RUMEN BIOPSY IN RUMEN-CANNULATED DAIRY COWS

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ABSTRACT

The current contribution describes rumen biopsy as a method to evaluate rumen health and development of rumen papillae in dairy cows. Rumen biopsies were performed in 12 pregnant rumen-cannulated Holstein-Friesian cows in their first lactation in week -8, -6 and -2 before the expected date of calving and at day 3, 7, 14, 28 and 56 after calving. First, samples of rumen fluid were taken to measure pH and volatile fatty acid content. Then a full rumen evacuation was performed, rumen content was weighed and samples of rumen papillae were taken with a sharp biopsy forceps at four locations. Inspected locations were 1) in the dorsal rumen sac, right rumen wall, directly across the cannula opening (A); 2) in the atrium ruminis, front right rumen wall (B); 3) in the caudodorsal blind sac (C); and 4) in the caudoventral blind sac (D). Based on the dimension (length and width) of rumen papillae the rumen scores at each location were determined. The current contribution presents results based on one cow as an example. The average pH at week -8 to -2 relative to calving was 6.99 (±0.43). After calving (from day 3 to 56) the average pH decreased to 6.39 (±0.36). There was a tendency for increasing amount of fresh feed in the rumen from one week postpartum, whereas body weight of the cow decreased after calving. The average rumen score was highest in regions C and D. In contrast, rumen papillae density and dimensions were lowest in the region B.

Key words: rumen evacuation, papillae, pH

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INTRODUCTION

The period after calving has been generally described as the period with increased incidence of health disorders in dairy cows (Mulligan and Doherty, 2008). The energy density of a diet should be increased in early lactation to supply the mammary gland with glucose as lactose precursor. As earlier reviewed (Nocek, 1997; Owens et al., 1998), increasing the energy density of the lactation diet by addition of readily fermentable carbohydrates (Lawrence, 1988; Penner and Oba, 2009) increases lactate production in the rumen which may result in an increased incidence of both clinical (pH < 5.0) and subclinical (pH < 5.5) acidosis (Van Knegsel, 2007). Due to clinical or subclinical acidosis the rumen wall may become damaged and fermentation and absorption can be impaired. Moreover, there are some suggestions that rumen acidosis may be related to other health problems such as laminitis (Goff and Hors, 1997; Nocek, 1997). The type of diet, and the proportion of volatile fatty acids produced by fermentative digestion of rumen micro-organisms, are responsible for the development and the structure of ruminal mucosa, which determines the absorptive and metabolic capacity of the organ (Sakata T. and Tamate H., 1979; Sakata and Yajima T., 1984; Dirksen et al., 1985). The length, width and surface of papillae increased in early weaned calves (6 weeks) fed higher amounts of concentrate and hay compared with calves fed milk and late weaned (9 weeks) calves (Zitnan et al., 1999). Following weaning, the development of the ruminant forestomach has been shown to be affected by the three most abundant volatile fatty acids, in the order: butyrate > propionate > acetate (Sakata and Yajima T., 1984). The absorptive capacity of the ruminal mucosa however, is influenced not only by its structure, but also by the respective pH of rumen content. At low pH value, acetate, propionate and butyrate are absorbed more rapidly than at a high pH (Masson and Phillipson, 1951). Usage of rumen-cannulated cows enables relatively easy collection of rumen fluid samples and rumen papillae samples. The main aim of the current contribution is to describe the rumen biopsy technique as a suitable method to evaluate rumen health and development of rumen papillae in dairy cows.

MATERIAL AND METHODS

Experimental design, animals and diets

All experimental protocols and interventions were approved by the Ethical Committee on Animal Experiments of the Animal Sciences Group of Wageningen UR.

In this trial, 12 pregnant rumen-cannulated Holstein-Friesian cows in their first lactation were used. The cows were housed in a cubicle barn at experimental farm “De Waiboerhoeve” in Lelystad, The Netherlands. Roughage was fed *ad libitum* in feeding troughs with automatic individual feed intake registration. All cows received 1 kg of concentrate per day starting 10 days before expected calving through individual concentrate dispensers. After calving, the amount of concentrate was raised from 1 to 8.5 kg per day at day 17 postpartum. Above this amount, 1 kg of concentrate per day was supplied in the milking parlour for lactating cows. The cows were milked twice a day (milking interval 11 to 13 hours). All cows were weighed two times per day, before each milking.

Rumen biopsy

The rumen was inspected 8 times during the trial: in week -8, -6 and -2 before the expected day of calving and at day 3, 7, 14, 28 and 56 after calving. Each time, the rumen cannula was opened to collect rumen fluid between 0800h and 0900h for determination of pH and volatile fatty acid content. After that, the rumen was evacuated through the cannula and rumen content was weighed. The rumen wall was inspected at four locations. Inspected locations were 1) in the dorsal rumen sac, right rumen wall, directly across the cannula opening (A); 2) in the atrium ruminis, front right rumen wall (B); 3) in the caudodorsal blind sac (C); and 4) in the caudoventral blind sac (D). At each location, rumen papillae development was scored on a scale from 1 to 4:

- 1: flat wall, no clear papillae
- 2: short thickenings or papillae
- 3: thin papillae (<2mm wide)
- 4: broad papillae (>2mm wide)

The amount of papillae per cm^2 was counted to determine papillae density and about four biopsy samples of rumen papillae were collected with a sharp biopsy forceps at each location. Papillae were cut at the base to be able to determine full papillae dimensions. Papillae were measured and stored in formalin until histological examination.

RESULTS AND DISCUSSION

The rumen biopsy trial has been a part of large-scale experiment (entitled “Why Dry?”) which is still running and therefore only data collected from one particular cow as an example are presented in this paper. The weight of rumen content and live body weight changes are recorded in Table 1. There was a tendency for increasing amount of fresh feed in the rumen, whereas body weight of the cow decreased after calving. These results are in accordance with previous observations which reported depressed dry matter intake around calving, loss of body weight and a negative energy balance in early lactation cows (Bertics et al., 1992; Drackley, 1999; Hayirli et al., 2002).

Tab. 1 The rumen content and live body weight from week -8 to 4 relative to calving

Week	-8	-6	-2	0.5	1	2	4
Rumen content (kg)	57	60	65	65	74	72	80
Live weight (kg)	615	654	686	630	635	619	621
Rumen content: LW	0.09	0.09	0.09	0.10	0.12	0.12	0.13

Table 2 shows changes in rumen pH in week -8, -6 and -2 before the expected day of calving and at day 3, 7, 14, 28 and 56 after calving. The average pH at week -8 to -2 relative to calving was 6.99 (± 0.43). The pH after calving (from day 3 to 56 postpartum) decreased to an average of 6.39 (± 0.36). The additional concentrate was supplied to the cows starting 10 days before calving which could be the reason of the decrease in rumen pH in the period around calving (Steele et al., 2011).

Tab. 2 Rumen pH from week -8 to 8 relative to calving

Period	Pre-calving					Post-calving						
Week	-8	-6	-2	-8 to -2	ST DEV	0.5	1	2	4	8	0.5 to 8	ST DEV
pH	7.25	6.67	7.05	6.99	0.43	6.25	6.24	6.83	6.53	6.11	6.39	0.36

Rumen papillae density and rumen score were assessed at four regions, marked as A, B, C, D. Results are recorded in table 3. Rumen papillae density and their development (length and width) on the scale from 1 to 4 was highest in regions C and D, where the rumen score averaged 3.3 (±0.46) and 3.4 (±0.52), respectively. The lowest rumen score was in the region B, where it averaged 2.0 (±0.53) during the week -8 to 8 relative to calving.

Tab. 3 Rumen score from week -8 to 8 relative to calving

Location	Week relative to calving									
	-8	-6	-2	0.5	1	2	4	8	-8 to 8	STDEV
A	3	3	3	3	3	3	3	4	3.1	0.35
B	1	2	3	2	2	2	2	2	2.0	0.53
C	4	3	3	3	3	3	3	4	3.3	0.46
D	4	3	3	3	3	3	4	4	3.4	0.52

CONCLUSION

The results of current contribution are based on one cow as an example and therefore they are not statistically conclusive. The amount of fresh feed in the rumen increased after calving, whereas live weight of the cow decreased in the same period. Average pH value of rumen fluid decreased around calving, coinciding with the addition of concentrates in the diet. The rumen score determined by rumen biopsy was highest in the regions C and D and lowest in the region B.

The rumen biopsy technique is a suitable and efficient method to evaluate rumen health and rumen wall development in rumen-cannulated dairy cows.

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