LONG-TERM CONTINUOUS MONITORING OF RUMINAL PH AND TEMPERATURE FOR DAIRY COWS WITH INDWELLING AND WIRELESS DATA TRANSMITTING UNIT

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Abstract. The ruminal pH and the temperature are important parameters to estimate the nutritional and metabolic status of dairy cows. The aim of this study was to evaluate the diurnal variation of the ruminal pH and temperature by using special boluses, antennae, a wireless data transmitting system an analogue to digital convertor and a memory chip produced by *SmaXtec Animal Care technology®, GmbH,* Graz, Austria. The research was performed over 80 days' period in the spring-summer season, in a dairy farm with 600 cows. The specific boluses were given to 4 cows orally. Measurements were acquired diurnally every 600 sec. Over the study period, the average ruminal pH varied from 5.32 to 7.14, while the rumen temperature varied from 24.28 to 42.30 ºC. The level of ruminal pH weakly correlated with the rumen temperature ($r = 0.12$). A low rumen pH can cause metabolic acidosis, lameness, formation of hepatic abscesses, pneumonia, other diseases and even death. Further research needs to address the issue of how accurately it is possible to predict the mean ruminal pH for other cows in a herd with similar feeding.

Keywords: dairy cows, bolus, wireless, rumen pH and temperature.

Introduction

Over the last ten years, the productivity of dairy cows has increased considerably necessitating the inclusion of high energy and protein feed materials in the feed ration. The most critical periods when cows exposed to inferior feeding are subjected to metabolic diseases are early lactation (19 %) and mid lactation (26 % of cases) [1-3]. Over the first 100 days in lactation, cows have higher productivity and more intensive metabolism [4], when animals are subjected to the highest risk for contracting metabolic diseases [5]. Subclinical rumen acidosis (SARA) is a metabolic disease characterized by abnormally low rumen pH resulting in decreased production, changes in milk components and depleted reproductive performance [3; 6]. The main cause of SARA is a high level of concentrated feed in the feed ration resulting in high production of lactic acid by lactic bacteria. Physiologically, the rumen pH should stay within the limits 6.4 to 7.0 [7], other authors, however, maintain the rumen pH 6.0 to 6.4 as an optimum [8]. Diagnosing of SARA within the herd is largely cumbersome due to the subclinical characteristics of this process. There are several methods of testing the rumen pH: testing of samples acquired by rumen puncture or the ruminal probe method, the rumen cannula method (fistulated cows) and the indwelling pH data accumulation method. Development of a non-invasive SARA diagnostic method, as little traumatic for cows as possible is a very important issue. A wireless data transmitting unit has been developed and introduced for the research purposes allowing for a continuous retrieval of data at small intervals without disturbing the normal daily routine of cows [9].

The objective of the study was testing the application of *SmaXtec Animal Care* equipment for monitoring of the rumen pH and temperature.

Materials and Methods

The research study lasted from May 15 to August 3 of 2012, in a dairy farm with 600 cows. The data were obtained from 2 multiparous and 2 first lactation Holstein dairy cows. All the test animals were kept in the same feeding group in individual stalls, on concrete floors covered with rubber mats and bedded with wood shavings. They had ad libitum access to drinking water. The cows were fed with total mixed ration (TMR). TMR was made available ad libitum, twice a day at 8.00 and 14.30 additionally providing for the pushing- up of feed several times a day. The Specific *SmaXtec* boluses were given orally for measuring of the ruminal pH and temperature. The dimensions of each bolus were 120 mm in length and 36 mm in diameter, their weight was 210 g. The shatterproof plastic casing of the measuring unit was made of the rumen acid-resistant plastic. The ruminal pH and temperature of all the cows was measured every 600 sec., or every 10 minutes over a 80 d period. In the period from 23. to 24.05. the rumen pH was tested for the cow No. 3555 and in 04.05., both, rumen pH and temperature for the cow No. 4525. The mean lifetime of the internal battery was 3 months. The data were measured with the help of a specific Mobile Reader device placed in the milking parlour, and readings were carried out three times per day during milking. Depending upon the volume of the data saved by the Bolus, the data are read through by the Mobile Reader in approximately 30 minutes. The process of reading is signalled by a blinking light on the Mobile Reader. To enable the reading of the results, cows must be placed within approximately 5-10 m radius from the Mobile Reader.

For monitoring of the ruminal pH and temperature, an indwelling and wireless data transmitting system (*SmaXtec Animal Care GmbH*, Graz, Austria) was used. The data on pH and temperature were collected by means of an analogue to digital converter and stored in an external memory chip. The milk yield and quality was registered three times per day at 3.00 a.m., 11.00 a.m. and 17.00, with *Afmilk*, the Automated Data Recording and Management System. The daily milk yield was calculated as the sum of three milkings and all data were recorded once a week for eleven weeks in succession.

The study made use of 4 different age dairy cows in early lactation phase, from 10 to 34 days in lactation, with the average milk yield of 32.6 kg, the fat content 3.86 % and the protein content 3.53 %. At the start of the study, the milk yield for the test cows varied from 28.6 to 36.8 kg per day, the fat content from 3.69 to 3.99 % and the protein content from 3.44 to 3.66 %.

The Arithmetic Mean and the Standard Error were the indicators of descriptive statistics applied for the analysis of the obtained data. The Single Factor Analysis of Variance was applied to establish the factors affecting the research results. The Pearson correlation coefficient was used for profiling the interrelations among the results obtained in the study.

Results and Discussion

The productivity and milk component indicators were measured for all the cows across the study period (Table 1). Across the animals included in the study, the milk yield was essentially different ($p < 0.05$). The second lactation cow No. 4525 had essentially the highest milk yield at the start of the lactation 44.2 ± 0.42 kg ($p < 0.05$) on the average. Her mean rumen pH was 6.24 ± 0.001, varying within the limits of 5.48 to 6.96, while the mean rumen temperature was 39.1 ± 0.03 ºC, varying between 26.63 and 42.30 ºC. This cow, in contrast to others, had statistically significant lower milk fat content 3.17 ± 0.270 %, while its mean milk protein content (3.27 ± 0.022 %) was statistically significantly lower than for the cow No. 4829 and significantly higher than for the cow No. 3555 ($p < 0.05$).

Table 1

Mean productivity indicators of the lactating cows over the study period

Parameters	Cow number			
	3555	4525	4829	4951
Parity	4	2	1	1
Days in lactation	50 ± 2.6^{a}	54 ± 2.6^{a}	71 ± 2.6^{b}	74 ± 2.6^{b}
Productivity, kg	28.9 ± 0.28^{a}	44.2 ± 0.42^{b}	34.4 ± 0.40^{dc}	31.8 ± 0.42^{dc}
Milk fat, %	3.39 ± 0.038^{a}	3.17 ± 0.270^{b}	3.28 ± 0.026^{c}	3.44 ± 0.025^{a}
Milk protein, %	3.12 ± 0.022^{a}	3.27 ± 0.022^{b}	3.34 ± 0.015^{c}	3.29 ± 0.020^{db}

^{a,b,c,d} – productivity indicators across the tested cows are significantly different; $p < 0.05$

One of the parameters indicative of the metabolic performance of a cow is the milk fat/protein ratio (F/P). The recommended ratio is 1.1-1.5 [10]. The F/P ratio below 1.0 signals the presence of acidosis symptoms in the body system of the cow [11]. In comparison to other animals involved in the study, for the cows No. 4525 and No. 4929 the F/P ratio was significantly lower, 0.97 and 0.98 accordingly, pointing to the potential risk of acidosis ($p < 0.05$). The mean rumen pH for the cow No. 4525 did not indicate the symptoms of acidosis despite the fact that for a short time its lowest rumen pH value was 5.48. During the study, it was established that healthy cows with an optimum rumen pH level could have a low F/P ratio. To measure the acidosis risk, the length of time in 24 hours during which the rumen microflora has stayed below the critical pH 5.8 level should be determined.

The ruminal pH measures of 4 dairy cows established over the study period are presented in Fig. 1. The mean rumen pH over the research period was 6.26 ± 0.002, varying between 5.32 and 7.14. The difference of mean rumen pH indicators across the cows involved in the study was statistically significant ($p < 0.05$). Mottram et al. [12] have pointed out in their findings that in many highproducing herds in the United Kingdom, the average rumen pH was retained within the limits of 6.2-6.8, which is indicative of a low acidosis risk.

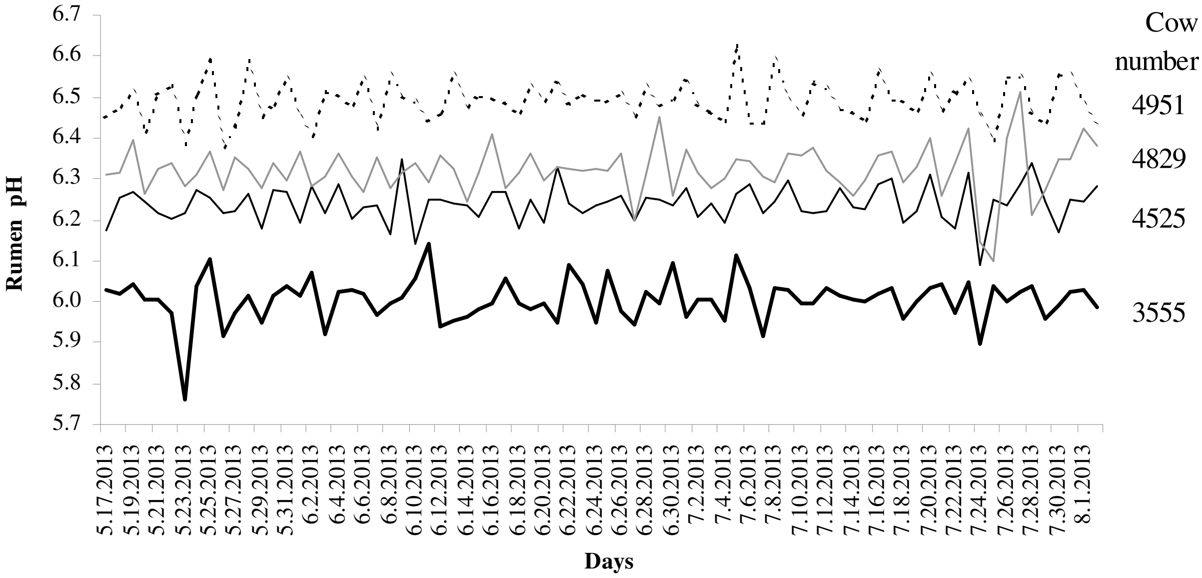

Fig. 1. **Rumen pH measurements for dairy cows over the study period**

The lowest mean rumen pH level (6.00 ± 0.002) was established for the fourth lactation cow No. 3555. It varied from 5.32 to 7.07. Different research findings report that older lactation cows ingest a larger amount of forage than first lactation cows, consequently the primiparous cows have lower risk of contracting acidosis than older cows [13; 14]. The cows No. 4829 and No. 4951 were primiparous cows with the mean rumen pH 6.32 ± 0.003 and 6.49 ± 0.002 accordingly, thus higher than the same indicator for the older cows No. 3555 (parity 4) and No. 4525 (parity 2). The acidosis risk is not identical for all cows, it depends on individual characteristics of each cow's body system, for instance, the amount of the feed ingested, the speed with which it is ingested, sorting of the feed, the components and amount of the rumen microflora population, physiological status of the cow, its behaviour and other factors [15].

Gasteiner et al. [9] have come to a conclusion that the optimum rumen pH level should stay between 6.14 and 6.49 and noted that SARA risk arises when the rumen pH value sinks below 5.8, moreover, not right away but only when it stays that low for a longer time – over five hours. [14]. As the result of the present study, accordant with findings of other scientists, we have concluded that cows kept in identical conditions can nevertheless have essentially distinct individual rumen pH values [16].

To keep the potential problems at bay, it is important to detect the rumen pH fluctuations at shorter time periods. In Fig. 2, the rumen pH fluctuations over the 2 day interval of the cow No. 3555 are shown. On day 2, the mean rumen pH was 5.9 ± 0.30, fluctuating from 5.32 to 6.45. On this day, for more than 10.5 h the rumen pH stayed below 5.8 bringing the body of the animal to F/P ratio 1.01 and thus posing a serious SARA risk.

It is possible to establish the number of meals the particular cow has had by the value of rumen pH. By determining the rumen pH it is possible to monitor that the particular cow ingests feed more than 10 times per day.

Over the research period, the mean rumen temperature, taken for all cows, was 39.05 ± 0.038 ºC, and it varied from 24.28 to 42.30 ºC (Fig. 3).

The cows No. 4525 and No. 4829 had significantly higher rumen temperature, 39.1± 0.06 ºC on the average, while the cows No. 3555 and No. 4951 had 39.0 ± 0.02 ºC ($p < 0.05$) on the average. The rumen temperature is materially influenced by the drinking behaviour of the cow and from instances when the temperature falls below 35 ºC it is easy to detect how many times per day the cow has been drinking water [12].

The amount of water ingested at drinking and its temperature also lay an impact on the rumen temperature. Ruminants take 20 min to 2 hours to regain the initial rumen temperature they had before the episode of drinking [9; 17]. Scientists have found the correlation between low rumen pH and elevated rumen temperature for SARA affected cows, namely, at rumen temperature 39 to 41 ºC, the rumen pH stayed within the range of 5.0 to 5.6 (r = 0.77) [8]. In our study, all the cows were healthy and the above correlation was not found despite that for some periods the rumen pH for some cows was below the optimum level. Over the study period, the rumen temperature of cows showed a weak correlation with rumen pH (r = 0.12). This correlation was different from cow to cow. For the cow No. 3555 (r = 0.16), cow No. 4525 (r = 0.20), cow No. 4829 showed practically no correlation, its value was negative (r = – 0.02) and the cow No. 4951 (r = 0.22).

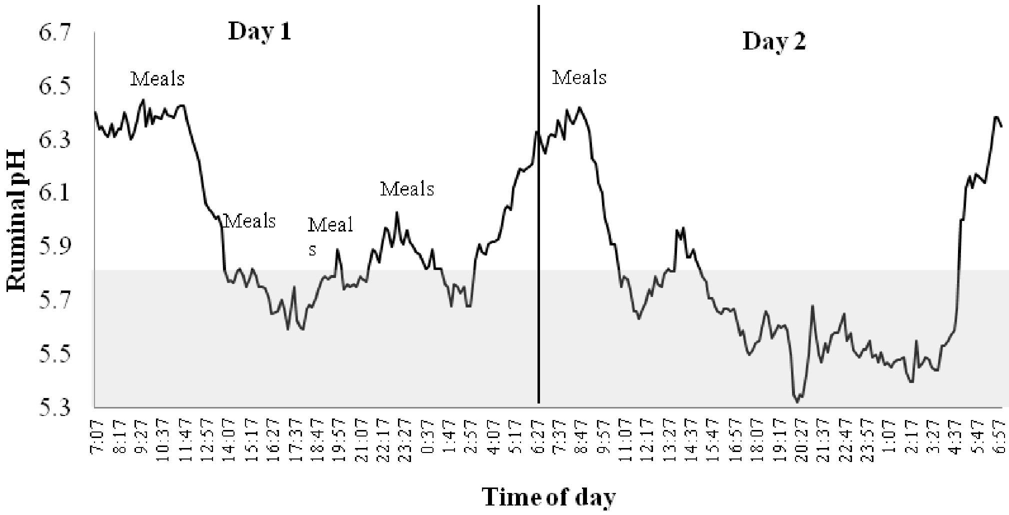

Fig. 2. **Rumen pH and the number of meals over the period of 2 days for the cow No. 3555**

In the research study, it was established that the time of feed ingestion did not impact the rumen temperature; similar observations were conveyed also by other scientists [9].

Within the time period from June 2 to June 6, all the cows had higher rumen temperature than within the rest of the research period. Fig. 3 reflects the analysis of the cow productivity and milk component indicators before this period. The mean rumen temperature from June 2 to June 6 was 39.39 ± 0.018 ºC, which is significantly higher than the week before or the week after this period. The rumen pH at this time however had no essential variations and it stayed at 6.24.

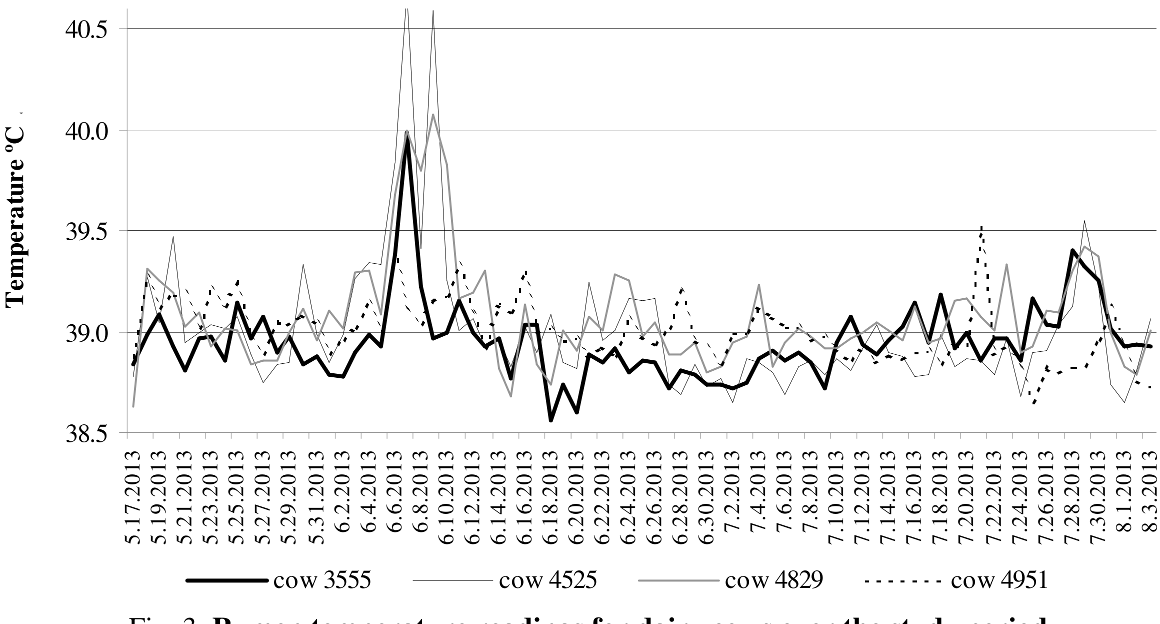

Fig. 3. **Rumen temperature readings for dairy cows over the study period**

Neither the milk yield nor the fat content essentially varied over this period. The protein content however was significantly varied: peaking a week before the rise of temperature it decreased with every coming week ($p < 0.05$). The F/P ratio gardually increased with each week indicating normalisation of the F/P ratio. Under the influence of the rumen temperature, the protein content in milk decreased, the same trend continued also at later period.

Table 2

Productivity and milk component indicators for cows involved in the study from 26.05 to 17.06

Indicators	26.05-01.06.	02.06-10.06.	11.06-17.06.
Milk yield, kg	36.8 ± 1.30	37.1 ± 1.11	36.2 ± 1.41
Fat content %	3.25 ± 0.035	3.25 ± 0.039	3.27 ± 0.030
Protein content %	3.48 ± 0.038[a]	3.21 ± 0.230[b]	3.05 ± 0.016[c]
F/P ratio	0.94 ± 0.010[a]	1.01 ± 0.016[b]	1.07 ± 0.008[c]
Rumen pH	6.26 ± 0.003	6.26 ± 0.003	6.26 ± 0.004
Rumen temperature ºC	39.00 ± 0.020[a]	39.39 ± 0.018[b]	39.09 ± 0.018[c]

[a,b,c] – productivity indicators across cows are significantly different; $p < 0.05$

In research literature it is emphasized that animals need approximately one week to get adjusted to each different feed material [18]. The milk protein fluctuations indicate that some feed material got replaced by a different one over the study period possibly resulting in the rise of the rumen temperature.

Within the study it was observed that the rumen temperture of cows decreases after drinking of water, Fig. 4. The drinking time of cows is related to their eating time which agrees with the findings of other scientists [13].

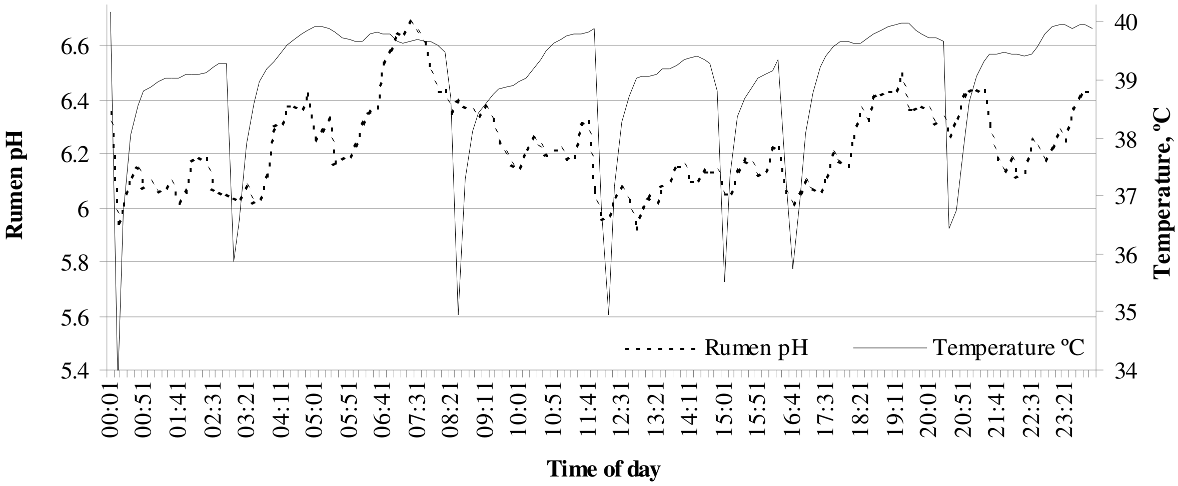

Fig. 4. **Rumen pH and temperature indicators over the 24 hour period for the cow No. 4525**

Over 24 hours, the cow No. 4525 drank 7 times, which is indicated by a swift drop of the rumen temperature.

Conclusions

1. The indwelling special boluses and the wireless data transmitting unit allow for a highly accurate, non-invasive evaluation of diurnal variation of the ruminal pH and temperature for an individual cow, as well as enable disclosing of heavy health conditions affecting the above prameters for all cows.
2. The indwelling special boluses and wireless data transmitting unit demonstrate the drinking and eating behavior of cows as well enable the monitoring of subacute rumen acidosis risk.
3. A weak, but statistically significant correlation between the rumen pH and temperature was observed for the cows under the study ($r = 0.12$, $p < 0.05$).

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