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CAMEL MILK AND MILKING

Physiology of lactation and machine milking in dromedary she-camel

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ABSTRACT

Dromedary camels have the capability and the genetic potential to achieve high levels of milk production. However, systematic breeding programs to increase milk production are not common in this species. Dromedary camels are not well adapted to machine milking. Milk removal obviously requires in most farms a pre-stimulation through calf suckling before the milking machine can completely harvest the stored milk. In camels, most of the milk is stored in the alveolar compartment (>90-95%) of the udder. Therefore, almost no milk can be obtained in the absence of milk ejection. In addition, the morphological, anatomical and physiological properties of the camel udder are complex and not fully understood. Because of all biological and economical limitations related to machine milking dromedary camels are mostly hand-milked. The introduction of machine milking makes only slow progress and is limited to intensive dairy camel farms in a few countries. Machine milking of dromedary camels showed so far acceptable results. However, some studies clearly showed that udder emptying by machine milking with the available equipment is not satisfactory. The amount of residual milk after machine milking is high and was up to 30 % or even more of the stored milk in some studies. This means that the used machine needs to be improved to fit the camel's udder. Nevertheless, some studies clearly showed that a major proportion of dromedary camels have a suitable machine milking ability. In conclusion special milking machines for camels are necessary, taking all morphological, anatomical, physiological, and economic aspects into account to allow a fast and complete milk removal and to maintain good udder health. Only then machine milking is efficient for the farmer and guarantees a milk production under high quality standards.

Key words: Camel, dromedary, Lactation, Milking machine, Oxytocin, Physiology, Productivity.

INTRODUCTION

There is a need for development of a milking machine designed for camel milking, which remove the milk immediately and fully and with no negative effect on udder health. However, an excellent milking unit, is a key to achieve good milk ability. In general camels are known to be difficult to milk using a milking machine (Wernery, 2006). Several researchers reported problem of disturbed milk ejection (Nagy & Juhasz, 2016). To avoid this problem, such as milk accumulation, storage of milk, and the milk ejection reflex. The most commonly used milking machines for camels are slightly modified machines designed for milking of cows. Knowledge of morphology, anatomy and physiology of camel udder is necessary to develop an appropriate milking machines for camel (Caja et al., 2011). Secondly, there is a need for implementation of breeding programs to improve milk production and udder morphology of camels, taking into consideration all aspects affecting it, if we know that different shapes and varying udders between globular, pear and pendulous shapes and forms teats varying between conical and cylindrical (Wernery, 2006; Ayadi et al., 2015b). This will make the milking process mechanism more efficient and economically feasible.

Anatomy of the udder

The udder of she-camel is divided into four quarters, two rear quarters and two fore quarters. Every quarter consists of two or three separate units each leading to a separate streak canal within the respective teat. This means that the camel's mammary gland possesses at least 8 (4 x 2) independent milk units (Wernery, 2006). Between the events of milk removal by suckling or milking in Camel as in other dairy animals, milk accumulates in the udder and is stored within two compartments: the cistern (including teat and, gland cisterns and in large and medium milk ducts) and the alveoli (alveoli and small milk ducts) (Fig. 1). However, the udder cistern of camel is absent or has very small volume and therefore,

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only a small cisternal fraction of milk (4-10%) is available (Juhasz & Nagy, 2008; Caja et al, 2011; Atigui et al, 2014a; Ayadi et al. 2016) and the alveolar fraction of milk is large (90-95%) (Caja et al, 2011). The amount of cisternal milk decreases in late stage of lactation compared with early and middle stage of lactation (Atigui et al, 2014a).

The cisternal milk can immediately be removed by suckling, hand and machine milking, whereas the alveolar milk is not available before it is actively shifted into the cistern by a positive pressure on the alveoli in response to the hormone Oxytocin after inducing the milk ejection reflex. Consequently, an ideal machine milking of the camel would attach the milking machine after the milk ejection reflex has been induced and when teats start to swell (Eberlein, 2007). This means that a sufficient pre-stimulation (by calf, manually or by machine) at the start of milking is very important to induce the milk ejection reflex and milk let down in camels. It is also notable that the pre-stimulation period to be used before the unit attachment of camels must be longer than for cows, about 2 minutes (Wernery et al, 2004; Eberlein, 2007; Ayadi et al., 2016).

Camel udder and machine milking

The first herringbone parlour for camels with 2 x 24 places, used standard cow milking machines with some modifications to the milking liners and claw (Juhasz & Nagy, 2008). One of the challenges for machine milking was the variation in the length of the teats ranging between 3 and 16 cm (7.10 ± 2.22 cm). Moreover, the size of the teats increased dramatically during the milking process, with about 50% in length and about 170 % in volume. Consequently, it is difficult to find a suitable liner. Use of in proper milking liners lead to the occurrence of oedema and enhances colonisation of *Staphylococcus aureus* during the period of machine milking (Juhasz & Nagy, 2008). The most important part of the milking machine is the liner, which is directly connected to the teat. Thus, the liner length must be adapted to the teat length. The use of short milking cups in camels (but suitable for cows) may be ineffective in the stimulation process. Nevertheless, the shape of the liner cup (conical or cylindrical), the diameter of the mouthpiece and softness of the lip, the quality of liner (natural, synthetic or silicon) are the main features of liner that must be taken into account to adapt to the teat (Marnet et al, 2015).

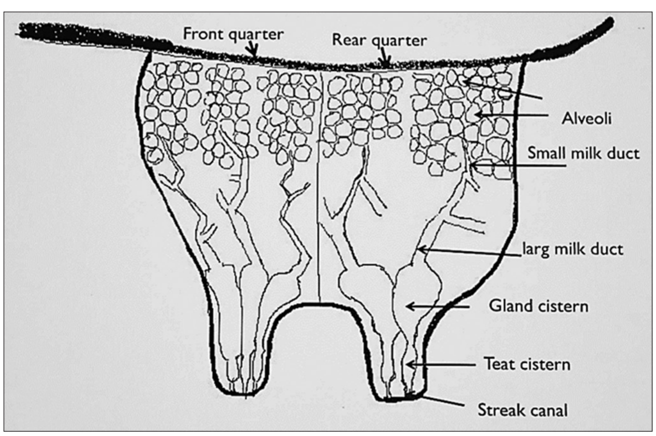

Fig 1. Schematic representation of a half udder in female camels (drawing kaskous)

Camels are sensitive, respond slowly and difficult to milking with machine. Consequently, camels must be accustomed to entering the milking parlour and being milked by the machine milking and the farmer must have basic knowledge of the behaviour of camel and field experience in dealing with such animals. A temperamental she-camel which does not like or know its milkman will simply cease production, but an accustomed camel, can produce milk for a very long period (Wernery, 2006). Camels need more stimulation than cows to evoke the milk ejection reflex. A wrong application of the milking machine, inappropriate use of the milking technique, or a change in milking routines can inhibit milk let down, thus affects negatively on the milk production. In the beginning of machine milking about 30% of the camels were not able to be milked by the milking machine (Juhasz & Nagy, 2008). Camels need an adoption period of 2 to 4 weeks, to get used to machine milking (Juhasz & Nagy, 2008). However, it should be noted that Multiparous she-camels (>12 years) were quieter and easier to train than primiparous camels (Hammadi et al, 2010).

Due to the slow of induction of milk ejection and a short milking time, many authors use high vacuum levels of machine milking to increase their efficiency. In dairy cows milking time decreased with increasing vacuum and wider pulsation ratio (O'Callaghan & Gleeson, 2004), The following table shows the milking time and the vacuum level used by some authors (Table 1).

The use of high milking vacuum for camels could lead to udder health problems reflected by a high somatic cell count in the produced milk and a negative impact on the health status of the teats. A positive relationship between increasing working vacuum and somatic cell counts in the milk has been found in buffalo (Pazzona & Murgia, 1992) and other dairy species (Hamann, 1990; Sinapis & Vlachos, 1999; Rasmussen & Madsen, 2000; Mein et al, 2003). The use of milking machine with lower vacuum level (38 kPa) leads to extension of the milking time to the almost doubled and low efficiency in obtaining full milk from the udder. Higher pulsation rates did not stimulate the camels better during milking, and on the contrary, it induced more bimodality and lower milk flow rates (Atigui et al, 2015). Ayadi et al (2014) found similar results when using a singletunnel milking parlour (equipped with medium-pipeline milking stalls) with 50 kPa and 60 pulsation/min were able to extract significantly more milk in a shorter time and higher milk flows rate at early and late stage of lactation (Table 2). However, these technical settings of the milking machine were not sufficient to empty the udder completely as shown in the table (Table 2). The amount of residual milk left within the udder after milking obtained by injection of oxytocin (20 UI/camel), was estimated to 30%. The researchers emphasized the necessity of long term studies to determine the impact on the health status of the udder. It is well known that the negative effect of the high pressure on the teat condition and increased mastitis incidence and it is no doubt that the milking machine used for cows is not suitable for camels. However, maybe the camels need a high vacuum to open the teat sphincters, especially by lower milk flow rate and longer duration of milking.

A new study has shown that milking camels at 50 kPa and 60 pulsation/min gave satisfactory milk performance without affecting teat condition and udder health negatively in dairy dromedary camels (Ayadi et al, 2015a). Camels were able to let down more milk in a shorter time and with a higher milk flow rate.

Among the factors influencing the milking machine is the asymmetry udder quarters in camel, which reflected in the performance of the milking process (Eisa & Hassabo, 2009), and this may lead to the occurrence of blind milking and the result incidence of mastitis. Some studies indicated that rear udder half produced more milk (56 until 59%) than that in the front quarters (41 to 44%) (Kulaeva, 1979; Eisa & Hassabo, 2009; Caja et al, 2011).

Farmers must pay attention to the interaction between physiology of lactation and machine milking of camels to maintain healthy udders and higher milk yield. This can be obtained by use of a suitable milking machine, good milking routine, regular camel hygiene, and mastitis control.

Udder Stimulation during the machine milking of camels

Usually, camels are milked by hand in most countries of the world in traditional farming systems (Rosati et al, 2003; Wernery, 2006; Nagy, 2014), after the calf can suckle until the milk is let-down and then the camel can be milked (Bekele, 2010; Kaskous & Abdelaziz, 2014). Without this stimulation, the camel cannot be milked (Farah & Fischer, 2004), because the presence of the calf is considered

Table 1: Types of milking machine used for dromedary camel

Authors and year	Type of milking machine	Vacuum (kPa)	Pulsation rate (cycles/min)	Pulsation ratio (%)	Pre-Stimulation (min)	Milking Time (min)
Wernery et al., 2004	Herringbone stand, automatic bucket milking machine	36-40	90	60:40	Hand	2
Eberlein, 2007	a single milking stand	38	90	60:40	Hand and machine	5-9*
Aljumaah et al., 2012	Pipeline milking machine system	45	60	60:40	-	7.5
Ayadi et al., 2013	Portable milking machine unit	45	60	60:40	By calf	2
Atigui et al., 2014a	Portable bucket milking machine	48	80	60:40	Hand	3.5
Ayadi et al., 2015a	Portable milking machine unit	50	60	60:40		

*the total duration of stimulation and milking.

Table 2: Milk yield (kg), Residual milk (kg), Peak milk flow rate (kg/min) and total milking time (min) at different of vacuum (kPa) and pulsation rate (P/min) in dairy camels at early and late stage of lactation (Ayadi et al., 2014)

Stage of lactation	Vacuum level	45		50	
	Pulsation rate	52	60	52	60
Early	Machine milk yield	1.68±0.39[b]	1.89±0.39[b]	1.90±0.40[b]	3.15±0.41[a]
	Residual milk	1.63±0.34[a]	1.60±0.34[a]	1.47±0.34[ab]	1.16±0.35[b]
	Peak milk flow rate	1.91±0.28[ab]	1.78±0.31[b]	1.61±0.27[b]	2.31±0.28[a]
	Total milking time	4.53±0.42[a]	4.16±0.42[ab]	3.94±0.21[ab]	3.70±0.21[b]
Late	Machine milk yield	1.92±0.40	2.04±0.40	2.10±0.42	2.53±0.42
	Residual milk	1.93±0.33[a]	1.43±0.34[ab]	1.36±0.44[ab]	1.14±0.44[b]
	Peak milk flow rate	1.59±0.30	1.34±0.37	1.44±0.32	1.91±0.29
	Total milking time	4.97±0.42[a]	4.29±0.41[ab]	4.19±0.22[ab]	3.84±0.23[b]

[abc:] Means in the same line with different letters were significantly different ($P<0.05$)

imperative for milk let down (Costa & Reinemann, 2004; Kaskous & Abdelaziz, 2014; Ayadi et al, 2016). But it is possible to milk by hand and without the presence of the calf (Caja et al, 2011). In this case, hand massaging is necessary to enhance this response (Costa & Reinemann, 2004). In a large–scale system, the calves and dams are allowed together during machine milking (Juhasz & Nagy, 2008), being a factor necessary to induce the milk ejection reflex and milk let-down. But this process is not easily compatible with machine milking and need specific parlours designed to allow the mother-young interactions (Marnet et al, 2015). Therefore, it is necessary to find an active process which stimulates the mammary gland before milking and induces the milk ejection without the presence of the calf during the milking process. Marnet et al (2016) reported that it could be efficient to separate the young immediately after birth (no suckling of colostrum and very limited hearing, smelling, seeing of the young), and to milk mothers immediately. Such a management has to be tested for camels. Until now, it has been difficult to separate the calves immediately after birth from the mother in camels. The mother can note cope psychologically and she dry off within a few days. However, the buffalo has similar problem like camels. The new research in buffalo showed that 2 minutes of manual pre-stimulation is enough for the removal of the alveolar milk fraction (Boselli et al, 2014). These studies show us the opportunity to milk the camels without the presence of calves during milking.

The milk ejection reflex has been known for a long time in cows which is triggered by mechanical stimulation (suckle, manually, milking machine) of the udder especially in the teat area (Tancin et al, 1995; Bruckmaier & Blum, 1996; Bruckmaier, 2007). The suckling of the calf is the most effective mechanisms for udder stimulation and induction of the milk ejection (Bruckmaier & Blum, 1998; Lupoli et al, 2001), because the suckling is the biological way to stimulate the teats (Uvnäs-Moberg et al, 2001). For instant, it has been shown that Syrian Shami cattle are not suitable for exclusively machine milked without the presence of their calves. Oxytocin concentration increased after the start of stimulation in the presence of the calf during machine milking, whereas without the presence of the calf oxytocin concentrations remained at the baseline level throughout the course of milking (Kaskous et al, 2006).

The induction of the milk ejection in camels is easy after a short period of suckling (1.5 min) (Yagil et al, 1999; Costa & Reinemann, 2003; Wernery, 2006), when the teats suddenly swell becoming much larger than before. Because of this fact, some researchers assumed that the camel udder does not have a gland cistern, due to the transfer of alveoli milk to the teat cistern immediately after the induction of milk ejection (Costa & Reinemann, 2003). The milking needs to be performed soon after teats swelling, because the duration of the milk let-down response is also very short, and does not exceed more than 1.5 min (Yagil et al, 1999) until 2 minutes (126.9 ± 41.1 seconds) (Wernery et al, 2004).

According to that, the presence of the calf during the milking process and suckling to stimulation the milk ejection as external factor is an important factor to activate the neuroendocrine reflex to release the hormone oxytocin from the posterior pituitary in camel (Costa & Reinemann, 2003).

We know little information about the situation in camels, whether the presence of the calf during milking is sufficient to induce the milk ejection or suckling plus physical contact with the calf is necessary to induce the milk ejection. It has been shown in many cases that if the calf dies just after birth the mother dries off, because the stimulation of the udder and its emptying of milk does not take place. In such cases, some nomads skinning dead calf to either tie a piece of the skin to the mother's side when being milked or fill the skin with grasses and bring it to the camel when she is being milked (Yagil et al, 1999). With this method, the camels can be stimulated during milking and induce the milk ejection reflex as well as the milk production will continue to be maintained. However, camels that lost their calf produced lower milk yield than those with a calf (Bekele, 2010). This shows that the presence of the calf during milking without tactile stimulation of the teat (suckling) is sufficient to induce the milk ejection. However, only physical contact with the calf also showed enhanced milk production compared to cows that were not suckled nor had physical contact with the calf. The results of Ayadi et al (2016) in camels with the presence of calves during machine milking without suckling and with different manual stimulation time showed that increased duration of manual udder stimulation to 90-120 s improved the machine milking efficiency in late stage of lactation.

Oxytocin release and milk ejection reflex

It is known that suckling, hand and machine milking may cause sufficient mechanical stimulation to induce milk ejection reflex during milking which releases hormone Oxytocin in the blood stream from the posterior of the pituitary gland (Fig. 2). The released oxytocin contracts the myoepithelial cells that surround the alveoli in the mammary gland and forcing the expulsion of the milk.

Some experiments have shown that the duration of releasing of hormone oxytocin during milking is very short and does not exceed more than 2 minutes (Yagil et al, 1999), which requires a fast milking (Caja et al, 2011). This explains why hand milking by two people milk, one in each side improved milk production compared with only one-person milking (Yagil et al, 1998; Bekele, 2010).

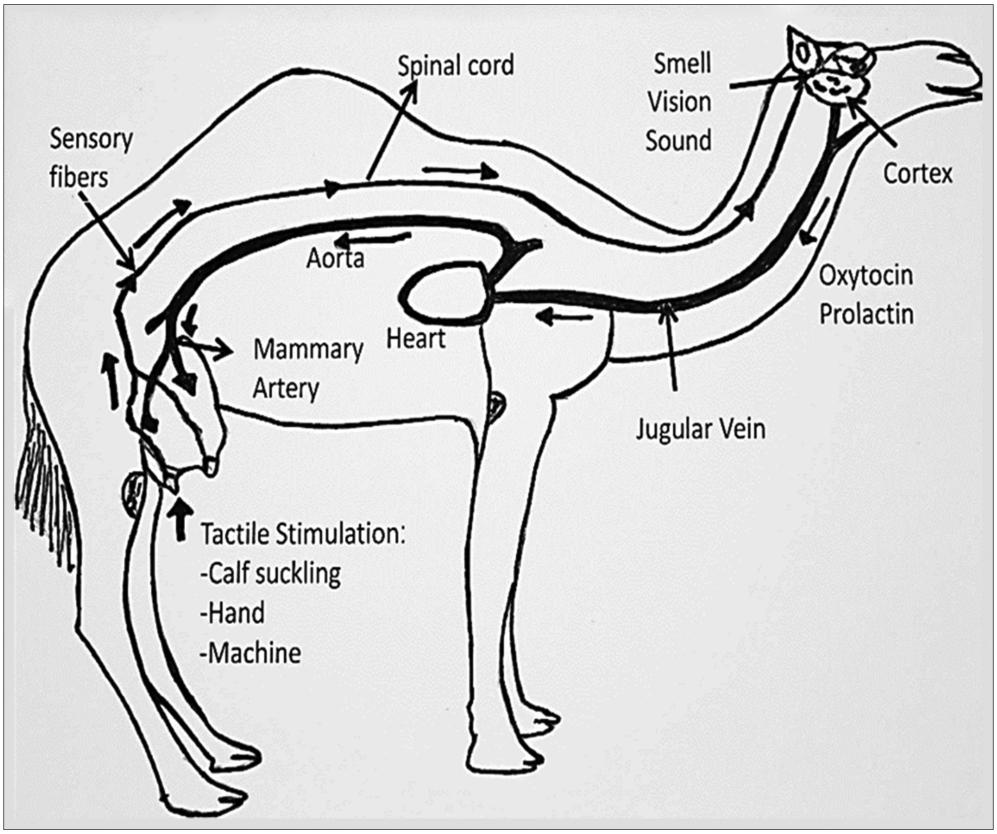

Fig 2. Milk ejection reflex in camels (drawing kaskous)

Yagil et al (1999) reported that massage by hand only did not induce milk ejection and calf suckling and hand massaging were a much more rapid and much greater effect on the teats than suckling only. However, it was found in some Bos indicus cows that milk removal by hands of unfamiliar persons or by milking machines are not well accepted (Costa & Reinemann, 2004). Eberlein (2007) showed by using machine milking in camels that the pre-stimulation by hand for 60 to 120 s until swelling of the teats was effective to begin the milk let-down. It is known that the inhibition or disturbance of the milk ejection occurs at the central or peripheral level of the nervous system under practical conditions. Therefore, the milking conditions exert an effect on regulation of milk ejection (Tancin et al, 2001). The milk ability of camels is influenced by her psychological state. That is, how high the camels are genetically developed to improve their productivity and milk ability. In some countries, where the milking machine has been used in camels, shows good results and no inhibition of the milk ejection. However, it turns out that a problem with complete emptying of the udder after machine milking and the milk ejection reflex must be improved (Nagy & Juhasz, 2016). In certain situations, the researcher suggested, that the injection of the hormone oxytocin specific doses could be a useful tool to induce milk ejection in cases where the calf dies and another stimulation as hand massage do not induce milk ejection (Yagil et al, 1999).

Yagil et al (1999) divided the milking process of camels with their calf present into the following stages:

- Stimulation period: It is the period from the moment of the calf suckles all four teats until the moment of the change in the shape and size of the teats (swelling of the teats). This stage takes about 1.5 minutes.
- Injection period: a time of change in shape and size of the teats until the moment of stop the milk ejection reflex. Milking can be done during this period. This time period takes about 1.5 minutes.
- The remaining period: a period in which the teats restore to their normal dimensions and the mother then moves away from the calf or the milking person.

It has been reported that camels are able to refill their udder for the calves in about one hour after complete milking by hand (Yagil et al, 1999). This confirms that the camels can be milked every hour. This is a very important point as it is assumed in many countries that calves require the milk from at least half the udder in order to survive (Knoess et al, 1986). Consequently, if the milk synthesis refills the udder for the calf within an hour after hand milking all the milk can be take when milking by hand or by machine for human consumption.

Caja et al (2011) showed similar results and the milk secretion rate decreased linearly with time elapsed after milking intervals of 4, 8, 12. 16, 20 and 24 hours (R^2=0.86). The camels were at mid of lactation after weaning and the milk secretion rate decreased markedly after 12 hours milking interval. Therefore, camels must be milked by hand or by machine at least twice a day with regular intervals close to 12:12 hour (Caja et al, 2011). Similar results have also been found by Ayadi et al (2009) that the camels gave the highest milk after 8-h intervals and this quantity of milk decreases continuously with the increase of the milking intervals. The estimated daily milk yield was 87% and 70% for 16 and 24-h intervals, respectively. This has reflected on the milk composition. The greatest value of total milk solids (14.1±0.4%), milk fat content (4.6±0.5%) and milk pH (6.66±0.05) were at 8-h intervals und the lowest value of total milk solids (12.3±0.9%), milk fat content (2.9±0.6%) and milk pH (6.54±0.02) were at 24-h intervals. However, milk protein (3.9±0.1%), lactose (4.5±0.2%), ash (0.84±0.01%) and density (1.028±0.01) remained constant for all milking intervals.

Inhibition of milk ejection reflex during milking in camel

The milk ejection reflex in lactating animals can be inhibited by: bad handling, the presence of animals in the new environment, and emotional stress (Wellnitz & Bruckmaier, 2001). These reasons are perhaps more pronounced in the camel than in other dairy animals. However, unusual sound at the beginning of milking or even after milk ejection occurrence caused inhibition or disruption of milk removal and modification of camel's behaviours (Atigui, et al, 2014b). In one study, it was observed that the basal concentration of cortisol remained low during milking (9.6±2.8 ng/ml) in normal conditions (Atigui et al, 2014a).

Whereas when some animals were clearly disturbed (cry, grumbling, agitation, kicking etc.) cortisol level was already elevated and remained high (47.1±7.8 ng/ml) during milking and slowly decreased after milk removal ceased (Atigui et al, 2014a).

It is known that the term stress, particularly during the milking process, leads to high level of cortisol in the blood (Tancin & Bruckmaier, 2001) and reduced sensitivity to ACTH (Bruckmaier & Wellnitz, 2007). That leads to a partial or total inhibition of milk ejection reflex (Wellnitz & Bruckmaier, 2001). Disturbed milk ejection is due to a reduction of or absence of oxytocin release from the pituitary (Bruckmaier & Wellnitz, 2008). Consequently, the milk ejection is delayed and reduced the milk flow. This leads to bimodal milk flow curves (Tancin et al, 2007). In primiparous cows, manual stimulation may fail to induce milk ejection and milk ejection is disturbed for several weeks immediately after parturition, if the animals do not adapt to the machine milking (Bruckmaier et al, 1992; Bruckmaier &Wellnitz, 2008).

Milk ejection was significantly delayed (1.58±0.17 min), residual milk increased over 40% of total milk yield and average and peak milk flow rates were significantly lowered when unusual noises were heard from the beginning of milking. These environmental disturbances increased signs of alertness and the number of attempts to escape the milking parlour (Atigui et al, 2014b). Remarkable, delay of cluster attachment for over 1 min after the end of udder preparation caused serious milk losses. Up to 62% of total milk was withheld in the udder when the delay reached 4 min. Average and peak milk flow rates also decreased significantly with delayed milking. After a 4-min delay, camels showed signs of acute stress (Atigui et al, 2014b).

Furthermore, Gjostein et al (2004) reported that smell, acoustic and visual contact with calves but no physical contact during milking of reindeer inhibited the milk ejection. It is possible to achieve a complete milk removal by machine milking after the mothers have been pre-stimulated by suckling of calves for a short time before attaching the milking machine (Gjostein et al, 2004).

Milk flow curve during machine milking in camels

It is known that the form of the milk flow curve is essentially influenced by the beginning of teat stimulation. Depending on whether and how long a pre-stimulation is performed prior to the actual removal of the milk, there is a temporary break of the milk flow curve (bimodality), when the cistern milk is removed before the first alveolar milk was pressed into the cistern. Atigui et al (2014a) reported that in camels, bimodal curves occurred in 41.9% of total recorded milk flow curves. Such higher percentage bimodality in camels could be explained, that since camels have very small cisterns and a delayed milk ejection reflex, bimodality occurs when the vacuum level provided by machine milking is able to open the teat sphincter and empty the cistern before the milk ejection takes place. Therefore, the camels need a good pre-stimulation before attachment of the teat cups (Ayadi et al, 2009), to avoid the bimodality. The percentage share of bimodality is changing, according to the stage of lactation, 70% of milk flow curves were bimodal in early lactation, while up to 8.9% at the end of lactation (Atigui et al, 2014a). However, a 30 s pre-stimulation decreased the incidence of bimodal milk flow curves and increased occurrence of the best milk ejection patterns with higher milk flow but had limited effect on milk production in well-trained animals within a good machine milking setting (Atigui et al, 2014b). However, the milk flow pattern depends on the milk partitioning in the udder, milk ejection reflex, the property of the used milking machine and teat anatomy.

In general, we can see three types of milk flow curves in camels during milking according to Atigui et al (2014a):

- Type 1: was characterised by a sharp and high peak flow curve with a continuous increase in the milk flow followed by a declining phase without going through a plateau phase. This pattern ratio ranges from experimental animals about 40%, which is easy to milk and provide more milk in relation to the following types and the milk yield per milking, average and peak milk flow were 4.24 kg, 1.49 and 3.54 kg/min, respectively
- Type 2: was characterised by milk flow curves with intermediate milk flow rate and a significantly longer plateau phase. This pattern ratio ranges about 38% and the milk yield per milking, average and peak milk flow were 3.30 kg, 1.12 and 2.12 kg/min, respectively
- Type 3: This pattern was characterized by milk flow curves with a low milk flow level and a longer total milking duration. The proportion of this pattern is 22% and the milk yield per milking, average and peak milk flow were 2.34 kg, 0.65 and 1.23 kg/min, respectively.

The changes of the milk flow curve in type 2 and 3 may be influenced by the change in the vacuum level and use of an inappropriate liner in relation to teat shape (Atigui et al, 2014a).

CONCLUSIONS

- An efficient milking machine should be able to remove milk from the udder as gently, quickly and completely as possible with the minimum residual milk remained in the udder after the machine milking.
- Successful training of camels to machine milking requires a good understanding of the behavior of this species and an experienced herdsman.
- In dairy camels, over 90% of milk is in the alveolar compartment of the udder, therefore milk ejection is required through suckling or manual per-stimulation of 2 min.
- Average and peak milk flow rates decreased significantly with delayed cluster attachment after the end of udder preparation over 1 min.
- Defecation prior to milk ejection and rumination during milking shows that the machine milking is running well, and the milk ejection reflex is induced.
- It is necessary to develop a milking machine for camels, which must consider all morphological, anatomical, and physiological as well as the productivity of the camels. Then, the new vision of milking machine must be to guarantee higher milk productions, better milk quality, and preservation of the udder health and improve the social status of camel farmers.

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