



Diagnosing sub-acute rumen acidosis in cows in the post-calving period with digital technologies

[*Diagnóstico de acidose ruminal subaguda em vacas no período pós-parto usando tecnologias digitais*]

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ABSTRACT

This study aims to determine the relationship between indicators of the motor activity, pH factor, rumen and rectal temperature within 10 days after calving and to analyze the possibility of using the studied parameters as prognostic signs for diagnosing sub-acute rumen acidosis (SARA). The measurements were taken using bolus with sensors designed to monitor cow health. The motor activity, pH factor and ruminal temperature of 10 cows were measured during 10 days at a measurement interval of every 60 seconds. Next, the researchers calculated the average values of the obtained readings, which were divided into 2 groups according to a measurement interval of every 12 hours. Rectal temperature was measured using a veterinary thermometer every 12 hours (at 8 a.m. and at 8 p.m.). As a result, 200 measurements were obtained. Descriptive sampling statistics were calculated using the SPSS Statistics program. An increase in motor activity reduces the pH level of the rumen environment. Lowering the pH factor of the rumen environment leads to an increase in ruminal temperature. There is a positive statistically significant correlation between ruminal and rectal temperature. The nosology of SARA can be predicted by measuring the motor activity and rectal temperature of dairy cows.

Keywords: cattle, rumen, SARA, pH factor, temperature, motor activity

RESUMO

Este estudo visa determinar a relação entre indicadores de atividade motora, fator de pH, temperatura ruminal e retal em até 10 dias após o parto e analisar a possibilidade de utilizar os parâmetros estudados como sinais prognósticos para o diagnóstico de acidose ruminal subaguda (SARA). As medições foram feitas usando bolus com sensores projetados para monitorar a saúde das vacas. A atividade motora, o fator de pH e a temperatura ruminal de 10 vacas foram medidos durante 10 dias em intervalos de medição de 60 segundos. A seguir, os pesquisadores calcularam os valores médios das leituras obtidas, que foram divididos em 2 grupos de acordo com um intervalo de medição a cada 12 horas. A temperatura retal foi medida com um termômetro veterinário a cada 12 horas (às 8h e às 20h). Como resultado, foram obtidas 200 medições. As estatísticas de amostragem descritiva foram calculadas usando o programa SPSS Statistics. Um aumento na atividade motora reduz o nível de pH do ambiente ruminal. A redução do fator de pH do ambiente ruminal leva a um aumento da temperatura ruminal. Existe uma correlação positiva estatisticamente significativa entre a temperatura ruminal e retal. A nosologia com SARA pode ser prevista medindo a atividade motora e a temperatura retal de vacas leiteiras.

Palavras-chave: gado, rúmen, SARA, fator de pH, temperatura, atividade motora

INTRODUCTION

Sub-acute rumen acidosis (SARA) is a widespread disease in cattle and other ruminants, characterized by increased production of lactic acid in the rumen and an acid-base disbalance in

the body. This happens due to eating a large amount of feed rich in easily digestible carbohydrates but with an insufficient number of roughages (Dorosh, 2007). The SARA symptoms in cattle are very diverse. The first stage is

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characterized by loss of appetite, weak or sometimes completely absent rumen motion, the body temperature drops below normal, but after 4–5 days, it may increase due to stomach inflammation. Affected animals suffer from tachycardia (increased heart rate), diarrhea, and anuria (disuria) (Mikhailova *et al.*, 2017).

The feed acidity determines the pH factor of the rumen environment. Gengler *et al.* (2010) observed a significant negative correlation ($R^2 = 0.77$) between the pH factor of the rumen environment and its temperature. When the pH factor of the rumen environment decreased, an increase in ruminal temperature was noticed. Therefore, by measuring ruminal temperature, the pH level can be evaluated, which ensures the timely diagnosis of SARA (Alzahal *et al.*, 2008). As practice shows, several methods use the pH factor of the rumen environment in cattle. The disadvantages of obtaining contents through a probe include the risk of mixing saliva, the procedure complexity, and the fact that the sample is "removed" from the surface of the feed mass in the rumen (the pH factor on the surface and in the middle may vary). In previous studies, it was found that as saliva got into a ruminal fluid sample, the pH readings turned out to be 0.5 units higher (Strabel *et al.*, 2007).

Experts have recently developed boluses with sensors to measure the pH factor, temperature and motor activity. These boluses are inserted orally into a cow's rumen to monitor these indicators throughout the life. The obtained readings are transmitted to the transceiver (Keunen *et al.*, 2002), and then to the cloud storage to be processed using algorithms and mathematical models and finally displayed as a graph in the application or interpreted into text messages (Alzahal *et al.*, 2008). The reliability of real-time monitoring of the rumen pH factor as compared with other methods for assessing the risk of SARA is significantly higher (Gasteiner *et al.*, 2012).

This method of evaluating the rumen pH factor in cattle was used in several scientific studies. Duffield *et al.* (2004) described and evaluated a method for continuous long-term monitoring the pH factor of the rumen environment, which uses a wireless data transmission unit. Antanaitis *et al.* (2018) found that temperature and pH readings of the rumen environment can be used as a probability predictor of reproductive success.

Antanaitis *et al.* (2016) revealed a correlation between rectal temperature, ruminal temperature, and the pH factor of the rumen environment. This study aims to determine the relationship between indicators of the motor activity, pH factor, ruminal temperature, and rectal temperature within 10 days after calving and analyzing the feasibility of the studied parameters.

MATERIALS AND METHODS

The study was conducted for ten dairy cows of the Holstein breed (Russia, the Yaroslavl region, JSC Voshchazhnikovo Agricultural Holding). In total, the herd consisted of 1317 dairy cows. A group of ten heads was formed according to the following criteria: all cows had a post calving period of up to 10 days, the same diet and housing conditions, the age of 2-3 lactations and weight not lower than 350kg, average milk yield at lactation peaks amounts to 30 (± 3) kg/day. The daily ration consisted of alfalfa hay (2.5kg), corn silage (16.0kg), alfalfa haylage (12.0kg), propylene glycol (0.2kg), glycerin (0.15kg), and mixed feed (8.78kg).

Before the study, the selected cows were examined in accordance with the clinical study order and were found completely healthy. The average body weight of the studied cows was 534 (± 2.05) kg. Clinical signs of SARA (diarrhea, decreased appetite, and low level of rumination) were not observed. The motor activity, temperature, and pH factor were measured using an internal cattle health monitoring system (smaXtec animal care GmbH, Graz, Austria), which were preinserted in the studied cows. Boluses were orally inserted into cows with a mass of more than 350kg. The chosen polycarbonate case material was resistant to ruminal fluid, and the internal protective metal casing prevented mechanical damage. The bolus pH meter was calibrated using a buffer solution prior to insertion.

Data were monitored through a radio transmitter on the ISM band (433 MHz). The obtained readings of the motor activity, pH factor and ruminal temperature were transmitted through the base station to a server via a GSM or Ethernet cable module. The server processed the transmitted data using algorithms and a mathematical model and displayed the results in the form of graphs and messages on a computer or

smartphone. The readings of ten cows were taken on a total of 10 days with the measurement interval of every 60 seconds. The entire array of measured indicators was transmitted to the server every 10 minutes. Then, the average values of the obtained readings were calculated and divided into 2 groups according to a measurement interval of every 12 hours. All data were uploaded from the system software database. Rectal temperature was measured using a veterinary thermometer (Genia Digiflash Thermometer for Pets & Large Animals, St. Hilaire de Chaléons, France) twice a day (at 8 am and 8 pm), 200 measurements were taken.

Descriptive sampling statistics (arithmetic mean \pm standard error) were calculated using the Windows program, IBM SPSS Statistics 23 (IBM..., 2017). The relationship between the indicators was analyzed using the Pearson coefficient and the linear regression equation: $y = bx + a$, where x - an independent variable (predictor), y - a dependent variable (response

variable); b - an angular coefficient (gradient of the estimated line), and a - a free term (intersection) of the estimation line, i.e. y , when $x = 0$. Coefficient of determination (R^2) was determined as a statistical measure of the data proximity to the fitted regression line. The data were considered reliable from a statistical point of view in case of $P < 0.05$.

RESULTS

The average pH of the rumen environment was 6.40 (± 0.14), and the ruminal temperature was 39.41°C (± 0.17). The average level of the motor activity index was 9.05 (± 1.63), and the rectal temperature was 39.42 ° C (± 0.17). The relationship between the indicators of rectal temperature, motor activity, temperature and pH factor of the rumen environment of ten Holstein cows having the same diet and housing conditions observed during the study are presented in Table 1.

Table 1. Relationship (Pearson's correlation, r) between the indicators of physical activity, rectal temperature, pH and the temperature of rumen environment

	Characteristics	RpH	RT	Act
RT	Pearson correlation	-0.932**	-	-
	(two-tailed)	0.0001		
Act	Pearson correlation	-0.263**	0.647**	-
	(two-tailed)	0.001	0.0001	
RecT	Pearson correlation	-0.140**	0.864**	0.628**
	(two-tailed)	0.001	0.0001	0.003

RpH = rumen; RT = ruminal temperature; Act. = motor activity, RecT = rectal temperature.

The following correlations have been revealed: a negative statistically significant correlation ($r = -0.932$, $P < 0.01$) between the pH factor of the rumen environment and motor activity. An increase in motor activity helps to reduce the ruminal pH factor. Positive statistically significant correlation ($r = 0.647$, $P < 0.001$) was revealed between ruminal temperature and motor activity. An increase in motor activity leads to an increase in ruminal temperature.

A positive statistically significant correlation ($r = 0.628$, $P < 0.001$) was found between rectal temperature and motor activity. An increase in motor activity leads to an increase in rectal temperature. A negative statistically significant correlation ($r = -0.932$, $P < 0.001$) has been observed between ruminal temperature and the pH factor of the rumen environment. A decrease in

the pH factor of the rumen environment leads to an increase in ruminal temperature. A negative statistically significant correlation ($r = -0.140$, $P < 0.05$) has been found between rectal temperature and the pH factor of the rumen environment.

A decrease in the pH factor of the rumen environment leads to an increase in rectal temperature. A positive statistically significant correlation ($r = 0.864$, $P < 0.001$) has been revealed between rectal and ruminal temperature. As ruminal temperature increases, rectal temperature increases too. The analysis of linear regression (Figure 1) has shown a regular linear increase in ruminal temperature along with a decrease in the pH level of the rumen environment ($y = 38.96 + 0.83 \cdot x$).

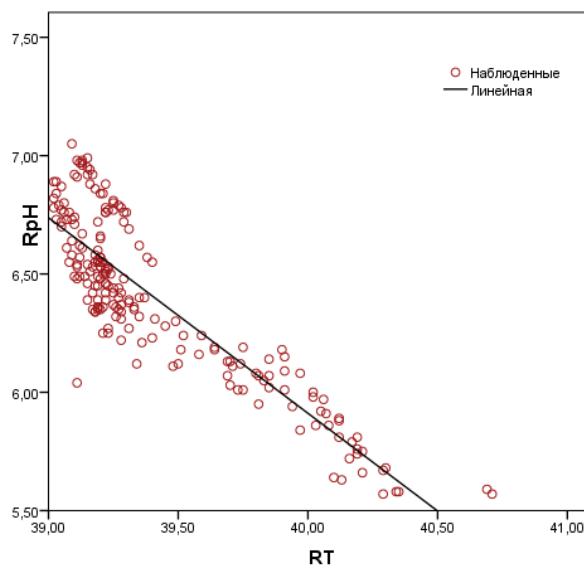


Figure 1. Analysis of the correlation between pH and ruminal temperature of ten Holstein cows under study, having the same diet and housing conditions. *Footnotes:* RpH: pH of the cicatricial medium, RT - temperature of the cicatricial medium.

DISCUSSION

The study results have shown a negative statistically significant correlation ($r = -0.263$, $P < 0.01$) between the pH factor of the rumen environment and motor activity. Kalyuzhny (1996) in his research work indicates that at the initial stage of SARA development, cows exhibit restless behavior (agitation). This is especially true for cows in the post-calving period when they are most susceptible to diseases due to weakened immunity. These cows were characterized by a low pH factor and, after some time, they showed the first signs of SARA (diarrhea, anuria, and fever). In conclusion, he states that monitoring the motor activity of cows in the post-calving period may contribute to the timely detection of SARA.

We have also confirmed the hypothesis of a high correlation between the pH factor and ruminal temperature of cattle put forward by Alzahal *et al.* (2008), as well as Antanaitis *et al.* (2016) in their scientific works. Their study results showed a negative statistically significant between ruminal temperature and the pH factor of the rumen environment. Alzahal *et al.* (2008) obtained a correlation of $r = -0.46$ between the pH factor and the rumen environment temperature, using a device for simultaneous monitoring the temperature and pH factor of the rumen environment in dairy cows. Still this result may have been obtained due to the close location of

two sensors. The authors got an equation for predicting the pH level of the rumen environment by monitoring ruminal temperature, and thus discussed the possibility of using ruminal temperature as an indicator for SARA detection in cows.

Antanaitis *et al.* (2016) observed a negative statistically significant correlation of $r = -0.199$ between the pH factor of the rumen environment and ruminal temperature using the SmaXtec health monitoring system. They concluded that the SARA nosology can be predicted by measuring ruminal temperature. Bewley *et al.* (2008) reported in their research paper that they obtained a high correlation ($r = 0.65$) between ruminal and rectal temperature in dairy cows as they used a large number of paired samples taken over several seasons. Alzahal *et al.* (2008) reported a significant increase in ruminal temperature due to feeding a large amount of grain as compared to a mixed hay diet.

Burns *et al.* (2002) conducted a similar study with cows, which were about to come into a sexual hunt. As a result, Sievers *et al.* (2005) obtained a correlation of $r = 0.50$ between ruminal and rectal temperature. Moreover, in their previous study, they made use of boluses to monitor cattle health and obtained a high correlation ($r = 0.92$) between ruminal and rectal temperature (Sievers *et al.* 2005). Drillich *et al.* (2001) in their research

concluded that regular measurement of the body temperature can be very useful for the daily monitoring of cattle health.

CONCLUSIONS

The following conclusions can be drawn from the results obtained. The research has proved that an increase in motor activity contributes to a decrease in the pH of the rumen environment. In its turn, an increase in physical activity leads to an increase in the temperature of the cicatricial environment. Also, an increase in physical activity leads to an increase in rectal temperature. A decrease in the pH of the rumen environment leads to an increase in its temperature, while a decrease in the pH of the rumen environment leads to an increase in rectal temperature. As the temperature of the rumen contents increases, the rectal temperature increases too. Linear regression analysis has shown a regular linear increase in the temperature of the ruminal environment with a decrease in its pH ($y = 38.96 + 0.83 \cdot x$). Thus, as the study results show, SARA can be predicted by measuring the motion and rectal temperature of dairy cows. Thus, the research results have confirmed the hypothesis put forward by Kalyuzhny that SARA can be predicted by measuring the motor activity of animals, as well as the hypothesis put forward by Antanaitis *et al.* that measuring rectal temperature can also help predict the contraction of SARA in dairy cows. The bolus system used to measure locomotion, temperature and pH has proven to be very useful for monitoring the physiological state of cattle. However, in order for the system to give accurate recommendations to livestock breeders, it is necessary to refine the existing mathematical models and algorithms for these purposes, which would provide for timely identification of deviations in their health indicators. This issue requires further research.

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