1.28	1.19	>0.50	0.55
Neutral detergent fiber (kg/day)	0.44	0.45	0.40	0.46	0.42	>0.50	0.64
	Apparent digestibility						
Dry Matter (g/Kg)	0.70 ^b	0.75 ^a	0.69 ^b	0.75 ^a	0.71 ^b	0.002	0.15
Organic Matter (g/Kg)	0.73 ^b	0.77 ^a	0.72 ^b	0.77 ^a	0.74 ^b	0.000	0.13
	Feeding behavior						
Rumination (hours/day)	6.50	6.86	7.18	6.04	6.99	>0.05	0.45
Idle (hours/day)	14.4	13.97	13.50	14.59	13.63	>0.05	0.26
Ingestion (hours/day)	3.38	3.17	3.32	3.37	3.39	>0.05	0.59

Means followed by different superscripts in the same row are significantly different ($P < 0.05$), SNK test.

1= Standart error of mean

Although the rumination time not show significant difference ($P > 0.05$) between the different dietary sequences, a brief comment is relevant, since outstanding behavior following: concentrate, hay, concentrate, spineless cactus; It was found compared to the other treatments. The sheep highlights were in rumination activity in said sequence (7:18 hours) as compared to others, indicating faster intake of the concentrate in your time of supply, as verified by (BEAUCHEMIN et al., 2008; DeVRIES & KEYSERLINGKT, 2009); if it is provided separately from the forage the animal can quickly eat all that amount.

It is consistent to the possibility that the intake of hay was fractionated 24 hours a day, with greater availability of rumination. The same authors emphasized that the hay offered once or twice a day might possibly be edible throughout the day, since ingestive behavior are competitive in the partition of time between the behavioral activities of ruminants.

Significant differences ($P < 0.05$) in the time spent on ingestion and rumination were found between the different diets sequences when the ingestive behavior was divided into four periods (4-h interval from the first feeding) - (Table 3).

Table 3. Time spent on eating and rumination in sheep fed in different sequences of food during circadian periods

Periods	Treatments					P	SEM ¹
	1	2	3	4	5		
Intervals (h)	Eating (min/day)						
7:00 -11:00	72	65	55	65	63	>0.05	0.65
11:00 - 15:00	17	14	6	23	11	>0.05	3.70
15:00 - 19:00	87	85	92	76	90	>0.05	0.91
19:00 - 23:00	14 ^b	17 ^b	36 ^a	27 ^{ab}	25 ^{ab}	0.045	2.23
23:00 - 3:00	10	3	10	4	6	>0.05	3.65
3:00 - 7:00	3	1	4	4	5	>0.05	7.45
	Ruminating (min/day)						
7:00 - 11:00	26 ^b	12 ^b	55 ^a	8 ^b	67 ^a	0.0009	2.16
11:00 - 15:00	81 ^a	41 ^b	94 ^a	35 ^b	106 ^a	0.0001	1.28
15:00 - 19:00	3	9	1	15	1	>0.05	8.59
19:00 - 23:00	56	75	35	56	44	>0.05	1.91
23:00 - 3:00	93 ^{ab}	118 ^a	105 ^{ab}	115 ^a	80 ^b	0.049	0.96
3:00 -7:00	133	153	130	135	127	>0.05	0.63

Means followed by different superscripts in the same row are significantly different ($P < 0.05$), SNK test.
1= Standart error of mean.

High non-fiber carbohydrates (NFC) contents diets, such as spineless cactus (FERREIRA et al., 2009), may not stimulate rumination and salivation, which can reduce the ruminal pH and lead to acidosis Beauchemin et al. (2003), altering the microbial

population and reducing ruminal digestibility. Thus, intake is reduced and fiber fermentation is compromised. The NFC and neuter detergent fiber (NDF) balance in the diet is important to maintain pH and does not compromise the feeding behavior.

Therefore, when ruminal pH (Figure 1) was measured at 9:00h the treatments TMR, 2 and 4 had smaller values, indicating selectivity for ingredients with high NFC (concentrate and spineless cactus) immediately after

feeding in the morning. Similar behavior was observed at 11:00h. These observations support the expectation of diet selection by sheep in the different periods.

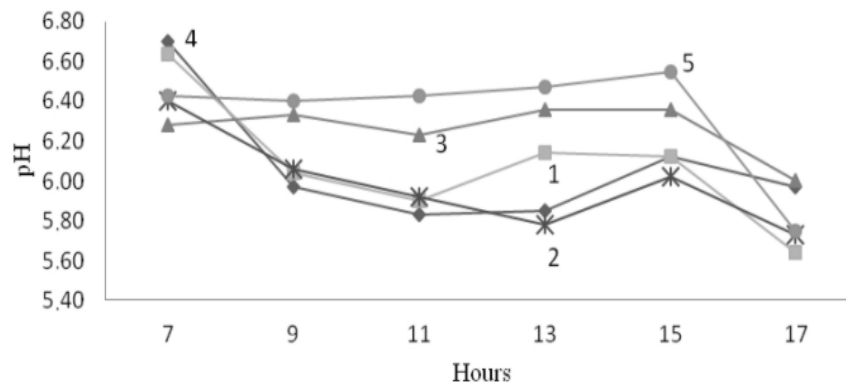


Figure 1. The pH of the ruminal fluid of sheep fed different sequences of food (Treatments = 1, 2, 3, 4, and 5)

These findings differ from those presented by Silva et al. (2005); DeVries & Von Keyserlingk (2009) and Vilela et al. (2010), who reported that TMR provides a more adequate balance of nutrients, reducing selectivity and imbalance between the diet offered and the food consumed. This suggests that animals prefer ingredients with greater acceptability, such as spineless cactus and concentrate. In the period from 19:00 to 23:00h (Table 3), animals on sequence 3 had higher eating time (36 minutes) than those on TMR and sequence 2 (14 and 17 minutes, respectively).

Perhaps greater amounts of concentrate were ingested in the morning, with transfer of hay ingestion for the period 19:00 - 23:00h. Moreover, the amount of nutrients (concentrate and spineless cactus) offered from 15:00 to 16:00h likely led to greater ingestion times in the observation period. This suggests that the food was more acceptable to the

animals and thus greater amounts were voluntarily consumed, thereby extending to ingestion. According to Ferreira (2005), large amounts of spineless cactus can be consumed, likely due to its low dry matter (DM) content and high acceptability. This consume depends on the animal category, feeding strategy, diet composition and number of meals. Feed with high NFC contents are rapidly fermented in the rumen, decreasing the ruminal pH and increasing of NFC's passage rate (CAVALCANTE et al., 2008). Therefore, the spineless cactus is a carbohydrate with high solubility, enabling increased ingestion time, unlike the ingredients provided in the treatments: TMR or (concentrate, spineless cactus, concentrate, hay), around to the time from 19 to 23 hours, where high fraction undegradable of hay NDF could be present.

Feeding with TMR resulted in a shorter ingestion time (14 min) than feeding with sequence 3, perhaps due to the

effect of the twice-a-day feeding strategy (50% in the morning and 50% in the afternoon). These findings support the inferences outlined by Dulphy & Faverdin (1987), who suggested that feedlot ruminants fed twice a day eat a large meal immediately after food is offered, which stimulates the beginning of the meals. In this study, greater ingestion times were detected, due to the urgency of the animals beginning to eat in response to stimuli related to feeding (CHASE et al., 1976).

These stimuli were not present in other periods, which decreased the activity. The positive effect of the feeding strategy in the beginning of meals is highlighted by the higher activity values recorded concomitant with the offering of food, as well as by the concentration of ingestion in the photoperiod (i.e., daytime), consistent with other research with sheep (HÜBNER et al., 2008). Much of this behavior is probably due to psychogenic factor, in which the frequency of the provision favors the stimulation of the voluntary consumption.

Mertens (1994) suggest that psychogenic regulation involves the behavioral response of the animal in front of the factors inhibiting or stimulating food or feed management. Reduced pH was observed when spineless cactus/concentrate and concentrate/spineless cactus (treatment 2 and 4) was offered in the morning (Figure 1), with lower pH values at 9:00; 11:00 and 13:00h observed on sequence 2 and 4 due to the lower NDF content, which resulted in less time spent on rumination on period 11:00 to 15:00h (41 and 35 minutes, respectively) as shown in Table 3. According to Mendonça et al. (2004), NDF content and quality alter rumination time. Animals receiving

sequences 3 and 5 spent more time ruminating (55 and 67; 94 and 106 minutes, respectively) at 7:00-11:00 and 11:00-15:00h than those that not received hay in the morning, except for TMR (81 minutes), which showed similar behavior of according Table 3. Higher ruminal pH values were observed for these sequences (3 and 5), at 11, 13 and 15 h (Figure 1), possibly due to the effect of fiber of roughage of tifton grass hay.

According to Zebeli et al. (2008) physically effective fiber in the ration is the most efficient nutritional measure to alleviate the pH decline after a meal. Less time spent on rumination was observed in TMR (26 minutes) from 7:00-11:00h, similar to the treatments without hay feeding in the morning, leading to the inference that the selection of ingredients (spineless cactus and concentrate) is more acceptable and did not strongly stimulate rumination; lower pH was also observed in this period (Figure 1). Furthermore, within these periods, sequences 2 and 4 were associated with higher dry matter and organic matter apparent tract digestibility ($P < 0.05$) than TMR, 3 and 5 (Table 2).

In relation to this superiority of digestibility for treatments 2 and 4, it is important infer that even with no significant change in intake between the different sequences of the diet, this increase in digestibility of dry matter and organic matter, took place because the high concentration of soluble carbohydrates, available in the morning. Even though the spineless cactus and concentrate not considered stimulants rumination, the spineless cactus provides intense chewing and consequently increased production of saliva, with considerable amounts of pectin favoring the production of acetate (notably weaker acid). Probably

this behavior provided better rumen fermentation pattern throughout the day, with more intense chewing, thus increasing saliva production, reflecting an improvement in digestibility. Misra et al. (2006) emphasized that the spineless cactus has a large buffering capacity, which in turn promotes increased microbial activity, concomitantly with a more efficient fermentation.

It is relevant to mention that spite of lower pH values observed during this period (morning) for their feeding sequences (Figure 1) they always remained above 5.64, not going beyond critical values. Thereby did not affect cellulolytic bacteria fermentation or NFC content digestibility, but they did alter the rumination time relative to the feeding of tifton hay in the same period. According to Van Soest (1994), Miron et al. (2004) and Carvalho et al. (2006); the time spent on rumination is affected by the diet composition and may be proportional to the cell wall content of the roughage. In the 23:00-03:00h period, less time spent on rumination was observed as hay distribution advanced, supported by the results of the 5 sequence (80 min) vs 2 and 4 (118 and 115 min, respectively), certainly the animals ingesting hay in the afternoon spend longer on activity than animals receiving other treatments.

The different feeding strategies for supply the ingredients of a spineless cactus based in diet do not alter the ingestive behavior of sheep with respect to total daily rhythms. The feeding strategy with separated ingredients as concentrated/spineless cactus/concentrate /hay or spineless cactus /concentrate /hay/concentrate, besides showing superiority in nutrient digestibility also reduces the work for the producer, being recommended to use these ingredients in feed for sheep

with no clear negative effect on the parameters evaluated.

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Data de recebimento: 12/06/2013

Data de aprovação: 26/02/2014