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The human factor's impact on the process of milking

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Abstract. This article explores the results of measurements that monitor human impact on the process of milking. Milk is an animal product that is intended for direct consumption but also for further processing. After obtaining milk from the mammary glands of dairy cows, it is treated so that it can be distributed to the customer in many forms. The customer may choose from a wide range of dairy products, which include milk as well as cream, cheese, yoghurt, etc. Large quantities of quality milk (from which other products are manufactured in consecutive steps) are used to satisfy the demand of consumers. The quantity and quality of cow milk is important for both the consumer and producer. This article discusses measurements focused on the effort of improving the preparation of cows before milking. This is the most important operation to ensure the best and fastest way of milking. A procedure for the preparation of the udder was proposed on the basis of professional literature and then measurements were performed in a building with a herringbone parlour. After evaluation it was revealed that the periods of milking were too long because insufficient preparation before milking. The performed measurements showed that when the udder had been prepared in the recommended way, the entire milking process showed significantly better results (shorter times of milking). The human factor can be therefore considered to be the milkers' behaviour towards the animals. It affects the welfare of dairy cows. We therefore recommend using the suggested process for preparing the udder.

Key words: herringbone parlour, milking equipment, mammary gland, teat cups, milking procedure, milking preparation.

INTRODUCTION

Milk is one of the most important components of food in our life. Humans and all other mammals world-wide feed on milk from their birth. All young mammals are fed by their mothers with milk (with colostrum at the beginning) from the mammary gland. However, milk accompanies humans also in other stages of life. Humans are the only adult mammals who consume the milk of other mammals (cow, goat, sheep, etc.). The most frequently consumed milk is cow milk. It contains easy-to-digest proteins, vitamins and minerals. It is almost an everyday part of our menus. The main way of obtaining milk is currently through milking machines in milking parlours (Gaworski & Leola, 2015). Machines do most of the work for people. They are constructed so that they copy the natural way young animals suckle and harm the adult animal to the smallest possible extent. Although these machines are already almost perfect, a lot of human work is still

needed for their servicing. The most significant task of a person performing machine milking is to ensure the necessary quiet conditions for the dairy cows and prepare them before milking. In terms of milk ejection, perfect udder stimulation before milking is necessary, as it leads to larger quantities of healthy milk being produced (Šimon et al., 2013; Rajaniemi et al., 2015).

The most important factors directly affecting the milking process include:

- Human impact–the milkers' behaviour towards the animals is always important, it affects the welfare of the dairy cows and the resulting performance. The milker should be friendly and calm and must not endanger the animal in any way.
- Udder stimulation impact–good stimulation contributes to faster and better milking, and it is therefore necessary to observe the correct procedure for udder preparation.
- Milking under-pressure impact–under-pressure should not be too high, as it can lead to teat damage. Too low under-pressure, on the other hand, leads to the lengthening of milking time, incomplete milking and subsequent decrease in performance. The average under-pressure should be around 32 kPa (50 kPa is the limit). The under-pressure should not fluctuate (Přikryl & Maloum, 2010; Přikryl et al., 2015).
- Pulsation impact and its ratio–the pulsation ratio has a positive impact on the duration of milking; with increasing pulsation the occurrence of mastitis decreases but the number of teat injuries increases (the optimal pulsation value is 60:40).
- Teat collar impact–these parts of milking machines, which are in direct contact with the dairy cow's teats, must be in perfect condition so that their defects would not disturb the milking process (for example, due to the set dropping, etc.) and their sizes must also be in correspondence with various teat sizes.
- Teat disinfection impact–using disinfection is an important step to prevent the occurrence of mastitis. Bacteria occur on teats and multiply if there is teat damage, which can lead to an infection. Disinfection immediately after milking causes the channel to close and the danger of transferring infection inside the teat is reduced.
- Impact of the time of milking in the parlour throughput–it represents the number of cows milked with one set of milking equipment per hour (Tančin et al., 2001).

The initial durations of milking measured were too long and above the recommended limit, which is why we investigated the possibilities of improving this process.

MATERIALS AND METHODS

Preparing the mammary gland before milking is the most important operation within the entire milking process. It has a hygienic, physiological and preventive function. The procedure focuses on tissues related to milk ejection. The main task is to stimulate the dairy cow's udder so that the greatest possible amount of the oxytocin hormone could be released and the milking could be as effective as possible. Oxytocin is released approximately one minute or one and a half minutes after the milker's first touch. This time limit must be observed and all necessary acts must be carried out within that time limit. Good preparation and stimulation of teats increases the pressure in the udder, the cow is milked in a better and faster way. The benefits of this are that the cow is in better health and the obtained milk has greater benefits. Preparation before milking

should be performed as follows (BouMatic, 2015): expressing the first milk; teat disinfection; teat cleaning and drying (stimulation).

All these operations must follow each other directly so that the time of stimulation by the milking machine fitting is maintained at a stable level (60–90s in the optimal case). Expressing the first milk means at least 6 control streams for each quarter. Thus most infected milk that could be produced between the individual milking sessions due to poor hygiene will be removed from the milk tank. Udder health and milk quality must be also checked. The colour and consistency of milk must be inspected. The first part of milk should be tested in a special control cup with a black bottom where any changes can be seen more clearly. Milk should never be expressed to the animal litter, onto the floor or hands of the milker. The first part of milk can help to discover possible inflammations in the udder (mastitis). In case of any suspected mastitis check streams must be performed repeatedly in special testing bowls with four holes into which a special chemical solution is added, which will acquire a different colour if the dairy cow has a disease. After the first part of milk has been milked the teats should be disinfected and subsequently cleaned and dried. This can be done in several ways: using the so-called 'wet toilette' is a less suitable tool and it is not very recommended, as it requires large amounts of water and the repeated use of a single towel, which deteriorates milk quality. The most suitable way known today is treating the teat with a disinfectant and cleaning and drying it with towels after that (Hulsen, 2011). In practice special jars are used for disinfectants (foaming non-returnable disinfectants) and the teats are soaked with the disinfectant located in the upper part of the jar. After repeated pressing the vessel forms foam (Pre-foam+ etc.) from a special solution, which must be spread on the teat and allowed to work for 30 s (or even better for 1 minute) because of the characteristics of the active substance. Thanks to the non-returnable design the vessel prevents the already used solution from flowing back to the flask. After that the teats must be cleaned and dried.

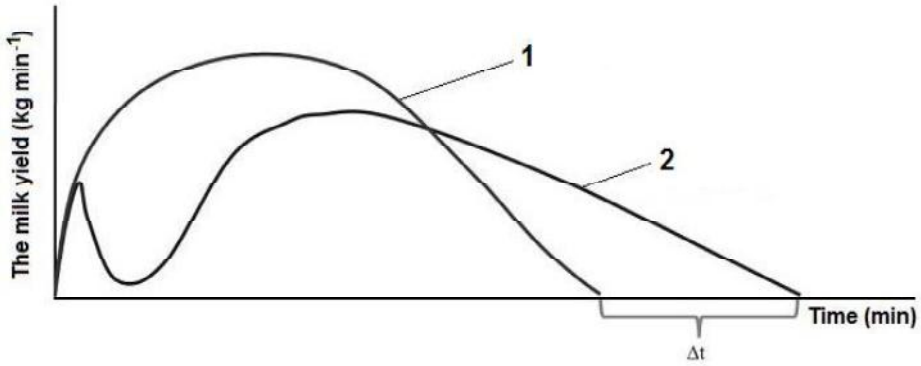
There are also several other options: either using textile towels soaked in disinfecting solutions, which are commonly used to clean the teats and duly washed and disinfected after use, or single-use paper towels, which are currently more frequently used due to their advantages, i.e., one towel is used per dairy cow and discarded afterwards. There is, however, also a third option, i.e., disinfection and cleaning in a single step by means of special towels soaked with a cleaning and disinfecting agent (Sani-WipesTM, etc.). Their advantage is that they make the milkers' work easier, help to prevent mastitis and can be easily recycled. After the first milk is expressed, the teats are treated with these towels and the milking machine can be fitted immediately. During cleaning the teats required stimulation is also performed. Each teat must be massaged with rotating downward directed moves for at least 4–6 s, which helps to stimulate and is also the proper way to clean a teat. Teat tips should be also massaged, as it is where most of the nerve endings can be found. This leads to the maximum filling of teats. The milking machine must be fitted immediately after that (BouMatic, 2015).

RESULTS AND DISCUSSION

In the chart (Fig. 1) it can be seen how the overall milking process should be performed with good preparation before milking, and in comparison, how milking proceeds when the preparation was poor. After having compared both curves, it can be

seen that if the preparations were good, the milking time is much shorter and the entire course of milking is ideal, i.e., the milk flow increases to the maximum (top flow) during the first minutes and afterwards the trend is decreasing. It shows that the oxytocin hormone is well released and it works ideally during the entire milking process. The dairy cow has been fully milked. To the contrary, if the preparation was poor, there are several peak points. The first peak point occurs when milk leaves the milk tank. After it empties, however, the milk flow decreases to zero as oxytocin has not been released yet. It is released after the teats have been stimulated by the teat collars (this can be repeated several times). This, however, leads to a period of dry milking (without milk), which prolongs the milking time and also the effect of under-pressure to the teats that are negatively affected.

Thanks to correct stimulation and observing the proper time for fitting the milking set we should obtain at least 50% of milk within the first two minutes and the overall milking time should not exceed 5 minutes, i.e., it is 15–20% faster than in cases when changes in stimulation occur. If this is achieved, we can be talk about the correct milking procedures leading to increased performance and the minimization of health problems in dairy cows.



Explanatory notes:
1 the curve of proper stimulation (preparation) of the udder (after changes)
2 the curve of poor stimulation (preparation) of the udder (before changes)

Figure 1. Comparison of milking curves with poor and good preparation (stimulation) of the udder (the curves show the final average values of fifty milking sessions).

Over-milking is the main cause of high somatic cell counts in milk. Approximately 0.1 L of milk should remain in each quarter of the mammary gland. So-called dry milking should be prevented. When the milking equipment is removed, the teats must be disinfected immediately. Timely disinfection helps the teat channel to close, which prevents the spread of bacteria. The regular disinfection of teats after every milking contributes to the good health of the udder and prevents mastitis. Measurement were made in a herringbone milking parlour with 2 times 6 milking positions. The milking procedure used in the parlour was as follows:

1. Expressing the first milk–check streaks are expressed after six cows have been led to one side of the parlour. 1 or 2 streaks are usually expressed on the floor below the dairy cows.

2. Disinfecting teats before milking–teat disinfection is performed with disinfectant vessels containing disinfectant agent (preparation 'Pre-foam+' effective in approximately 30 s). Milkers soak the teats in disinfectat before each milking.

3. Cleaning teats–milkers use wet textile towels (previously soaked in water and duly rinsed) for cleaning the udder (teats). During milking the towels are placed in plastic containers. After use the towels are washed using a common washing detergent and reused. A different towel is used for each cow.

4. Milking–after teat cleaning milkers fit the milking machine.

5. Disinfecting after milking–Prepost is used as disinfectant after milking.

The preparation is applied directly on the teat with a disinfecting vessel.The udder preparation is thus not ideal at all in view of current expertise. During the milking procedure measurements were made every second day in the period from October to November 2014 to ensure that milking was performed by the selected group of workers and only during afternoon shifts (9 measurements in total). The target group of this experiment was a group of dairy cows (the most productive) comprising 55 cows. The milk flows were recorded in certain time periods (at 0–15 s, 15–30 s and 30–60 s) and they include the maximum flow and milk flow during the first two minutes of milking. The measured values connected to milking recorded before the suggested changes were made have been provided in Table 1.

Table 1. Measured values connected to milking before suggested changes

Date	Average time per cow (min)	Flow 0–15 s (kg min^{-1})	Flow 15–30 s (kg min^{-1})	Flow 30–60 s (kg min^{-1})	Peak of flow (kg min^{-1})	Milk for the first 2 min (kg)	Milk for the first 2 minutes (%)
19.10.2014	6.3	0.4	1.9	1.7	2.2	5.3	35
21.10.2014	6.4	0.3	1.8	1.5	2.1	4.9	31
23.10.2014	6.5	0.1	1.3	1.3	1.9	4.6	30
25.10.2014	6.9	0.2	1.6	1.3	2.1	4.9	31
27.10.2014	6.2	0.3	2.4	2.3	2.6	5.3	36
29.10.2014	6.3	0.2	2.1	1.8	2.4	5.1	34
31.10.2014	6.5	0.1	1.9	1.6	2.1	4.8	31
2.11.2014	6.2	0.4	2.3	2.3	3.5	5.4	37
4.11.2014	6.3	0.4	2.4	2.2	3.1	5.4	31

The recommended average time in which milking should be terminated is maximally 5 minutes. All values obtained at measurement dates exceed 6 minutes (Fig. 2). These values were the first reason for changing the existing milking tactics. Milking time is very important for the dairy cow. Longer milking time creates significant health complications for the dairy cow's udder and it prolongs the shift of the milkers.

Other important indicators of udder preparation are the following three flow values that indicate milk flows for certain time periods: first at 0–15 s, second at 15–30 s and third at 30–60 s. These three values should have a rising trend during the entire milking time and should never fluctuate. Fluctuation would mean that milking is started after the poor stimulation of the udder and the oxytocin hormone does not fulfil its function in

full. This, however, is visible from the measured values. The following chart shows how the flows at measurement dates before introducing changes decreased during the first minute of milking (Fig. 3).

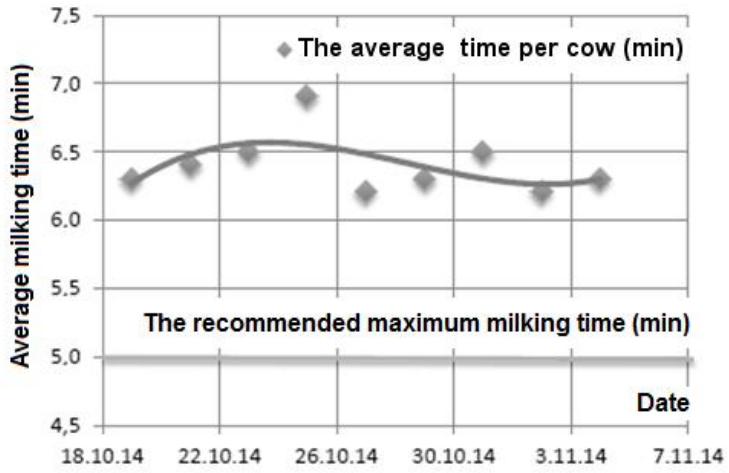


Figure 2. Chart showing the original milking times for the particular days before changes were made.

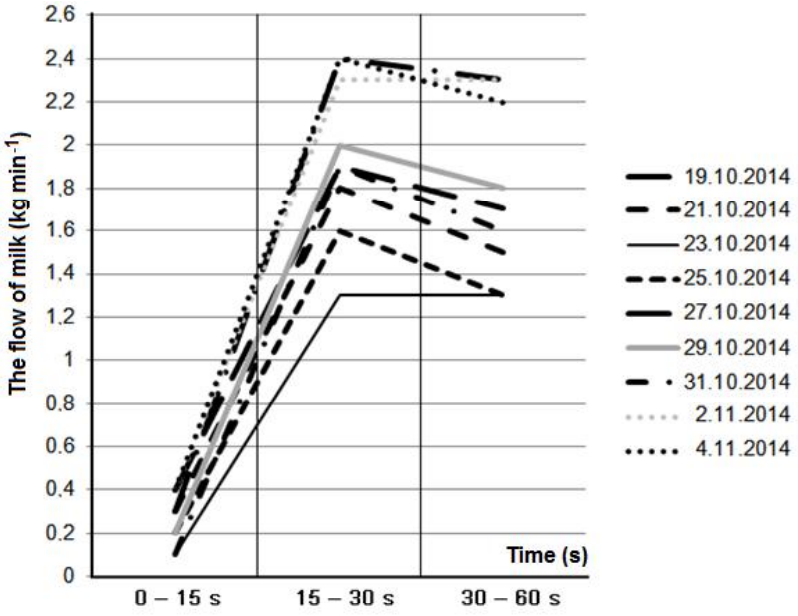


Figure 3. Original chart of flows at individual days before changes were made.

The decrease in the values recorded in the range of 30–60 s before changing the milking procedure compared to the values in the range of 15–30 s is significant. This decrease was most probably caused due to the fact that the oxytocin hormone was not

released as a result of poor udder stimulation, and the amount of milk flowing from the udders started to decrease. This is also the result of poor teat preparation before milking.

The last measured value is the amount of milk received during the first two minutes of milking. A duly stimulated cow udder should release 50% of the overall amount of milk during the first two minutes of milking. It can be seen from the last column of the measured values regarding the group milking outputs on particular measurement dates (expressed in %) that the amounts do not converge at 50% at all, i.e., the required milk output was not reached in either day. We can study the following chart (Fig. 4) for details.

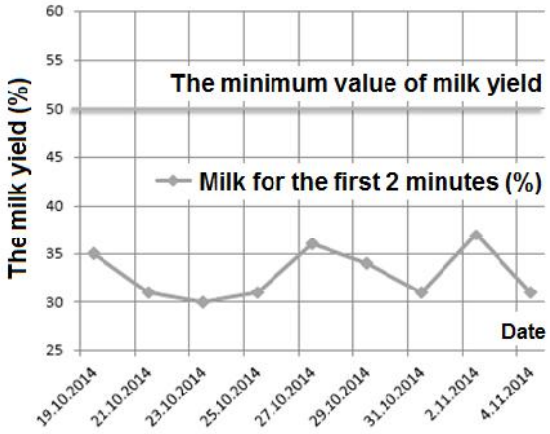


Figure 4. Daily milk outputs for the first 2 minutes before changes were introduced.

The results of this measurement therefore confirm the theoretical presumption that the poor preparation of the udder significantly affects overall milking performance. It can be seen from the originally measured values that this is the case in the milking parlour assessed herein.

Milking time has been exceeded by more than one minute, which means that the pulsating impact on the cow's udder could have been reduced by one minute. This can lead and leads to health problems.

The individual milk flows tend to fluctuate, which is typical for insufficient teat stimulation and failure to release oxytocin to the cow's blood. Udder stimulation reaches quite a low level and leads to poor milking and a significantly longer milking period. The discrepancies described above are the main reasons why this problem occurred. All these mistakes are mainly made by the milkers themselves and, therefore, this problem can be certainly rectified.

The following part includes basic recommendations to improve udder stimulation in the monitored milking parlour, which will lead to the overall better performance of dairy cows and the improvement of their health condition. The proposals have also been tested experimentally in this parlour. The recommended milking procedure involves all theoretical findings on correct milking (and is currently used in the monitored milking parlour). The procedure is as follows:

1. Expressing first streams–milkers always express 6 streams from each teat. The streams are caught in special cups.

2. Teat disinfection before milking–after expression and milk quality checks milkers perform teat disinfection before milking.

3. Teat cleaning and drying (udder stimulation)–milkers clean the teats with wet textile towels soaked in peracetic acid solution.

4. Milking procedure–after the udder is stimulated during cleaning the milking machine is fitted.

5. Disinfection after milking–when the milking machine is removed, milkers perform teat disinfection.

6. Milking machine disinfection–after each milking the milking machine is rinsed with peracetic acid solution.

The values measured during the recommended procedure are provided in Table 2. The table shows that milking time decreased after each measurement. Compared to the 6 minutes measured during the original measurement, the milking time was much shorter, i.e., less than 5 minutes, after training the milkers. Fig. 5 shows total time development.

Table 2. Measured daily milk outputs after the application of the recommended procedure

Date	Average time per cow (min)	Flow 0–15 s (kg min^{-1})	Flow 15–30 s (kg min^{-1})	Flow 30–60 s (kg min^{-1})	Peak of flow (kg min^{-1})	Milk, first 2 min (kg)	Milk for the first 2 min (%)
6.11.2014	6.0	0.5	2.5	2.7	3.6	5.7	38
11.11.2014	6.0	0.4	2.1	2.7	3.5	5.7	37
16.11.2014	5.4	0.7	2.5	2.7	3.0	5.4	40
21.11.2014	5.9	0.6	2.5	2.6	3.1	5.5	41
26.11.2014	5.9	1.0	2.4	2.7	3.1	5.3	40
1.12.2014	5.5	0.8	2.4	2.7	3.0	5.2	42
6.12.2014	5.6	0.7	2.4	2.8	3.0	5.2	40
11.12.2014	5.9	0.6	2.4	2.8	3.5	5.7	41
16.12.2014	5.3	0.8	2.4	2.7	3.1	5.2	41
21.12.2014	5.2	1.0	2.7	3.0	3.3	5.8	43
26.12.2014	5.8	0.7	2.5	2.8	3.6	5.6	40
31.12.2014	5.2	0.9	2.5	2.9	3.3	5.6	43
5.1.2015	4.9	0.8	2.4	2.8	3.2	5.4	51
10.1.2015	5.3	0.8	2.6	3.0	3.4	5.8	42
15.1.2015	4.9	0.8	2.4	2.6	3.3	5.4	49
20.1.2015	5.4	0.7	2.5	2.7	3.1	5.3	39
25.1.2015	5.4	0.8	2.3	2.8	3.2	5.4	44
30.1.2015	5.3	0.7	2.2	2.7	3.2	5.5	46
4.2.2015	5.4	0.8	2.1	2.7	3.1	5.6	49
9.2.2015	5.2	1.1	2.7	3.0	3.4	5.9	52
14.2.2015	5.3	0.9	2.4	2.9	3.6	5.8	51
19.2.2015	5.1	0.9	2.3	2.9	3.4	5.4	48
24.2.2015	5.0	1.1	2.5	3.1	3.6	5.6	52
1.3.2015	4.9	1.0	2.6	2.9	3.3	5.6	46
6.3.2015	4.8	1.0	2.3	2.7	3.2	5.3	48

The first sign of the fact that the milking procedure change has led to positive developments is the reduced milking time, which is nearly the maximum prescribed (5 minutes). Before the milkers' training this time was around 6 minutes. When the milking system and udder stimulation procedure were changed, the milking time started to shorten gradually.

Fig. 5 shows a declining curve displaying the average milking time from October 2014 to March 2015. It can be derived that improved teat preparation affects the length of milking. The shorter the time the better. Other indicators of the situation improving in the monitored milking parlour are the measured flow values for the particular measurement dates during the entire measurement period.

Fig. 5 fully corresponds with Table 2 (but the x axis does not show all measurement dates as in the table).

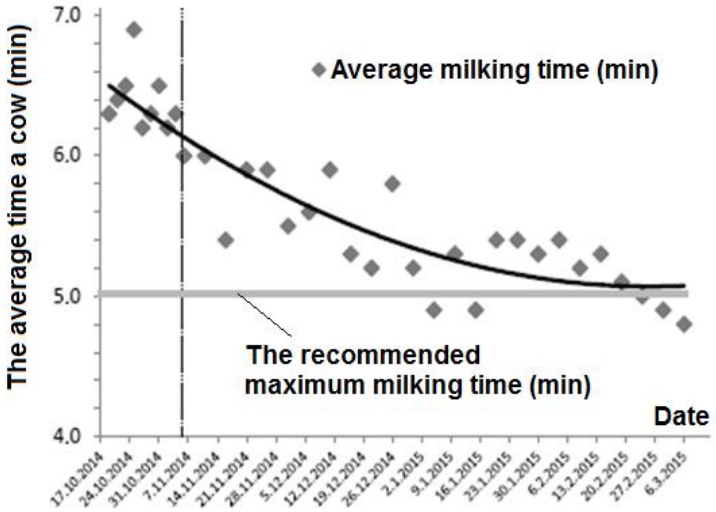


Figure 5. Chart of milking time development.

During all milking intervals the milk flows increased, while the flow values show an increasing trend (Fig. 6).

It means that the required situation has been reached in all milking sessions while the milk flow has gradually increased in the time period from 0 to 60 s. This confirms the fact that if the udder is well stimulated, oxytocin is duly released and great milk outputs are reached. In the first fifteen-second interval the milk flow ranged around 0.3 kg min^{-1}, by the end of this period it increased up to 1 kg min^{-1}. In the interval from 15 to 30 s the original flow amounted to approximately 1.9 kg min^{-1}, after the training it increased to the average amount of 2.4 kg min^{-1}. In the third interval of 30 to 60 s the milk output reached approx. 1.7 kg min^{-1} at the beginning, while at the end of the second measurement it amounted to up to 2.8 kg min^{-1}.

Compared to the measurements performed before the milkers' training, the new values indicated to an ideal situation and no measurements showed flow fluctuations. Owing to perfect stimulation the flows increased up to the top flow that also increased rapidly (Fig. 7) and then decreased very slowly until the milking machine was removed.

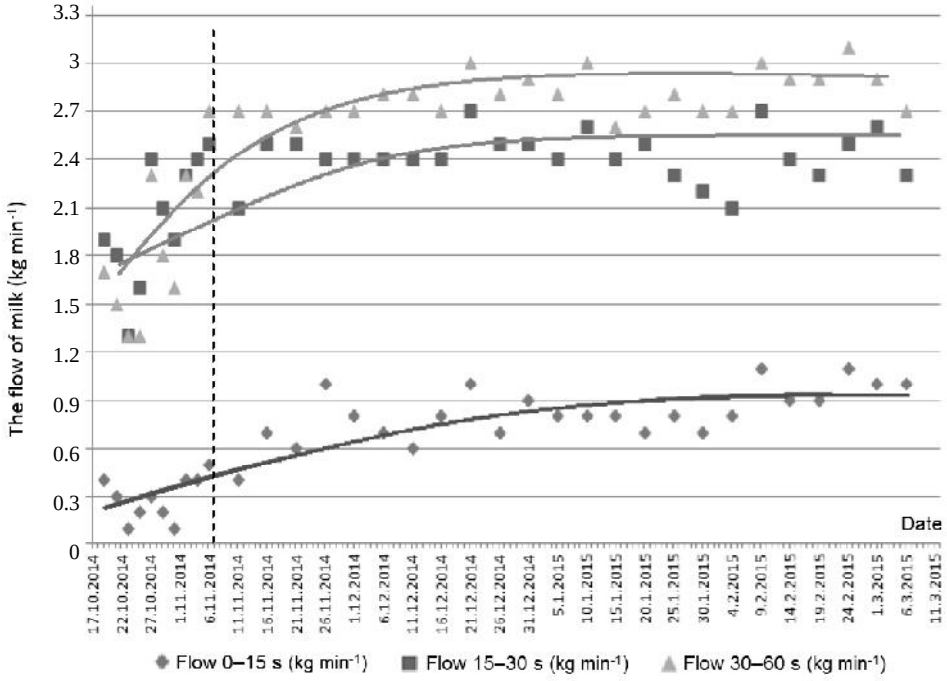


Figure 6. Chart of average flow development for the entire measurement period.

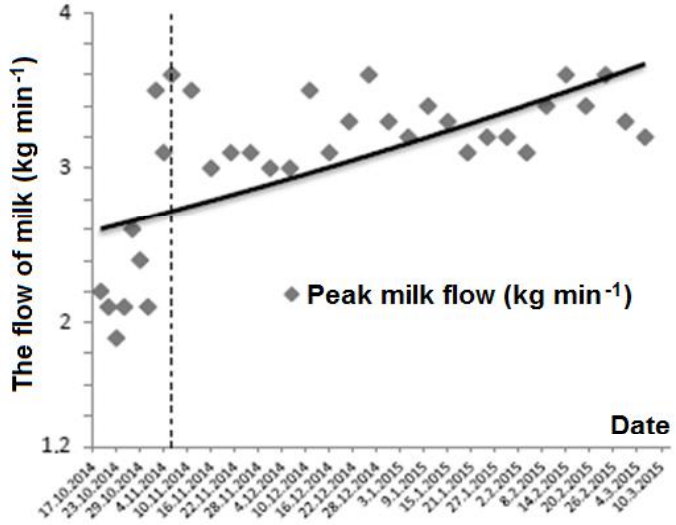


Figure 7. Chart of top flows in the period October 2014–March 2015.

The last value that can be compared in view of the previous measurements is milk output in % during the first two minutes (Fig. 8) of milking. During the first measurements the value was far below the limit, i.e., approximately 35%. After the milkers' training this value gradually increased until it finally reached the required 50%. This is another sign of the good stimulation of the udder before milking.

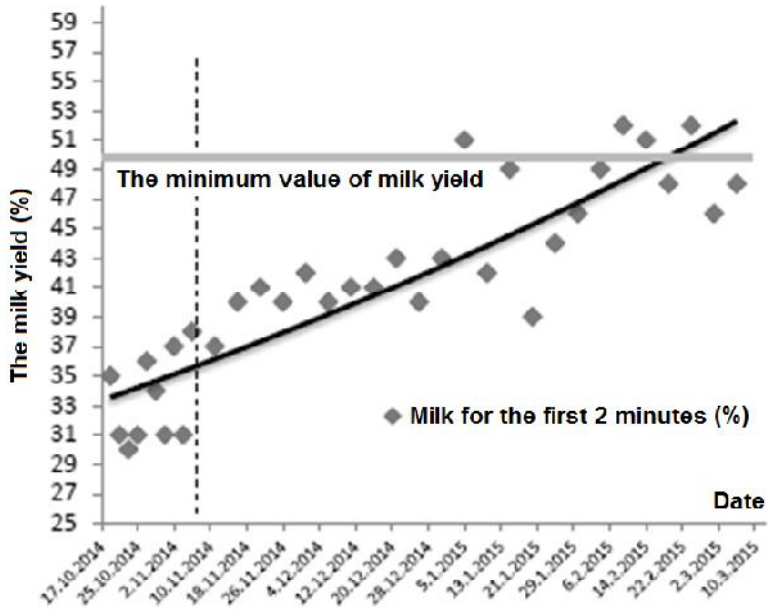


Figure 8. Chart of the milk output development during the first two minutes of milking.

CONCLUSIONS

The purpose of this contribution was to clarify the human impact on the milking process, and more specifically the ways in which people could affect dairy cow preparation before milking. Another task was to assess the most suitable preparation procedure and to recommend it for practical use.

On the basis of expertise on correct milking provided in literature, basic measurements were performed in the monitored milking parlour in the period from October 2014 to March 2015. The measurements were mainly concerned with the issue of milk ejection, which is undoubtedly the most important part of the entire milking process. To ensure fully-fledged ejection, proper udder stimulation must be performed before milking. A herringbone milking parlour with 2 times 6 milking positions was selected for making the measurements. Regular cow (mainly Holstein cattle) milking is performed in this milking parlour. The measured values were obtained with a computer programme. The programme records the overall milking times, flows in time, top flows and flows during the first two minutes of milking. These values clearly show how udder preparation affects the resulting milk output.

The first measurement was performed before changes were made to the milking procedure in the farm. The initial procedure contained five basic steps including wrong stimulation, which was not properly organized and resulted in the wrong performance and diseases of dairy cows. The individual steps were not performed in compliance with the expertise provided in professional literature. The values measured afterwards proved this. The time of each milking before the introduction of changes exceeded the 5-minute limit, which was recommended as the maximum value, by one minute. Flows in the particular time periods fluctuated, which clearly shows the poor stimulation of the udder, and the top flow values were also quite low (around 2.3 kg min^{-1}). The amount of milk

received during the first two minutes did not correspond to the required value of 50% (35% was measured). The measurements showed that the original procedure of udder preparation was entirely unsuitable.

The measurements were made in the same conditions after the introduction of changes, with the exception that before the second measurement the milkers underwent a special training course where they were introduced the proposal for the improvement of the udder preparation procedure before milking. This correct procedure that includes six basic steps was duly observed by the staff during the entire second measurement period. The output values were completely different from the values reached during the previous poor preparation. The milking times improved and fit within the 5-minute limit in most cases. The time flows gradually grew up to the average top flow of 3.2 kg min^{-1}, which is about one litre more than what was initially measured. The percentage of milk output also grew with each measurement and at the end it reached almost 50%.

The results of both measurements confirm that udder preparation before milking is a very important part of the entire milking process. It depends who and how performs the stimulation procedure. Dairy cows can be duly milked only if proper stimulation is performed. If a dairy cow is not ready for milking, it can create a number of complications both for the cow and milker. If we want to get milk with an increasingly higher quality, we should treat dairy cows increasingly better. We also claim that the proposed procedure observes all rules of proper milking and it can be recommended for practical use to get positive results.

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