RUMINANT NUTRITION

Influence of diet moisture content on behavioral, feeding, and productive parameters of lactating Holstein cows

Kauani Borges Cardoso[1]* , **Jordani Borges Cardoso[1], Tatiane Peres Marques[1], Camila Pizoni[2], Eduardo Schmitt[2] and Cássio Cassal Brauner[1]**

[1]Departamento de Zootecnia, Faculdade de Agronomia Eliseu Maciel, Universidade Federal de Pelotas, Avenida Eliseu Maciel, s/n, Capão do Leão, 96001-970, Pelotas, Rio Grande do Sul, Brazil. [2]Faculdade de Medicina Veterinária, Universidade Federal de Pelotas, Pelotas, Rio Grande do Sul, Brazil. *Author for correspondence. E-mail: kauaniborgescardoso@gmail.com

ABSTRACT. This study aimed to evaluate the effect of dry matter content on the feeding behavior and milk production of Holstein cows. The study was conducted on lactating, multiparous Holstein cows. To assess feeding behavior, automatic feeders (Intergado®, Brazil) were used. The duration of rumination and activity was quantified using electronic collars (Chip Inside, Brazil). The diets were classified according to their dry matter content: high (> 60%), medium (45 to 59%), and low (< 45%). The NCSS statistical program (2005) was employed for statistical analysis. The data were subjected to analysis of variance (GLM-ANOVA), and when statistical differences were identified (p < 0.05), the Tukey-Kramer test was performed for mean comparisons. The Holstein cows that received a diet with a low dry matter content (< 45%) exhibited a reduction in intake (p < 0.001), an increase in milk production (p < 0.001), an extension in rumination time, and a reduction in activity time (p < 0.002). In conclusion, variations in the dry matter content of the diet have an impact on the feeding behavior and milk production of Holstein cows.

Keywords: Efficiency; milk; nutrition; productivity.

Introduction

With the increased use of intensification systems, feeding in troughs has become necessary to provide dairy cows with a nutritionally balanced diet (Azevedo et al., 2021). As a result, the use of a Total Mixed Ration (TMR) has become essential (Miller-Cushon et al., 2017). This is characterized as a homogeneous mixture that aims to minimize selective consumption. Studies show that dairy cows select less when a diet is provided in the TMR format (Leonardi & Armentano, 2003; Devries et al. 2007).

The selection of particles in the diet alters the proportion of food consumed, generally increasing the intake of fermentable carbohydrates, which results in a risk of ruminal pH acidification and can lead to cases of metabolic disorders (Kononoff & Heinrichs, 2003; Devries et al., 2008). It also affects dry matter intake (DMI), potentially causing undesirable effects on milk/meat production (Devries et al., 2008; Miller-Cushon & Devries, 2009). According to Leonardi e Armentano (2003), cows tend to select smaller concentrate particles over long forage particles, leading to a gradual increase in the neutral detergent fiber (NDF) content of the TMR throughout the day (Custodio et al., 2016).

A proposed method to reduce TMR sorting is the addition of water, believed to bind fine and short particles to long particles, making it more difficult for cattle to sort. This hypothesis was tested in an experiment by Leonardi et al. (2005), which showed a reduction in sorting when water was added to a TMR (80% DM) (Miller-Cushon & Devries, 2009).

Voluntary intake is the amount of dry matter (DM) that an animal consumes over 24 hours and provides the nutrients required by the body, some regulatory mechanisms of intake, such as rumen fill, may be influenced by the dry matter content of the diet and digestibility, which consequently modulate feeding behavior (Allen, 2000). This study hypothesizes that different levels of dry matter provided to cows alter their behavior and feed intake, reducing milk production. Thus, an evaluation of the effect of DM content in TMR on the feeding behavior and milk production of Holstein cows was carried out.

Materials and methods

This retrospective study utilized a database with 1,563 observations from a commercial dairy farm in Rio Grande, southern Brazil. For this study, lactating multiparous Holstein cows raised in an intensive system were selected. The animals were housed in a compost barn, milked twice daily (at 06:00 and 18:00), and fed three times a day (at 07:00, 12:00, and 19:00).

All data were collected individually. Feeding behavior was evaluated using automatic feeders (Intergado®, Brazil), monitoring Intake (kg DM day^{-1}), Number of visits without consumption (times day^{-1}), feeding frequency (visits with consumption – times day^{-1}), and total number of visits (times day^{-1}) (Schirmann et al., 2012). Rumination and activity time was evaluated using monitoring collars (Chip Inside, Brazil), and daily milk production (morning and afternoon) was recorded by milk meters (Flow Indicator, @DeLaval).

The diet was calculated to meet nutritional requirements according to the National Research Council (2001), and feeding was provided in the form of TMR (Total Mixed Ration) (Table 1) with water provided *ad libitum*. To obtain feed conversion data (kg of dry matter of total diet per kg of milk produced), the ratio of the total dry matter of the diet consumed by the animal (TMR) and milk production was evaluated.

Table 1. Ingredients of the diet used during the experimental period, based on inclusion percentage.

Item	% of Inclusion
Ryegrass Haylage	3.96
Wet Corn Silage	3.96
Ground Corn	1.96
Corn Silage	53.56
Soybean Meal	6.41
Rice Bran	3.76
Rice Residue	1.98
Soybean Residue	5.15
Buffers	3.96
Mycotoxin Adsorbent	0.01
Water	15.87

To determine the percentage of dry matter, TMR samples were collected from each feeder to compose a daily pool immediately after feeding and then sent to the Nutrition Laboratory of the Center for Research, Teaching, and Extension in Livestock (NUPEEC-UFPel, Pelotas, Capão do Leão Campus), where pre-drying was performed in a forced air circulation oven at 55°C for 72 hours, using the methodology described by Easley et al. (1965). Based on the analysis data, the TMR was classified according to its DM content: High (> 60%, n = 120), Ideal (between 45% and 60%, n = 963), and Low (< 45%, n = 480), adapted from the methodology of Schingoethe et al. (2017).

For statistical evaluation, an analysis of variance (GLM-ANOVA) was performed using the NCSS statistical software (2005), considering the fixed effects of the three treatment groups based on the classification of TMR DM (high, ideal, and low), the random effect of the cow, and correction for days in lactation. The study variables were individual dry matter intake and feeding-related behavioral characteristics (intake in kg DM day^{-1}; number of visits without intake in times day^{-1}; feeding frequency in times day^{-1}; and total number of visits in times day^{-1}) and milk production. When there was a statistical difference ($P < 0.05$), the Tukey-Kramer mean comparison test was performed using the same software.

Results and discussion

The dry matter content of the TMR influenced intake (Table 2). Cows receiving a diet with low DM (< 45%) reduced intake by 3.47 kg and 5.64 kg compared to animals fed a diet with ideal DM (45-60%) and high DM (> 60%), respectively ($p < 0.001$). The number of visits and feeding frequency did not differ between groups ($p > 0.05$).

Milk production showed an effect ($p < 0.01$) amongst groups (Table 3). Animals in the low DM treatment produced 5.06 and 1.95 kg day^{-1} more than diets classified as high and ideal, respectively. This indicates that animals in the low dry matter group had better feed conversion (0.414) than other groups (High = 0.643 and Ideal = 0.525).

There was also an effect on rumination and activity time (Table 3). Animals with low DM had greater rumination time ($p = 0.02$) and lower activity time ($p = 0.02$) than other groups.

Table 2. Effect of dry matter content in the total mixed diet on intake and feeding behavior parameters.

Variables	Groups			p-value
	High	Ideal	Low	
Intake[1]	22.44 ± 0.42[a]	20.23 ± 0.33[b]	16.76 ± 0.96[c]	< 0.001
Visits without intake[2]	42.50 ± 2.9	36.45 ± 1.10	38.46 ± 2.89	0.14
Feeding frequency[3]	26.61 ± 0.85	25.88 ± 0.63	23.64 ± 1.84	0.33
Total number of visits[4]	58.77 ± 1.74	60.78 ± 1.32	62.11 ± 3.85	0.57

[1]Kg DM day[-1]; [2]Number of times day[-1]; [3]Number of visits with intake – times day[-1]; [4]Times day[-1]. [abc]Lowercase letters that differ within the same row represent a statistically significant difference.

Table 3. Effect of Dry Matter Content in the Total Mixed Diet on Milk Production, Rumination, and Activity.

Variables	Groups			p-value
	High	Ideal	Low	
Milk production[1]	35.37 ± 0.94[a]	38.48 ± 0.46[b]	40.43 ± 0.50[c]	< 0.001
Rumination[2]	645.96 ± 11.00[ab]	631.36 ± 5.17[a]	651.90 ± 5.41[b]	0.02
Activity[3]	199.82 ± 7.34[b]	185.34 ± 3.45[ab]	178.19 ± 3.61[a]	0.02

[1]Kg day[-1]; [2]Minutes day[-1]; [3]Minutes day[-1]. [abc]Lowercase letters that differ within the same row represent a statistically significant difference.

The reduction in intake may be related to the water volume present in the diet, which aligns with findings reported by Schingoethe (2017) and Felton and Devries (2010), who observed decreased intake in TMR with DM less than 45%. In diets with low %DM, an increase in NDF consumption and milk fat percentage was noted compared to drier diets (Felton & Devries, 2010; Leonardi et al., 2005). This linear decrease in intake with decreasing DM (78, 65, 53, and 40% DM) had already been documented in previous studies (Lahr et al., 1983).

Particle size distribution can be affected by the moisture content of the diet, as studies show a linear decrease in the percentage of feed retained in the 3 and bottom screens (< 8 mm) with an increase in the retention of particles in screens 2 and 1 (> 8 mm), thereby increasing the physically effective NDF of the diet. This result can be attributed to the binding effect of water, causing smaller particles to adhere to larger particles (Leonardi et al., 2005; Miller-Cushon & Devries, 2009; Felton & Devries, 2010). However, water should be added to TMR with caution, as it can make the diet more prone to spoilage (Eastridge, 2006).

The increased milk production in animals consuming a low DM diet may be associated with the diet's digestibility. One factor determining nutrient utilization in cattle is that milk production pre-determines intake, but it can be limited by ruminal fill and hormones that create a sense of satiety (Allen, 2000).

A reduction in DMI decreases the digesta passage rate, improving nutrient digestibility and modulating production (Souza et al. 2018). This improvement in digestibility occurs because a slower passage rate allows food particles to remain in the rumen longer, increasing the reaction time between enzymes and substrates, which enhances nutrient absorption (Souza et al., 2018; Golher et al., 2021).

The effect on rumination confirms the previously mentioned suggestion that a higher water content diet reduces sorting, increasing fiber intake as the animal consumes a more uniform diet (Leonardi et al., 2005; Miller-Cushon & Devries, 2009; Felton & Devries, 2010; Llonch et al., 2020).

Activity time is related to feeding time; therefore, animals with reduced DMI have less time spent eating and, consequently, less activity time. Activity is determined by the time the animal is moving (Beauchemin, 2018). Thus, diets with low dry matter and reduced activity time may have provided more energy for milk production.

Conclusion

The variation in DM content of the TMR influences the feeding behavior and milk production of Holstein cows. Diets with low dry matter (< 45%) decrease intake, improve rumination, and increase milk production, making cows more efficient within the production system. However, this practice should be adopted cautiously, and diet quality should be carefully monitored.

Data availability

The data can be found in the body of the article.

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