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Linear correlations between feeding behavior and intake of dairy cows supplemented using lipidic sources on pasture

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SUMMARY

The feeding behavior of grazing ruminants has been used to guide and underpin many discussions related to the intake found in research. Therefore, the measurements of these correlations can break some paradigms, because probably not all behavioral variables are correlated with nutritional parameters. This study aimed to evaluate the linear correlations between feeding behavior and intake of dairy cows supplemented on pasture. Twelve Holstein × Zebu crossbred cows, at 100 to 150 days in milk, with an average body weight of 466.9 ± 33.2 kg, received concentrate supplementation to provide variations in their feed intake and feeding behavior. Their feed intake and feeding behavior were measured in four evaluations held every 17 days during the experimental period. Pearson's linear correlation analyses were carried out using the "t" test, with values considered significant at 5% probability level. The grazing and rumination times and the time spent performing other activities did not have significant correlations with the intake variables (P>0.05); however, the time spent feeding at the trough had a low but positive correlation with the intake of non-fiber carbohydrates (NFC) (P<0.05). The number of grazing periods showed a low negative correlation (P<0.05) with the intakes of crude protein and NFC. However, the correlation coefficients were low in relation to the feeding behavior variables, because of factors linked to characteristics of the concentrate, such as appearance and texture, which were not controlled in the experiment.

Additional keywords

Bites.
Cattle.
Rumination.
Chewing.

Correlações lineares entre comportamento e consumo por vacas leiteiras suplementadas

RESUMO

O comportamento alimentar de ruminantes de pastagem tem sido usado para orientar e apoiar muitas discussões relacionadas com a ingestão encontradas em pesquisa. Por conseguinte, as medições destas correlações podem quebrar alguns paradigmas, porque provavelmente nem todas as variáveis de comportamento estão correlacionadas com os parâmetros nutricionais. Este estudo teve como objetivo avaliar as correlações lineares entre comportamento alimentar e ingestão de vacas leiteiras suplementadas em pastagem. Utilizou-se 12 vacas mestiças Holandês x Zebu, com 100 a 150 dias de lactação com peso corporal de 466,9 ± 33,2 kg PV. Foi mensurado o consumo da dieta e o comportamento ingestivo dos animais em quatro avaliações a cada 17 dias durante o período experimental. Foram feitas análises de correlações lineares de Pearson utilizando o teste "t", sendo consideradas significativas a 5% de probabilidade. O tempo de pastejo, ruminação e de outras atividades não apresentaram correlações significativas com as variáveis de consumo (P>0,05), entretanto tempo de alimentação no cocho apresentou correlação positiva baixa com o consumo de carboidratos não fibrosos (CNF) (P<0,05). O número de ciclos de pastejo mostrou uma correlação negativa baixa (P<0,05) com os consumos de proteína bruta e carboidratos não fibrosos. Contudo os valores dos coeficientes de correlação do consumo alimentar foram baixos em relação a variáveis do comportamento ingestivo. Isso devido a fatores ligados a características do concentrado, como aparência e textura, que não foram controlados na condução do experimento.

Palavras chave adicionais

Bocados.
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INTRODUCTION

The growth in milk production in the last years in Brazil has been highly expressive, just as the competitiveness in the world market. The northeast region of the country has been considered an important agricultural frontier for animal production in the country, holding the future prospect of becoming one of the largest dairy cattle producing regions.

The inclusion of small amounts of concentrate supplement can positively affect the use of the available forage, even in high-quality pastures in the rainy season (Santana Júnior et al., 2013).

Understanding the feeding behavior of animals is considered a useful tool for the herd management, as it is intrinsically related to their production (Lima et al., 2013). The study of the ingestive behavior has been used as a tool to evaluate diets that allows for the adjustment of the animal-feeding management in order to achieve better performance (Pereira et al., 2011; Pinheiro et al., 2011; Santana Júnior et al., 2013), guiding and reinforcing various discussions about intake. Therefore, the measurements of these correlations can break some paradigms, because probably not all behavioral variables are correlated with nutritional parameters.

Carvalho et al. (2007) claimed that the intake of animals on pasture cannot be determined directly, and several methodologies have been developed to estimate it. In this regard, Santana Júnior et al. (2013) reported that knowing the feeding-behavior variables that are interrelated with intake will be necessary in order to determine which variables should compose a mathematical model that determines intake through the feeding behavior.

Although behavioral variables have a high potential for estimating intake, their use has been unfortunately trivialized by many researchers who employ them without any prediction model and without properly investigating the cause-effect relationships of the grazing process. They have been used only as "emerging variables" and treated merely as additional information in scientific publications, especially in the Brazilian studies (Carvalho et al., 2007).

The present study aimed to evaluate the linear correlations between feeding behavior and intake in grass in dairy cows supplemented on pasture.

MATERIALS AND METHODS

The experiment was conducted on Paulistinha Farm, located at Macarani - BA, Brazil, between February and April 2009. Laboratory analyses were carried out at the Experimental Cattle Laboratory and the Laboratories of Animal Nutrition, Forage Crops and Pasture at the Department of Animal Science of Southwest Bahia State University (UESB), located in Itapetinga - BA, Brazil.

The fieldwork was implemented at 42-ha area divided into eight paddocks with an average area of 5.3 ha each, formed by *Brachiaria brizantha*, with water available to the animals in all paddocks. The period of permanence of the animals in the paddocks varied according to the number of days required for the grass to reach the 20 cm exit height.

Twelve Holstein × Zebu crossbred cows (pedigree ½ to ¾), with a body weight of 466.9 ± 33.2 kg at 100 to 150 days in milk, received supplementation. Their feed intake and feeding behavior were assessed in four moments times every 17 days throughout the experiment.

Concentrates supplements were supplied to the animals twice daily, immediately after milking in individual stalls with area of 4 m^2, provided with feeders and drinkers.

To estimate total fecal production, chromic oxide was used as the external marker, supplied daily right after the milking session in a single dose of 10 g, for 10 days, consisting of 5 days for adaptation and regulation of the marker's excretion flow and 5 days for feces collection within each experimental period, which lasted 17 days. Feces samples were collected directly from the rectal ampulla of the animals and stored in a freezer at –10 ºC. Later, they were packed in aluminum containers and pre-dried in a forced-air oven at 60 ºC for 72 to 96 h, and then ground in a mill with 1 mm mesh sieve. Afterward, they were grouped proportionally, based on the air-dry weight, forming composite samples of each animal per period, and stored for later analyses.

The fecal samples were analyzed by atomic absorption spectrophotometry for the chromium level. Fecal production was determined by using the followed equation: $FP = CO_S/CO_F$, where FP is the daily fecal production (g/day); CO_S is the chromic oxide supplied (g/day), and CO_F is the chromic oxide concentration of in the feces (g/g DM).

Indigestible neutral detergent fiber (iNDF) was used as an internal marker, as recommended by Detmann et al. (2007). The DM intake was obtained by the followed equation: $DMI = \{[(FP \times CMF_E) - MS]/CMF_O\} + SDMI$, where DMI = dry matter intake (kg/day); FP = fecal production (kg/day); CMF_E = marker concentration in the feces (kg/kg); MS = marker concentration in the supplement (kg/kg); CMF_O = concentration of the marker concentration in the forage (kg/kg); and

Table I. Chemical composition of roughage and experimental diets (% DM) (Composição química do volumoso e das dietas experimentais (% da MS).

Item	Roughage	Additional fat source			
		Control	Cottonseed	Soybeanoil	Soy (frying) oil
Dry matter	23.3	41.7	41.1	40.5	40.4
Crude protein	8.2	12.0	11.9	12.0	11.9
Ether extract	4.0	4.0	5.6	5.6	5.1
Neutral detergent fiber	63.8	53.5	55.3	55.5	55.5
Acid detergent fiber	42.6	33.0	35.7	34.5	34.5
Non-fiber carbohydrates	15.7	20.2	17.5	17.7	18.2
Total digestible nutrients	59.4	57.1	56.5	57.1	57.3

SDMI = dry matter intake from the supplement (kg/day).

The chemical composition of the feed supplied (**Table I**), forage, and feces was evaluated by measuring the dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber corrected for ash and protein (NDFap), and acid detergent fiber (ADF) contents according to Detmann et al. (2012). Non-fiber carbohydrates (NFC) were obtained by the followed equation: NFC (%) = 100 – (%CP + %EE + %NDFap + %Ash). The total digestible nutrients (TDN) were calculated by the followed equation: TDN (%) = DCP + DNDFap + DNFC + 2.25 × DEE, where D = digestibility of each component.

Feeding behavior was recorder by observations made every five minutes during 24 h, according by methodology of Carvalho et al. (2011). To determine the total time in minutes (min) spent on each activity, digital watches were used. Behavioral variables (grazing, rumination, feeding at the trough and other activities) were considered mutually exclusive. Total chewing time (TCT) and total feeding time (TFT) were determined by the followed equations: TCT = GRZ + TRH + RUM; TFT = GRZ + RUM, where GRZ = grazing time; RUM = rumination time; and TRH = time spent feeding at the trough. The other activities were considered rest, water intake, interactions.

The discretization of time series was performed directly on the data collection spreadsheets by 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 activity by the number of discrete periods of that activity.

Three observations were made in each period of the day to determine the number of 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 = RUM / TRC; ChS = RChC / TRC; ChT = TRC / RChC; RChD = CRD * RChC, where CRD (n/day); RUM (s/day) = rumination time; TRC (s); ChS (chews/s); RChC (n/cud); ChT (s); and RChD (n/day).

During the same diurnal periods of evaluation of animal behavior, when the animals had been grazing longer than 30 min, their bite rate (BTR) was estimated in each treatment, as the time spent by the animal to take 20 bites (Hodgson 1982). To calculate the bite mass (BTM), the daily intake was divided by the total number of daily bites.

The number of bites and the time spent between swallows were also observed. The results of the biting and swallowing observations were recorded in six occasions throughout the day, according by Baggio et al. (2009), with three performed in the morning and the other three in the afternoon. These data were also used to determine the number of bites per day (NBD), which is the product between bite rate and grazing time.

Feed efficiency were calculated by dividing the intake of nutrients by the total feeding time (feed efficiency, FE) or by the rumination time (rumination efficiency, RE) expressed grams of DM, NDF, TDN, NFC, and CP per minute; or DM and NDF, respectively.

Associations were calculated by Pearson's linear correlations coefficients and the "t" test, with values significant considered when p<0,05. All data analysis was performance using SAS® 9.2 software (reference).

RESULTS AND DISCUSSION

Time spent on grazing (GRZ), rumination (RUM), other activities (OTH), total chewing time, and total feeding time did not show correlations with the intake variables (P>0.05); however, the time spent feeding at the feeders (TRH) had a low positive correlation with NFC intake (P<0.05) (**Table II**).

The conditions under which this study was conducted did not allow for correlations between the feeding behavior and intake variables (kg or BW). However, Gontijo Neto et al. (2006) reported that the grazing time is highly correlated with forage intake and can be used in the development of models to predict forage

Table II. Linear correlations between feed behavior and feed intake in dairy cows supplemented on pasture
(Correlações lineares entre comportamento ingestivo e consumo do alimento em vacas leiteiras suplementadas à pasto).

Variable (intake)	GRZ[1]	OTH[2]	RUM[3]	TRH[4]	TCT[5]	TFT[6]
DM (kg)[7]	---	---	---	---	---	---
DM (% BW)	---	---	---	---	---	---
NDFap (kg)[8]	---	---	---	---	---	---
NDFap (% BW)	---	---	---	---	---	---
OM (kg)[9]	---	---	---	---	---	---
ADF (kg)[10]	---	---	---	---	---	---
CP (kg)[11]	---	---	---	---	---	---
NFC (kg)[12]	---	---	---	0.39 (0.0030)	---	---
EE (kg)[13]	---	---	---	---	---	---

[1]Grazing time; [2]Time spent on other activities; [3]Rumination time; [4]Time spent feeding at the trough; [5]Total chewing time; [6]Total feeding time; [7]Dry matter; [8]Neutral detergent fiber corrected for ash and protein [9]Organic matter; [10]Acid detergent fiber; [11]Crude protein; [12]Non-fiber carbohydrates; [13]Ether extract.

intake or the performance of an animal under such conditions. However, in the current experiment there was a weak correlation between the variables because the diet contained only 55.5% NDF intake, Figueiredo et al. (2013) cite that there is a correlation between rumination and NDF intake.

Santana Júnior et al. (2013) stated that the lack of correlations for grazing time may be due to factors causing alterations in this variable that are not directly from intake, but rather conditions of the forage sward, since an increase in grazing time can be caused by a low pasture height without it leading to increased intake.

Regardless of the food, the chewing time during rumination may facilitate the hydration of the particles, in addition to breaking physical barriers, which facilitates microbial colonization (Kozloski, 2009).

Among the factors that permit variations between feeding behavior and the intakes of dry matter and nutrients is the NDF content in the roughage and in the total diet. The fact that the animals grazed in the same paddock during the evaluation period and consumed a diet with similar NDF contents between the treatments did not allow for a variation that could provide changes between the variances, which results in a correlation between the studied factors.

The correlation between TRH and NFC intake is because, at the trough, the animals consumed the concentrate supplement, which results in the ingestion of starch, a NFC source that varied in the composition of the diets, which made it possible to detect this result. Another factor that might have contributed to the differences in TRH between the evaluated treatments was the physical nature of the concentrate. The evaluated diets were available in mash and pasty form, the latter form allowing the animals to consume with greater facility and in less time.

Number of grazing periods (NGP) had a low negative correlation ($P<0.05$) with the intakes of CP and NFC (**Table III**). The correlation between these variables can be explained by the composition of the diet. Low-digestibility or high-fiber diets lead to a higher NGP. The variation between the presentation of the concentrate (mash and pasty form), resulting from the fat source, prevented the bacterial attack, reducing the digestibility of the diet, with a correlation observed between the intakes of CP and NFC. Although there was no variation between the level of EE of the diets, the way they reached the rumen caused them to coat the feed, preventing the adherence of microorganisms.

The lack of correlation for these variables demonstrates that the variation in NGP may result from an increased or decreased use of the abovementioned nutrients. In this case, the fat source led to a variation in the microbial condition, providing higher or lower digestibility.

A low negative correlation was detected between the number of idle periods and the intake variables ($P<0.05$); however, the same effect was not observed for the intakes of NDF and ADF ($P>0.05$).

Time per grazing period showed low but positive correlations with NFC intake ($P<0.05$). The longer time spent grazing allowed for a larger volume of rumen

Table III. Linear correlations between discrete periods of the feeding behavior and intake in dairy cows supplemented on pasture (Correlações lineares entre períodos discretos do comportamento ingestivo e consumo em vacas leiteiras suplementadas à pasto).

Variable (intake)	NGP[1]	NOP[2]	NRP[3]	TGT[4]	TPO[5]	TRP[6]	TTP[7]
DM (kg)[8]	---	– 0.35 (0.0075)	---	---	0.37 (0.0043)	---	---
DM (% BW)	---	–0.33 (0.0105)	---	---	0.42 (0.0015)	---	---
NDF (kg)[9]	---	–0.25 (0.0448)	---	---	0.29 (0.0247)	---	---
NDF (% BW)	---	---	---	---	0.32 (0.0129)	---	---
OM (kg)[10]	---	–0.33 (0.0110)	---	---	0.37 (0.0053)	---	---
ADF (kg)[11]	---	---	---	---	---	---	---
CP (kg)[12]	–0.30 (0.0202)	–0.4403 (0.0009)	–0.25 (0.0409)	---	0.39 (0.0030)	0.26 (0.0369)	---
NFC (kg)[13]	–0.27 (0.0297)	–0.35 (0.0075)	---	0.25 (0.0440)	0.29 (0.0227)	---	0.39 (0.0030)
EE (kg)[14]	---	–0.32 (0.0139)	---	---	0.27 (0.0334)	---	---

[1]Number of grazing periods; [2]Number of periods on other activities; [3]Number of rumination periods; [4]Time per grazing period; [5]Time per period on other activities; [6]Time per rumination period; [7]Time per period feeding at the trough; [8]Dry matter; [9]Neutral detergent fiber corrected for ash and protein; [10]Organic matter; [11]Acid detergent fiber; [12]Crude protein; [13]Non-fiber carbohydrates; [14]Ether extract.

Table IV. Linear correlations between rumination aspects and intake in dairy cows supplemented on pasture (Correlação lineares entre aspectos da ruminação em vacas leiteiras suplementadas à pasto).

Variable (intake)	RChC[1]	TRC[2]	ChS[3]	ChT[4]	RChD[5]	CRD[6]
DM (kg)[7]	---	---	---	---	---	---
DM (% BW)	---	---	---	---	---	---
NDFap (kg)[8]	---	---	---	---	---	---
NDFap (% BW)	---	---	---	---	---	---
OM (kg)[9]	---	---	---	---	---	---
ADF (kg)[10]	---	---	---	---	---	---
CP (kg)[11]	---	---	---	---	---	---
NFC (kg)[12]	---	---	---	---	0.24 (0.0532)	---

[1]Number of rumination chews per cud; [2]Time per ruminated cud; [3]Chewing speed; [4]Time per chew; [5]Number of rumination chews per day; [7]Number of cuds ruminated per day; [7]Dry matter; [8]Neutral detergent fiber corrected for ash and protein [9]Organic matter; [10]Acid detergent fiber; [11] Crude protein; [12]Non-fiber carbohydrates; [13]Ether extract.

content, which in turn provided a greater dilution of the diet components, facilitating the use of the NFC from the forage.

Time per period on other activities showed low positive correlations with all intake variables (P<0.05). The increased diet of intake reduces the time per period on other activities, because a higher forage intake increases the rumination frequency and reduces the idle time.

Time per rumination period (TRP) had a low positive correlation with CP intake (P<0.05). The need for chewing is related to the quantity and quality of the material consumed, to the resistance of the material, and to the reduction of the particle size, to Van Soest (1994), the rumination time is influenced by the nature of the diet and seems to be proportional to the cell wall content of roughages, concentrate feeds, and hays. Another factor compromising TRP was mentioned by Manzano et al. (2007), who reported that supplementation reduced the rumination time due to the substitution effect, caused by the supply of concentrate on NDF intake.

Alterations in the time spent feeding and ruminating have been observed frequently in studies in which the diets had variations in the fiber content (Carvalho et al. 2007).

The rumination aspects showed no correlation with intake (P>0.05), except for the variables number of rumination chews per day and EE intake (P>0.05) (**Table IV**). This is because the supplement contains oil as one of the ingredients, which compromised the microbial attack to the feed, reducing the microbial degradation

Table V. Linear correlations between bite-related aspects and intake in dairy cows supplemented on pasture (Correlações lineares entre os aspectos de bocado e consumo em vacas leiteiras suplementadas à pasto).

Variable (intake)	NBD[1]	TPS[2]	BTR[3]	BTM_{DM}[4]	BTM_{OM}[5]
DM (kg)[7]	---	---	---	0.69 (0.0000)	0.69 (0.0000)
DM (% BW)	---	---	0.26 (0.0390)	0.70 (0.0000)	0.70 (0.0000)
NDFap (kg)[8]	---	---	---	0.67 (0.0000)	0.67 (0.0000)
NDFap (% BW)	---	---	---	0.67 (0.0000)	0.67 (0.0000)
OM (kg)[9]	---	---	---	0.68 (0.0000)	0.68 (0.0000)
ADF (kg)[10]	---	---	---	0.64 (0.0000)	0.64 (0.0000)
CP (kg)[11]	---	---	---	0.71 (0.0000)	0.71 (0.0000)
	---	---	---	0.36 (0.0065)	0.36 (0.0065)
NFC (kg)[12]	---	---	---	0.48 (0.0003)	0.48 (0.0003)

[1]Number of bites per day; [2]Time per swallow; [3]Bite rate; [4]Bite mass in grams of dry matter; [5]Bite mass in grams of organic matter; [6]Number of bites per day; [7]Dry matter; [8]Neutral detergent fiber corrected for ash and protein [9]Organic matter; [10]Acid detergent fiber; [11]Crude protein; [12]Non-fiber carbohydrates; [13]Ether extract.

Table VI. Linear correlations between the feeding-behavior efficiencies and intake in dairy cows supplemented on pasture (Correlações lineares entre as eficiências do comportamento ingestivo e consumo em vacas leiteiras suplementadas à pasto).

Variable (intake)	FE_{DM}[1]	FE_{NDFap}	FE_{NFC}	FE_{CP}	RE_{DM}[2]	RE_{NDFap}
DM (kg)[3]	0.78(0.000)	0.78 (0.0000)	0.68(0.000)	0.66(0.000)	0.57(0.000)	0.60 (0.000)
DM (% BW)	0.76(0.000)	0.76 (0.000)	0.60(0.000)	0.67(0.000)	0.52(0.0001)	0.56 (0.000)
NDFap (kg)[4]	0.76 (0.000)	0.80 (0.0000)	0.66 (0.000)	0.62(0.0000)	0.52(0.0001)	0.59 (0.000)
NDFap (% BW)	0.73(0.0000)	0.78 (0.0000)	0.58(0.0000)	0.63(0.0000)	0.48(0.0003)	0.55 (0.0000)
OM (kg)[5]	0.77 (0.0000)	0.78 (0.0000)	0.69 (0.0000)	0.64(0.0000)	0.58(0.0000)	0.61 (0.0000)
ADF (kg)[6]	0.75 (0.0000)	0.75 (0.0000)	0.41 (0.0021)	0.65(0.0000)	0.45(0.0006)	0.49 (0.0002)
CP (kg)[7]	0.78 (0.0000)	0.76 (0.0000)	0.59 (0.0000)	0.76(0.0000)	0.45(0.0007)	0.46 (0.0005)
NFC (kg)[8]	0.44 (0.0008)	0.44 (0.0000)	0.86 (0.0000)	0.30(0.0187)	0.48(0.0003)	0.50 (0.0002)
EE (kg)[9]	0.58 (0.0000)	0.59 (0.0000)	0.32 (0.0132)	0.55(0.0000)	---	---

[1]FE = feed efficiency; [2]RE = rumination efficiency; [3]Dry matter; [4]Neutral detergent fiber corrected for ash and protein [5]Organic matter; [6]Acid detergent fiber; [7]Crude protein; [8]Non-fiber carbohydrates; [9]Ether extract.

and increasing the number of rumination chews per day.

Number of bites per day and time per swallow were not correlated with the intake variables (P>0.05) (**Table V**).

Bite rate (BTR) had a low positive correlation with DM intake expressed in relation to body weight (P<0.05). Variations in BTR are closely related to the structure of the forage sward. The height and density of the forage may facilitate or compromise the seizure of the food, decreasing or increasing the bite mass, which is present in the calculation of BTR. According to Santana Júnior et al. (2013), variations in the bite mass do not lead to differences in intake due to the compensation of the bite rates.

Bite mass expressed in grams of dry matter and organic matter had moderate positive correlations with the intake variables (P<0.05). Cattle seize their food with the tongue, and as the forage density is increased, the animal tends to seize the food within its reach, which may facilitate or compromise the consumption of roughage (Carvalho et al., 2008).

Number of bites per day had low negative correlations with the intakes of DM (%BW), NDFap, and CP (P<0.05). According to Santana Júnior et al. (2013), intake increases with the number of bites per day, which is explained by the greater seizure and ingestion of roughage by the ruminant. Thus, as the intakes of NDF, CP, and DM are increased, the number of bites taken per day is decreased, considering that the consumption of concentrate is restricted to its supply.

Feed efficiencies of DM, NDFap, NFC, and CP had moderate-high positive correlations with intake (P<0.05) (**Table VI**). It can thus be inferred that the animals fed properly according to the availability of nutrients in the diet. Under certain conditions, even with milk production remaining unchanged, a reduction in intake caused by the presence of oil can improve feed efficiency, because the food provides energy, as this ratio is defined as the amount of milk produced per kg of DM of the consumed feed.

Rumination efficiency in DM and NDFap was not correlated with EE intake (P>0.05). The presence of fat in the diet usually leads to lower digestibility of the fiber, but in the present study, no significant effects were observed with its increase or reduction in the diet. However, correlations were positive between the rumination efficiency and the other intake variables (P<0.05). Rumination occurs due to the presence of physically effective fiber in the diet, expressed by the NDF from the roughage, requiring the feed to be fragmented into smaller portions easier to be swallowed.

Fontenelle et al. (2011) mention that a prolonged rumination activity does not always compensate for a reduction in rumination efficiency.

CONCLUSION

There are correlations among feeding behavior variables, discrete periods, aspects of rumination and feed and rumination efficiencies, and nutrient intake.

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