

# Influence of low vacuum levels on milking characteristics of sheep, goat and buffalo

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## Abstract

Different settings of the operating parameters (pulsator rate, pulsator ratio and vacuum) are used for milking dairy species in different parts of the world. The level of the operating vacuum in machine milking is one of the principal factors which influence the integrity of the tissues and the milk quality. High vacuum levels (>42 kPa) are often used to facilitate the opening of the teat canal by overcoming the biological closing forces within the teat sphincter, but can result in severe machine-induced teat tissue damage. In this study characteristics and performances of mechanical milking at low vacuum levels have been investigated in different dairy species. Milking times and milk productions have been obtained from milk emission curves, recorded by electronic milk-meters (LactoCorder®) during the milking at different vacuum levels of sheep, goats and buffaloes. The results of the comparative experiments clearly indicate that a low vacuum level modifies the kinetics of milk emission, the machine-on time and, thus, the throughput of milking system, in all the dairy species considered. Milk yield was satisfactory at any level tested, showing that low vacuums can be adequate to completely empty the udder. Slight differences were found across species concerning the increase in the milking time per head associated with low levels of milking vacuum. Our study represents a contribution to encourage the decrease of the working vacuum during mechanical milking, also for those dairy species generally considered hard to be milked, as buffaloes. Milking

should be performed applying the lowest vacuum level, compatible with not excessively prolonging milking time, in line with the animal welfare on dairy husbandry.

## Introduction

There are three operative parameters that regulate mechanical milking: working vacuum, pulsator

rate, and pulsator ratio. In general, the parameters of the pulsations are specific for each species of animal, while the vacuum is regulated on the basis of the type of milking system (high and low level) and the customs of the country and area (Billon *et al.*, 1999).

High vacuum levels (>42 kPa) are often used to facilitate the opening of the teat canal by overcoming the biological closing forces within the teat sphincter, but can result in severe machine-induced teat tissue damage. These vacuum levels seem to be extremely high when compared with the vacuum needed to open the teat canal in Sarda sheep (26 kPa), Lacaune sheep (25.0 to 35.9 kPa; Marnet *et al.*, 1999), the mountain Greek breed Boutsiko (16.59 kPa; Sinapis *et al.*, 2007), Saanen goats (34.6 kPa; Le Du and Benmederbel, 1984), and buffaloes (over 30 kPa; Aliev, 1969).

High vacuum levels can cause several undesirable effects in small ruminants, such as an increase in somatic cell count (Sinapis and Vlachos, 1999; Le Du, 1983, 1985; Pazzona and Murgia, 1993) even when combined with a low pulsator rate (Fernandez *et al.*, 1999). By contrast, Peris *et al.* (2003) reported that in the short term neither somatic cell count of the milk nor teat thickness changes were affected by differences in vacuum level (36 vs. 42 kPa). It is well known that application of the vacuum slows blood circulation in the teat tissue, thus influencing its temperature. Recent studies (Stelletta *et al.*, 2007) have shown that the teat returns to its normal physiological temperature more rapidly if the milking vacuum is reduced. Increase in milking time and increased frequency of the teatcups falling off are the principal negative factors that have up to now discouraged the use of low vacuum (Spencer and Rogers, 1991). In recent years, there has been a tendency to reduce the vacuum level used for milking small ruminants (34 to 36 kPa). In Sardinia, most systems used for milking sheep and goats operate at vacuum levels between 41 and 44 kPa, with a maximum level of 50 kPa (Pazzona and Murgia, 2003).

A positive relationship between increasing working vacuum and the milk SCC has been found in buffalo (Badran, 1992; Pazzona and Murgia, 1992), which confirms preceding works on cows where raising the vacuum from 33 to over 50 kPa had a negative effect on teat condition (Langlois *et al.*, 1980) and increased mastitis incidence (Galton and Mahle, 1980; Langlois *et al.*, 1980; Osteras and Lund, 1988). By contrast, increase in milking time and increased frequency of the teat cups falling off are the principal negative factors caused by lowering the milking vacuum level (Spencer and Rogers, 1991). Because little or

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no cisternal milk is available in buffalos, the animals are often exposed to a long period of vacuum without any ejection of milk. The use of high-working vacuums combined with the absence of milk can cause irritation in the delicate mammary tissues and, thus, stress the animals (Bruckmaier and Blum, 1996).

Buffalo are considered to be slow and hard milkers (Sastry *et al.*, 1988) because of their slow milk ejection reflex and their sphincter muscle around the streak canal is thicker than in cattle (Stahl Hogberg and Lind, 2003). For these reasons the working vacuum applied to buffalo is generally higher than the level used in cows so as to shorten the milking time. In a recent field survey carried out in 189 installations for buffalo milking in Italy, the working vacuum levels varied from 40 to 53 kPa. The most frequent values (45%) ranged between 44 and 46 kPa, whereas only 4% of the installations were set at  $\geq 50$  kPa (Associazione Italiana Allevatori in 2009, Rome, Italy, personal communication).

In line with the current interest in animal welfare, this study investigates characteristics and performances of mechanical milking at low vacuum levels in dairy sheep, goats and buffaloes.

## Materials and methods

### Sheep

A prototype milking system specifically designed to optimize vacuum stability and allow low vacuum milking was used in the experiment. The milking parlor prototype was one platform with 24 sequentially gated stalls, with 12 milking units in a low line system. The technical innovation of the prototype is the internal diameter of the milk line, 74 mm instead of 50 mm normally used for sheep (UNI 11008, 2002). The greater diameter of the milk line optimizes the flow conditions even when air suddenly enters, a very common event during sheep milking due to the short milking time for this species (Pazzona and Murgia, 1997). Stabilizing the vacuum in the milking system minimizes the possibility of the clusters falling off (Pazzona and Murgia, 2001). The milking units were assembled from different types of components, chosen taking into consideration both the suitability of the teatcups for the flock and the total mass of the components. This mass was 490 g, the average mass for clusters commonly used in sheep milking, which vary between 390 and 640 g in mass based on our own survey of eight commercial units. The experiment was carried out on 48 pluriparous Sarda breed sheep. The animals were randomly divided into two groups of 24, and one group was assigned the working vacuum of 28 kPa while the other was assigned the 42 kPa. Milking was performed twice daily at 6.00 a.m., and 6.00 p.m.; for the trial the data was recorded one time a day for three months, at the afternoon milking. During the experiment, the operator's work time for each sheep was measured, including access time and downtime. The milking routine was performed by two operators, each of whom managed six milking units. From these data, the throughput of the milk installation, in terms of sheep milked per hour and sheep milked per man hour, was calculated for both low vacuum and standard vacuum (Pazzona *et al.*, 2009). The milking routine did not include any form of preparation of the udder or mechanical stripping.

### Goats

Comparative tests were carried out to evaluate the effect of the two operative vacuum levels during milking of goats (35 and 44 kPa). Forty Camosciata breed goats were milked in the experiment, using a bucket milking system equipped with two milking units. The data obtained from the test were then used to simulate the milking routine applied in

a 12 stalls in a low-line system, equipped with 12 milking units and automatic cluster removal. The throughput of the milking installation and the operator performance, was calculated for both vacuum levels tested, using the mathematical model developed by Caria *et al.* (2011).

### Buffalo

A herd of 450 milking Mediterranean breed buffalo, in different parity and stage of lactation, were used in the experiment. The milking system was a 2 × 28 parallel parlor with a low-level milking system equipped with a light-weight (1.80 kg) cluster (Harmony Plus, DeLaval, Tumba, Sweden), automatic cluster removers, and electronic herd management system (Alpro system, DeLaval). The cluster was equipped with conic rubber liners and the pulsator rate was set at 60 cycles/min and 65% ratio. The working vacuum was tested for values of 42 kPa and 36 kPa. Milking took place at intervals of 9 h (daytime) and 15 h (overnight). The milking routine involved the attachment of the milking unit, without any preparation of the udder either by pre-stimulation or pre-dipping, and the manual removal of the teat cups without mechanical or manual stripping. During milking the animals were not given any concentrates. The operator work time for each buffalo was measured, including access time and idle/waiting times. These data allowed us to calculate the throughput of the milking system and the operator performance at vacuums of 36 and 42 kPa (Caria *et al.*, 2011).

### Equipment used and statistical analysis

For all the experiments carried on, the milking time (the time from attaching to removing the teat cups) and the milk yield were recorded using electronic mobile milk flow meter (Lactocorder®, WMB, Balgach, Switzerland).

Statistical analysis was carried out by comparing the milking time and milk yield between low vacuums and standard vacuums, using a Mann Whitney *U* test from SPSS (ver. 15.0, Chicago, Ill.: SPSS, Inc.).

## Results and discussion

Table 1 reports the statistics on milking performances of all the dairy species investigated.

The tests on ewe milking have shown no significant differences on milk production (0.49 kg) when milking at 42 and 28 kPa, while milking time increased ( $P < 0.01$ ) passing from 0.94 min to 1.10 min (+17%). This is due to the lower pressure difference across the teat canal exerted by the teatcups on the udder, that lowers the milk flow rate through the teat, prolonging the milking time.

The delay of the milking time for an individual ewe obtained using the vacuum of 28 kPa do not affect so consistently the total session milking time, when the operator managing 6 milking units. The throughput of milking system obtained by specific equations (Pazzona *et al.*, 2009) shows a little difference between the two levels of vacuum: 333 sheep/h at 42 kPa vs 321 at 28 kPa (Table 2).

In goats, in contrast to what is observed in ewes, both the time and the milk produced per milking were increased when lowering the vacuum from 44 to 35 kPa. As a consequence, also for this specie the throughput of the milking system, equipped with automatic cluster removals, as hypothesized in this study, resulted lower than 12 goats/h (-7%) using the vacuum of 35 kPa (Table 2). The difference between the average milk yield/goat per milking was statistically different at the two vacuum levels: 1.24 kg at 35 kPa and 1.05 kg at 44 kPa). These values could be interpreted as the longer milking time due to low vacuum level allows to remove both the cisternal and alveolar milk.

The response of buffaloes to the decrease in milking vacuum was

Table 1. Mean milk production and milking time per all dairy species studied for 2 vacuum levels tested.

	Sheep			Goat			Buffalo		
		P			P		P		
Vacuum (kPa)	28	42	-	35	44	-	36	42	-
N	108	117	-	335	323	-	192	288	-
Milk yield (kg)	0.49	0.49	N.S.	1.24	1.05	< 0.01	3.6	4.1	N.S.
SE	0.01	0.01	-	0.02	0.02	-	0.15	0.14	-
Milking time (min)	1.10	0.94	< 0.01	2.51	2.13	< 0.01	8.13	7.36	< 0.01
SE	1.61	1.49	-	0.04	0.04	-	0.34	0.24	-

similar to ewes. Comparison of the milk yield was not statistically different at the two vacuum levels (Table 1). The average values obtained during our tests, 3.6 kg/milking at 36 kPa and 4.1 kg/milking at 42 kPa, mirror the data recorded in previous studies (Bava and Zucali, 2007; Borghese *et al.*, 2007). The high variability in individual milk production was related to the presence of animals at different stages of lactation.

During the whole milking session, the duration of each phase of the routine was analyzed, to define the operator performance and the milking system throughput as a function of the individual milking time at the working vacuums of 36 kPa and 42 kPa (Table 2). The optimal number of milkers is calculated to ensure the presence of the operator at the end of milking of the first buffalo that has had the clusters attached.

Referring to the 28 + 28 stalls milking system and to the results obtained from the milk curves, the model was applied to a milking routine without pre-stimulation or post-milking treatment, stripping of the udders, and the use of automatic cluster removers set at 0.20 kg/min. Considering 2 milkers, the total herd milking time resulted in 3.25 h at 42 kPa of vacuum and 3.36 h at 36 kPa, corresponding to a throughput of the milking system (*Co*) of 139 and 134 buffalo/h, respectively. Operator performance (*P*) is 69 buffalo/man-hour, at a vacuum of 42 kPa and 67 buffalo/man-hour at a vacuum of 36 kPa, with a difference of 2 buffalo/man-hour.

These results clearly showed that even a vacuum of 36 kPa is more than enough to guarantee that the teat canal opens. By contrast there was a significant increase in milking time (0.77 min) due to a longer latency time and a prolonged time for the complete emptying of the udder. Anyhow, this aspect should be taken into account considering that the duration of milking in cows seems to influence teat tissue reactions less than the high vacuum (Hamann *et al.*, 1993). In farms where the latency time could be shortened by inducing milk let down through pre-stimulation of the udders along with feeding concentrate in parlor, the use of a low milking vacuum level might represent an appropriate choice, considering the advantages which it offers in terms of animal health and well-being.

## Conclusions

The results of the study concerning the effects of dairy milking at low vacuum levels on both milk emission parameters and milking parlour throughput showed that:

- Considerations concerning the effect of vacuum setting on the milking time and consequently the throughput of the milking system, are similar for all three dairy species examined.
- The milking time for small ruminants increased on average by 17.0 – 17.8% using the lower levels of vacuum. In buffalo the milking time

Table 2. Throughput of milking system and operator performance at different vacuum levels as a function of the routine.

	Sheep <sup>1</sup>		Goat <sup>2</sup>		Buffalo <sup>3</sup>	
Vacuum (kPa)	28	42	35	44	36	42
Co (heads/h)	321	333	152	164	134	139
P (heads/man*h)	161	166	152	164	67	69

Co = throughput of the milking system; P = operator performance. <sup>1</sup>Two milkers; <sup>2</sup>One milker; <sup>3</sup>Two milkers.

increased by just 10.5%, probably because of the difference between the vacuum levels tested, that was 6 kPa for this specie instead of 14 and 9 kPa, respectively for sheep and goats.

- As a consequence, the efficiency of milking routine was also influenced by the level of working vacuum. When reduced, it slightly affected the throughput of milking system and the operator performance. The *Co* was decreased of about 12 heads/h, corresponding to 3.6 and 7.3% for sheep and goats respectively. In buffalo milking, the *Co* was reduced of about 3.6%, corresponding to about 7 minutes increase in the time spent for the whole milking session. This short time does not compromise the management of the milking and the farm labour organization, considering that the use of automatic cluster removal strongly reduces the milking time.
- The results obtained show that the choice of setting the milking vacuum at a lower level than those commonly used, for all the species investigated, is not compromised by the slight decrease of throughput, especially if the amount of milk yield per milking is the same as found in sheep and buffalo or even higher (+18%,  $P < 0.01$ , in goats).

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