American Journal of Animal and Veterinary Sciences

Research Articles

Do Cows Under Subacute Ruminal Acidosis (SARA) Attempt to Self-Medicate?

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Article history
Received: 18-05-2015
Revised: 10-08-2015
Accepted: 22-08-2015

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Abstract: The objective of this study was to examine feed-sorting behavior of dairy cows in response to a grain challenge that leads to Subacute Ruminal Acidosis (SARA). Sixteen multiparous, rumen-cannulated lactating Holstein cows were used. During the first 49 days of the experiment, all cows received a High-Forage diet (HF; 77:23, F: C; NFC=35). Cows were then transitioned to a High-Grain (HG; 50:50, F: C; NFC=48) diet on days 50 and 51 and remained on the HG until day 72. Feed intake was recorded daily. Particle size distribution of feed and orts were analyzed using the Penn State Particle Separator (PSPS) on days 36 (HF) and 71 (HG). The extent of feed-sorting was evaluated by calculating sorting indices for each PSPS dietary fraction for each given diet. A sorting index of a given fraction of the PSPS was calculated as the actual DMI expressed as a percentage of the predicted DMI of that fraction. Ruminal pH was recorded continuously every minute using an indwelling system on days 36 (HF), 50, 51 (onset of SARA) and day 71 (chronic SARA). Data were analyzed using Proc Mixed of SAS with day as a fixed effect and accounting for repeated measurement. Orthogonal contrasts were utilized to compare days. Ruminal pH on day 36 (16±46 min/d <5.6) indicated healthy rumen conditions. Ruminal pH recorded on days 51 and 71 (551±46 min/d <5.6 and 246±46 min/d <5.6, respectively) indicated an established SARA. Sorting assessment on day 36 showed that cows while on HF diet sorted against large particles (>19 mm, $p<0.05$) and concurrently sorted for the short and fine particles (<8 mm, $p<0.05$). Under SARA (HG), the cows showed an altered preference by sorting for ($p<0.05$) long particles and against ($p<0.05$) the short and fine particles. The results suggested that cows undergoing SARA may alter their feed-sorting behavior, likely in an attempt to self-medicate their condition, by selecting long particles and avoiding short and fine particles.

Keywords: Subacute Ruminal Acidosis, Feed-Sorting Behaviour, Self-medicate, Holstein Cow

Introduction

Feeding nutrient dense diets in response to increasing milk yields in dairy cows can result in a buildup of organic acids in the rumen and reduced rumen buffering which can cause a depression in ruminal pH (Plaizier *et al*., 2008). When ruminal pH is depressed between 5.2 and 5.6 for prolonged periods each day, with pH recovery, Subacute Ruminal Acidosis (SARA) occurs (Plaizier *et al*., 2008). After the initial bout of SARA, animals become increasingly more susceptible and recovery becomes prolonged (Beauchemin and Penner, 2009). Subacute Ruminal Acidosis is a nutritional disorder in dairy cattle that has significant economic impact on the industry.

The incorporation of Total Mixed Rations (TMR) in dairy cow diets aims to provide feed as a homogenous mixture for a balanced diet. However, dairy cattle will sort their feed and selectively consume the more palatable components of the TMR, resulting in an imbalanced diet (DeVries *et al*., 2008). When cows select for short particles they reduce their amount of

Physically Effective Fiber (peNDF). The result is an increase in Volatile Fatty Acid (VFA) production and reduced rumen buffering. Adequate particle size in the diets of dairy cows helps prevent the occurrence of SARA and promotes healthy rumen function because long dietary particles stimulate chewing and saliva production, which help maintain rumen buffering capacity (Yang *et al*., 2009).

Previous research has shown that healthy cows will sort their TMR against the longest particle size for the higher starch, more palatable fractions, thus increasing their risk of inducing SARA (DeVries *et al*., 2008). Sorting behavior seems to become altered in accordance to depressed rumen pH when cows are exposed to an acidosis challenge (Keunen *et al*., 2002; DeVries *et al*., 2008). The study done by Keunen *et al*. (2002) showed that when given a choice between alfalfa hay and alfalfa pellets, cows will choose the alfalfa hay more strongly when in a state of SARA. DeVries *et al*. (2008) showed that cows reduced their preference for short and fine particles (<8.00 mm) during the first two days after the grain challenge. However the study by DeVries *et al*. (2008) did not induce acidosis. Animals in that study had transient ruminal pH depression and recovered from it within a few days.

We hypothesize that when cows are induced into a state of SARA, they will alter their feed sorting behavior by selecting for large feed particles with high rumen buffering capacity, likely in an attempt to self-medicate their condition. The objective of this study was to examine feed-sorting behavior of dairy cows in response to a grain challenge that leads to SARA.

Materials and Methods

Animals, Housing and Diets

Sixteen multiparous rumen-cannulated lactating Holstein cows were housed in a tie-stall facility at Ponsonby Dairy Research Centre, University of Guelph, Guelph, Ontario. The experiment was approved by the University of Guelph Animal Care Committee and all animals were managed according to guidelines set by the CCAC (1993).

Cows were milked twice daily at 05:00 and 15:00 h. Feed intake and milk yield were monitored daily throughout the experiment. Feed was offered as a TMR at 07:00 and 13:00 h daily. Cows were exposed to two different dietary treatments, a high forage: concentrate (F: C) diet and a low F:C diet. During the first 49 days of the experiment, all cows received a High-Forage diet (HF; NFC=35%, F: C; 77:23). On days 50 and 51 cows were transitioned over to a High-Grain diet (HG; NFC=48%, F: C; 50:50). The cows were transitioned by feeding 50% HF and 50% HG on day 50. On day 51 the cows were exposed to the full HG diet and remained on this diet until day 72.

Table 1. Mean ingredient composition of experimental High-Forage (HF) or High-Grain (HG) TMR

	Diet	
Item	HF	HG
Ingredients, % of DM		
Corn silage	16.0	22.0
Alfalfa silage	16.0	22.0
Straw	3.6	4.9
High-moisture corn	11.7	16.0
Protein supplement[1]	11.0	15.1
Hay	41.7	0.0
Grain pellets[2]	0.0	20.0
Chemical composition, % of DM (unless otherwise noted)		
DM, %	59.0	48.2
CP (N x 6.25)	14.3	16.4
Soluble Protein	6.4	5.3
ADIN	1.7	1.2
ADF	32.5	18.4
NDF	44.9	28.2
NFC[3]	31.5	45.2
Starch[4]	16.6	26.2
Ether extract	2.3	3.4
Ash	7.0	6.9
NE_L,[5] Mcal/kg	1.4	1.6

[1]Supplement contained (as-fed basis) 9% high-protein corn gluten meal, 30% soybean meal 48 (containing 48% CP), 7% Tri-Pro Gold (Tri-County Protein Corp., Winchester, ON, Canada), 14% canola meal, 10% beat pulp, 3% herring meal, 4% dry corn distillers grains, 12% mineral mix, 5% soybean hulls, 2% molasses and 3% tallow.
[2]Contained 2:1 wheat and barley.
[3]NFC = 100 − (NDF + CP + ether extract + ash).
[4]Analyzed according to Hall (2000).
[5]Estimated according to NRC (2001).

The amount of feed was adjusted based on the average DMI of the previous week to allow for approximately 5 kg/day of feed-refusals for evaluation of feed sorting. The ingredients and chemical composition of the HF and HG diet are shown in Table 1.

Feed Sorting Analysis

Feed and ort particle size was assessed on day 36 while cows were in a steady state on the HF diet and on day 71, where cows were in a steady state on the HG diet. Duplicate TMR samples were taken before feeding (7:00 h) on day 36 and 71. Twenty-four-hour feed refusals were collected individually from each cow the following morning. Feed particle size and sorting assessment was analyzed using a Penn State Particle Separator (PSPS), (model C24682N, Nasco, Fort Atkinson, WI) as described by Kononoff *et al*. (2003). The PSPS had 3 sieves and a solid bottom pan, allowing the diet to be separated into four fractions. Particles retained on the top, middle and bottom screens and in the pan were classified into either long (L, >19.0 mm), medium (M, 8.0 – 19.0 mm), short (S, 1.18 – 8.0 mm), or fine (F, <1.18 mm), respectively.

Materials remaining on each sieve and in the pan were removed, weighed and oven dried at 100°C for 48 h to determine the distribution of feed particles (% of DM) retained on each sieve and in the pan. The extent of feed-sorting was evaluated by calculating sorting indices for each PSPS dietary fraction for each given diet. A sorting index of a given fraction of the PSPS was calculated as the actual DMI expressed as a percentage of the predicted DMI of that fraction as described by Leonardi and Armentano (2003). Values >100% indicate preferential selection of the particular fraction (sorting for), values <100% indicate selective refusal (sorting against) and values equal to 100% indicate no sorting.

Ruminal pH Measurements

Ruminal pH was recorded continuously every minute using an indwelling system on days 36 (HF), 50, 51 (transition to HG) and day 71 (HG), using a pH recording system as described by AlZahal *et al*. (2007a). SARA was achieved based on the time below and is defined as a pH below 5.6, exceeding 3 h (AlZahal *et al*., 2007b).

Statistics

Data was analyzed using Proc Mixed of SAS with day as a fixed effect and accounting for repeated measurement. Orthogonal contrasts were used to compare days. Significance was declared at p-value <0.05.

Results

Ruminal pH

Results concerning ruminal pH are shown in Fig. 1. On day 36 (HF) cows had an average ruminal pH of 16±46 min/d <5.6. SARA was successfully induced on days 50 and 51 (transition to HG) with an average rumen pH of 347±46 min/d <5.6 and 551±46 min/d <5.6, respectively. Cows showed some adaptation to the HG diet by day 71 with the average pH being 246±46 min/d <5.6, indicating chronic SARA conditions.

Sorting Data

Results concerning sorting data analysis are shown in Fig. 2. There were significant differences in feed sorting index between the two dietary treatments for all four fractions (p<0.05). On day 36 (HF), the cows significantly sorted against the large particles (p<0.001) and significantly sorted for the short (p<0.001) and fine (p = 0.001) particles. There was no significant sorting of the medium particles on day 36 (p>0.05). On day 71 (HG), the cows significantly sorted for the large particles (P = 0.027) and significantly sorted against the short particles (p = 0.017). There was no significant sorting of the medium and fine particles on day 71 (p>0.05).

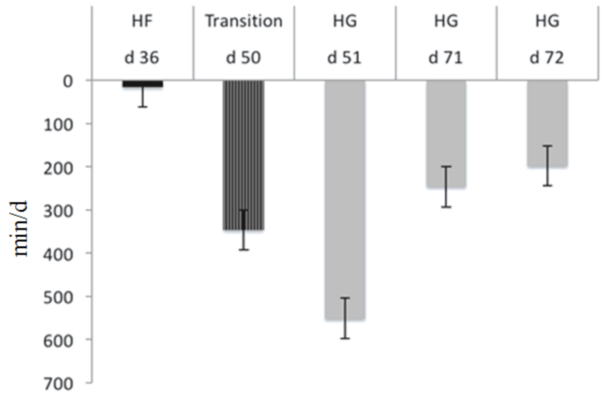

Fig. 1. Average 24 h ruminal time below pH 5.6 on 4 separate test days

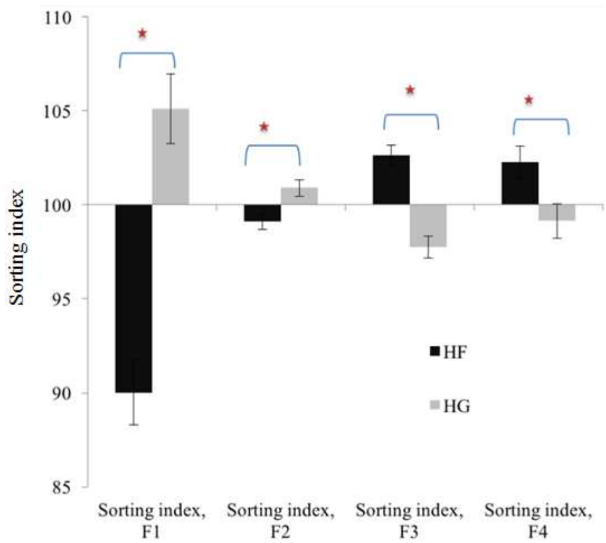

Fig. 2. Sorting index values of cows on HF or HG diet. Sorting index 1, 2, 3 and 4 represent large, medium, short and fine particles respectively

Discussion

Physically effective fiber refers to fiber in the diet that is effective in promoting chewing and rumen buffering (Zebeli *et al*., 2010). Saliva production is stimulated by peNDF, which serves as a buffer to neutralize acidic rumen conditions and plays a key role in maintaining rumen motility (Plaizier *et al*., 2008). Providing high-producing dairy cows with adequate amounts of physical fiber is critical in maintaining proper rumen functions, decreasing the risk of metabolic disorders and avoiding suppression of fiber digestion, feed intake and milk production (Zebeli *et al*., 2010). A study done by Pitt *et al*. (1996) showed that ruminal pH was improved by increasing peNDF, although an upper limit of 30% DM inclusion rate, creates a plateau at pH

6.2. In addition, Kmicikewycz and Heinrichs (2014) showed that supplementing long hay in addition to TMR aided the recovery of pH after SARA induction. The pH depression observed when cows were transitioned to the HG diet in this study was a result of the decrease in peNDF and increase in the fine particle fraction with its high concentration of starch, which was very rapidly and extensively degraded in the rumen. When high rates of fermentable carbohydrate are included in the diet, rate of passage increases, saliva production decreases and consequently ruminal pH will decrease (Zebeli *et al*., 2010). Ruminal pH is a critical factor in the normal and stable functioning of the rumen because of its profound effect on microbial populations, rumen fermentation products and on physiological functions of the rumen (Zebeli *et al*., 2010).

The current study suggests that cows will selectively choose to consume either more or less peNDF depending on their physiological state. Figure 2 demonstrates the variation in feed sorting index of particular fractions in the diet. These variations can be explained in part by differences in ruminal pH as seen in Fig. 1. Cows on the HF diet had a higher average rumen pH. The HF cows sorted for the short and fine fractions and sorted against the long particles. All of the cows in the study were induced into a state of SARA when they were transitioned over to the HG diet. Cows on the HG diet altered their feeding behavior and started sorting for the large particles and against the short particles, despite their high palatability. In addition DeVries *et al*. (2014), found a strong correlation between the duration of pH <5.5 and a greater change in sorting for long and medium particles in beef cattle while on a HG diet. Collectively, it is believed that when cows were transitioned to the HG diet they selectively chose large particles and sorted against short particles in an attempt to attenuate their low rumen pH conditions. These results are consistent with a study done by Maulfair *et al*. (2013) which showed a selection increase of 20.2% favoring long particle size during SARA. The previous study by Keunen *et al*. (2002) also agrees with findings by DeVries *et al*. (2008). Differences across studies regarding the preference of cows for or against a dietary fraction are expected taking into account diet type, feeding frequency (DeVries *et al*., 2005) and feeding amount (Leonardi and Armentano, 2007).

It is noteworthy that the HG diet did contain a higher fraction of smaller particles which may have had an effect on feed sorting. However, the calculation of sorting indexes was not based on the amount of fraction left but rather on the proportion of fraction left relative to the proportion in the feed. This is believed to minimize the bias introduced by using diets with different particle size distribution.

Conclusion

In conclusion, the results of our study were consistent with our hypothesis that when cows are induced into a state of SARA, they will alter their feed sorting behavior by selecting for large feed particles with high buffering capacity and avoid short and fine particles. Cows fed a high-forage diet with healthy rumen conditions will selectively sort against large particles and for the short and fine particles. Therefore, cows undergoing SARA alter their feed-sorting behavior, likely in an attempt to self-medicate their condition and attenuate the effects of a low rumen pH.

Acknowledgement

The authors would like to acknowledge funding from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), as well as the Natural Sciences and Engineering Council of Canada (NSERC).

Author's Contributions

Erin Hendriksen: Contributed to planning and excution of experiment, data analysis and writing of manuscript.

Ousama AlZahal: Contributed to planning and excution of experiment, statistical analysis and editing of manuscript.

Tom C. Wright and Alexandra M. McGinnis: Contributed to results interpretation and writing of the manuscript.

Brian W. McBride: The principal investigator of the study.

Ethics

This study was carried out with the approval of the Animal Care Committee at the University of Guelph, under the guidelines of the Canadian Council for Animal Care.

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