

Control of subacute ruminal acidosis in high-yielding dairy cow herd by measuring the rumen wall thickness

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Abstract. The study aimed to investigate whether the rumen wall thickness (RWT) follows with the data from the collar sensor system and how deeply it depends on feeding management used in the high-yielding dairy cow farm, as well as what benefit it could bring to diagnose subacute rumen acidosis (SARA) in cows. The data obtained from the collar sensors about chewing activity were analysed in relation to milk recording results, the rumen wall thickness (RWT) and the context of the composition of feed easily digestible carbohydrate changes during the intensive lactation phase. The dynamic of RWT was evaluated concerning milk amount and quality, its relation to fertility, and the size of the cows, which were taken into account. The results showed that the sensor system provides information about cow behaviour but does not provide direct information about the SARA problem in the herd. The RWT was related to the changes in feed easily digestible carbohydrate content and chewing activity. In conclusion, the sensor system allows monitoring of feed ingestion, but overall data about productivity and milk composition are necessary to make conclusions and induce ideas about corrections. Additional RWT measures are necessary to monitor rumen health and SARA presence timely, so monitoring the RWT may lead to a longer productive life for the cow.

Key words: TMR, sensor systems, RWT, SARA.

INTRODUCTION

Subacute ruminal acidosis (SARA) is an actual subclinical problem with obvious consequences in high-producing dairy cattle if fed with a ration too high level of easily digestible carbohydrates (EDC). Due to its subacute nature and lack of clearly expressed clinical signs, this metabolic disease is difficult to monitor. However, information and parameters have been identified that indicate the presence and intensity of SARA in the herd or cow group less or more (Humer et al., 2017). Specialists of highly productive dairy farms manage the situation according to the financial and technological possibilities available to the farm.

Direct and indirect criteria and methods can be used to diagnose SARA. As a direct parameter is the dropping of pH in the rumen content below 5.6 for more than three hours (Kleen et al., 2003; Gozho et al., 2005). A pH value could be established by obtaining the ruminal content sample using an oro-gastral probe via rumen-centesis or using a

cannula previously operated surgically (Metwally et al., 2015; Lozier & Niehaus 2016). Monitoring of the milk fat and milk protein content and ratio, chewing score, monitoring of body condition score (BCS), appearance and consistency of faeces, urine pH and some blood biochemical parameters, and filling of rumen could be used as indirect criteria (Aditya et al., 2017; Antanaitis et al., 2019; Yang et al., 2020). All invasive methods disturb animals and are not in line with welfare standards if they are used just for prophylactic or just monitoring measures. A frequency of incidence of laminitis, rumenitis, and displacement of abomasum also could be indirect criteria proving SARA in the herd (Stone, 2004; Gasteiner et al., 2012). A questionnaire to monitor dairy herd health and investigate the causes of the SARA was elaborated based on evaluating feed composition and quality, farm management, animals and production (Liepa & Šematoviča, 2017). However, these methods are subjective and need to be monitored through regular visits provided by an educated and experienced specialist. The intra-ruminal boluses are elaborated to measure the reticulo-ruminal pH and temperature permanently, but a restricted time of battery capacity limits their wide use of them in practice.

The aim of the study was to determine whether the level of sensor systems (*Allflex Livestock Intelligence*TM, *Heatime*® *Pro*+) and feeding management used in the high-yielding dairy farm allows them sufficient control of the presence and dynamics of SARA. To achieve the goal, the data obtained from sensors used in the farm were analysed in the context of cow milk monitoring results, the RWT, feed changes, and the cow size measured as the height at the sacrum dorsal point from the ground.

MATERIALS AND METHODS

The research took place in 2022 on a free-stall housing system farm of 660 dairy cows with an average milk yield of 12,300.00 kg per cow per year. The work was carried out using the data of 44 cows (16 primiparous and 28 older cows) in their intensive lactating period in May and June of 2022. Milk monitoring information (productivity, milk fat (MF), milk protein (MP), MF and MP ratio, somatic cell count (SCC) and artificial insemination (AI) times per pregnancy were taken from the Agricultural Database of Latvia ten days after changes in feeding recipes. The cows' size was taken into account.

Cow nutrition during the study period consisted of free accessible total mixed ration (TMR) delivered to cows 2 times per day and pushed closer to cows every 3 h. The recipe and preparation of the feed were not affected by the study. The study was conducted under the real production conditions of the farm. The feed's easily digestible carbohydrate (EDC) amount in the TMR was determined according to the recipes used during the study period (Table 2 and Table 3). Feed recipes before May included Beet pulp, which provided easily digestible fibre. A dry matter intake (DMI) during May reached 27–28 kg a day per cow because of the use of Beet pulp, but the first lactation cow reached 24–25 DMI kg per day, respectively.

During May, the Beet pulp ran out, and there was a sharp drop in edibility, even down to 23–24 kg of DMI, at the same time, the 1c grass ran out, and 2c grass was started. The quality of the two kinds of grass was different (Table 1). Grass 2c has less protein and was drier.

In May and June, cow chewing activity as time spent chewing feed (min per day) was obtained using sensors on neckties (*Allflex Livestock Intelligence system*). Data about everyday chewing activity were retrieved from *Allflex Livestock Intelligence software/system* corresponding to the study period.

Cow height in cm was established using a height measurement stick by related professionals on the farm. The RWT in cm was measured in the region of the middle third of the left abdomen (just under the paralumbar fossa) by the same veterinarian using ultrasound equipment MyLab30VetGold with a 7.7 MHz linear probe and according to the methodology previously described

by (Roozbahani et al., 2013; Neubauer et al., 2017). The RWT measurements were recorded two times with 30-day intervals - 1st time was on May 2, and the 2nd time was on the 1st of June.

Table 1. Grass silage quality in the investigation period

	1c grass	2c grass
Moisture %	64.8	59.7
Dry matter %	35.2	40.3
Crude protein %	13.1	10.4
Adjusted protein %	13.1	10.4
Soluble protein %	9.1	6.2
Ammonia %	0.99	0.96
Rumen degradable protein %	11.1	8.3

Table 2. Feed recipe for the 1st lactation cow at the time of the study

Ingredients	May		June	
	Fresh kg	DM kg	Fresh kg	DM kg
Corn silage	21.32	6.80	23.51	7.50
Grass silage	11.36	4.00	15.24	5.70
Grass hay	0.60	0.51	1.10	0.93
Beet pulp	6.80	1.70	...	...
Glucose syrup	0.80	0.30	1.00	0.38
Rapu	7.10	6.18	0.70	0.61
Soybean meal 44%	1.20	1.08	4.90	4.41
Megalac	0.15	0.15	0.15	0.15
Mix Wheat50-Brley50	4.10	3.60	...	...
Soft wheat fine ground	...	...	5.20	4.50
High prod. concentrate	...	...	...	...
Sodium bicarbonate	0.20	0.19	0.15	0.14
Calcium carbonate	0.05	0.05	0.09	0.09
Calcium Phosphate	...	...	...	...
Sodium chloride	0.08	0.08	0.11	0.11
Premix Llet	0.10	0.10	0.10	0.10
Q-Boost	...	...	0.13	0.13
Totals	53.86	24.73 (45.9%)	52.38	24.73 (47.2%)

All procedures performed in the present study were in accordance with ethical standards. The Council for Ethical Treatment of Animals, Food and the Veterinary Service Republic of Latvia was approved for this study (No. 1.1-13E/20/891).

Mean \pm standard deviation (SD) was used to express the data obtained and they were analysed using SPSS 18.0 software (*SPSS Incorporated, Chicago, IL, USA*). Graphical pictures were created using *MS Excel* software. The *Student's test* was

used to detect a statistically significant difference between related and non-related groups. A P value < 0.05 was considered statistically significant.

Table 3. Feed recipe for the 2nd and more lactation cows at the time of the study

Ingradients	May		June	
	Fresh kg	DM kg	Fresh kg	DM kg
Corn silage	26.65	8.50	26.65	8.50
Grass silage	10.80	3.80	15.24	5.70
Grass hay	0.50	0.42	0.90	0.76
Beet pulp	6.80	1.70	...	...
Glucose syrup	1.00	0.38	1.10	0.42
Rapu	...	...	0.60	0.52
Soybean meal 44%	4.60	4.14	5.20	4.68
Megalac	0.30	0.30	0.30	0.30
Mix Wheat50-Brley50	...	...	...	...
Soft wheat fine ground	6.50	5.63	6.50	5.63
High prod. concentrate	9.11	8.07	7.40	6.50
Sodium bicarbonate	0.14	0.14	0.14	0.14
Calcium carbonate	0.07	0.07	0.07	0.07
Calcium Phosphate	0.03	0.03	0.03	0.03
Sodium chloride	0.12	0.12	0.12	0.12
Premix Llet	0.10	0.10	0.10	0.05
Q-Boost	0.14	0.14	0.14	0.10
Totals	66.85	33.53 (50.2%)	64.49	33.51 (52%)

RESULTS AND DISCUSSION

When drawing up the feed composition for dairy cows on the farm, the mode and quality of the available feedstock must be considered. To fully satisfy the needs of yielding cows, some ingredients were bought and included in calculating a specific TMR. During the period of the study, the feed ingredients composition ratio was as follows (Fig. 1). The amount of EDC in TMR was higher in May than in June. Subsequently, the total productivity diminished from May to June (44.8 ± 8.83 vs 36.46 ± 7.06 kg day⁻¹ per cow, $P > 0.05$). Milk composition average indices (MF, MP, SCC and MF:MP ratio see Table 5) were not changed statistically significantly, $P > 0.05$).

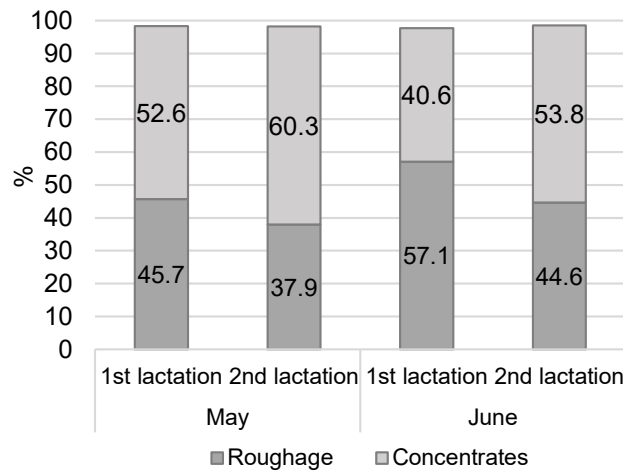


Figure 1. The proportion of EDC and roughage in the feed of the 1st and older cows in May and June.

In June, grass 2c (Table 1), which was included in TMR, was too dry and possibly prepared in too long fractions, and farm personnel noticed that the animals started sorting the feed. In June, a lower amount of EDC was included in the feed with almost the same amount of sodium bicarbonate, but most of the cows had increased RWT, which the noticed feed sorting can explain. In most cows (51.9%), the number of chewing movements decreased, and at the same time, the thickness of the rumen wall increased in 70.8% of cows. Most likely, this is due to the influence of the type of TMR preparation from the feed composition described earlier. In some cows (48.1%), the situation was the opposite, and 29.2% out of them were primiparous cows (Fig. 2). There may be hierarchy issues within the cow group and feed sorting due to the preparation and composition of the TMR. Individual qualities could be considered regarding feed metabolism in cow forestomach (Sematovica et al., 2017).

The mean results of the chewing activity during the study period in primiparous and older cows are represented in Table 4. They were kept in one group together and it was essential to rule out the superiority of older cows over young ones. So, it seemed that older cows ate more EDC as judged by the significant increase in RWT ($P < 0.05$). It has been approved that older cows are more resistant to high-grain feeding than young cows (Neubauer et al., 2018).

Table 4. The dynamic of chewing activity and RWT in the 1st lactation and older cows in the study period

Month	Lactation		Chewing activity min day ⁻¹	Rumen wall thickness cm	Milk productivity day ⁻¹
May	1 st lactation	Min.	519	0.12	26.5
		Max	621	0.48	54.4
		Mean ± SD	583.4 ± 33.76	0.28 ± 0.146	41.0 ± 8.50
	More lactations	Min.	544	0.15	35.0
		Max	620	0.60	63.7
		Mean ± SD	570 ± 26.57	0.39 ± 0.134*	47.5 ± 8.24
June	1 st lactation	Min.	541	0.10	30.5
		Max	638	0.65	50.0
		Mean ± SD	590.4 ± 27.19	0.42 ± 0.198	39.1 ± 6.49
	More lactations	Min.	508	0.21	21.9
		Max	643	0.94	50.0
		Mean ± SD	564.7 ± 37.46	0.64 ± 0.214*	34.3 ± 6.94

*($P < 0.05$).

No significant differences were observed between the mean chewing activity obtained in May and June ($P > 0.05$). However, the thickness of the RWT was increased statistically significantly (0.34 ± 0.161 vs 0.56 ± 0.224 cm, $P < 0.05$). Moreover, the following RWT data for individual cows (Fig. 2) brightly showed individual chewing behaviour for particular cows in that period. A negative statistical correlation was found between chewing activity and RWT dynamic ($r = 0.45$; $P < 0.01$). Interestingly, the thickness of the rumen wall changed statistically significantly in older cows (Table 5).

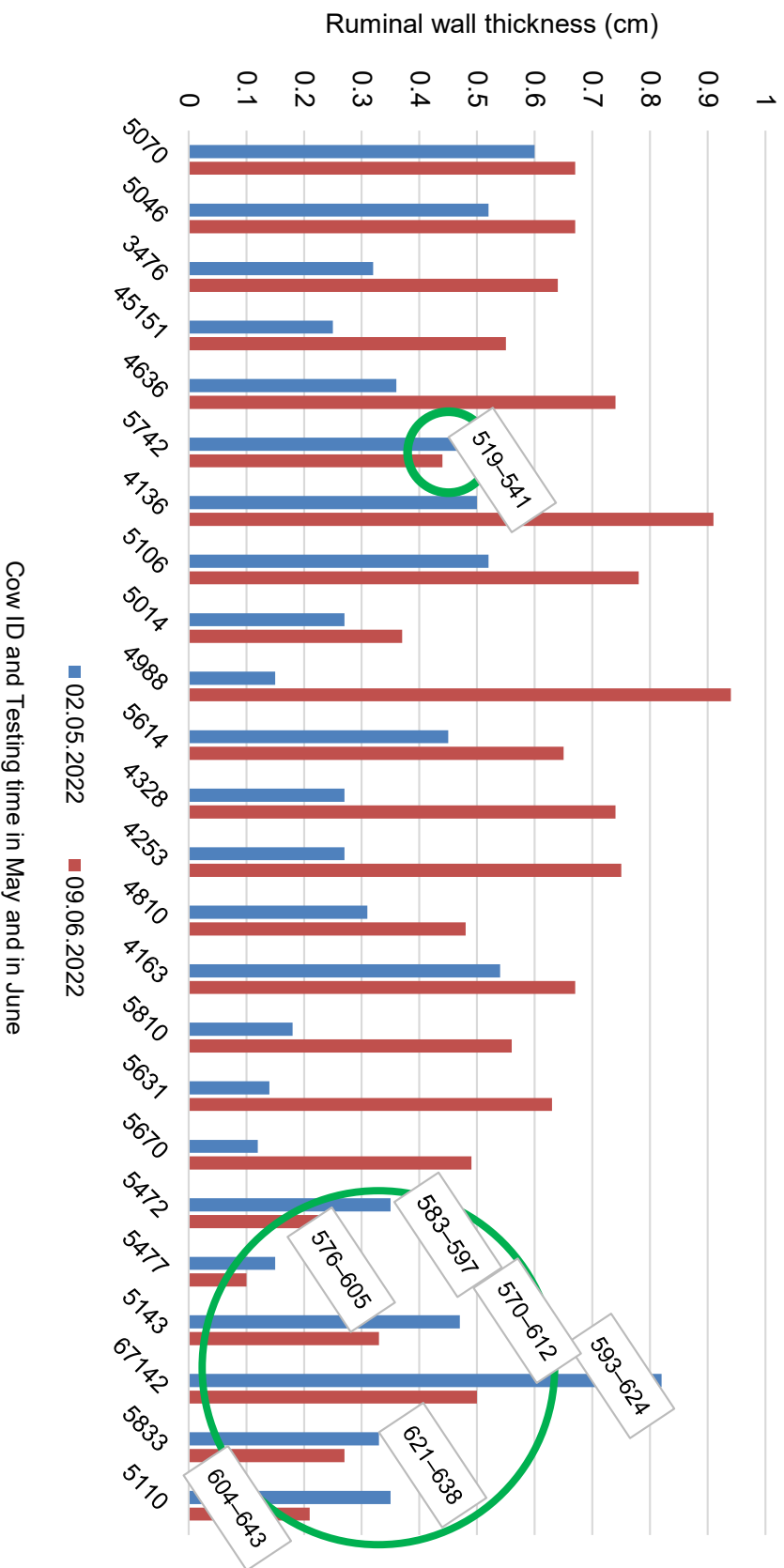


Figure 2. Dynamics of the rumen wall thickness (circle expresses some particular cow chewing activity increasing and simultaneous rumen wall thickness decreasing (indices in boxes)).

In cows whose chewing activity increased was higher productivity (38.2 ± 7.15 vs 35.8 ± 6.66 kg day⁻¹), their MF, MP, SCC AI times per pregnancy and size did not differ significantly ($P > 0.05$). Cows whose RWT increased became less productive (35.3 ± 6.94 vs 40.0 ± 8.14 kg day⁻¹) and other parameters like MF, MP, SCC, AI times per pregnancy and cow size were also not statistically different at the time of investigation ($P > 0.05$). It can be concluded that decreased chewing activity and increased RWT have a tendency to diminish cow productivity. These cows may become less productive despite higher EDC intake because in SARA there is a high concentration of lipopolysaccharides and inflammatory components in the rumen, which increase the expression and synthesis of pro-inflammatory

cytokines in the rumen epithelium, thus causing ruminitis and opening the way for inflammation to the entire body (Zhao et al., 2018; Jiang et al., 2021).

It is well-known that reduced chewing activity could be one of the signals of SARA (Cao et al., 2021). The duration of chewing and rumination are closely related to dry matter intake. TMR particle size influences chewing activity and is closely related to the neutralisation of rumen composition by saliva. So, it is a direct criterion for rumen pH value. If TMR particles are too short, insufficient saliva rises to neutralise pH in the rumen. In our study despite the EDC proportion diminished, rumination/chewing activity proportionally did not reduce because of feed sorting which was noticed by farm personnel. During the study, the difference between minimal and maximum chewing value in 1st lactation cows was 100 ± 5 min day⁻¹, but in the older cow group, this value increased from 76 to 135 min day⁻¹ in May and June, respectively.

Moreover, a big difference was noticed between minimal and maximal milk productivity levels in the older cow group (21.9 vs 56.2 kg day⁻¹), and it is obvious that different feeding requirements had to be considered.

At the time of the study, in 51.9%, the number of chewing movements decreased, and the thickness of the rumen wall increased in 70.8%, but in 48.1% of cows' the situation was the opposite, and 29.2% of them was primiparous cows. Thus, we cannot claim primiparous cows were more sensitive to changes in TMR and feed composition than older cows in our study. So, totally it could be explained by differences regarding the composition of TMR and grass quality, which particularly could affect the overall ruminal fermentation and metabolism in this field study. In addition, not possible to exclude feed sorting during June.

A weak but statistically significant correlation was found between RWT and MF content in milk ($r = 0.35$, $P < 0.05$).

Table 5. Parameter dynamic at time of investigation

Parameter/Time	May	June
Productivity kg day ⁻¹	44.8 ± 8.83	36.5 ± 7.06**
MF %	3.5 ± 0.81	3.8 ± 0.77
MP%	3.4 ± 0.36	3.5 ± 0.32
SCC thousand mL ⁻¹	395 ± 1,752.1	151 ± 412.1
Urea mmol L ⁻¹	30.3 ± 7.84	32.8 ± 6.13
MF: MP ratio	1.0 ± 0.21	1.0 ± 0.17
AI per pregnancy	2.0 ± 1.67	2.2 ± 1.67
RWT mm	0.34 ± 0.161	0.56 ± 0.224**
Chewing activity time min day ⁻¹	572.1 ± 28.83	574.1 ± 47.52

**($P < 0.05$).

A negative statistically significant correlation was found between cow size and MF% ($r = -0.47$; $P = 0.01$). It could be explained if a hierarchy existed and larger animals sorted feed. So, these animals could receive more easily digestible feed than smaller, physically weaker cows.

A negative statistically significant correlation was found between MF and MP ratio and artificial insemination times carried out ($r = -0.33$, $P < 0.05$). It could be because SARA cows eat digestive carbohydrates more easily, so they have a lower MF and MP ratio, and the SARA negative influence on reproduction is well known (Kh et al., 2014; Vallejo-Timarán et al., 2020).

Productivity has a mild negative correlation with RWT ($r = -0.54$, $P < 0.001$). So, in cows with thinner, healthier rumen walls, productivity is higher, and subsequently, these cows had to provide more time for chewing ($r = 0.32$, $P < 0.05$).

RWT has a statistically significant mild, negative correlation with chewing activity, showing that cows with lower chewing activity develop thicker ruminal wall, which can be connected with rumen mucosa proliferation caused by low pH levels in rumen during SARA (Mirmazhari-Anwar et al., 2013; Neubauer et al., 2018). The measurement of the rumen wall has attracted interest in recent years and more detailed measurements of the rumen wall have been carried out (Fiore et al., 2020).

CONCLUSIONS

The sensor system provides information about cow behaviour but does not provide direct information about the SARA problem in the herd. It can be seen that there is an individual response to feed change that requires further investigation to understand whether it is a feature of individual cows or a feed sorting option that cows use. Thickening of the rumen walls is a sign related to the effect of the ingested feed on the cow's organism and productivity. The long-term effects of long-term rumen wall thickening on the cow's productivity, health and longevity should be investigated. Monitoring the thickness of the rumen wall may lead to a longer productive life for the cow.

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