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Short communication

Close relationship between pre- and post-calving reticuloruminal pH levels in dairy cows

A. Steinwidder [a,*], M. Horn [b], R. Pfister [a], H. Rohrer [a], J. Gasteiner [c]

[a] Agricultural Research and Education Centre Raumberg-Gumpenstein, Institute of Organic Farming and Farm Animal Biodiversity, Trautenfels 15, A-8951 Stainach-Pürgg, Austria
[b] BOKU-University of Natural Resources and Life Sciences Vienna, Division of Livestock Sciences, Gregor-Mendel-Straße 33, A-1180 Vienna, Austria
[c] Agricultural Research and Education Centre Raumberg-Gumpenstein, Institute of Farm Animal Welfare and Animal Health, Altirdning 11, A-8952 Irdning-Donnersbachtal, Austria

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ABSTRACT

The aim of the present study was to investigate the effects of prepartum reticuloruminal pH values on postpartum pH values of lactating cows at two concentrate supplementation levels. An indwelling pH measurement system with a wireless data transmitting unit was given to 9 heifers and 11 cows orally 2 weeks before expected calving. The pH was measured from week 2 prepartum to week 6 postpartum. Prepartum, all animals were fed hay and grass silage only. After parturition the animals were assigned to one of two concentrate supplementation levels (Con and Low). During the first 6 weeks postpartum, 5.6 kg and 2.9 kg dry matter per day of concentrates were fed to cows in groups Con and Low, respectively. Before parturition, no effect of the week on the mean pH was found, but pH values varied considerably between individual animals. During the last week prior parturition, the median, lower and upper quartile values of the mean pH values were 6.47, 6.41 and 6.59 for heifers and 6.29, 6.19 and 6.39 for cows, respectively. Standard deviations of the mean pH values for heifers and cows were 0.15 and 0.12, respectively. After parturition, no diet effect on the mean pH and maximum pH values was found. The minimum pH differed between Con and Low, but the absolute levels were almost equal (6.02 and 6.04, resp.). A strong correlation ($r > 0.8$; $P < 0.01$) between the mean pH value before parturition (pH_{week-1}) and pH values after parturition was found. Animals having lower pH levels before parturition continued to have lower mean pH and minimum pH values during weeks 1 to 6 postpartum. Furthermore, these animals had stronger short term fluctuations of H_3O^+ concentrations and a longer time span with pH values below 6.2. The results support the theory of the existence of cow-specific baselines concerning rumen pH, pointing to individual differences in the rumen environment, fermentation and metabolism and emphasising the importance of further research on this topic.

1. Introduction

Because pH values in the rumen influence ruminant health and microbial growth, continuous pH measurements represent a valuable tool to assess feeding strategies (Phillips et al., 2010; Gasteiner et al., 2011). It is long-established that ruminal bacterial communities respond to

* Corresponding author. Tel.: +43 368222451400; fax: +43 368222451410.
E-mail address: andreas.steinwidder@raumberg-gumpenstein.at (A. Steinwidder).

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changes in diet and environmental conditions. The peri-parturient period is known as being the most critical phase for dairy cows, as it includes the transition from gestation to lactation as well as the change from dry-period diet to the early-lactation cow diet. This is also reflected in ruminal physiology as the risk of acute ruminal acidosis and subacute ruminal acidosis (SARA) is highest in the first weeks after calving (Kleen et al., 2003; Fairfield et al., 2007). However, there is evidence of individual variability concerning: (1) microbial community composition; (2) regulatory mechanisms to sustain or recover physiological pH levels; (3) volatile fatty acid concentrations and (4) risk of SARA (Weimer et al., 2010; Mohammed et al., 2012; Gao and Oba, 2014). Palmonari et al. (2010) reported remarkable differences in the mean pH and pH range between lactating cows fed the same ration and having a similar ruminal bacterial community composition. This variability was reported to be highest after parturition and during phases of adaption to dietary changes (Bevans et al., 2005; Penner et al., 2007).

The objective of the present study was to prove the increasingly discussed theory of the existence of cow-specific pH-baselines and individual cattle variability related to sustaining balanced pH levels during the transition period. The central hypotheses of the present study were: (1) that reticuloruminal pH variability in dairy cattle can also be found at the end of a uniform forage-based prepartum feeding period; and (2) that prepartum pH-levels affect pH profiles after parturition. To test these hypotheses, reticuloruminal pH profiles were continuously monitored with an indwelling wireless data transmitting system starting two weeks before the predicted date of calving (week −2) until the end of week 6 of lactation.

2. Animals, materials and methods

The data of the present study were collected in the second year of a two-year feeding trial designed to investigate the response of two different dairy cow types to a reduction of early lactation concentrate supplementation in an organic low-input milk production system (Horn et al., 2014). All of the experimental procedures were performed in accordance with the Austrian Experimental Animal Protection Law (Tierversuchsgesetz BGBl 501/1989). Between November 2012 and March 2013, the reticuloruminal pH of 20 dairy cows (12 Holstein Friesian and 8 Brown Swiss cows; thereof 9 heifers before parturition) was continuously measured. During the experimental period all animals were housed in a cubicle loose house system. Starting 50 days before the expected calving date until week 6 of lactation, all animals were fed 40 kg dry matter (DM) of hay (permanent grassland 2nd cut) and had free access to grass silage (permanent grassland 1st cut). The main species in the permanent grassland were *Lolium perenne, Trisetum flavescens, Dactylis glomerata* and *Trifolium repens.* Until parturition, no concentrate was fed. After parturition the experiment included two dietary treatments, which differed in concentrate supplementation—one group (Low) received a concentrate supplementation that was 50% lower than the supplementation level supplied to the control group (Con). The concentrate amount in Con was adapted to the common concentrate supplementation rate of organic dairy farms in Austria (Horn et al., 2012). The concentrate supplementation was increased from 2 to 7.5 kg DM and from 1 to 3.7 kg DM during the first 21 days in milk for Con and Low, respectively. Between 22 and 35 days in milk, the concentrate supplementation was maintained at 7.5 and 3.7 kg DM for Con and Low, respectively. From day 36 onwards, the concentrate supply depended on the milk yield. Cows yielding less than 16 kg/d did not receive any concentrate. Supplementation increased for every additional kg of milk yield by 0.5 and 0.25 kg DM but was limited to a maximum of 7.5 and 3.7 kg DM cow^{-1} for Con and Low, respectively. The concentrate consisted of 52% barley, 20% maize, 5% oat and 23% pea. Additionally, cows received 40 g of mineral supplementation (12% Ca, 8% P, 8% Na, 3% Mg, vitamins and trace elements) and had free access to salt and mineral lick. During the experimental period, individual rations were calculated twice weekly. Within each breed, the cows were assigned to a dietary treatment according to genetic merit, parity, body weight (BW) and body condition score (BCS). For the nine heifers, the age at first calving was also taken into account. In average, cows were in 2.6 ± 1.43 and 2.4 ± 1.36 lactation, weighed 601 ± 96.0 and 609 ± 32.4 kg and had a BCS of 2.9 ± 0.31 and 3.0 ± 0.38 in the diet groups Con and Low, respectively. Forage ration components were provided separately twice daily after milking via Calan gates, while the concentrate was fed individually using a concentrate transponder with a maximum amount of 1.5 kg per visit.

Milk yield was recorded daily throughout the first six weeks of lactation. Milk samples for determination of milk fat and protein were taken three times per week. Starting two weeks before the predicted date of calving (week −2) until the end of the measuring period (week +6) individual forage intake was measured on five consecutive days a week, while individual concentrate intake was recorded daily. Feeds offered and feed refusals were weighed on five consecutive days a week at each meal and analysed for DM (drying at 105 °C for 24 h). The feed samples were pooled over 4 weeks and subjected to oven drying for DM determination, proximate analysis (CP, ether extract, crude fibre, ash) according to the guidelines of the Association of German Agricultural Analytic and Research Institutes (VDLUFA, 2007) and analysis of cell wall contents, neutral-detergent fibre (NDF) and acid-detergent fibre (ADF) (Van Soest et al., 1991; VDLUFA, 2007) using a Foss Fibertec System. The average nutrient and energy content of feedstuffs are presented online in Table S1. For continuous measurement of the reticuloruminal pH value, an indwelling wireless data transmitting system (SmaXtec Animal Care, Austria) was used (Gasteiner et al., 2009; DLG, 2010). The pH measurement interval was set to 10 min; a detailed technical description can be found in Gasteiner et al. (2015).

For statistical analysis, daily milk yield, feed intake data and reticuloruminal pH data were pooled into weekly means. Additionally, daily minima and maxima of the reticuloruminal pH values were pooled into weekly means and are denoted as “minimum pH” and “maximum pH”,