Milking management of dairy buffalo

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ABSTRACT: In this note, the Authors report a summary of a coming bulletin on milking management of dairy buffaloes published by the International Dairy Federation (IDF). The bulletin includes the following chapters: introduction, milk composition and quality, anatomy of the buffalo udder, physiology of milk ejection, udder health, milking machines for dairy buffaloes, milking routines, milking hygiene, storage of milk, and milk recording. The present paper focuses on anatomy, physiology of milk ejection and how the management around milking can improve milk quality, milk yield and milk flow.

Key words: Milkability, Milk flow, Udder physiology.

Udder anatomy and physiology

The gross anatomy of the mammary gland differs a lot among different species. The number of glands and teats are not the same for the cow, buffalo, sow or the horse. However, the microscopic anatomy is very similar among species. Buffaloes have longer, thicker teats with longer teat canals compared with dairy cows, which is important to consider when milking them with a machine (Sastry et al., 1988; Saxena, 1973; Thomas, 2004a). Sastry et al., 1988 classified the teats of Murrah buffaloes as cylindrical (44%), funnel (35%) and bottle shaped (23%). The length of fore and hind teats ranged from 5 to 14 cm and 8 to 16 cm, respectively. The teat girth ranged from 7 to 14 cm (diameter 2.2-4.5 cm) and 8 to 16 cm (diameter 2.5-5.0 cm), respectively. The Mediterranean Buffalo breed has teat lengths from 6.3 to 8.5 cm (Borghese, 2007). Milk ejection caused more than a 10% increase in the teat length and teat girth (Thomas et al., 2004a).

The amount of cisternal milk in buffaloes is less than 25% of what is reported for cows (Thomas et al., 2004b; Bruckmaier et al. 1994). The cisternal area can be measured two-dimensionally with ultra sound and Bruckmaier & Blum (1992) found a total cisternal area (teat and gland) of around 22 cm² for a single Buffalo quarter which is less than half of that seen for cows (40–45 cm²). The Mediterranean Buffalo has cisternal volumes of 75 to 220 cm³ and the volume of the alveolar tissue varied from 3000 to 4000 cm³ (Borghese, 2007). The volume of the teat and gland regions is about the same size (Thomas et al., 2004b) in contrast to cows that have more volume in the gland cistern. The gland cistern area showed several pocket-like areas, which are only partially seen in cows (Bruckmaier...
& Blum, 1992). This has been observed in both Murrah and Egyptian (riverine type) buffaloes (El-Ghousien et al. 2002). In buffaloes 95% of the milk is stored in the secretory tissue even after a milking interval of 10 to 12 hours. It is only possible to extract this alveoli milk with an active milk ejection (Thomas et al., 2004b). In buffaloes, it is imperative that this milk is removed as completely as possible by complete milk ejection and an efficient milking technique. Incomplete milk removal causes immediate production losses and apoptosis in the mammary epithelium (Stefanon et al. 2002).

The physiology of the buffalo udder differs slightly from that of the bovine. Buffaloes are said to be slow and hard milkers because of their slow milk ejection reflex and their hard teat sphincter muscle. Normally milk ejection occurs within 2-3 minutes after manual prestimulation, but may be as long as 10 minutes with the concomitance of oxytocin and prolactin release. The intramammary pressure increases at the onset of milking, is highest during peak flow, and decreases to about 1-2 kPa at the end of milking. The high intramammary pressure contributes in pressing out the milk (Hogberg & Lind, 2003). The pressure is higher in buffaloes during milking than in cattle. The intramammary pressure varies between individuals and milkings, but its level is not always indicative of a high milk production. Time until milk ejection is shorter in the early and middle stage of lactation as compared with late lactation. A faster milk flow is observed when the yield is higher. If buffaloes are carefully selected for yield and milkability, improvement in these characteristics is possible (Borghese, 2007).

Oxytocin is the hormone essential for milk removal. Continual ejection of milk is dependent on the presence of elevated oxytocin concentrations during the entire milking. The basal levels of oxytocin concentrations are from 4.8 to 6.7 ng/L. The peak concentration can be as high as 90 ng/L, but the normal level during teat stimulation, milking and feeding during milking is about 30 ng/L. This physiological action is linked to the milking time and continuous stimuli of afferent nerves. Milk ejection in the buffaloes without prestimulation may be delayed from 3 to 7 minutes or completely lack. Oxytocin injections are used frequently in larger buffalo herds to initiate milk let down (Figure 5).

The disadvantages are that the continuous oxytocin treatment could lead to a progressive addiction and lack of response to normal milk ejection stimuli. Prolactin is the principal lactogenic hormone secreted by the anterior pituitary and it is critical to the establishment of lactation, milk macronutrient content and milk production. However, prolactin is prevented from exerting its effect on milk secretion by elevated levels of progesterone. Following clearance of progesterone and estrogen at parturition, copious milk secretion begins. The minimal hormonal requirements for normal lactation to occur are prolactin, insulin and hydrocortisone. Induction of milk synthesis is under the strict dependency of prolactin. The levels of this hormone decrease as lactation is established, but nursing stimulates prolactin release from the pituitary which promotes continued milk production. Prolactin is secreted into milk at levels representative of the average circulating concentration.

Buffaloes are sensitive to changes in the environment. They may withhold the milk if they are uncomfortable with the situation. If the animals are stressed, scared or in pain, the hormone adrenaline is released. This hormone causes constriction of the blood vessels, thereby hindering the supply of a sufficient amount of oxytocin to the udder. Adrenaline also
directly acts on the myoepithelial cells in the alveoli by blocking the oxytocin receptors. The inhibition of milk let down will leave the milk in the secretory tissue of the udder. The central inhibition of milk ejection can be totally abolished by exogenous oxytocin in physiological amounts. Continuous exposure to stress will affect the milk production of the buffaloes negatively.

Feedback inhibitor of lactation (FIL) is a milk protein synthesized by secretory cells which has an inhibitory action on the alveoli cells that limit further milk secretion. FIL is only active in the alveoli, in contact with the secretory cells, and its effect is concentration dependent. The excess of residual milk due to incomplete milk ejection increases the concentration of FIL in the alveoli and decreases milk secretion. However, the distribution of milk between the cisternal and alveolar compartment can influence the degree of feedback inhibition (Costa & Reinemann, 2004).

Health management

Although mastitis is not very frequent in buffalo species, it is a costly disease and the exposure of teat ends to pathogens must be minimized. In Italy, buffalo livestock management is usually performed in the open land or in paddocks and the animals are used to roll in puddles or lie on the dirty floor. This behaviour increases the possibility of animal infections and milk pollution. Sanitation of teats at milking helps to remove manure, mud and pathogens that have accumulated at the teat end before milking and reduces the number of pathogens that are deposited on liners and consequently could be transferred to other animals. The milking process also plays a role in the removal of pathogens that have become trapped in the keratin lining in the teat canal and thus plays an important role in reducing the risk of mastitis infection (Costa & Reinemann, 2004). In order to face this problem, several farms in Italy utilize a swimming pool in front of the premilking room, into which the animals are used to plunge. The swimming pool only reduces the dirtiness if the water is changed after each milking; otherwise, the swimming pool will become a breeding ground for germs. Another possibility is the use of sprinklers before milking. In our opinion, this device cannot be recommended, because bacteria drain to the teat ends. The use of sprinklings with water from the floor can only be recommended if teats are dried afterwards.

Premilking teat preparation for dairy cows consists of prestripping and some sort of cleaning of the teats. Prestripping is mainly done to detect clinical mastitis as several countries legislate that abnormal milk must be withheld from delivery. Failure to prestrip may seriously affect bulk milk cell count. Prestripping and withholding of abnormal milk from delivery are the single most efficient factors to reduce bulk milk cell count of problem herds. Besides, prestripping has only minor effects on the milk quality. There are several efficient methods for cleaning and drying teats before attachment of the milking unit. Individual cotton towels were found superior to paper towels in terms of reducing bacterial and spore count in milk and especially in procedures that include cleaning of the teat ends. Paper has a tendency to go smoothly over the dirt instead of removing it. The drawbacks of cotton are that it neutralizes halogens in wash water, especially at high temperatures, and certain bacteria can cling to the cotton yarns and thereby be protected. The use of cotton towels requires mechanical cleaning (washing machine) between milkings. Drying of teats after application of a predip solution is mandatory. A cotton towel used for 20 s was found supe-
rior to other treatments in removing iodine from teats (Rasmussen et al., 1991).
The hands of operators and towels are able to transfer pathogens from the teat surface of
infected to uninfected quarters. Increased new infection rates of cow-dependent bacteria
have been shown where prestripping was combined with udder preparation when milking
with a cluster which prevents cross-contamination (Grindal & Bramley, 1989). By use of
disinfectants in the wash water, the transfer of pathogens is only minimized, not prevented
totally. It is well established that postmilking teat dipping reduces new infections with cow
dependent bacteria and that the main target for premilking teat disinfectants is environ-
mental bacteria. Hillerton et al. (1993) conclude from farm studies that predipping has no
influence on udder health compared with general information about prevention of mastitis.
In conclusion, the method of cleaning teats at premilking teat preparation rather than the
use of chemicals will affect the rate of new infections. The effect depends on the present
pathogens.

Methods to induce milk ejection

Buffaloes have a low proportion of cisternal milk and in order to harvest milk stored
in the alveoli compartment the premilking stimulation is of extreme importance for milk
ejection removal in buffaloes and milking units should only be attached after the initiation
of the milk ejection response (Thomas et al., 2003). In general it has been observed in dairy
cows that different kinds of stimulation such as the presence of the calf, suckling, manual
prestimulation and feeding during milking improve the milking-related release of oxytocin
and result in shorter milking time.

Presence of the calf during milking

The presence of the suckling calf enhances the maternal secretion of oxytocin (Akers
& Lefcourt, 1984) and this leads to an efficient milk ejection from the udder. In buffalo
species, the technique based on the presence of the calf is usually adopted in those coun-
tries where the animals are hand milked. These situations are frequent in some developing
countries, such as India and Pakistan, where more than 120 millions of buffaloes are bred.
It is common practice to allow buffalo calves to suckle for a limited time (usually a couple
of minutes) before each milking to initiate milk ejection (Usmani et al., 1990). El-Sayed et
al. (1991) report that the presence of buffalo calves with their dams lowers the milk yield of
the latter. The Authors state that the presence of the calf inhibits the maternal secretion of
prolactin, as reported by Akers & Lefcourt (1984). Prolactin is necessary for initiation and
maintenance of milk synthesis and secretion, hence, the quantity of released hormone is po-
sitively correlated with milk yield (Koprowski & Tucker, 1973; Walsh et al., 1980). Moreover,
in another study it was reported that cows kept with their calves showed minimal prolactin
levels, leading to the hypothesis that the presence of the calf inhibits the maternal secretion
of oxytocin (Akers & Lefcourt, 1984). Contrarily, in a trial with Nili-Ravi buffaloes (Usmani
et al., 1990), limited suckling was associated with a small but significant increase in milk
yield during the first 75 days after calving. According to El-Sayed et al. (1991), buffalo milk
composition was not significantly affected by the presence of the calf.
The knowledge of the effects of limited suckling on postpartum reproductive efficiency of
dairy buffaloes is limited (El-Fouly et al., 1976; Usmani et al., 1985b). In a study carried out
on Nili-Ravi buffaloes (Usmani et al., 1990), animals that were allowed to nurse their calves twice daily for two minutes (limited suckling) showed a more rapid uterine involution (1 week) compared to non-suckled buffaloes. It has been proposed that an oxytocin mediated increase in the frequency and magnitude of uterine contractions may explain this phenomenon, although some studies performed in cattle seem to not support this hypothesis (Stewart & Stevenson, 1987). However, the resumption of follicular development (palpable follicle ≥ 10 mm in diameter) appears longer (1 week) in suckled buffaloes, as well as the postpartum intervals to the first progesterone rise and formation of the first palpable corpus luteum (Usmani et al., 1990). These results are in agreement with previous reports carried out in Nili Ravi (Usmani et al., 1985a) and Murrah buffaloes (Singh et al., 1979).

In conclusion, the practice of using a suckling calf during milking, although it results in a higher oxytocin release and a more rapid uterine involution compared to control animals, causes a prolonged resumption of ovarian activity and, consequently, a higher intercalving period. Furthermore, this technique can not be applied to machine milked buffaloes (Svennersten-Sjaunja, 2000), where stimulation would be carried out by other methods (feeding during milking, strong manual prestimulation).

**Feeding during milking**

The combined stimulation of feeding during milking and manual prestimulation resulted in a faster and more pronounced release of oxytocin, prolactin and cortisol compared with milking with only manual prestimulation and no prestimulation. These observations have recently been confirmed also for Murrah buffaloes where milk ejection occurred significantly earlier in the combined treatment of feeding and manual prestimulation, than milking with prestimulation and in-parlour feeding, milking with prestimulation but without in-parlour feeding, and milking without prestimulation or feeding (Thomas et al., 2005). Changes in the milking routines, such as not feeding during prestimulation or reduced concentrate feeding during milking, had an immediate influence on oxytocin release, milk ejection, and complete removal of milk and this was reflected in the fat percentage in strip milk (Thomas, 2004a).

**Manual udder stimulation**

To make the best use of the manual stimulation the first contact with the cow should include application of predip, manipulation of the teats in order to remove debris, and fore-stripping to detect abnormal milk. In our opinion, a correct udder prestimulation is fundamental for milk letdown, particularly in buffalo species. Independently of the adopted stimulation technique, it is important that coordination of milk letdown with milking unit attachment is correctly performed.

It has been reported that 10 to 20 seconds of tactile stimulation is sufficient to elicit oxytocin secretion in high producing cows (Ruegg et al., 2000). The lag time from start of tactile teat stimulation until full milk ejection in cattle ranges from 60 to 120 seconds and depends on the degree of udder filling, which, in turn, depends on the interval between milkings and the stage of lactation (Bruckmaier, 2001). This lag between oxytocin release and milk ejection is accounted for by the time required to transport the hormone from the brain to the udder and for the alveoli to fully contract. These relationships have given rise to recommendations for optimal prep-lag times (Rasmussen et al., 1992; Reneau and Chastain, 1995). Hence, the
period between stimulation and unit attachment and the consistency and duration of udder preparation are critical factors in milking efficiency (Rasmussen et al., 1990, 1992). It is likely that some differences may be present also in buffalo species, although the response of the animals to different premilking stimulations is not fully evaluated, and it is therefore difficult to establish. However, the presence on the same farm of subjects which show higher or lower milkability, led to the assumption that a real selection in this sense has still not been carried out. Furthermore, milk ejection in buffaloes may require up to about two minutes of tactile stimulation, which is rarely performed.

Use of oxytocin ejection

Recent intensification of buffalo rearing techniques has exposed these animals to a rapidly changing environment that imposes physical and psychological stressors so far unknown to this species. Machine milking presents both physical (poor maintenance of the machine) and psychological components (negative behaviour of the stock person and calf separation) which may interfere with the milk ejection. As reported by Thomas (2004a) and discussed in the previous paragraphs, buffaloes are known to be difficult to milk and many authors confirmed problems with disturbed milk ejection in this species (Aliev, 1969, 1970; Cockrill, 1974; Ragab, 1975; Pathak, 1992). In a survey conducted in India on milking practices, Varma & Sastry (1994) reported that a majority of farmers experienced these problems with their buffaloes. In order to overcome the problems, 65% of the farms used concentrate feeding during prestimulation to improve milk letdown, while 13% injected oxytocin to induce milk ejection. It is difficult to estimate the percentage of buffalo farms that use oxytocin in Italy, but it is probably high. According to our experience, it is normal to find at least 15-20% receiving oxytocin injection before milking on each farm. In a study carried out in Italy on 17 buffalo farms and 1030 Mediterranean buffaloes (Saltalamacchia et al., 2005), 13% of all lactating buffaloes were treated with oxytocin before milking. However, 24% of the primiparous buffalo cows were subjected to oxytocin injections. Thus, the Authors suggested that milk letdown difficulties were more prominent for primiparous than for multiparous buffaloes. Oxytocin injections were distributed evenly throughout the lactation (Saltalamacchia et al., 2005).

Buffaloes appear to be very sensitive, and especially the milk ejection can be disturbed easily (Thomas, 2004a). The results of an Italian study indicated that the behaviour of the stock person is related to buffalo behaviour at milking and the latter to the use of oxytocin injections. Significant correlations were found between prevalence of oxytocin injection and stepping and kicking (Saltalamacchia et al., 2005). Also, Bruckmaier (2005) reported that in buffaloes oxytocin injections are often performed to allow a complete milk ejection, whereas they are used only occasionally in the dairy cattle milking routine. The magnitude of the increase in milk production from oxytocin injections is quite variable, ranging from 10 to 12% of milk production in some studies, but showing no significant effects on milk production in others. In general, the factors that control milk production vary and are dependent on dosage and time of oxytocin injection.

Regarding somatic cells, Singh & Prasad (2001) found that oxytocin administration during the early lactation for a period of 5 days significantly increased the number of lymphocytes. However, secretion of neutrophils, monocytes and cytoplasmic particles was not affected. Eosinophil and basophil cells remain unaffected by oxytocin administration although they
were present in few samples. Saltalamacchia (2005) found that chronic oxytocin treatment in Italian Mediterranean buffaloes lengthened the lactation period, but milk yield and protein content decreased. On the contrary, the fat content seems not to be affected by the oxytocin administration. The use of a supraphysiological dose of oxytocin is strictly recommended only for the first 3-4 days after delivery, in order to improve uterine involution and, consequently, milk production.

From our experience some buffaloes, although properly stimulated during premilking teat preparation, can be machine milked for several minutes (up to 15 minutes) without obtaining milk ejection. Obviously, in these conditions the udder undergoes strong mechanical manipulation for a long period of time resulting in physiological stress to the teat skin and tissues. In these cases the use of a physiological dose of oxytocin would be reasonable, also taking into account that buffaloes store 95% of their milk in the alveolar compartment (Thomas et al., 2003). This characteristic is extremely important, because cisternal milk can be removed by overcoming the teat sphincter barrier, while removal of alveolar milk is possible only by activating the milk ejection reflex that requires oxytocin release from the posterior pituitary gland. If this does not happen, the use of exogenous oxytocin would be recommended. However, it is advisable that the character “milkability” would be included in the selection process of buffaloes in the future, in order to avoid the presence of these animals on the farm.

Milking frequency and milking intervals

In Italy, there are no experiences of farms in which buffaloes are milked thrice daily. This condition would mean higher management costs and consequently be economically disadvantageous. Usually, the farms milk twice daily, with a milking interval of 11-12 hours. However, some farms (around 20%) milk buffaloes once daily, losing probably around 30% of milk from each animal, but reducing the management costs. Furthermore, in some cases, the cheese factories require that the animals are milked once, in order to obtain milk characterized by higher fat and protein contents.

Milkability of buffaloes

Milk ejection and milk flow can be graphically presented by measuring the milk weight continuously during milking. Milk flow curves or milkability are typical and characteristic for each species (e.g. buffalo, cow, sheep, and goat) and they are influenced by anatomical and environmental factors (Thomas, 2004a). Milk flow rates of buffaloes are normally lower than of cows because of the lower milk yield, differences in udder and cistern structure and a tighter teat canal. Moreover, milk flow is influenced by stage of lactation, lactation number, udder health, milking equipment, milking routines, and under which conditions the machine milking is taking place. Milk flow curves have been well studied in the cow, partially in sheep and goat, and constitute 3 different phases:
- the first is the increase in milk flow, represented by the time elapsed between the attachment of the milking clusters and the time until constant milk flow;
- the second is the plateau with a constant milk flow (peak of milk flow is generally in this phase);
- the third is the decreasing phase and represents the time from the plateau phase till detachment of the milking cluster and stop of milk flow;
- an eventual fourth phase may be the stripping yield.

Figure 1 shows a normal milk flow curve, but from a farm where overmilking was applied often. Visualisation of the long phase of overmilking could make the milkers change the milking routine and solve this problem. Milking of the cisternal fraction is shown in Figure 2 and is known as a bimodal curve, which is rather seldom in buffaloes due to the small proportion of the cisternal fraction. Figure 3 is a curve from a buffalo with very low flow rates probably due to a tight teat canal, which is seen frequently in Italian buffalo herds. Most buffaloes need at minimum 8 minutes of milking time, but exceptions can be seen for buffaloes with peak flow rates and a short plateau time (Figure 4). Figure 5 is a milk flow curve of a buffalo not responding to stimulation during teat preparation and the tactile stimulation of the milking machine until oxytocin was injected.
In the Mediterranean Italian breed, Borghese *et al.* (2007) found a mean time from stimulation to milk letdown of 133±14 s, with no difference between morning and evening milkings. In this trial the mean recorded production was 3.95 ± 0.15 kg with a maximum flow 1.32 ± 0.05 kg/ min, mean milking machine time was 12.13 ± 0.05 min, increasing time was 2.22 ± 0.19 min, plateau time 1.70 ± 0.10 min, and decreasing time 2.04 ± 0.13 min. A total of 7.4% of the milk flow curves were classified as bimodal. Boselli *et al.* (2004) report mean values of 105 s. versus 99.6 s. in the morning and in the evening, respectively, to reach the plateau phases. They calculated a peak flow of 1.32 kg/min in the morning versus 1.22 kg/min in the evening. Mean decline slope times of 110 s. in the morning versus 137 s. in the evening were calculated. Average flow rates were 0.86 kg/min in the morning and 0.77 kg/min in the evening.

In Murrah buffaloes, Thomas (2004a) found times until milk let down of 69 s. versus 154 s. in two groups with a different concentrate feeding during milking. Time until a milk flow of 500 g was 195 versus 329 sec in the morning and 224 versus 383 s. in the evening, which highlights the importance of concentrate feeding during milking. In the same experiment peak milk flow was 1.18 and 1.13 kg/min in the morning versus 1.05 and 0.93 kg/min in the evening for the groups, respectively. Dogra *et al.* (2000) found an average milk flow rate of 0.92 kg/min. Thomas *et al.* (2006) calculated mean flow rates of 0.49 kg/min, 0.18 kg/min and 0.10 kg/min among groups of Murrah dairy buffaloes submitted to different regimes of concentrate integration and manual prestimulation or not, respectively.

Electrical conductivity can be measured simultaneously with the milk flow using the Lactocorder. Conductivity is related to udder health, somatic cells count (SCC) and mastitis onset. Boselli *et al.* (2005) found mean values of 4.11 mS/cm in milk of Mediterranean Italian buffalo. The correlated with SCC was r = 0.37 (Pearson P<0.001) and indicates possibilities to use electrical conductivity in mastitis detection.

General udder health and particular teat pathologies may influence milk production in quantity, quality and milk ejection parameters. Other differences in the milking response are strictly connected with the quarters’ milk distribution (Weiss *et al.*, 2004; Rodrigues Amaral & Corrêa Escrivão, 2005) as reported in other milking species (Bruckmaier *et al.*, 1994b). The general health of the animals and good livestock conditions are very important in milk production. Moreover, the milking machine is a very critical factor for the milk flow rates because of the characteristics of milking vacuum, milking pulsation and pulsation frequency, and other technical characteristics connected to the milking equipment (Pazzona, 1989; Dogra *et al.*, 2000).

Response time from prestimulation until milk ejection is one of the most important phases for the milking process. A correct udder prestimulation with the contemporary addition of a concentrate integration in the milking room has positive effects on milk quantity and milk...
flow (Thomas et al., 2006). One minute of manual prestimulation produced the best results in terms of milk ejection, average and peak milk flow, milking time and stripping yield. It was also seen that feeding along with manual prestimulation gave better results of these milking characteristics. However, milk ejection took longer, milk yield was significantly lower and stripping yield was significantly higher with only tactile stimulation of milking machine than when adding manual prestimulation. This indicates that in the absence of the cisternal fraction, milking on empty teats may cause discomfort to buffaloes and so manual prestimulation is consequently important (Thomas, 2004a).

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