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MONITORING OF RUMINATION LENGTH IN DAIRY COWS

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Keywords*: rumination length, milking robot, dairy performance, protein, fat, lactation*

Abstract. *The aim of the work was an analysis of chosen milk usability indicators of herd of cows kept in a freestanding barn, in which the Lely Astronaut A4 type robot was installed together with a specialist software and QWES-HR device used for registration of feed belching from reticulum to the mandible as well as length of rumination of Polish Holstein-friesian cows. The research was performed in the herd consisting of 62 dairy cows of an average performance of about 9463 kg of milk. The animals were fed with full dose TMR which consisted of: haylage, corn silage, straw, cereal meal, rapeseed meal, soy and mineral-vitamin additives. Milking was performed with the use of LELY ASTRONAUT A4 robot. Each cow had a QWES-HR transponder hanging on the neck which registered neck muscle movements which were responsible for mandible movements thus showing daily rumination length. Three study groups of the examined cows based on rumination length were created i.e. KP group (rumination length below 400 minutes), SP group (from 400 to 500 minutes) and DP group (over 500 minutes). In the research it was shown that the average rumination length of cows of KP group was 336 min/day; SP group - 422 min/day and DP group - 514 min/day. It was also proven that as rumination length increased their daily performance increased as well from 26,95 kg (KP group) to the 31,20 kg (DP group) level. Small changes also concerned components content, which was mirrored in dry weight which was highest in DP group (13,27%). Casein content was highest in cows with the shortest rumination length i.e. in KP group and was 2,72%. Urea in all groups was on the similar level of about 300 mg/l proving little impact of rumination length on its content. The share of protein in feeding dose is of higher importance here. The connection between the age of first calving and the*

length of rumination was reported. Cows beginning their use at the age of 941 days were characterised by the shortest rumination (KP group), whereas at the age of 837 days (DP group) the longest. It was noticed that the time spent on rumination decreased as lactation time progressed reaching its highest level at the beginning phase of lactation. Cows in the 96th day of lactation showed the longest rumination length per day (492 minutes), highest milk performance per day reaching 33,78 kg which was 1,38 kg of milk higher than the average achieved in group A. The decrease in performance and content of components appeared in cows at over 150th day of lactation. In the study it was also shown that multiparous cows (3D lactation) were characterised by the longest, whereas primiparous by the shortest (421 minutes) rumination length. Cows in second lactation were characterised by the highest milk performance (30,71 kg of milk). The impact of rumination length on the length of calving interval was not proven as it was similar in each of the groups and amounted about 383 days.

(Поступила в редакцию 02.06.2017 г.)

Introduction. Rumination is a highly essential element influencing roughage feed digestibility collected by cattle. Rumination should be uninterrupted, proceed in such a way that the feed content which got into the rumen after some time gets to the mandible, through the reticulum, in order to be grinded with molar teeth. Crushing of feed into small parts increases the area of impact of rumen bacteria and produced by them enzymes, thus improving and increasing the speed of feed intake digestion. The next task of rumination is to increase saliva production level, which neutralizes acids produced during fermentation in rumen. A proper rumination decides of health and is an evidence of good comfort of cows.

Rumination is an inseparable element of proper functioning of dairy cows. Throughout a day healthy cow lies for 12-15 hours, including about 10 hours during which it should ruminate. The next 4-6 hours it spends consuming feed and rest of the time is connected to different activities such as milking or accessing the feeding table. Rumination process can be divided into several phases lasting from 30 to 60 minutes. The most often, 10-17 of such phases can be distinguished during a day. In each of them 30 to 60 cycles of single "boluses" of rumination appear, each lasting 40-60 seconds. The lowered length of rumination can lead to many problems connected with animal health [Kowalski 2010]. Proper rumination is assessed by measuring the time which cow spends on this activity, as well as length and number of cycles throughout the day. Conditions in which the cattle is kept have a significant impact on the quality of rumination. Cows ruminate much better when lying. Due to this fact, it is needed to allow them access to couching-places as well as their appropriate area. Too excessive stocking of animals in a barn is undesirable [Kowalski 2014].

An appropriate nutrition and length of resting are both significant factors influencing proper rumination process. Health disorders which appear interrupt this process [Kowalski, 2010].

Thanks to rumination process monitoring it is possible to easily and simply asses healthiness of cows looking at the appearances of some metabolic disorders, especially in the so-called transitional period, as well as diagnose different diseases for example mammary gland inflammation (mastitis). Early diagnosis is very important as it recognizes subclinical forms of diseases and thanks to the fast therapeutic effect it minimizes losses caused by clinical forms of diseases allowing cow to regenerate faster [Koźlicki, 2015].

Application of inappropriate feeds, of inappropriate composition has a negative impact on the survivability process. Physical structure of feeding dose, in which the main element is the amount of structural fiber which stimulates salivary glands in order to produce the highest amount of saliva, is important as well, During a proper feeding and rumination process cow can produce about 60 liters of saliva which is an ideal buffer for the rumen. Buffering contributes to maintaining of proper rumen acidity, preventing acidosis and lowering chance of the laminitis [Kowalski, 2010].

Throughout a day a cow should spend 400-600 minutes (about 10 hours) ruminating. The best time to ruminate is the couching-area resting time, where cows rest lying down at the same time making chewing mandible movements. It has a practical dimension as both of these activities are performed at the same moment. If cows ruminate while standing, their welfare may be interrupted [Lewandowski, 2014].

Monitoring of the age of cow activity is possible thanks to individual transponders located on the neck of each animal, which are used for identification and automatic registration i.e. of their movement activity and rumination length, thus enabling breeder to look into the reproduction state, cow wellbeing and analysis of their health [Lewandowski 2014].

At the moment on the market there are two devices which monitor such parameters as length of rumination or movement activity are available, as SCR Heatime HR System as well as additional device for Lely Astronaut A4 milking robot – the QWES HR. The SCR Heatime HR system consists of the terminal, sensor, collar and basic unit. The terminal consists of a touch screen and light alarm. Terminal processes data from sensors of the basic unit (BU) installed on the farm. Thanks to the advanced algorithm, with no need to use computer system, it presents reports and charts helping to increase work effectivity and certainty while making decisions. Sensor is permanently placed on the collar and monitors rumination, movement and its intensity, saving it to microcellular memory of 2 hour-capacity, thus

guaranteeing precise estrus recognition and health status monitoring. Sensor is equipped with 12 pieces of microcellular memory and each can store data up to 2 hours allowing for 24-hour data storage. Collar consists of the belt, sensor and counterweight. Sensor is placed on the left side of the upper part of the neck.

Basic unit – receives information from sensors and forwards it to the system several times per hour and thanks to this system is constantly updated, no matter where the cow is. Basic unit can also forward data to sensors which enables updating the software and different advanced functions, predicted in the future.

Collected results are forwarded through system and described in the form of reports as well as charts. For each cow a separate report or chart is assigned thus enabling early cattle breeding problem recognition. The device is also equipped with a mobile system allowing supervision as well as access to all of the information concerning herd in every place by installing special application on the mobile phone or tablet.

SCR Heatime HR system enables early estrus recognition and decreases rate of quiet estruses, what increases insemination effectivity. By increasing reproduction indicators it increases dairy efficiency, allows to solve health issues early thus lowering costs of veterinary tasks. As an effect it improves farm effectivity and facilitates making important decisions [http://www.scrdiary.com 14.12.2016].

The next device is Qwes – HR. It is an additional device of LELY ASTRONAUT A4 robot, specifically these are the transponders hanging on the neck, on the collar, so that the sensors in them are able to detect neck muscles movement without any problem. The structure of this device is very similar to the earlier one, although it does not have terminal that enables us to review all parameters assigned to one cow without using computer system. The information concerning rumination or movement activity is saved in 2-hour blocks and then forwarded to the computer system. Special program prepares separate reports as well as charts for each cow and sums up results collected from one herd and calculates their means. Collected data is then compared to earlier results. When results decrease below a certain limit system signalizes it instantly [https://www.lely.com/pl/ 14.12.2016].

Inappropriate access to couches as well as their insufficient quantity prolongs standing time of cows and as a consequence can lead to hoof diseases and to a decrease in time spent on rumination. In addition, it leads to an increase in cortisol level in blood. Higher cortisol share in blood appears in stressful situations. As an effect dairy efficiency decreases and mammary gland problems can also start appearing [Chromkowska and Oprządek 2016].

Rumination is majorly dependent on the amount and quality of applied feeds. Many factors connected to used feeding have an impact on length of rumination. Higher share of fiber feeds increases intensity of rumination while higher share of concentrated feeds decreases the rumination activity. A significant element impacting the length of life in dairy cows is a proper fragmentation of feeds. Excessive fragmentation causes a decrease in secreted and transported to rumen saliva. As a consequence it leads to a bad buffering of rumen content. Therefore, it may lead to rumen acidosis caused by pH decrease of rumen content. Rumen acidosis results in economic losses connected to a lower milk production, decrease in life longevity as well as costs of animal treatment [Gołębiewski 2014].

Nowadays, as a result of years of breeding work, a high efficient cow "appeared" which demands high amount of concentrated feeds in order to allow its high productivity. It is then needed to provide a suitable amount of energy through a proper amount of structural fiber [Kowalski 2010]. The so-called "effective fiber" stimulates the animal to ruminate. Inappropriate amount of effective fiber in dose may lead to laminitis, subclinical acidosis as well as lowered content of fat in milk [Beauchemin and Yang 2006].

Shortened time of rumination appears when a cow is in estrus. At about 2 days before estrus the decrease in rumination rate can be clearly seen. It is connected to the stress which decreases the amount of feed intake by a cow due to a decrease in appetite. In accordance to the research in four farms in Hesse it was shown that cows which showed a decrease in rumination throughout the estrus had its parturition interval decreased as well, which was not observed in cows that had its rumination time decreased slightly during estrus. It was also reported that the highest decrease during rumination in estrus appeared in young cows. The reason for this could be an increased number of secreted estrogens in this period that lead to a disappearance of appetite. Usually, the rumination time came back to normal 1 day after insemination [Hoy 2012].

The aim of the work was an analysis of chosen dairy use indicators of cow herd kept in a freestanding barn, in which the Lely Astronaut A4 type milking robot was installed together with the specialist software and the QWES-HR device used for registration of feed belching from reticulum to mandible, as well as the length of rumination of Polish Holstein-Friesian cows.

Materials and methods. The research was conducted in the individual farm belonging to Piotr Magdziński. The farm is located in a small town near Bieżuń, Żuromin county. In 2002 a barn for 65 cows with an average efficiency of about 9500 kg of milk was built. The new freestanding barn of 21x45m dimensions is destined for cows kept in the alcove system all year

round. The floor in this building is grated and couching places are found on one side of the barn only. Milking is performed automatically by the installed milking robot. The average milking frequency is 3-4 times a day. Animals are fed with a full dose TMR. The content of TMR is: haylage, corn silage, straw, cereal meal, rapeseed meal, soy as well as mineral-vitamin additives. A part of cows' herd is located in an old barn of 18x32m dimensions and kept in the alcove-pasture system. There is also a specially added room of 9x10m dimension destined for the De Laval "fish spear" 2x4 type milking hall, where milking is performed twice a day.

In 2003 LELY ASTRONAUT A4 milking robot together with QWES-HR device was installed in the new barn. Robotized milking system is an ideal solution for herd management as well as fast monitoring of many factors which are necessary in a properly managed dairy cattle herd. LELY ASTRONAUT A4 robot has a positive impact on cows health and their wellbeing. The cow reaches the milking box with no obstacles and its moves are not restricted. The device guarantees pre- and after-milking hygiene. Before the start and after milking teats, as well as teat buckets are carefully disinfected.

The QWES-HR device - the transponder, which is precisely placed on the cow's neck so that it can analyze neck muscle movements which are responsible for mandible movement. Transponder is equipped with a sensor which registers and saves such parameters as: movement activity and rumination length. The collection of data on movement activity allows for an earlier estrus detection, thus increasing insemination efficiency. The possibility to control rumination length of a cow throughout the day signals the early appetite-connected or dairy efficiency problems. The QWES-HR system collects and saves data every 2 hours, which are then forwarded to the computer. The installed computer software prepares a separate chart for each cow, that is why it is possible to collect current information about any animal [http://centrumrolnictwa.pl/robot-udojowy-lely-astronaut-a4/ 28.11.2016].

Studies were conducted in the period from 28th of August to 15th of September 2016. Their aim was to analyze achieved reports of rumination length against chosen milk parameters. The herd of 62 cows was divided into three groups basing on rumination length in a day:

- KP group (below 400 minutes)
- SP group (400 – 500 minutes)
- DP group (over 500 minutes)

The aim of rumination length was to assess the impact of such indicator on chosen milk parameters (fat, protein, dry weight, lactose, casein, urea). The other usability features such as: calving interval, the age of first

calving, daily milk efficiency [kg] as well as sequence and lactation day. Four groups of cows were separated basing on the lactation phase:

- Group A – (6-50 days of lactation)
- Group B – (51-150 days of lactation)
- Group C – (151-300 days of lactation)
- Group D – (over 300 days of lactation)

Used cow division with the age of cows taken into account allowed to specify 3 groups:

- Group 1 – (I lactation)
- Group 2 – (II lactation)
- Group 3 – (III lactation)

The arithmetic means (LSM) were calculated as well as standard deviations (Sd). It was all presented in appropriate tables.

Results and Discussion. In Table 1 the usability indicators were presented depending on the length of rumination of cows which were in KP, SP and DP groups. In the KP group, which had the lowest rumination length per day of less than 400 minutes, the observations covered 10 cows, in which the shortest rumination length was 279 minutes, whereas the longest 386 minutes. The average rumination length in this group was 336 minutes. Those cows produced averagely 26,96 kg of milk per day with 3,9% fat, 3,53% protein, 4,77% lactose and 2,72% casein content. The dry weight of milk components was 12,71%

Table 1– Chosen usability indicators in dependence on length of rumination

Group [No]	Length of chewing [min]	Length of lactation [days]	Statistical measurements	Milk [kg]	Fat [%]	Protein [%]	Lactose [%]	Casein [%]	Dry matter [%]	Urea [mg/l]	First calving [days]	Length of inter-calving period [days]
KP	336	192	LSM	26.95[a]	3.69	3.53	4.77	2.72	12.71[a]	325	941[a]	383[a]
			Sd	2.31	0.24	0.26	0.45	0.33	1.77	76.02	155.64	62.32
SP	422	95	LSM	28.72[a]	3.96	3.45	4.80	2.64	13.13[b]	284	845[b]	369[b]
			Sd	1.82	0.22	0.18	0.36	0.37	1.45	68.00	189.23	99.09
DP	514	138	LSM	31.20[b]	3.78	3.45	4.80	2.65	12.86[a]	306	837[b]	383[a]
			Sd	3.38	0.17	0.22	0.48	0.29	1.96	88.74	190.42	121.70

a,b – $p \leq 0,05$

Chosen usability indicators in dependence on the length of rumination per day by SP group cows, thus of rumination length in compartment be-

tween 401 to 500 minutes (Tab. 1), showed that the average rumination length of cows in the same group was 422 minutes. The observations covered 11 cows in which the lowest rumination length was 393 minutes, whereas the highest 443 minutes. Those cows produced 1,77 kg of milk more per day than those from KP group. The content of milk components in this group was as follows: fat (3,96%), protein (3,45%), lactose (4,80%), casein (2,64%). Dry weight content was higher in this group of cows as well, in comparison to KP group and amounted 13,13%.

DP group, which was the one with the highest rumination length amounting over 500 minutes, consisted of 40 cows, in which the shortest rumination length was 457 minutes, whereas the longest 607 minutes. The average rumination length of cows in this group was 514 minutes (Tab.1). Those cows produced 2,48 kg of milk more per day than those from SP group and 4,25 kg more than cows from KP group. Milk components content in this group was: fat (3,78%), protein (3,45%), lactose (4,80%), casein (2,65%) and dry weight (12,86%).

The studies showed that as the rumination length increased their daily efficiency increased as well from 26,95 kg (KP group) to the 31,20 kg level (DP group). However small changes concerned milk components content which were mirrored in dry weight that was the highest in SP group (13,13%), casein content was highest in cows of the lowest rumination time i.e. KP group and amounted 2,72%. Urea was at the similar level (about 300 mg) proving the low impact of rumination on its content. The content of protein in the feeding dose was of higher importance in this case. The connection between the age at the day of first calving and length of rumination was noticed. Cows starting their use at the age of 941 days were characterised by the shortest rumination (KP group), whereas at the age of 837 days the longest (DP group).

In Table 2 chosen usability indicators and length of rumination of cows in dependence on the lactation phase were presented. Group A consisted of 7 cows in the lactation period from 17 to 48 days. Averagely, those cows were in the 33rd day of lactation. The average rumination length of those cows was 476 minutes, so it was within the average rumination length of the examined cows. The animals in this phase produced averagely 33,78 kg of milk per day with 3,80% fat, 3,16% protein, 4,89% lactose and 12,62% dry weight content.

Table 2 – Chosen usability indicators and length of rumination in dependence on lactation phase.

Group [No]	Length of chewing [min]	Length of lactation [days]	Statistical measurements	Milk [kg]	Fat [%]	Protein [%]	Lactose [%]	Casein [%]	Dry matter [%]	Urea [mg/l]	First calving [days]	Length of inter-calving period [days]
A	33	476	LSM	33.78^{a}	3.80^{a}	3.16^{a}	4.89	2.38^{a}	12.62^{a}	283^{a}	860^{a}	391^{a}
			Sd	4.08	1.28	0.82	1.33	0.74	1.63	58.73	99.41	105.73
B	96	492	LSM	32.4^{a}	3.67^{a}	3.25^{a}	4.87	2.49^{a}	12.57^{a}	295^{a}	869^{a}	376
			Sd	2.55	1.23	0.67	0.59	0.80	1.66	89.33	96.12	128.73
C	207	451	LSM	27.82^{b}	3.83^{a}	3.63^{b}	4.77	2.80^{b}	13.08^{b}	314^{b}	874^{a}	390^{a}
			Sd	1.76	0.38	0.29	0.67	0.59	1.73	78.84	167.41	101.80
D	342	423	LSM	22.81^{c}	4.10^{b}	3.84^{c}	4.53	2.95^{b}	13.34^{c}	312^{b}	960^{b}	364^{b}
			Sd	2.08	0.46	0.52	0.37	0.54	1.73	98.54	155.40	77.60

a,b – $p \leq 0,05$

Group B consisted of 22 cows in lactation phase from 52 to 140 days. Averagely, those cows were in the 96th day of lactation, the average length of their rumination was 492 minutes so it was similar to the period of the longest rumination length. Cows of this group were characterised by daily milk performance of 32,40 kg. Such performance was 1,38 kg lower than the average achieved in group A. Fat and lactose content, as well as dry weight in milk of B group cows were also lower in comparison to group A animals.

Group C consisted of 19 cows in the phase from 151 to 300 days of lactation. Their average milking phase was 207 days of lactation, whereas the average length of rumination per day was 451 minutes. Hence it follows that as lactation progressed, rumination length decreased. Cows in this phase produced 27,82 kg of milk per day in average with 3,8% fat, 3,63% protein, 4,77% lactose, 2,80% casein and 13,08% dry weight content.

In the last group (group D) there were 6 cows in the lactation phase from 320 to 376 days. Averagely, those cows were in the 342nd day of lactation (Table 2). Their average rumination length was 423 minutes, so it was the lowest of all the examined lactation phases. Cows of this group were characterised by the lowest milk performance per day amounting 22,81 kg. However, the components and dry weight content (apart from lactation) was

highest in this group and was: 4,10% fat, 3,84% protein, 4,53% lactose, 2,95% casein and 13,34% of dry weight.

The time spent on rumination decreased as lactation progressed, being the highest from 51-150 days of lactation. Cows in the 96th day of lactation showed the longest rumination length per day (492 minutes). The decrease in performance and content of components appeared in cows below 150th day of lactation.

In research it was also presented that the longest rumination length was showed by multiparous cows (3D lactation), whereas the shortest by primiparous cows (421 minutes). Cows in the 2nd lactation were character-ised by the highest (30,71 kg of milk per day) milk performance, however. The impact of rumination length on parturition interval was not proved, as in all groups it was on the similar level and amounted about 383 days.

In Table 3 chosen usability indicators in dependence on the order of lactation were presented. In group 1 eleven cows being in the first lactation were under observation and it was their 126th day of lactation. At the time, the average rumination length in this group was 421 minutes, so it placed itself in the range of medium rumination length of the examined cows. The average milk performance was 26,12 kg, whereas content of individual milk components was as follows: fat (3,98%), protein (3,44%), lactose (4,84%), casein (2,65%), dry weight (13,07%).

Table 3. Chosen usability indicators and length of rumination of cows in subsequent lactations.

Group No]	Length of chewing [min]	Length of lactation [days]	Statistical measurements	Milk [kg]	Fat [%]	Protein [%]	Lactose [%]	Casein [%]	Dry matter [%]	Urea [mg/l]	First calving [days]	Length of inter-calving period [days]
1	126	421	LSM	26.12^{a}	3.98^{a}	3.44	4.84	2.65	13.07	289	861^{a}	422^{a}
			Sd	3.21	1.20	0.89	0.79	0.95	2.78	74.23	86.32	128.73
2	127	469	LSM	30.71^{b}	3.79	3.49	4.81	2.68	12.89	312	884	391^{b}
			Sd	2.44	2.27	0.97	0.79	0.84	1.99	99.23	86.52	118.13
3	152	481	LSM	29.70^{b}	3.72^{b}	3.41	4.75	2.64	12.78	302	907^{b}	375^{c}
			Sd	2.55	1.23	0.69	0.51	0.60	1.36	85.31	93.17	108.13

a,b – $p \leq 0,05$

In group 2 there were 26 cows in the second lactation; the average day of lactation was 127 days here. The average rumination length in this group was higher in comparison to group 1 and amounted 469 minutes. This group

was characterised by the highest milk performance; the average milk production was 30,71 kg, so it was 4,59 kg of milk higher than group 1 result. The milk components content was as follows: fat (3,79%), protein (3,49%), lactose (4,81%), casein (2,68%), dry weight (12,89%).

Group 3 consisted of 23 cows in 3rd and later lactations. Averagely, those cows were in their 152nd day of lactation (Table 3). The average rumination length here was 481 minutes, thus it was the highest of all the analysed groups. Daily milk performance was averagely 29,70 kg, whereas content of individual components in this group was lower than earlier groups and looked as follows: fat (3,72%), protein (3,4%), lactose (4,75%), casein (2,64%), dry weight (12,78%).

Performed analysis shows that as the age of cows increased, the time spent on rumination increased also from 421 min/day (gr. 1), to 481 min/day (gr.3). The highest milk performance appeared in cows in 2nd lactation, with the average performance of 30,71 kg of milk. It was also observed that as lactation progressed fat content in milk decreased slightly from 3,98% (gr.1) to 3,72% (gr.3) and a small decrease in lactose level was also noted. Dry weight was characterised by a higher decrease, which as lactation progressed decreased by 0,29%.

Summary. In the research concerning rumination length in dairy cows it was shown that the increased rumination length had a positive impact on good milk performance. It appeared as follows: with 336 minutes of rumination per day the daily milk performance was 26,95 kg, with 422 min/day – 28,72%, increasing to the level of 31,20 kg of milk with 514 minutes of rumination per day.

The urea level was similar in each of the groups (about 300 mg/l), proving that the rumination length has a small impact on its content. Larger share of protein in the feeding dose is of higher importance here. The connection between the age at the day of first calving and rumination length was also noticed. Cows beginning their use at the age of 941 days were characterised by the shortest rumination and at the age of 837 days the highest. The time spent on rumination decreased in subsequent phases of lactation and was shortest at the 342 day of lactation, amounting 423 minutes. A decrease in performance and content of components appeared in cows over the 150th day of lactation. In research it was also shown that the longest rumination length appeared in multiparous cows (481 min/day) and the shortest in primiparous cows (421 min/day). Whereas, the highest milk performance (30,71 kg of milk per day) appeared in cows in 2nd lactation. The impact of rumination length on the length of calving interval was not proven as it was similar in each of the groups.

In summary, it can be assumed that the assessment of activity and length of rumination process allows breeder to determine milk usability indicators of owned herd and is a basis to match rumination length with threats of some metabolic disorders. Breeder analyses the so-called "rumination quality" of his cows and can determine if their health condition is proper. Such state has a beneficial impact on cow productivity, decreases treatment costs thus allowing to avoid financial losses connected to milk production.

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