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Swedish University of Agricultural Sciences
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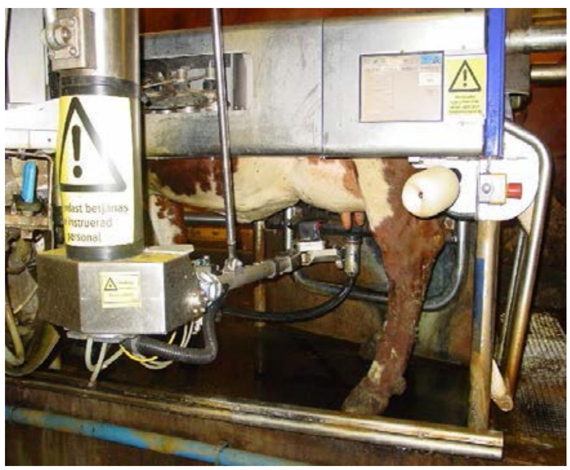

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-milking, feeding during milking, take off level.

<u>Abbreviation key:</u>

- -AMS: automatic milking system
- -VMS: voluntary milking system
- -AMR: automatic milking rotatory
- -ACR: automatic cluster remover

1. Abstract

Feeding during milking has been observed to increase milk yield and milk flow, and decrease milking time. High take off levels compared to low take off levels, measured as g/min at the end of milking has also been reported to increase milk flow. However it is not known how a combination of the two routines influences the milking parameters milk yield, milking time and milk flow. The hypothesis tested was that a combination of feeding during milking and high take off levels increase milk flow and decrease milking time, producing a higher milking efficiency.

A crossover study design was used with four treatments, four groups, and four periods. The four treatments were take off level at 800 g/min + feeding during milking, take off 800 g/min no feeding, take off at 200 g/min + feeding and take off 200 g and no feeding. All cows got all four treatments. The experiment lasted for four weeks and each period lasted one week. 32 Swedish Red cows belonging to the same barn participated in the experiment. Parlor data were captured, summarized, and analyzed from 2322 separate milking sessions.

There was no statistical difference between treatments for the milk yield. The milking time was significantly lower when the high take off levels were used, milking time was reduced with 51.3 seconds in average per cow per milking. The milk flow was significantly increased with the higher take off level. Feeding during milking did not affect milk yield, milking time or milk flow at the high take off level, while a tendency for higher milk flow and shorter milking time was observed at low take off levels when cows were fed concentrate during milking. There was no effect on udder emptying due to treatment.

In conclusion automatic cluster removal at a higher level offers an important potential opportunity to increase parlor efficiency in commercial dairy herds

2. Introduction

Milking cows every day two or three times per day is a heavy and stressful work for the farmer. The milking efficiency has to be high with the purpose to decrease the labor and cost.
Milking efficiency is understood as, the balance between the amount of milk produced and the time it takes to get it, trying to get a the volume of milk that is expect, in the shortest time possible, without causing side effects in any factor within the barn.

The development of the milking machine started in 1862 when the first milking machine was created by the American L. O. Colvin. Thereafter the system for the milk extraction was developed and 1992 the first AMS (Automatic Milking System) was introduced in the Netherlands (Svennersten-Sjaunja and Pettersson, 2008). In 1998 DeLaval produced the first VMS™ (voluntary milking system). The AMS changed the traditional milking work significantly, since reduced labor for milk collection in AMS was required. The AMS also became a time saver for the farmers, since the farmer was able to devote to other tasks, such as management of the dairy cows.

The AMS collects a lot of useful information each milking, such as the milk yield per cow, the time estimated to be milked, and indication of mastitis. To get an indication of mastitis is important since mastitis is the most common and costly disease in dairy cows.

The number of dairy enterprises with AMS has been steadily growing in Europe during the last years. One of the most common reasons for producers to move toward AMS is the expectation of a decreased need for labor. Many studies are therefore related to the performance of the AMS regarding milking efficiency and the effect of automatic milking on the udder health of cows, as well as the cow's adaptability to the robot (Bach et al., 2007).

Studies have been done where the effect of feeding during milking on behavior of cows (Prescott et al., 1998), milk production and the release of the hormone oxytocin (for review see Svennersten and Pettersson, 2008) have been studied. But not many studies are done on how the feeding during milking affects the efficiency in the barn.

On the other hand it is known that programming different take off levels can influence efficiency within the barn, depending on which take off levels that have been chosen (higher or lower take off levels) (Stewart et al., 2002).

Since feeding during milking seems to influence the milk let down and the take off level might have an effect on milking time, it was of interest to test if a combination of feeding during milking and take off level could improve the milking efficiency in the AMS. So to clarify these questions in order to get a better efficiency on the AMS, an experiment was conducted. The objective of the experiment was to evaluate the effects of feeding concentrate during milking in the AMS on milk yield, milking time and milk flow, and evaluate if earlier take off of the teat cups affect the efficiency (milk yield harvested per hour), milk flow and milking time and udder emptying. The hypothesis tested was that the milking efficiency can be improved with high take off level of the cups and feeding concentrate in the AMS.

3. Literature background

3.1 Development of the dairy farming

The dairy industry has changed substantially over the last 100 years. At the turn of the twentieth century, as the general population shifted from small rural villages to larger cities, the need for mass-produced and distributed milk products arose. Since then, significant advances in genetics, milking machines, nutrition, and farm management have combined to create the dairy industry we know today. These improvements have led to a 6-fold increase in average production per cow, considerably greater total annual milk production, and a sharp decrease in total cow numbers from 1900 to the present (Jacobs and Siegford, 2012). Much of the significant advancement in the twentieth century dairy industry has focused on maximizing milk production. AMS and automatic milking rotary (AMR) parlors represent the most recent technological efforts, offering the potential for frequent milking events without depending on human labor. The majority, about 90 %, of AMS are located in northern Europe (de Koning, 2010).

The motivations for installing an AMS can be diverse. The main motivations for the farmers to invest in an AMS rather than in a conventional milking system are: less labor, increased flexibility, the possibility of milking the cows more than twice daily, replacing an employee, or the need for a new milking system (Hogeveen et al., 2001). Data from 2003 showed that farms with an AMS used 29% less labor than farms with conventional milking systems (Bijl et al., 2007). However, as with any other investments, it is crucial to optimize the efficiency of the machine to recoup the costs of the system early. Milk yield, milking frequency, milking interval, teat cup attachment success rate, and length of the milking procedure are important functional aspects of an AMS. Individual cow production and duration of milking unit attachment are particularly important.

3.2 Effect of pre-stimulation and feeding during milking on the milking efficiency

Milking efficiency is a limiting constraint to profitability on many dairy farms. While there are many factors influencing overall milking efficiency and parlor performance, individual cow production and duration of unit attachment are particularly important. One variable affecting milking duration is the pre-stimulation time before the cows are milked. It has been proven that the routine pre-milking stimulation has significant effect to evoke milk ejection and thereby increase milk flow and shorten the milking time (Bruckmaier and Blum, 1998).

Another topic of debate within the use of AMS is the feeding during milking. Studies have concluded that the feeding within the robot increases the motivation for the cows to enter the milking unit, resulting in improved cow traffic within the feeding and the waiting area at the entrance of the AMS (Prescott et al., 1998; Halachmi et al., 2000).

3.3 Take off levels

One variable affecting milking duration is the flow settings at the end of milking, or switch point setting, for the automatic cluster remover units (ACR). The operating principle for ACR is to detach the unit once milk flow has dropped below a preset level, or switch point (g/min). An additional adjustment, usually called the ACR delay time, determines how long time (s) the unit remains attached after the switch point is reached. Historically, cows were considered milked out when the milk flow rate decreased to 200 g/min and most ACR's were set to this level (Ginsberg, 2012). Early studies by Sagi (1978) and Rasmussen (1993) concluded that the cluster can be detached at a flow rate of 400 g/min. Milking time was significantly shorter, with no negative effect on the milk yield and the incidence or prevalence of clinical and sub clinical mastitis. There are some more studies where the ACR switch point setting was gradually increased from 0.32 to 0.59 kg/min (0.7 to 1.3 lb/min). These adjustments coincided with a reduction in average milking duration from 7.8 to 6.4 min per cow and a reduction in total milking time of 30 to 60 min per milking for the entire herd, with milk production staying constant between 38.6 and 39.5 kg/cow per day, supporting the results of the previous studies (Reid and Stewart, 1997). Field experience in commercial dairy farms suggests that deviating from the ACR factory default settings can decrease milking duration while maintaining the quality and volume of milk harvested (Reid and Stewart, 1997; Stewart et al., 1999).

3.4 Milking efficiency in AMS

In some occasions, enterprises with AMS cannot decrease labor needs, because cows must be fetched to attain at least two milkings per day. Milking frequencies of more than twice daily are desired in high-yielding cows because three milkings daily are expected to increase lactation milk yield by 10 to 15% on average (Klei et al., 1997; Osterman and Bertilsson, 2003). The potential increase in milking frequency does not always result in increased milk production, especially in primiparous cows (Speroni et al., 2006). Cows do not visit the AMS the same number of times nor at the same time of the day along their lactation, forcing the udders to store different amounts of milk depending on irregularity of milking intervals. This irregular milking (or visits to the AMS) has been shown to impair milk production, especially in multiparous cows (Bach and Busto, 2005). On the other hand, to improve the number of visits to the milking unit and decrease the need for labor and variation in milking intervals, the AMS manufacturers frequently recommend offering concentrate feeding in the AMS. However, there is no scientific evidence that this practice is efficient (Halachmi et al., 2005).

4. Materials and methods

4.1 Animals and Management

The study was conducted at the Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, at the Swedish Livestock Research Centre in Lövsta, Uppsala. The study was approved by the local ethics committee, Uppsala.

The cows were housed in a loose house system and milked in AMS (Voluntary Milking System™, DeLaval, Tumba, Sweden). The cows had milking permission after seven hours since last milking and if the milking interval was longer than eight hours the cows were fetched to the milking during daytime (from 06.00-20.00). The vacuum level in the milking unit was 44 kPa, pulsation rate 60 cycles/min and pulsation ration 65:35. The cows had free access to grass silage and were fed concentrate according to milk yield.

For the four week long experiment 32 cows of the breed Swedish Red were selected and divided into four groups, combined to have the most uniform groups possible in terms of lactation number, days in milk and milk yield (Table 1). All the cows had a milk somatic cell count below 100 000 cells/ml milk at the start of the experiment.

Table 1. Status of the cows in the four groups at the start of the experiment, mean and range. Each group included 8 cows

Group	Lactation number	Days in milk	Milk yield (kg)
1	1.9 (1 - 4)	152 (84 - 219)	30.0 (21.5 – 46.3)
2	1.9 (1 - 4)	153 (84 - 212)	29.7 (15.8 - 47.4)
3	1.8 (1 - 3)	132 (77 - 210)	29.8 (16.3 - 40.8)
4	1.8 (1 - 3)	158 (103 - 226)	29.9 (22.1 - 39.1)

For the residual milk determination, 16 cows were selected from the groups above and divided in other smaller groups (Table 2).

Table 2. Status of the cows used for residual milk determination, mean and average. Each group included 4 cows

Group	Lactation number	Days in milk	Milk yield (kg)
1	2.3 (1 – 3)	145 (84 - 208)	31.6 (21.5 - 46.3)
2	2.0 (1 – 4)	148 (84 - 212)	33.7 (24.2 - 47.4)
3	1.8 (1 – 3)	120 (77 - 169)	32.4 (25.6 - 40.8)
4	1.8 (1 – 3)	141 (103 - 202)	30.6 (24.1 - 39.1)

4.2 Experimental design

The study included four different treatments (Table 3). The take off level was either 200 g/min or 800 g/min. When the cows received the treatment feeding during milking, they were fed max 2 kg concentrate during milking.

Table 3. The four treatments used in the experiment

Treatment	Description of treatment
A	Take off at 800g/min and feeding
B	Take off at 800g/min and no feeding
C	Take off at 200g/min and feeding
D	Take off at 200g/min and no feeding

All the cows were tested with the four different treatments in a changeover design (one treatment per week per group), (Table 4).

Table 4. Treatment plan for the experiment, groups, weeks and treatment (take off level, g/min, and feeding or not during milking)

Group	Week 1	2	3	4
1	200/feeding	800/no feeding	800/feeding	200/no feeding
2	800/no feeding	200/no feeding	200/feeding	800/feeding
3	800/feeding	200/feeding	200/no feeding	800/no feeding
4	200/no feeding	800/feeding	800/no feeding	200/feeding

4.3 Measurements

A computerized system with software MSSW 14.2+ (exchange hard disk) VC 3033 (software) was used in the AMS. Individual milk production was recorded automatically at each milking by the AMS in terms of milk yield and milking time. Milk flow (kg/min) was calculated by dividing the milk yield by milking duration for each cow at each milking.

For the residual milk determination the cows received an oxytocin injection (intramuscular) on the last day of each treatment (after being milked by the AMS). The routine was as follows:
-oxytocin injection, 25 IU intramuscular
- wait 2 min
- attach the cups manually from a separate milking bucket, milking as long there was a milk flow but max 5 min, thereafter massage on the teats (max 2 min)
- take off of the cups

Residual milk yield was measured using a 1000 ml tube capacity.

4.4 Statistical analyses

T-test was used to test significant differences between the treatments.

5. Results

Parlor data were captured, summarized, and analyzed from 2322 separate milking sessions. The mean milk yield (kg/cow) were 24.9 kg/cow per day (SD = 0.41), milking duration 7,16 min/cow and milking (SD = 0.51), milk flow 3.57 kg/min (SD = 0.24) and residual milk average 8,0 kg (% of milk yield) (SD = 2.21) for all groups over the entire project period.

The milk yield didn’t show any statistical significant difference between the different treatments (Table 5). Regarding the milking time and the milk flow significant differences between the treatments, 1- 3, 1-4, 2-3, 2-4 and a tendency between 3 to 4 were observed (Table 5). There was a big variation both between and within treatments for the residual milk yield.

Table 5. Means and SD for the different treatments on average milk yield per milk day, average milking time, and average milk flow, per milking session

Parameter	Treatment	Mean	SD	T-Test (P- value)
Milk yield (kg/day)	1-800 g/ min feeding (1)	24,82	5,66	1-2=0,859 1-3=0,819 1-4=0,993 2-3=0,779 2-4=0,826 3-4=0,263
	2-800 g/min no feeding (2)	24,71	6,08	
	3-200g/min feeding (3)	25,60	5,24	
	4-200g/min no feeding (4)	24,82	6,24	
Milking time (min/milking)	1-800 g/ min feeding (1)	6,79	1,45	1-2=0,478 1-3=***[1)] 1-4=*** 2-3=*** 2-4=*** 3-4=(*)
	2-800 g/min no feeding (2)	6,68	1,36	
	3-200g/min feeding (3)	7,46	1,66	
	4-200g/min no feeding (4)	7,72	1,89	
Milk flow (kg/min)	1-800 g/ min feeding (1)	3,73	0,81	1-2=0,597 1-3=*** 1-4=*** 2-3=*** 2-4=*** 3-4= (*)
	2-800 g/min no feeding (2)	3,77	0,86	
	3-200g/min feeding (3)	3,53	0,77	
	4-200g/min no feeding (4)	3,25	1,01	
Residual milk (% milk yield)	1-800 g/ min feeding (1)	8,31	6,26	1-2= 0,204 1-3=0,581 1-4=0,237 2-3=0,411 2-4=0,457 3-4= 0,937
	2-800 g/min no feeding (2)	5,56	3,81	
	3-200g/min feeding (3)	7,19	5,60	
	4-200g/min no feeding (4)	10,83	6,83	

1) Statistically significant difference $p<0.001$= ***, $p<0.10$ = (*)

6. Discussion

The current study is the first study performed in dairy herds where the effects of two treatments take off levels and feeding during milking has been combined. The results of the study were consistent with the findings of previous reports regarding take off levels, demonstrating that higher take off levels resulted in higher milk flow and shorter milking time. However, there was no effect of feeding during milking on the milking parameters, only a tendency for higher milk flow and shorter milking time was observed when feeding during milking occurred at low take off levels.

The study showed that with the treatments take of level 800 g/min, regardless if it was combined with feeding during milking or not, reduced milking time on average with 51.3 seconds per cow per milking. It was also found that higher take off levels resulted in higher milk flow with the difference of 0,360 kg per min per milking. The take off level did not affect the milk yield. Taken together the results indicate a higher milking efficiency. It was expected that increasing the ACR to 800 g/min would result in a reduction of the milking time and a higher milk flow per minute compared with treatments ACR 200 g/min, which also have been shown in some previous studies (Reid and Stewart, 1997). Regarding the degree of udder emptying there was no significant differences between the two different take off levels.

The next question was how feeding or no feeding in relationship with take off level could influence the efficiency on the AMS. Earlier studies have indicated that feeding during milking increased milk yield and milk flow (for review see Svennersten and Pettersson, 2008). It has also been shown that feeding during milking attract the cows to the milking unit by increasing their motivation to enter the milking unit (Prescott et al., 1998; Halachmi et al., 2000). There are also some studies that have concluded that an increased amount of feeding in the AMS does not increase milk production, rather that the feeding serve as an incentive for the cows to feel more attractive to go the AMS (Bach et al., 2007). Our study showed that regardless of feeding or not during milking similar results were obtained in all parameters (milk yield, milking time, milk flow) at high take off levels (800g/min) and only a trend was observed for higher milk flow and shorter milking time when cows were exposed to low take off levels (200 g/min).

The last week of the experiment, there was an epidemic virus that affected most of the cows in the barn, thus the experiment was postponed for two. This might have affected the results because, although the cows turned healthy again, they produced less milk than previously.

7. Conclusion

Treatments with take off level at 800 g/min have better milking efficiency than the treatments with take off level at 200 g/min, resulting in higher milk flow and less milking time. There was no effect of feeding during milking on milking efficiency at take off level 800g/min, but a trend for an effect of feeding during milking at take off level 200g/min, with a tendency for a higher milk flow and shorter milking time when cows were fed during milking. There were no differences in udder empty degree due to treatment.

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