Influence of pulsation parameters on milking and udder health of dairy goats

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Summary

Two experiments were carried out on 24 goats each (6 groups of 4 goats) of the two main breeds kept in France : Alpine and Saanen breeds.

In two distinct Latin Square designs, they compared three pulsation frequencies (60, 90 et 120 cycles per minutes) combined with 2 pulsator ratios 50 and 60%. Each period lasted on week.

At each period, milk yield, milking times, average and peak milk flow rates were recorded during two morning and evening milkings consecutively, milk samples were taken for analyse of fat and protein content and SCC and teat end thickness was also recorded once with the cutimeter method and level of oxytocin in blood, before, during and after milking was recorded.

In both breeds, no statistical difference was found on milk yield and composition between de six treatments. The highest pulsation frequencies (90 and 120 cycles/min) combined with the larger pulsator ratio (60%) statistically lead to shorter milking times, shorter lag times, higher average and peak flow rates. On the contrary, every combinations with small frequency and short ratio lead to longer milking times and lower flow rates. Results at the highest pulsation rates could be explained by a better udder stimulation due to a higher level of oxytocin release into blood during the whole milking.

Because SCC and teat end thickness and conditions were not statistically different between the 6 treatments within the two studied breeds, we can conclude that increasing pulsation frequency up to 120 cycles/min with a 60% pulsator ratio would be a good mean in order to decrease individual milking time for dairy goats in Alpine and Saanen breeds.

Key words: *Goats, milking, pulsation, udder health*

Introduction

French goat farmers have two main objectives: a quick milking in order to get more efficiency and less labour time, and in the meantime to secure udder health and especially Somatic Cell Count (SCC). Pulsation characteristics are among numerous parameters able to lead to a quicker milking by improving stimulation of the udder as clearly demonstrated by Marnet et al (2000) on dairy ewes. Nevertheless, oxytocin release due to the stimulation of the udder is surely less crucial for goats than for cows or ewes because around 70 % of the total milk yield is cisternal milk which flows from alveoli to the cistern between milking. Obviously oxytocin is needed in order to get the 30% remaining milk within the acini.

Le Du (1989) thought that it is possible to milk goats at a low frequency similar to the one used for cows (60 cycles/min), but higher frequencies might be useful in order to strengthen the needed endocrinal reflex. However, Lu et al. (1990) showed that the best pulsation characteristics for the Alpine breed seemed to be a pulsation rate of 90 cycles/min with a 60% pulsator ratio. However, these authors advised a 45-52 kPa vacuum level for milking which is very high compared to those used especially used in France.

The main goal of the experiments was to study effects of different pulsation rates combined with different pulsators ratios on milking characteristics and on udder health of dairy Alpine and Saanen goats.

Materials and methods

Two different experiments were carried out at the experimental herd of the National Institute for Agronomical research (INRA) (Le Rheu, France) with two different breeds usually kept in France; the first one in January and February 2000 on Saanen goats and the second one in June and July 2003 on Alpine goats.

In each experiment 24 goats were used and milked on one side of the double 12, 12 units side by side parlour with a low milk line of the experimental farm. The vacuum level was 38 kPa and the cluster used during the two experiments was the Delaval SG 10 with automatic teatcup valves.

Three pulsation rates: 60, 90 and 120 cycles/min combined with 2 pulsator ratios: 50 and 60% were studied as shown in table 1.

Table 1. The different studied pulsation parameters.

Treatment	Pulsation rate (cycles/min.)	Pulsator ratio (%)
1	60	60
2	60	50
3	90	60
4	90	50
5	120	60
6	120	50

6 groups of 4 goats were alternatively milked during 6 weeks at the different studied pulsation rates and pulsator ratios in a specific Latin square design such as it was possible to figure effect of the previous experimental period. Thus, average results presented in the following paragraph will be adjusted means from this calculated effect.

Milking was done twice a day at 6h45 am and 4h30 pm. Clusters were attached immediately without any udder washing or pre-dipping and immediately removed after milk flow stopped.

Milking kinetics were recorded during two morning and evening milkings for the 24 goats. Milk yield was measured every 1.5 seconds and recorded every 3 seconds. The following parameters were directly recorded or figured from the milking curves: total milk yield (TMY), total milking time (without overmilking) (TMT), lag time (between attachment and beginning of milk flow) (LAG), milk flow rate during the first minute of milking without overmilking and lag time (MF1), real average flow rate (without lag time and overmilking) (RFR), peak flow rate (PFR), plateau of peak flow rate (average maximum peak flow rate during at least 9 seconds) (MAXPLAT), time during attachment of cluster and the beginning of the plateau (TPLAT) and duration of the plateau (DUR). Milk samples from each goats were taken as usually during one evening and one morning milking and milk analysed for fat and protein content and Somatic cells count. Teat end thickness was also recorded with a cutimeter (Hamann and Mein, 1990). During the first experiment with the Saanen goats, oxytocin level in blood was measured during two consecutive milkings (one morning and one evening) on 12 goats among 24 (2 by group of 4) (Marnet et al., 1994). Oxytocin was recorder 5 minutes before milking, at the attachment of cluster, after 30, 60, 90 and 180 seconds of milking and 6 and 12 minutes later.

In addition, after the last experiment on Alpine breed, the milking machine was adjusted with the 120 cycles/min pulsation rate and the 60% pulsator ratio during 2.5 months. Somatic cells cont and teat end condition were recorded at the beginning and at the end of this period.

Results

During both experiments, neither during morning milking nor during evening milking, any statistical difference on TMY was found. TMY was in average within the range of 1.74-1.82 litres at morning milking and 1.20-1.28 litres at evening milking in Saanen breed and in average within the range of 1.35-1.41 litres at morning milking and 1.03-1.08 litres at evening milking in Alpine breed. No difference where noticed on milk composition (fat and protein contents). Fat content was within the range of 3.25-3.41% for Alpine and 3.66-3.81% for Saanen breed. Protein content was within the range of 3.17-3.24. for Alpine and 3.12-3.23% for Saanen breed.

Statistical differences were found on TMT between the studied pulsation parameters (table 2). Except during evening milking for Alpine breed (no statistical difference between each treatment), milking time was the lowest when pulsation rates and pulsators ratios were the highest (treatment 5 and 3 with pulsation rate respectively 120 and 90 cycles/min with 60% pulsator ratio). Pulsation rates of 60 and 90 cycles/min with a 50% pulsator ratio led to the highest TMT.

Table 2. Influence of pulsation parameters on TMT (time in seconds).

Milking	Breed	Treatments					
Morning	Alpine	3	5	6	1	2	4
		166^{a}	171^{ab}	177^{abc}	180^{abc}	185^{bc}	189^{c}
	Saanen	5	3	6	1	4	2
		172^{a}	190^{a}	196^{ab}	198^{ab}	205^{bc}	215^{c}
Evening	Alpine	5	4	1	3	6	2
		135^{a}	139^{a}	139^{a}	142^{a}	145^{a}	153^{a}
	Saanen	5	3	6	1	2	4
		138^{a}	144^{ab}	146^{ab}	147^{ab}	160^{b}	161^{b}

Values with different letters within the same line indicate significant differences ($P<0.05$)

The lag time (LAG) elapsed between attachment of cluster and the beginning of milk flow is a typical characteristic of small ruminants. When significant statistical differences were found (both breeds in morning milking and only in Alpine breed in the evening milking), the shortest lag time was noticed for treatment 5 firstly and treatment 3 secondly. LAG with treatment 5 lasted around 15 seconds and with treatment 3 around 17 seconds (table 3). Furthermore, highest LAG were noticed for treatment 1 and 2 (60 cycles/min) but also for treatment 4 and 6 (90-120 cycles/min and 50% pulsator ratio).

Table 3. Influence of pulsation parameters on LAG time (in seconds).

Milking	Breed	Treatments					
Morning	Alpine	3	5	6	1	2	4
		166[a]	171[ab]	177[abc]	180[abc]	185[bc]	189[c]
	Saanen	5	3	6	1	4	2
		172[a]	190[a]	196[ab]	198[ab]	205[bc]	215[c]
Evening	Alpine	5	4	1	3	6	2
		135[a]	139[a]	139[a]	142[a]	145[a]	153[a]
	Saanen	5	3	6	1	2	4
		138[a]	144[ab]	146[ab]	147[ab]	160[b]	161[b]

Values with different letters within the same line indicate significant differences (P<0.05).

Milk flow rate during the first effective minute of milking (without overmilking and lag time) (MF1) was similar to the lag time: the highest flow rates were noticed when milking with the highest frequencies (90 and 120 cycles/min) and the widest ratio (60%). Treatment 5 could led to the highest flow rate in Alpine breed (morning milking) and in Saanen breed (evening milking). Treatment 3 was equivalent to treatment 5 in Alpine breed (evening milking) and in Saanen breed (morning milking) (table 4). For example at the morning milking, MF1 raised of 21.5 % from treatment 2 to treatment 5 (opposite results) and of 16.7 % from treatment 6 to treatment 5 (same pulsation rate but two different ratios in Alpine breed). Treatment 2 (60 cycles/min and 50% ratio) always led to the lowest flow rate.

Table 4. Influence of pulsation parameters on MF1 (l/min).

Milking	Breed	Treatments					
Morning	Alpine	2	6	4	1	3	5
		0.712 [a]	0.741 [ab]	0.746 [b]	0.746 [b]	0.816 [c]	0.865 [d]
	Saanen	2	4	1	6	5	3
		0.620 [a]	0.625[a]	0.655 [ab]	0.691 [ab]	0.703 [b]	0.727 [b]
Evening	Alpine	2	4	6	1	5	3
		0.700 [a]	0.755 [ab]	0.760 [ab]	0.800 [b]	0.857 [bc]	0.897 [c]
	Saanen	2	4	1	6	3	5
		0.635 [a]	0.690 [ab]	0.711 [bc]	0.733 [bcd]	0.773 [cd]	0.797 [d]

Values with different letters within the same line indicate significant differences (P<0.05).

The peak flow (PFR) was measured as the highest flow recorded during 3 seconds. Tables 5 shows the same response to the different treatments as previously seen for LAG and for MF1 of milking. In addition, treatment 5 led to the highest peak flow except for Saanen breed at the evening milking where it was similar to the one noticed for treatment 3.

Table 5. Influence of pulsation parameters on PFR (l/min).

Milking	Breed	Treatments					
Morning	Alpine	2	6	4	1	3	5
		0.907 ^{a}	0.941 ^{a}	0.958 ^{ab}	0.998 ^{bc}	1.025 ^{cd}	1.069 ^{d}
	Saanen	2	4	1	6	3	5
		0.881 ^{a}	0.907 ^{ab}	0.948 ^{bc}	0.964 ^{bc}	1.002 ^{c}	1.057 ^{d}
Evening	Alpine	2	4	6	1	3	5
		0.922 ^{a}	0.941 ^{a}	0.967 ^{ab}	1.004 ^{b}	1.016 ^{b}	1.094 ^{c}
	Saanen	2	4	1	6	5	3
		0.809 ^{a}	0.856 ^{a}	0.929 ^{b}	0.946 ^{b}	0.965 ^{b}	0.980 ^{b}

Values with different letters within the same line indicate significant differences ($P<0.05$)

From treatment 2 (the lowest peak flow) to treatment 5 (the highest peak flow), PFR raised approximately from 18% up to 20% in both breeds at morning and evening milking respectively. In the meanwhile, PFR raised from 10 up to 21 % from treatment 2 to treatment 3.

The level of the plateau (MAXPLAT) was also figured as the highest flow rate between at least 3 consecutive recordings representing 9 seconds. A very similar classification of the studied treatments was obtained.

Time elapsed between the attachment of cluster and the beginning of the plateau (TPLAT) showed also the same classification: the shortest time was noticed for treatments 5 and 3. Duration of the plateau (DUR) was inverse of MAXPLAT; DUR was the shortest when using treatments 3 and 5 which led to the highest MAXPLAT.

SCC in milk samples hand taken at each period for each goats were analysed and the difference of teat end thickness between after and before milking was calculated in order to investigate possible effects of one or several treatments on udder and teats health. SCC were transformed into logarithms for statistical analysis but no difference were found between the six studied treatments.

Difference in teat end thickness shown in table 6 is related to the morning milking. No statistical difference was found especially because of the high variability of results as a consequence of the great differences in teat morphology and of response of animals. In addition, table 6 shows a different classification and different results for both right and left udder halves and within the two breeds. These results show that there was no marked effect of the different treatments on teat end thickness. However, it can be noticed that every values are positive. That indicates that teat end after milking is, in average, always thicker than before milking. This is a specific characteristic of goats which can be explained by more or less congestion due to a bigger sensitivity to milking than cows and ewes.

Table 6. Influence of pulsation parameters on teat end thickness (difference after-before morning milking in mm).

Udder half	Breed	Milking	Treatments					
Right	Alpine	morning	4	5	6	1	2	3
			0.19 a	0.26 a	0.28 a	0.38 a	0.38 a	0.39 a
		evening	5	4	3	1	2	6
			0.24 a	0.30 a	0.30 a	0.35 a	0.35 a	0.43 a
Left	Saanen	morning	4	6	1	2	3	5
			0.10 a	0.19 a	0.21 a	0.23 a	0.31 a	0.32 a
		evening	6	2	1	4	5	3
			0.09 a	0.15 a	0.19 a	0.20 a	0.37 a	0.49 a

Values with different letters within the same line indicate significant differences ($P<0.05$)

Discussion

Average data of this study related to milk yield, milking time, lag time and flow rates (during the first minute of milking, peak flow and plateau level) are very similar to those mentioned by Billon et al. (2000) in a general study of milk ability of goats for the two studied breeds.

There is no particular influence of the pulsation characteristics on milk production and composition which indicates that stimulation of the udder by the milking machine seems to be sufficient even when using small pulsation rate to get the 30% alveolar milk still remaining in the acini before milking. No stripping was done during the two experiments and contrary to ewes, there is no tendency for a more complete milking when using high pulsation rates (Casu and Carta, 1974; Le Du and Benmederbel, 1985).

Milking times and flow rates are greatly influenced by the pulsation characteristics. The highest pulsation rates combined with the largest studied pulsator ratio lead to the shortest machine on time, lag time and the highest milk flow rates (average milk flow rate and flow rate during the first minute of milking, peak flow and plateau level).

Shorter milking time can be explained by the highest milk flow rates noticed during the study. Influence of the pulsator ratio is very high since most of the studied flow rates were the lowest when using treatments 2, 4 and 6 with the smaller ratio (50%). It seems obvious that because the ratio is more important, time when the liner is open and milk is flowing is greater leading to a higher flow rate. Our results are in accordance with Ricordeau and Labussière (1970) who showed that the average milk flow rate raised to 23% when moving from the 50% ratio to 60%.

When using a 60% pulsator ratio, machine on time and lag time were the lowest and milk flow rates the highest with the highest pulsation rates. Additional measurements of liner movements were recorded with a flow simulator with artificial teats at 1 and 1.5 l/min milk flow rates respectively with 90 and 120 cycles/min pulsation rates. Results showed that within 1 second milking, time when the liner is fully open is higher at 90 cycles/min than at 120 cycles/min (respectively 410 and 360 ms at 1 l/min milk flow rate and 415 and 380 ms at 1.5l/min milk flow rate). In addition, if we consider that milk approximately begins flowing when the liner is half open and flow stops when the liner is half closed, time during which milk effectively flows respectively lasts 528 and 522 ms at 90 and 120 cycles/min with a 1l/min milk flow rate and 522 and 516 ms at 90 and 120 cycles/min with a 1.5 l/min milk flow rate. That indicates that milk flows during a nearly similar time (difference not more than 10 ms) when using 120 cycles/min compared with 90 cycles/min.

These results may explain why no large difference were noticed in results with 90 and 120 cycles/min. However, oxytocin concentration in blood was always higher after stimulation and during the whole milking when using 120 cycles/min pulsation rate. That may indicates that the highest pulsation rates could lead to a more intensive and persistent stimulation of the udder inducing a higher intra mammary. Long-term experiments should be undertaken in order to investigate the effects of the highest level of oxytocin in blood noticed with the 120 cycles/min pulsation rate during several consecutive lactations.

If milking with higher pulsation rate and pulsator ratio seems to have a great interest for farmers who want to get a better efficiency in their milking parlour, we have to ensure that these new adjustments do not lead to worst teat end conditions, more clinical mastitis and more SCC. Results of the two experiments showed no difference between treatments in teat end thickness and SCC. However, the Latin square design with 6 period of one week was not a good enough experimental plan to investigate results related to udder health.

After the second experiment with Alpine breed, the milking machine was adjusted with a pulsation rate of 120 cycles/min with a 60% pulsators ratio and the whole herd (around 90 goats) was milked with these adjustments during the rest of the lactation (2.5 months). Milk samples were analysed for SCC and teat end conditions for the 24 Alpine goats involved in the previous study were recorded .

No particular evolution of SCC was noticed and most teat ends were similar to the one shown on figure 1 with a black spot which looks like hyperkeratosis but which is very common on goats at the end of their lactation. This cannot be considered as a particular trouble due to the pulsator adjustments.

However, duration of the experiment was too short (2.5 months) and period no adequate (end of lactation); so longer observations should be undertaken in order to ensure that high pulsation rate and wide pulsator ratio do not lead to udder health troubles.

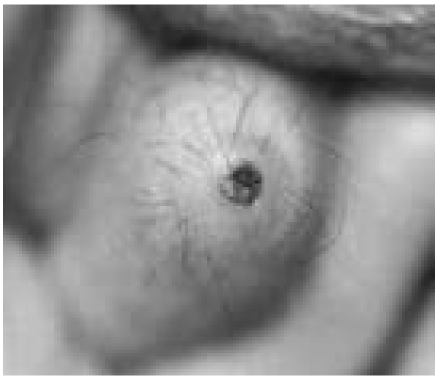

Figure 1. Teat end of goats at the end of lactation.

Conclusion

Pulsation characteristics have a great influence on dairy goats milking, especially regarding milking times and flow rates.

Low pulsation rate (60%) and short ratio (50%) are not adequate for milking Alpine and Saanen goats. On the contrary, the wider 60% ratio is strongly recommended combined with a pulsation rate of 90 or 120 cycles/min. 120 cycles/min pulsation rate can be advised in order to milk quicker and to improve efficiency of labour.

However, further researches are needed in order to ensure that high pulsation rates do not lead to udder health troubles.

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