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Ingestive behavior of Guzerat and Sindhi heifers under the effects of feed restriction

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ABSTRACT. This study aimed to evaluate the effect of feed restriction on the ingestive behavior of Guzerat and Sindhi heifers. A total of 36 heifers were used, 18 from each breed, randomly distributed in a completely randomized design, in a 2 x 3 factorial scheme. The treatments used were 20 and 40% restriction compared to intake by animals from the third group, which were fed ad libitum (without restriction). For the behavioral analysis, the scan sampling method was used by logging and recording times in five-minute intervals during 24 hours, thus estimating the time spent feeding, ruminating and idling. With regard to the imposed restrictions, it was observed that non-restricted animals showed greater feeding time and lower resting time ($p < 0.05$); the two breeds showed the same feeding efficiency. When subjected to levels up to 40% of feed restriction, both studied genotypes perform similarly with regard to ingestive behavior, feeding efficiency and cud chews. However, there was an effect of the restriction levels on the patterns of ingestive behavior and cud chews, although there were no changes to feeding efficiency or chewing time per cud.

Keywords: ethology, nutrition, zebu.

Comportamento ingestivo de novilhas Guzerá e Sindi sob efeito de restrição alimentar

RESUMO. Objetivou-se com este estudo avaliar o efeito da restrição alimentar sobre o comportamento ingestivo de novilhas da raça Guzerá e Sindi. Foram utilizadas 36 novilhas, sendo 18 de cada uma das raças, distribuídos aleatoriamente em um delineamento inteiramente casualizado, em arranjo fatorial 2 x 3. Os tratamentos utilizados foram de 20 e 40% de restrição em relação ao consumido pelos animais do terceiro grupo que se alimentavam à vontade (sem restrição). Para a análise comportamental utilizou-se o método de amostragem scan com registro temporal em intervalos de cinco minutos durante 24 horas contínuas, estimando-se assim o tempo despendido em alimentação, ruminação e ócio. Em relação às restrições impostas, notou-se que animais que não passaram por restrição alimentar apresentaram maior tempo de alimentação e menor tempo em ócio ($p < 0,05$), observando-se a mesma eficiência alimentar para novilhas das duas raças em confinamento. Os genótipos estudados quando submetidos até um nível de 40% de restrição alimentar se comportam de maneira igual quanto ao comportamento ingestivo, eficiência alimentar e mastigação merícica. Contudo houve efeito dos níveis de restrição que são alterações nos padrões de comportamento ingestivo, mastigação merícica, apesar de não ter ocorrido alterações na eficiência de alimentação e no tempo de mastigação por bolo.

Palavras-chave: etologia, alimentação, zebuínos.

Introduction

In order to efficiently explore dairy production, feed use must be perfected to ensure greater competitiveness, as feeding is among the factors with the greatest impact on production costs. This requires studies applying feeding restrictions to determine a point of equilibrium between feeding losses from leftover and profit. One way to evaluate these practices would be by observing ingestive behavior.

In quantitative feeding restriction for heifers, the amount offered should reach the best adjustment in ingested amount and provide the best weight gain around 700 g day^{-1}, without causing reproductive damages, while reducing feeding costs.

Cardoso et al. (2006) showed that studying ingestive behavior is a useful tool to understand animal response, and is essential to evaluate the results of using different diets, allowing adjustments

to animal feeding management to obtain the best possible productivity results.

Neumann et al. (2007) affirm that the biology of voluntary intake and animal performance response are complex, and their effects depend on the interaction of factors regarding the animal, diet and environment; these factors are associated not only to the volume of roughage, but also to the rate of roughage in the diet and/or level of concentrate. To fully understand daily feed intake, it is necessary to study components individually, which can be described by the number of feedings per day, mean duration of these feedings, and eating rate of each feeding (PEREIRA et al., 2004).

Genotypes Guzerat and Sindhi are quite common in the State of Paraíba, Brazil, showing high potential for that region. As such, it is quite important to study the ingestive behavior of these breeds in order to better understand the relationships that define animal performance under restricted feeding conditions. Such studies could determine how these different-sized Zebu breeds behave under those conditions, and infer which breed should be chosen depending on the behavioral parameters that best adapt to the impact of soil and climate conditions during the drought period, with regard to qualitative and quantitative restrictions of forage in the semi-arid region of Paraíba.

The need to understand the ingestive behavior of ruminants leads to studies that provide researchers and producers with data to adequately manage animal nutrition (SILVA et al., 2008).

Therefore, the objective of this study was to evaluate the effect of feeding restrictions on the ingestive behavior of Guzerat and Sindhi heifers.

Material and methods

The experiment was carried out between June 18 and August 27, 2008 at the Cattle Breeding Sector of the EMEPA Experiment Station in Alagoinha, Paraíba State, Brazil, located Agreste mesoregion of Paraíba, Guarabira microregion, municipality of Alagoinha, Paraíba State, Brazil. The station is located at 6º57'00"S, 35º32'42"W. Gr., elevation 135 m.

The experiment lasted 77 days: 15 days for animal acclimation to the diet and facilities, plus four observations of ingestive behavior every 15 days.

A total of 36 heifers were used (18 from each breed), with initial age of 21 months and average body weight of 268.17 kg for Guzerat and 211.7 kg for Sindhi. The animals were distributed into three groups containing 12 plots, with six from each genetic group. They were dewormed, allotted randomly according to breed and restriction level, and housed in a barn containing 36 individual stalls, 7.5 m^2 each, with feeders and drinkers.

The experimental diets were formulated to meet the nutritional requirements of growing heifers for an average gain of 700 g day^{-1}, from initial to adult weight (NRC, 2001), by using the "Viçosa feed formulation system" (LANA, 2007) for adjustments. Two diets were used, one for each breed – treatment 1: 0% restriction (diet for 700 g day^{-1} gain); treatment 2: 20% restriction; and treatment 3: 40% restriction compared to the control group.

The ingredients used in the diets (elephant grass at 70 days of regrowth, cassava root, corn meal, soybean meal, urea and mineral mix) were processed and provided as a complete ration.

The chemical composition of the ingredients is shown in Table 1, and the percentage of each ingredient and the chemical composition of the experimental diet are found in Table 2.

Table 1. Chemical composition of the ingredients of the experimental diet on a dry-matter basis.

Nutrients	Elephant grass	Cassava root	Corn meal	Soybean meal
Dry matter (DM)	26.00	38.30	88.90	87.55
Crude protein (CP)	6.15	3.83	12.19	47.49
Ether extract (EE)	2.17	1.27	5.47	1.19
Neutral detergent fiber (NDF)	71.23	17.98	16.36	14.84
Neutral detergent fiber ap[1]	67.39	11.72	12.98	8.13
Acid detergent fiber (ADF)	42.55	11.74	8.07	8.29
Total carbohydrates (TC)	82.15	92.00	80.64	45.02
Non-fiber carbohydrates (NFC)	14.76	80.48	71.66	36.00

[1]Corrected for ash and protein.

Table 2. Percentage of each ingredient and chemical composition of the experimental diet on a dry-matter basis.

Ingredients	(%)	
	Guzerat diet	Sindhi diet
Elephant grass	39.17	30.00
Cassava root	30.00	31.31
Corn meal	21.76	24.70
Soybean meal	5.87	10.90
Urea	1.65	1.58
Sal mineral	1.55	1.51
Chemical composition	(%)	
Dry matter	49.32	54.35
Crude protein	13.51	15.55
Ether extract	2.49	2.53
Neutral detergent fiber	37.73	32.66
Neutral detergent fiber ap[1]	33.20	27.96
Acid detergent fiber	22.43	19.34
Total carbohydrates	79.97	78.28
Non-fiber carbohydrates	42.21	37.99

[1]Corrected for ash and protein.

Animals were fed two daily portions, at 7 a.m. and 3 p.m. – 40% in the morning and 60% in the afternoon. Water was provided *ad libitum*. For animals not subjected to restrictions, the amount of ration was adjusted daily according to intake the day before, so that 10 to 20% of the provided total was left over,

allowing voluntary intake. Feed-restricted animals were offered 20% less (20% restriction group) or 40% less (40% restriction group) compared to the voluntary intake of the non-restricted group.

Bromatological analysis was conducted at the CCA/UFPB Animal Nutrition Laboratory. Materials were pre-dried in a forced-air oven at 55°C for 72 hours. The samples were then processed in a Wiley-type knife mill, and later analyzed to obtain levels of dry matter (DM), mineral matter (MM), crude protein (CP) and ether extract (EE), as per AOAC (2005). The methodology proposed by ANKON (Ankon Technology Corporation) was used to assess neutral detergent fiber (NDF) using amylase and acid detergent fiber (ADF); CP and ash levels in NDF were quantified according to Mertens (2002) and Licitra et al. (1996), in order to obtained corrected NDF (NDFap) values with changes to the bags, as non-woven fabric bags were used, 100 mm weight, manufactured at the Animal Nutrition Laboratory. The percentage of total carbohydrates (TC) was obtained through the equation: 100 – (%CP + %EE +%ash), and the percentage of NFC was calculated as 100 - (%NDFap + %CP + %EE + %ash) according to Sniffen et al. (1992).

The scan sampling method was used to record the time spent on eating, rumination and idling. This was done in five-minute intervals starting at 7 a.m. during 24 straight hours, for a total of four observations at 15-day intervals throughout the course of the experiment; this resulted in 24 replications per treatment, totaling 288 records per animal. Artificial lighting was used during nighttime observations.

Ingestive behaviors were considered to be mutually exclusive – that is, for each record, each animal was classified into one activity only (PARDO et al., 2003). From these data, the mean times spent eating, ruminating and idling were analyzed.

To obtain rumination time, the times spent on regurgitation, remastication, resalivation and redeglutition of the cud were added. The eating and feeding time included biting, chewing and swallowing of the bolus. Idling consisted of the time spent not feeding, ócio representou o tempo de não apreensão e ingestão e o de não ruminação (GOULARTE et al., 2011).

Eight animals were used to evaluate cud chew, alternating the animals in each observation. Two rumination periods were evaluated – 10 p.m. to midnight and 4 to 6 a.m., assessing the number of cud chews and the time spent ruminating each bolus (seconds/bolus), using a stopwatch. Chewing was calculated by three times of 15 seconds each, with the average multiplied by four to obtain chewing time/minute.

The results for ingestive behavior factors were obtained from the ratios: FE = DMI/FT; RUE = DMI/TRU; RUE = NDFI/TRU; TCT = FT+TRU; NRC = TRU/CUD_{tc}; CUD_{nd} = NRC x CUD_{nc}; GDM_{cud} = DMI/NRC; $GNDF_{bolus}$ = NDFI/NRC; DFN = number of daily feedings; MDF_{tf} = mean duration of each feeding, in that: FE (g DM h^{-1}) = feeding efficiency, DMI (g DM day^{-1}) = dry matter intake, FT (h day^{-1}) = feeding time, RUE (g DM h^{-1}) = rumination efficiency, TRU (h day^{-1}) = rumination time, TCT (h day^{-1}) = total chewing time, NRB (no. day^{-1}) = number of cuds in rumen, TRU (s day^{-1}) = rumination time, CUD_{tc} (s cud^{-1}) = duration of cud chews per ruminal bolus; NCC_{nd} (no. day^{-1}) = number of cud chews; and NCC_{nc} (no. $bolus^{-1}$) = number of cud chews per bolus; GDM_{bolus} = grams of DM per bolus, $GNDF_{bolus}$ = grams of NDF per bolus, DFN = daily number of feedings, MDFtf = mean duration of each feeding (CARVALHO et al., 2004). When calculating DFN and MDF_{tf}, only feedings equal to or greater than 15 minutes long were considered, so as to minimize errors of observation or in the psychogenic characteristics of the animals – such as smelling or playing with the ration, but not actually eating.

The experimental design was entirely randomized in a 2 x 3 factorial scheme (two breeds and three restriction levels), totaling 36 experimental units. The data were evaluated using analysis of variance. Whenever significant, the means were compared using Tukey's test at 5% probability. All statistical analyses were carried out using the Statistical Analysis System software suite (SAS, 2005).

Results and discussion

There was no interaction between breed and restriction levels ($p > 0.05$) on the behavioral variables analyzed. No differences were observed ($p > 0.05$), either, in the times spent feeding, ruminating and idling, between Guzerat and Sindhi heifers (Table 3). These results are likely due to the fact that all experimental diets were made from the same ingredients in order to meet the 700 g day^{-1} weight gain requirement for both breeds, with comparable NDF levels. This determined the similarity, as the time spent feeding and ruminating is influenced by NDF levels in the diet, as observed by Silva et al. (2011), working with nanny goats fed different levels of neutral detergent fiber.

There was a significant effect for the time spent on feeding as a function of restriction levels ($p < 0.05$) (Table 4). This can be explained by the growing restriction levels of offered diet (20 and 40%) compared to the intake by animals without restriction. Thus, non-restricted animals showed the highest ($p < 0.05$) time spent feeding (3h and 34 min.), as the offered feed was much greater and they therefore had 24-hour feed availability. Even though not evaluated, it is believed there was a visual stimulus for greater DMI, which probably led to this result; conversely, the animals subjected to 20 or 40% restriction spent less time feeding (2h and 43 min., and 2h and 3 min., respectively), as the offered amount was lower (Table 4).

Table 3. Means and coefficients of variation (CV %) of the time (in hours) spend feeding, ruminating and idling by Guzerat and Sindhi heifers.

	Guzerat	Sindhi	CV %
Feeding	2.92	2.65	16.11
Ruminating	6.29	6.10	12.39
Idling	14.78	15.24	5.40

According to Fontenele et al. (2011), in order to understand daily feed intake it is necessary to study the components individually, which can be described by the amount of feed provided and ingested daily, by the mean time duration to ingest it, and by the eating rate of all feeding items provided. Each one of these processes is the result of the interaction between animal metabolism and the physical-chemical properties of the diet, stimulating satiety receptors.

Table 4. Mean time (in hours) spent feeding, ruminating and idling by Guzerat and Sindhi heifers as a function of the restriction levels.

Variables	Treatments		
	0%	20%	40%
Feeding	3.57a	2.72b	2.05c
Ruminating	7.15a	6.49a	4.95b
Idling	13.27c	14.78b	16.99a

Means followed by different letters, in the same row, differ according to Tukey's test at 5% probability.

With regard to the time spent ruminating, there was no difference ($p > 0.05$) between non-restricted and 20% restriction animals; 40% restriction animals had lower ($p < 0.05$) results than the other treatments. However, there was a difference ($p < 0.05$) among the treatments for time spent idling, inversely proportional to time spent feeding.

It can be observed that the highest mean DMIs were found for Guzerat compared to Sindhi, as shown in Table 5; this is likely due to the larger size of Guzerat, meaning they have larger GI tracts that enable higher feed intake, as confirmed by the similar data for NDF intake for both breeds.

Table 5. Daily intake of dry matter (DMI), of neutral detergent fiber (NDFI), dry matter feeding efficiency (FE), ruminating efficiency of dry matter (RUE_{DM}) and of neutral detergent fiber (RUE_{NDF}), and ruminating efficiency in grams of DM per bolus (GDM_{bolus}) and in grams of NDF per ruminated bolus ($GNDF_{bolus}$) observed in Guzerat and Sindhi heifers under different feeding restriction levels.

Variables	Breed		
	Guzerat	Sindhi	CV %
DMI (g day^{-1})	7565.22a	6439.55b	11.84
NDFI (g day^{-1})	3941.93a	3231.93b	11.82
FE (g de DM h^{-1})	2634.14	2476.54	17.36
RUE_{DM} (g of DM h^{-1})	1198.78a	1057.91b	16.74
RUE_{NDF} (g of NDF h^{-1})	625.49a	531.67b	16.67
GDM_{Cud} (g cud^{-1})	20.99	21.29	27.22
$GNDF_{Cud}$ (g cud^{-1})	10.96	10.69	27.47

Means followed by different letters, in the same row, differ according to Tukey's test at 5% probability; CV = coefficient of variation.

According to Pereira et al. (2003), feed intake by ruminants can be regulated by several mechanisms. Accordingly, the size, body condition, rumen distension ability, breed and physiological status are characteristics that influence intake, by altering animal requirements.

Results obtained by Marcondes et al. (2011) highlighted an increase in energy demand as the body weight of cattle from different genetic groups increases. This is the result of the increased maturity of animals, in which protein deposition begins to decrease and metabolism transfers the flow of energy to body reserves.

Feeding efficiency (FE), expressed as g of DM h^{-1}, did not differ ($p > 0.05$) between the genotypes, demonstrating a similar behavior for Guzerat and Sindhi heifers for that variable.

For rumination efficiency (RUE), expressed both as g of DM h^{-1} and g of NDF h^{-1}, a genotype effect ($p < 0.05$) was observed, with Guzerat heifers being more efficient in ruminating, which may be justified by the higher intake of dry matter (DMI) and neutral detergent fiber (NDFI).

Although the DMI of each breed was different, the variables grams of DM per ruminated bolus (GDM_{bolus}) and grams of NDF per ruminated bolus ($GNDF_{bolus}$) did not differ ($p > 0.05$) between the studied genotypes, indicating that these variables are not influenced by DMI and rumination efficiency, which were different in the two breeds.

As seen in Table 6, DMI and NDFI were influenced ($p < 0.05$) by the restriction levels, decreasing as restriction increased. This was due to the reduced amount of feed offered, resulting in lower voluntary intake of dry matter and its components.

No effect ($p > 0.05$) of the restriction levels was observed with regard to feeding efficiency (g of DM h^{-1}). These results are in accordance with those obtained by Fischer et al. (2002), who studied certain behavioral variables in Holstein cows and observed that the time spent ingesting varied more, over a 24-hour period, than the time spent ruminating.

Table 6. Daily intake of dry matter (DMI), of neutral detergent fiber (NDFI), dry matter feeding efficiency (FE), ruminating efficiency of dry matter (RUE_{DM}) and of neutral detergent fiber (RUE_{NDF}), grams of DM per bolus (GDM_{bolus}) and grams of NDF per cud ($GNDF_{bolus}$) for Guzerat and Sindhi heifers as a function of the restriction levels.

Variables	Treatments		
	0%	20%	40%
DMI (g day^{-1})	9305.64a	6692.06b	5009.45c
NDFI (g day^{-1})	4703.19a	3464.24b	2593.37c
FE (g de DM h^{-1})	2605.06	2479.83	2581.12
RUE_{DM} (g of DM h^{-1})	1313.05a	1044.71b	1027.29b
RUE_{NDF} (g of NDF h^{-1})	663.36a	540.33b	532.05b
GDM_{bolus} (g $bolus^{-1}$)	25.94a	20.49ab	16.99b
$GNDF_{bolus}$ (g $bolus^{-1}$)	13.09a	10.60ab	8.78b

Means followed by different letters, in the same row, differ according to Tukey's test at 5% probability.

For rumination efficiency, expressed both as g of DM h^{-1} and g of NDF h^{-1}, an influence of the restriction levels was observed ($p < 0.05$), in that non-restricted animals showed higher rumination efficiency when compared to the animals subjected to the restriction levels of 20 and 40%.

It was observed that the variables grams of DM per ruminated bolus (GDM_{Bolus}) and grams of NDF per ruminated bolus ($GNDF_{bolus}$) differed ($p < 0.05$) with the increase in restriction levels, in that non-restricted animals ruminated more grams of DM $bolus^{-1}$ and more grams of NDF $bolus^{-1}$ than animals under 40% restriction; heifers under 20% de restriction did not differ from the other restriction levels.

There was no difference ($p > 0.05$) between genotypes in total chewing time expressed as h day^{-1} (Table 7). As this variable is the sum of FT + TRU, it was to be expected that there would be no difference, because there was no difference in these two parameters of ingestive behavior between the studied breeds.

The number of rumen bolus (no. day^{-1}), number of cud chews (no. day^{-1} and no. cud^{-1}) and the duration of chews per cud (s cud^{-1}) were similar ($p > 0.05$) between the two studied genotypes. There was a difference ($p < 0.05$) between the two genotypes for the daily number and mean duration of feedings; Sindhi heifers showed higher DFN compared to Guzerat, while the mean duration of each feeding was the opposite of MDF_{tf} ($p < 0.05$) for both breeds, resulting in a roughly similar total feeding time (DFN x MDF_{tf}) between them, as shown in Table 4.

Table 7. Total chewing time (TCT), number of rumen bolus (NRB), daily number of cud chews (CUD_{nd}), chews per cud (CUD_{nc}), duration of chews per cud (CUD_{tc}), number of daily feedings (DFN) and mean duration of each feeding (MDF_{tf}) for Guzerat and Sindhi heifers under different restriction levels.

Variables	Raça		
	Guzerat	Sindhi	CV %
TCT (h day^{-1})	9.21	8.75	9.03
NRB (no. day^{-1})	352.54	320.29	23.37
CUD_{nd} (no. day^{-1})	21,923.67	20,020.44	18.85
CUD_{nc} (no. cud^{-1})	63.45	63.37	18.70
CUD_{tc} (s cud^{-1})	65.78	71.16	18.09
DFN (no. day^{-1})	2.72b	3.62a	23.28
MDF_{tf} (min.)	46.78a	37.33b	14.73

Means followed by different letters, in the same row, differ according to Tukey's test at 5% probability; CV = coefficient of variation.

According to Oliveira et al. (2011), animals ingest during given periods of time, each period representing a feeding, and this number of daily feedings varies according to feed availability and is distributed unevenly over a 24-hour period. Nevertheless, ruminants can have a series of small feedings depending on the room available for digestion and digesta passage (MAGGIONI et al., 2009).

Total chewing time showed a significant difference ($p < 0.05$) between the restriction levels, as seen in Table 8. This behavior was inversely proportional to the application of restriction levels – that is, as the restriction level increased, TCT decreased. This can be explained by the reduction in DMI and FT according to the increasing levels of restriction.

Table 8. Total chewing time (TCT), number of rumen bolus (NRB), daily number of cud chews (CUD_{nd}), chews per cud (CUD_{nc}), duration of chews per cud (CUD_{tc}), number of daily feedings (DFN) and mean duration of each feeding (MDF_{tf}) de Guzerat and Sindhi heifers as a function of different restriction levels.

Variables	Treatments		
	0%	20%	40%
TCT (h day^{-1})	10.73a	9.22b	7.01c
NRB (no. day^{-1})	376.28a	337.06ab	290.76b
CUD_{nd} (no. day^{-1})	25757.60a	20992.81b	15642.31c
CUD_{nc} (no. cud^{-1})	69.93a	63.05ab	56.69b
CUD_{tc} (s cud^{-1})	70.69	70.53	64.06
DFN (no. day^{-1})	4.12a	3.02b	2.34b
MDF_{tf} (min.)	36.21b	47.04a	42.57a

Means followed by different letters, in the same row, differ according to Tukey's test at 5% probability.

Variables NRB and CUD_{nc} showed similar behavior for all restriction levels – non-restricted heifers behaved similarly to 20% restriction heifers, differing statistically ($p < 0.05$) from the treatment with 40% restriction; however, the 40% level did not differ from animals subjected to 20%

restriction. With regard to CUD_{nd}, there was an effect of the restriction levels ($p < 0.05$), decreasing as restriction levels increased. These results may have occurred due their relationship with NDFI, which behaved similarly. Indeed, there is a close link between NDF diet levels/intake and rumination; in this experiment, the differences in NDFI among the treatments were expressive and may have significantly influenced those results.

Rumination time is highly correlated with NDF intake. Finely milled or pelletized concentrates and hays reduce rumination time, whereas roughages with high cell wall levels tend to increase it. Higher intake tends to shorten rumination time per gram of feed, which was likely responsible for the larger size of fecal particles in cases of greater intake. Nevertheless, CUD_{tc} was not influenced by the treatments.

Pereira et al. (2004), working with confined ruminants fed twice a day, observed two main feedings after feed was provided, lasting one to three hours, as well as a varying number of smaller feedings between them. In the present work, the number of daily feedings (DFN) was higher for non-restricted animals compared to heifers under 20 and 40% restriction. However, the opposite occurred for mean duration of each feeding (MDF_{tf}). These results are likely due to the fact that non-restricted animals had feed in their troughs for more time and necessarily spent less time at the trough, with shorter feeding time. Conversely, animals under 20 and 40% restriction had less available feed, which influenced the number of trips to the trough; because those animals were not full, the mean duration of each feeding was higher than that of non-restricted animals.

Overall, the number and duration of feedings are more variable than ruminating periods (DULPHY; FAVERDIN, 1987). By modifying the number of daily feedings and their size (duration x intake rate), the intake of dairy cows can be adjusted in short period of time (GRANT; ALBRIGHT, 1995).

Conclusion

When subjected to levels up to 40% of feeding restriction, the studied genotypes behave similarly with regard to ingestive behavior, feeding efficiency and cud chews. However, there was an effect of the restriction levels on the patterns of ingestive behavior and cud chews, although there were no changes to feeding efficiency or chewing time per cud.

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