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Original article

The challenge of machine milking in dromedary camel

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A B S T R A C T

Machine milking is widely spreading and practised in she-camel many years ago, but in some countries still used only in small scale due to some constraints; of which non effective use of the machine, difficulty of the machine usage or the restraining of the machine by the she-camel. This study presents some of problems that hinder the usage of machine milking in she-camel due to variations in the daily milk yield, lactation yield and length. Since genetic improvement programs planed towards improvement of camel reproductive and production performances were very scarce.and hand milknig is practised in a wide range in small sacle production systems. The other constraint facing machine milking is the variations in morphological, anatomical and physiological aspects of camel udder and teats. These variations exist not only between countires, but between herds and within herds and this explore the inconvienice to practise machine milking. The third challenge is that most of camel milking necessitate the presence of calves beside their mothers to stimulate milk ejection reflex. Added to that camels must be trained enter milking which may take between 2-4 weeks based on the background of the animal.

1. Introduction

The dromedary camel plays an important economic role in tropical and subtropical regions of Asia and Africa not only as milk, meat and wool producer but also used for transport. It is also very important for sport racing in Gulf countries. Dromedary camel is well known for its ability to survive drought period, and camel milk is called the white gold of the desert (Wernery, 2006). The population of camels in the world is small compared to ruminants species. There are about 26.64 million camels in the world (FAO, 2013), of which 22.68 million (85.19%) in Africa and 3.96 million (14.81%) in Asia and a few thousand in other world regions. About 94% of the estimated world`s camel population is thought to be one-humped or dromedary camels, whereas the two-humped (Bactrian camels) comprise 6% and they are primarily found in Asia.

The use of milking machine in the world is practiced by small numbers of camel keepers, as they mostly prefer hand milking. However there are some breeders in Russia (Baimukanov, 1974), United Emirate Arabic (Wernery, et al. 2004), Tunisian (Ayadi et al., 2009; Atigui et al. 2013), Saudi Arabia (Aljumaah et al., 2012; Ayadi et al., 2013) and Netherlands (www.Welt.de) practicing machine milking in their herds. Low milk yield in she-camel is one of the most important challenges preventing the use of machine in milking, in addition to variation in lactation length, lactation season and differences in morphological, anatomical and physiological characteristics of the udder, particularly the difference in size of the udder, length of the teats and their diameters (Tibary and Anouassi, 2000; Albrecht, 2003; Wernery et al., 2004). The presence of the calf as stimulant of milk let down during milking process is also a factor that hinder the use of machine in milking. Faye and Bonnet (2012) reported that dairy productivity of camels did not change for the last 48 years in Saudi Arabia , despite the importance of camels in the region, as the camel has not passed through process of selection for improvement of milk production (Eisa, 2012). Generally Dromedary camels are not systematically bred for milk production (Damian et al., 2009).

The aim of this review paper is to shedlight on some of the currently available data on challenges of using milk machine in the dromedary camels, with especial emphasis on the existing milking machines that did not take into consideration the previous challenges. In addition to suggestion of providing new vision of a milking machine to be used in camels. As milking machines must guaranteed higher milk production, better milk quality, keeping the health of the udder and improve the social status of farmers.

1.1. Differences in milk yield and lactation length

Camel milk play an important role in human nutrition in arid and semi arid zones of the world (Schwartz, 1992; Eisa and Hassabo, 2009; Pasha et.al., 2013), and the potential for high milk production exists (Köhler-Rollefson, 1991; Breulmann et al. 2007), but the data on the production potential of dromedaries is scarce as reports vary widely and are difficult to compare (Faye, 2008). The mean daily milk production of 6.7 ±0.10 kg for 400 days is a good overall indicator of production potential in dromedaries, with a range of 2.4-17.4 kg/day in the United Arab Emirates (Nagy et Al., 2013). Other studies in Pakistan reported a daily milk yield of 6.9-18.2 kg/day (Rao, 1974), 6.7-10 kg/day (Leopold, 1978), 15-35 kg/day (Knoess et al., 1986), 4-12 kg/day (Aujla et al., 1998), 6-11.7 kg (Raziq et al., 2011) and 3-8 L (Pasha, et al., 2013). However, under good management conditions the milk yield varied from 15-20 kg/day during a lactation period of 8-18 months (Raziq et al., 2008). In general, about 20% of the lactating camels in Pakistan produce an average yield of 3000 kg per lactation (Raziq et al., 2008) and the daily yields of up to 35 kg and yearly yields of 12775 L are reported also from Pakistan (Knoess, 1984). Whereas other domestic animals rarely produce more milk under the same climatic and feeding conditions (Faye, 2005). Musaad et al. (2013) claimed that the mean milk yield in northwest of Saudi Arabia was 1970±790 L per lactation (12.5 months) and the highest average yield recorded in the sixth parity. Researcher in India recorded a daily milk yields of 6 kg/day (Raghvendar et al., 2005) and 7.4-8.54

L/day in different months (Nagpal and Patil, 2012). Hussien (1989) found a daily milk yield in camels in Eastern Africa (Somali, Ethiopia, Kenya and Djibouti) to be 5-6 L, whereas Abebe (1991) found, that a daily milk yield in camel in Eastern of Ethiopia was 8-10 kg. Abdulrahman (2006) indicated that the lactation cycle varies between 8-18 months and the milk production varies from 800 to 3600 L/lacation in Eastern regions of Ethiopia. Other Studies reported 3.2-5.4 kg/day in Ethiopia (Reta and Mekonnen, 2002). In Egypt the daily milk yield was 3.5-4.5 kg (El-Bahay, 1962), while the milk yield was 4.5-9.1 kg/day in Tunisia (Burgemeister, 1974). Musinga et al. (2008) demonstrated that the camel milk yield in Kenya is related to the type of camels to the extent that Somali type has the highest milk yield which was estimated to be 5-8 L/day, Gabbra/Redille Type has lower production with the average of 3-4 L/day for a lactation period of 12 months, and Turkana Type has much lower with yields averaging 2-3 L/day over a lactation period of 9 to 10 months. Studies in Somalia reported that the milk yield was 5 kg/day (Yagil, 1982), 4.5 kg/day (Tezera, 1998), 3-10 kg/day (Farah et al., 2004). Milk production of camels in Sudan ranged between 820 and 2400 L/ lactation for 12-18 months (Faye, 2004), which is dependent on farming management type, with intensive management the total milk production per lactation was 2633 L/lactation in semi-intensive system vs 1204 L/lactation only in traditional system (Bakheit et al., 2008).

Lactation length of the camel depends on various factors and varies from 6 to 24 months. According to some researchers the lactation length of Pakistani camel averaged 15 months (Baloch, 2001), whereas some farmers reported a lactation length of 9-18 months (Jasra and Aujla, 1998). Raziq et al., (2011) reported that the lactation length of Pakistani mountainous camel was 8-9 month. Whereas, the lactation length in Saudi camels ranged from 6 to 19 months, with an average of 12.5 months. Lactation length in Indian camels varies from 12 to 18 months (Nagpal and Patil, 2012). Other studies reported 171.2±90 days in Tunisia (Kamoun and Jemmali 2012), 360 days in Ethiopia (Reta and Mekonnen, 2002), 390-450 days in eastern Ethiopia (Belay and Getahun, 2002), 360-540 days in Somalia (Farah et al., 2007). The lactation period in United Arab Emirates camels was reprted to be 330 days (Wernery et al., 2004). Bekele (2010) observed that the Lactation length of camels in Ethiopia varies from 7 to 18 months, with an average of around 12 months (353±14 days) and it showed variations based on parity. The longest period was obtained for the 6th parity (406+6 days) and the shortest for parity seven and eight (291±90 days).

Camel milk yield varies extremely between areas and lands and ranges from 1 kg to 35 kg per day and the length of lactation varies from 6 to 18 months (Yagil and Etzion, 1983; Wilson, 1984; Jasra and Aujla, 1998; Yaqoob and Nawaz, 2007; Al- haj and Al-kanhal, 2010).

Based on the foregoing studies, it can be concluded that high individual variations in milk production and lactation length depend on many environmental factors, the most important of which were management systems, cow and calf status, pregnancy status, food conditions and availability of drinking water. These factors make the milking process by machine difficult, especially in large-scale production systems.

2. Morphological, anatomical and physiological characteristics of dromedary camel udder

The udder of the camel is situated in the inguinal region and consists of four glandular quarters, each with its own teat. Dairy camels are characterized by a well developed udder and milk vein (Wardeh a. Al-Mustafa, 1990). Therefore the udder's weight of the lactating she-camel (1985 g) is heavier compared to the non-lactating she-camel (857 g) (Ismail, 1986).

The anatomical and morphological characteristics of the mammary gland and their relation with milk production, machine milkability and manageability in dairy camel have become of greater interest to farmers and researchers. The anatomy and morphology of the camel udder has been described in earlier studies (Saleh et al., 1971) and more information about anatomical and physiological features of camel udder is necessary for the development of camels milking machine (Caja et al., 2011), because the teat represents the interface between the mammary gland and the teat cup liner. It is worth mentioning in this sector clear contrast to the form and size of the udder teats in the dromedary camel. Sometimes small teats may be hard to milk or large bulbous teats, due to enlarged teat canal or cistern (Tibary and Anouassi, 2000). These abnormal conformations may hinder the use of milking machine in dromedary camels (Figure 1, A and B; Figure 2, A and B).

A B

Fig. 1. Mammary gland in Syrian Dromedary Shami Camel.
(A) Mammary gland in 5th lactation (B) Mammary gland in 3rd lactation.

A B

Fig. 2. Mammary gland in dromedary Camel in Germany.
Mammary gland in 1st lactation (B) Mammary gland in 2nd lactation.

Morphological and anatomical studies of the camel udder indicated that the rear quarters are larger compared to the front quarters. For this reason more milk will be received from the back-quarter, 56.4 percent to 43.6 percent from the forward-quarters (Yagil, 1982).

Zayeed et al. (1991) demonstrated that, there was a great variation in udder and teat size and length in the camel, which may be attributed to variable factors including, camel type, stage of lactation, parity number and disease. Eisa et al. (2010) observed that the udder and the teat measurements in typical features of the Arabi-lahwee camel (Camelus dromedarius) in eastern of Sudan and the measuring parameters varied from Animal to animal as shown in Table (1) below.

Table 1
Udder and teat measurements (cm) of Lahween camel in Sudan (Eisa et al., 2010).

Parameters	Means	SD	Parameters	Means	SD
Udder Depth	16.9	2.5	Fore teats diameter	2.1	0.7
Udder circumference	91.4	10.0	Rear teats diameter	2.5	0.9
Udder size cm3	1560	388	Distance bet. Fore teats	13.1	2.5
Udder height at fore quarters	111	7.1	Distance bet. rear teats	10	1.7
Udder height at rear quarters	110	7.6	Distance bet. right teats	3.1	1.8
Fore teats length	4.3	1.4	Distance bet. left teats	3	1.5
Rear teats length	4.4	1.5			

Furthermore, it was found that udder and teat measurements have been subjected to change before and after milking.

Ismail (1986) demostrated that the measurements of the teat in the camels of Sudan were lower compared to above results and the average length of the teat was 3.2 cm, whereas the average diameter of the teat was 1.4 cm at the base and 0.8 cm at the apex and the distance between the front teats is greater than that in the hind teats.

Other studies showed that there was a great variation in teat length in camels and the average value was 7.1±2.22 cm (min: 2.93 cm and max: 16.0 cm) and only 2 cm of the teat end fits into a commercial bovine liner. In addition, the teat undergoes significant volume changes during milking (Juhasz a. Nagy, 2008).

Abdallah and Faye (2012) estimated some udder measurements of the Dromedaries camel in Saudi Arabia and showed some individual udder and teat length changes among types such that values ranged between 6-50 cm and 1-26 cm, respectively (Table 2), in addition to the positive correlation between teat Length and udder length ($r=0.29$, $P<0.05$).

Table 2
Mean udder measurements (cm) of 12 types of female camel in Saudi Arabia (Abdallah and Faye, 2012).

Type	Udder length	Teat length	Type	Udder length	Teat length
Hadhana	17	4.2	Saheli	16.7	5.1
Aouadi	15	4.7	Shaele	24.8	4.1
Asail	6.3	2	Shageh	17	5.2
Awrc	18.5	4.6	Sofor	22.7	4.3
Homor	25.6	4.7	Waddah	25.4	4.8
Majaheem	25	6.8	Zargah	22	4.5

These results showed that the dromedary camels are not phenotypically identical in Saudi Arabia and the difference in type is clearly indicated. According to their breeding characteristics, Wardeh (2004) classified dromedary camels into four major classes: beef, milk, dual purpose and racing camels. Whereas, in Sudan camels were classified into 10 types based to the size of the udder and teat (Ishag et al., 2011) (Table. 3):

Table 3
Phenotypic descriptions of camel types in Sudan (Ishag et al., 2011).

Type	Udder size	Teat size	Type	Udder size	Teat size
Kenani	Large, medium	Large, medium	Kabbashi	Medium	Medium
Rashaidi	Large	Large	Maganeen	Large	Large
Lahawee	Medium, Large	Medium, Large	Shanbali	Large	Large
Anafi	Rudimentary	Rudimentary	Maalia	Large	Large
Bishari	Rudimentary	Rudimentary	Butana	Medium	Medium

As shown in table (3) the udder and teat size in the Kenani, Rashaidi, Maganeen, Shanbali as well as Maalia camels is large to medium and have a well developed milk vein (Ishag et al., 2011). This explains their good performance and ability in milk production and may be classified as dual purpose camels, but other types of camels have small size udders and teats.

Kausar et al. (2001) have reported that the udder- and teats form changed markedly in dromedary camels in Pakistan with change the physiological status. In lactating females, the conformation of teats turned noticeably round at the tip. The length of teat varied significantly among the four different groups studied. The circumference and diameter of teat increased from tip to base. The morphometerical data revealed that teat length at maturity increased twice the size of immature heifer (7.95± 0.01vs. 3.23±0.26 cm). The Teat length increased (P<0.05) in lactating compared to non-lactating she camel, which might be attributed to the functional activity. The circumference at apex and mid points of teat decreased significantly (P<0.05) in non-lactating compared to lactating camels. However, the difference was statistically non-significant at base of teat (Table 4).

Table 4
Morphological Observations (cm) on the teat of camelus Dromedarius under different physiological conditions in Pakistan (Kausar et al. 2001).

Parameter	Immature heifer	Mature heifer	Lactating	Non-Lactating
Teat length	3.23	7.95	11.8	8.83
Teat circumference (Apex)	2.45	6.00	6.48	3.40
Teat diameter (Apex)	0.77	1.90	2.05	1.09
Teat circumference (Mid)	3.31	7.06	7.91	6.08
Teat diameter (Mid)	1.05	2.24	2.51	1.93
Teat circumference (Base)	7.96	8.96	9.10	8.78
Teat Diameter (Base)	2.53	2.85	2.89	2.79

Saleh et al. (1971) found in the dromedary camels in Egypt that the fore-teats are placed further apart from each other than the hind ones and the teat in general is short and cone-shaped and somewhat flattened from side to side. Furthermore it showed that both fore and hind teats are almost equal in length (table 5).

Table 5
Length and Diameter of the teat of the Dromedary camel (cm) in Egypt (Saleh et al., 1971).

Parameter		R. fore		L. fore		R. hind		L. hind	
Teat length	Average	2.38		2.40		2.41		2.38	
	Minimum	1.6		1.6		1.5		1.2	
	Maximum	4.0		4.0		3.1		3.3	
Teat diameter		Base	Apex	Base	Apex	Base	Apex	Base	Apex
	Average	1.4	0.6	1.5	0.53	1.5	0.6	1.5	0.62
	Minimum	0.9	0.3	0.9	0.2	0.8	0.4	1.0	0.4
	Maximum	2.3	1.3	2.3	1.1	2.4	1.0	2.2	1.8

Eisa (2012) found a great variations in udder and teat size and length in the she-camel according to different parity of animals (table 6). This results seemed that the udder measurements increased with increasing parity order.

Table 6
Udder measurements (cm) in different parity of the Dromedary camel in Sudan (Eisa, 2012) .

Parameter	3rd lactation	4th lactation	5th lactation
Udder depth	15.3±1.3	16.0±1.9	19.9±1.1
Udder circumference	85.7±7.8	91.1±3.6	100.9±8.9
Udder size (cm3)	1311.8±200.7	1454.9±230.3	2018.6±271.6
Udder height	114.5±5.2	108.0±3	105.8±9.0
Fore teat length	3.4±0.8	4.1±1.0	6.0±0.7
Rear teat length	3.4±0.6	4.1±0.9	6.1±1.3
Fore teat diameter	1.7±0.3	1.7±0.2	3.1±0.4
Rear teat diameter	1.9±0.4	2.3±0.4	3.7±0.5
Distance between fore teat	12.9±2.9	13.2±1.2	10.2±1.9
Distance between rear teat	9.9±1.9	10.1±1.1	10.2±1.9
Distance between right teat	2.3±1.3	3.3±0.2	3.7±2.9
Distance between left teat	2.6±1.7	2.4±0.6	3.7±1.3

Eisa and Hassabo (2009) reported that there is a clear difference between fore and rear udder-Halves in dromedary camel according to the depth ($P<0.01$), height ($p<0.05$), teat diameter ($p<0.01$) and distance between teats ($p<0.01$) (table 7).

Table 7
The fore and rear udder halves measurements (cm) in dromedary camels in eastern Sudan (Eisa and Hassabo 2009).

Measurements	Fore halves Udder	Rear halves udder
Depth	20.9	13.1
Height	110.9	110.2
Distance bet. teat	13.2	9.9
Teat length	4.3	4.4
Teat diameter	2.1	2.5

3. Anatomical characteristics of dromedary camel udder

Anatomical picture of the mammary gland of dromedaries may help to understand the physiology of milk yield and milk synthesis as well as the using of milking machine. As it has been mentioned above the mammary gland of female camel has four quarters, each quarter is consisted of two distinct glands, each leading to a separate gland cistern; and each gland cistern connected to the teat cistern, which were completely separated from each other (Saleh et al. 1971; Ismail, 1986; Tibary and Anouassi, 2000; Abshenas et al., 2007). The left and right glandular halves of the udder are separated from each other by fibroblastic tissue-lamina medial's. The cranial and caudal quarters are independent but there is no visible separation between them (Smuts and Bezuidenhout, 1987; Abshenas et al., 2007). Kauser et al. (2001) reported that the length of streak canal was double in mature than immature heifers (4.56 vs. 2.56 mm) and it was also greater ($P<0.05$) in lactating compared to non-lactating camel. Schwartz and Dioli, (1992) demonstrated that the teat of the camel possess 2-3 cisterns. Each teat cistern is spindle shape, tapers distally, and possess streak canal. The streak canals are short and small.

Tibary and Anouassi (2000) reported that each mammary gland consists of parenchyma, connective stroma, ducts and alveolar systems. A distinction is especial in the glandular parenchyma, for milk synthesis, milk secretion and milk storage and the cavity system has the milk ducts and cistern (Kausar et al., 2001; Abshenas et al., 2007). According to Bank (1993) it was found that the actively lactating glands have much parenchyma and little connective tissue.

Ismail (1986) found that the lactating udder possesses alveoli of various sizes and shapes and some alveoli communicate with each other. The epithelium of the alveoli is simple and its height varied according to the stage of secretary cycle. The secretion inside the alveoli iss homogenous and rarely vacuolated. The alveolar epithelial cell attained their maximum height during lactational phase (kauser et al., 2001; Eisa et al. 2010). The epithelial cells were columnar, ovoid and piriform in shape. Number and size of alveoli per lobule were decreased, similarly the parenchyma reduced and replaced by loose connective tissue during non-lactating phase.

The teat morphology has been associated with milk yield and milk composition (Eisa et al. 2010) and also between fore and rear udder-halves (Eisa ans Hassabo, 2009).

Damian et al. (2009) indicated that, the main arterial mammary vessels are the external pudendal arteries, which irrigate the right and the left udder through the cranial mammary artery and the caudal mammary artery. It has been found that in camel, the perforant arterial branches are missing and the mammary arteries do not split into medial and lateral mammary arteries. It also found that two limphocenters for each glandular half are present.

4. Physiology of lactation in the dromedary camel

The synthesis of camel milk like the synthesis of cow milk takes place inside the alveoli epithelial cells as the basic compounds enter the synthetic cells from the blood. The secretion is stored in the alveoli in the intervals between milking and lastly will be stored in the miking cistern, but the storage cisterns like cows are not large (Simpkin, 1998; Ayadi et al., 2009; Caja et al., 2011), which results build-up intra-mammary pressure and ultimately results in reduction of secretion rate. Therefore the milking frequency in camels will affect the milk yield, so that with increasing the milking frequency the daily milk yield will be improved (Al-Shaikh and Salah, 1994; Wernery et al., 2004; Ayadi et al., 2009). Yagil (1982) in his study revealed that the daily milk yield was lower (1.26 kg) for one time milking to (6.77 kg/day) for four times milking. Bekele, (2010) showed that the milk yield was 6.77±0.15 kg/day in camels milked four times a day, 4.70±0.05 kg/day in those milked three times a day and 3.67±0.08 kg/day in those milked twice a day.

Some researchers reported increase in milk yield in dairy camels according to milking frequency (3 times daily, 5 to 10%; 4 times daily, 30%; Kamoun, 1995) and on the contrary reducing milking frequency to 16 h/day in camels will decrease milk yield by 9% in late of lactation (Al-Shaikh and Salah, 1994). Dependenant on the results of Ayadi et al., (2009) the milk secretion rate in camel udder was greatest for the shortest milking interval (8 h) and daily milk yield decreased when milking interval increased (8 to 24 h) and daily milking frequency was reduced (3 to 1 milking daily) compared with 12-h milking interval (6.1 L/d=100), estimated daily milk yield was 113, 87, and 70% for 8-, 16-, and 24-h intervals, respectively (table 8).

Table 8

Milk yield and milk secretion of dromedary camels at different milking intervals in Tunisia (Ayadi et al., 2009).

Parameter	Milking interval, h			
	8	12	16	24
Milk secretion rate (ml/h)	288	267	206	183
Milk yield, L/milking	2.3	3.2	3.3	4.4
Milk yield L/day	6.9	6.1	5.3	4.3
Milk yield %	113	100	87	70

Similar results was observed by Caja et al., (2011), and the milk secretion rate decreased linearly with time elapsed after milking (4 to 24 h) in camel and milk accumulation decreased markedly after 12 h milking interval. Other studies observed that camels can be milked any time during 24 h and six times milking frequencies were noticed in some animals (Qureshi, 1986).

In addition to that Ayadi et al., (2009) reported that the percentage of cisternal milk was small (19.3% of total milk in the udder at 24 h) when compared with other dairy animals and the authors recommend to use the prestimulation for machine milking and selection for larger udder cisterns. Other researchers reported that camels do not have noticeable mammary cisterns (Yagil et al., 1999), and

Baimukanov (1974) indicated that camel cisternal milk represents only 10% of the total machine-milked milk. Similar results appeared by Ayadi et al. (2013), that the cisternal milk accounted for 11% of the total udder milk after 9 h milking, whereas Caja et al., (2011) showed that camel has a small cistern milk (7%). It is known that cows with large cisterns produce more milk, and are milked faster and more tolerant to longer milking intervals (Knight and Dewhurst, 1994; Ayadi et al., 2003).

It could be concluded that milking frequency in camels is affecting the milk yield and can also affect the milk quality. So that the total milk solids, milk fat content, and milk pH decreased with increasing milking interval. Milk protein, lactose, ash and density remained constant for all milking intervals. Milk k+, Ca++, and Mg++ contents increased as milking interval increased, but Na+ content do not change (Ayadi et al., 2009).

It seems that the asymmetry udder quarters in camel is reflected on milk quantity and quality. Kulaeva (1979) reported that in camel, slightly more milk was received from the rear-quarters (56.4%) compared to (43.6%) from the fore quarters. Other study from Eisa and Hassabo (2009) indicated that rear udder half produced 57.5% (524.6±48.8 ml) of the total milk yield, whereas the fore quarters yielded only 42.5% (387.6±48.8 ml) (P<0.01). Caja et al., (2011) observed that the milk ratio from fore to rear quarters in the udder of dairy camels was 41.2±2.8% to 58.8±2.9% respectively. Gawali and Bhatnagar, (1975) observed that both fore and rear udder halves should be in the ratio 50:50 for better milk ability.

Regarding milk composition, the analysis of milk samples from rear and fore quarters revealed that rear quarters milk is significantly richer in protein, K+ and P++ , while the fore quarters was significantly higher in lactose percentage (Eisa and Hassabo, 2009). These differences in percentage of milk composition between the two udder haves could not be readily extrapolated to variation in udder measurements, it might be due to either increased growth and number of secretory cells, or increased secretory activity of the mammary tissue of the rear quarters (Manar et al., 1956) or because some time the rear quarters might have three glands (Zayeed et al. 1991). Other studies indicated that, the milk of all quarters appears to have the same composition (Ohari and Joshi, 1961).

5. The relationship between udder and teats measurements and milk yield

Many studies indicated that there is very scary correlation between udder and teat measurements and milk yield in the dromedary camels. Eisa et al.(2010) showed that the udder depth, udder circumference, udder size and length of fore and rear teats were positively and significantly correlated with milk yield in dromedary camels, whereas the height of the udder measured for both fore and rear quarter was negatively but insignificant correlated with daily milk yield in camels. While, diameter of fore and rear teats were positively but insignificant correlated with daily milk yield. Similar results were showed by Ayadi et al. (2013) as milk yield was positively correlated (P<0.05) with udder depth (r=0.37), distance between teats (r=0.57) and milk vein diameter (r=0.28), whereas a negative correlation was found with udder height (r=-0.25) (table 9).

Table 9
Correlation between udder measurements and daily milk yield in dromedary camel in Sudan (Eisa et al., 2010),

Parameter	Correlation with milk yield
Udder depth	0.48
Udder circumference	0.46
Udder size (cm3)	0.49
Udder height at fore quarters	-0.37
Udder height at rear quarters	-0.30
Fore teat length	0.34
Rear teat length	0.36
Fore teat diameter	0.20
Rear teat diameter	0.29

6. Presence of the calf during milking process

The importance of the presence of the calf on milk let-down is well known by camel farmer and in most circumstances calves are always present to stimulate the udder before milking. Camels have limited cistern volume just as stated earlier (Ayadi et al., 2013) and milk let-down is usually induced by the suckling effect of the calf (Juhasz and Nagy, 2008). Therefore camels may have an absolute requirement for Oxytocin release during milking process if the calf is present. In a large-scale system, milking would be very difficult to manage if calves were present in the parlour. For that reason the presence of the calves stimulated milk let-down and then the camels will be hand-milked by their caretakers (Bekele et al., 2011). Other method could be used like manual teat stimulation that should be developed to induce milk let-down (Juhasz and Nagy, 2008). Other studies noticed that stimulation in dromedary camel in average of 123.2±84.4 second is enough to induce milk let-down without presence of the calf but the milking time was short (126.9±41.1 sec.)(Wernery et al., 2004). Camel has a unique capability that it can be milked any time during 24 hours and six times milking has also been noticed in some animals (Qureshi, 1986). In Netherlands it was found that the presence of the camel calf is required during milking process to give milk (www.Welt.de). Caja et al., (2011) reported that milking usually done by hand using suckling camel calves for inducing milk letdown. Camels whose calves survived past weaning had mean daily yield 65% higher than camels whose calves died before weaning (El-Agamy, 2006). Other studies observed that Camels lost their calves produced on average 3.75±0.09 kg/day and those with live calves produced 4.22±0.04 kg/day, and the total milk yield per lactation was lower from camels without a calf (1188±146 kg), than from those with a calf (1492±81 kg). In addition to that shorter duration of lactation (330±16 days) was recorded for camels that lost their calf compared to camels with a surviving calf (352±18 days) (Bekele, 2010). In Egypt, the nomadic people believe that if the calf dies she camel will stop lactating and will not accept any other calf to suckle her (El-Agamy, 2006). Bekele et al., (2011) observed that milk let-down was achieved by the calves which massaged the udder for about 70 s. The total milk yield increases clearly when the camels separated from their calves between milking times (Simpkin et al., 1997). Other authors have shown that young camels could be removed from the dam without any negative effect on the milk yield (Wernery et al., 2004). On the contrary Eisa et al., (2010) observed that the presence of the calf is imperative for milk let-down in the camel.

7. Suggesting a scheme to improve the machine milkability in camel

The current milking machines do not take the previous challenges into consideration and the proof of this low fat values observed in the milk of camels after machine milking, which appeared to be due to short milk let-down from the udder during milking (Ayadi et al. 2013). Therefore it is still closely practised in some countries and on a small scale. The new vision of milking machine must be guarantee higher milk productions, better milk quality, preserve of the udder health and improve the social status of camel farmers. In general, it is difficult to develop milking machines for camels because of the great variations in shape and size of udders and teats in addition to great variation in milk yield and lactation length.

The following table shows types of Milking machine used world wide.

Table 10
Types of milking machine used in dromedary camels.

Characteristic Parameter	Herringbone stand, automatic bucket milking machine	Pipline milking machine system	Portable milking machine unit	Portable milking machine unit
Vacuum	36-40 kPa	45 kPa	48 kPa	45 kPa
Pulse	90 cycle/min	60 cycle/min	60 cycle/min	60 cycle/min
Pulsation ratio	60: 40	60:40	60:40	60:40
Milking time	2 min	7.5 min	3.5 min	2 min
Milking cluster	claw and four individual teats cups	claw and four individual teats cups	claw and four individual teats cups	claw and four individual teats cups
Prestimulation	hand stimulation 2-3 min		hand stimulation	by calf
Authors	Wernery et al., 2004	Aljumaah et al., 2012	Atigui et al., 2013	Ayadi et al. 2013

References

Abdallah, H.R., Faye, B., 2012. phenotypic classification of Saudi Arabian camel (Camelus dromedaries) by their body measurements. Emir. J. Food. Agric., 24 (3), P, 272-280.

Abdurahman, O.A.S.h., 2006. udder health and milk quality a mong camels in the Errer valley of eastern Ethiopia. Livest. res. rur. Dev., 18 (8), P, 1-9.

Abebe, W., 1991. traditional husbandry practice and major health problem of camels in Ogaden. Nomad. People., P, 21-30.

Abshenas, J., Vosough, D., Masoudifard, M., Molai, M.M., 2007. B-mode ultrasonography of the udder and teat in camel (Cemelus dromedaries). J. Vet. Res., 62, (2) P, 27-31.

Albrecht, C.E.A., 2003. production of camel milk –first experiences in machine milking of dromedaries. Master thsis Agr., Göttingen, Germany.

Al-Haj, O.A., Al-Kanhal, H.A., 2010. compositional technological and nutritional aspects of dromedary camel milk- A review. In. Dairy J., 20, P, 811-821.

Aljumaah, R.S., Samara, E.M. and Ayadi, M. (2012) influence of introducing machine milking on biothermal parameter of lactating camels (Camelus dromedaries). Ital. J. Anim. Sci. 11:e73, P: 414- 418.

Al-Shaikh, M.A. and Salah, M.S., 1994. effect of milking interval on secretion rate and composition of camel milk in late lactation. J. Dairy Res., 61, P, 451-456.

Atigui, M., Hammadi, M., Khorchani, T., 2013. effects of oestrus on milk yield and composition in Tunisian Maghrebi camels (Camelus dromedaries). Emir. J. Food Agric., 25 (4) P, 291-295.

Aujla, K.M., Jasra, A.W., Munir, M., 1998. Socio-economic profile of camel herders in South-western Mountainous areas of Pakistan. Proc. 3rd Annu. Meet. Anim. Product. under Arid condit., 2, P, 154-174.

Ayadi, M., Aljumaah, R.S., Musaad, A., Samara, E.M., Abelrahman, M.M., Alshaikh, M.A., Saleh, S.K., Faye, B., 2013. relationship between udder morphology traits, alveolar and cisternal milk compartments and machine milking performance of dairy camels (Camelus dromedaries). Spanish J. Agri. Res., 11 (3), P, 790-797.

Ayadi, M., Caja, G., Such, X., knight, C.H., 2003. effect of omitting one milking weekly on lactational performances and morphological udder changes in dairy cows. J. Dairy Sci., 86, P, 2352-2358.

Ayadi, M., Hammadi, M., Khorchani, T., Barmat, A., Atigui, M., Caja, G., 2009. effects of milking interval and cisternal udder evaluation in Tunisian Maghrebi dairy dromedaries (Camelus dromedaries L.). J. Dairy Sci., 92, P, 1452-1459.

Baimukanov, A., 1974. a machine milking in female camels. In:Proc.3rd Symp. physiological principles of machine milking. Borovsk., USSR P, 67-68.

Bakheit, S.A., Abu-Nikheila, A.M., Kijora, C., Faye, B., 2008. The impact of farming system on Sudanese camel milk production. In: Nagy, P.; Huszenicza, G. and Juhasz, J. (Eds.) WBC/ICAR 2008 Satellite meeting on camelid reproduction, 12-13 July, Budapest, Hungary., P, 1-4.

Baloch, M.N., 2001. Documentation and characterization of camel breeds of Pakistan. PhD Thesis. Sindh Agr. Univ., Tandojam, Islamabad, Pakistan.

Banks, W.J., 1993. Applied veterinary histology. 3rd ed. Mosby year Book, London., P, 306-310.

Bekele, T., 2010. Milk production, fluid balance and temperature regulation in lactating camels (Cemelus dromedaries). Doctoral Thsis, Faculty of Vet. Med. And Anim. Sci., Uppsala. Swed. Univ. Agr. Sci., Sweden.

Bekele, T., Lundeheim, N., Dahlborn, K., 2011. Milk production and feeding behavior in the camel (Cmamelus dromedaries) during 4 watering regimens. J. Dairy Sci., 94, P, 1310-1317.

Belay, K., Getahun, T., 2002. production and utilization of camel milk in eastern Ethiopia: The case of Jijiga and Shinnilie zones. Folia Vet., 46 (2), P, 75-82.

Breulmann, M., Böer, B., Wernery, U., Wernery, R., El-Shaer, H., Alhadrami, D., Gallacher, J., Peacock, J., Al-Chaudhary, S., Brown, G., Norton, J., 2007. the camel, from tradition to modern times. UNESCO publ., Doha, Qatar., P, 44.

Burgemeister, R., 1974. problems of dromedary behavior and husbandry in south Tunisia, Thesis. Inst. Trop. Vet. Med., Giessen., P, 95.

Caja, G., Salama, O.A., Fathy, A., El-Sayed, H., Salama, A.A.K., 2011. Milk partitioning and accumulation in the camel udder according to time elapsed after milking. 62nd Annu. Meet. EAAP 2011, August 29th –September 2nd Stavanger, Norway.

Damian, A., Socaciu, A., Chirilean, I., Stan, F., Gudea, Al., Crisan, M., Dezdrobitu, C., Tuns, F., Pop, A.l., Ayman, A.R., 2009. Bulletin Uasvm, Vet. Med., 66 (1), ISSN 1843-5270; Electronic ISSN 1843-5378.

Eisa, M.M.O., 2012. udder conformation and milk ability of she-camel (camelus dromedaries). LPA Lambert Academ. publish. AG and Co kG.

Eisa, M.O., Hassabo, A.A., 2009. variations in milk yield and composition between fore and rear udder-halves in she-camel (camelus dromedaries). Pakistan J. Nutrit., 8 (12), P: 1868-1872.

Eisa, M.O., Ishag, I.A., Abu-Nikhaila, A.M., 2010. A note on the relationships between udder morphometric and milk yield of Lahween camel (Camelus dromedaries). Livest. Res. Rur. Dev., 22 (10), On-line edition (www.Irrd.org/Irrd22/10/eisa22188.htm).

El-Agamy, E.I., 2006. Camel milk. In: Park, Y. W. and Haenlein, G F.W. (ed) Handbook of milk of non-Bovine. Wiley-Blakwell, P, 297-344.

El-Bahay, C.M., 1962. normal contents of Egyptian camel milk. Veter. Med. J., 8, P, 7-17.

FAO., 2011. statistic Year Book, room, Italy.

Farah, K.O., Nyariki, D.M., Ngugi R.K., Noor, I.M., Guliye, A.Y., 2004. the Somali and the camel: Ecol., Manag. Econom. Anthropolog., 6 (1), P, 45-55.

Farah, Z., Mollet, M., Younan, M., Dahir, R., 2007. camel dairy in Somalia: limiting factors and development potential. Livest. Sci., 110, P, 187-191.

Faye, B., 2004. Dairy productivity potential of camel, In: Proceedings of the 34th meeting FAO/ICAR (International Committee for Animal Recording) Session on camelids, 28 May-3 June 2004, Sousse (Tunisia), P, 93-105.

Faye, B., 2005. productivity potential of camel. In: Faye, B. and Esenov, P. (Ed) Desertification combat and food safety.IOS. Press, Amesterdam., P, 127-134.

Faye, B., 2008. the production potential and importance of camels and Camelids in the world. In: Nagy, P.; Huszenicza, G. and Juhasz, J. (Eds.) WBC/ICAR 2008 Satell. meet. camel. reproduct., 12-13 July, Budapest, Hungary. P: 1-4.

Faye, B., Bonnet, P., 2012. camel sciences and economy in the world: current situation and perspectives. In: Proc. 3rd ISOCARD conference, 29th January- 1st February, 2012, Muscat, Sultanate of Oman. P: 2-15.

Gawali, S.R., Bhatnagar, D.S., 1975. variations in individual quarter yields in dairy cows. J. Dairy Sci., 28, P, 225-227.

Hussien, M.A., 1989. husbandry and management of camels in Somail, Ethiopia, Kenya and Djibouti. Options Mediterraneennes- Serie Seminaires., 2, P, 37-44.

Ishag, I.A., Eisa, M.O., Ahmed, M-K. A., 2011. Phenotypic characteristics of Sudanese camels (Camelus dromedaries). Livest. Res. Rur. Dev., 22 (10), On-line edition (www.Irrd.org/Irrd23/4/isha23099.htm)

Ismail, H.I., 1986. Morphological, Morphometric and Histochemical observations on the udder of the camel (Camelus dromedaries). PhD thesis, faculty of agriculture. Univ. Khartoum, Sudan.

Jasra, A.W., Aujla, K.M., 1998. Socio-economic profile of camel herders in south-western mountainous areas of Pakistan. camel newsletter., No. 15, P, 14-17.

Juhasz, J., Nagy, P., 2008. Challenges in the development of a large-scale milking system for dromedary camels. In: Nagy, P.; Huszenicza, G. and Juhasz, J. (Eds.) WBC/ICAR 2008 Satellite meeting on camelid reproduction, 12-13 July, Budapest, Hungary., P, 1-4.

Kamoun, M., 1995. Le lait de dromadaire: Production, aspects qualitatifs et aptitude a la transformation. Options Mediterr., B 13, P, 105-130.

Kamoun, M. and Jemmali, B. (2012) Milk yield and characteristics of Tunisian Camel. J. Anim. Sci. 1 (1), 12-13.

Kausar, R., Sarwar, A., Hayat, C.S., 2001. gross and microscopic anatomy of mammary gland of dromedaries under different physiological conditions. Pakistan Vet. J., 21 (4), P, 189-193.

Khan, B.B., Iqbal, A., 2001. production and composition of camel milk (Review) Pak. J. Agri. Sci., vol 38, (3-4), P: 64-68.

Knight, C.H., Dewhurst, R.J., 1994. once daily milking of dairy cows: relationship between yield loss and cisternal milk storage. J. Dairy Res., 61, P, 441-449.

Knoess, K.H., 1984. The milk dromedary. In: Cockrill, W.R.: the camelid, an all purpose animal. The Scandinavian institute of African studies, Uppsala., 1, 1-544; P: 176-198.

Knoess, K.H., Makhudum, A.J., Rafiq, M., Hafeez, M., 1986. milk production potential of the dromedary, with special reference to the province of the Punjab, Pakistan. World Anim. Rev., FAO Rome, 57, P, 11-21.

Köhler-Rollefson, I.U., 1991. Camelus dromedaries. Mammallian Species. The American society of Mammalogists Nr., 375, P, 1-8.

Kulaeva, V., 1979. konevodstvo I koayis port. Konavodetova., 34, P, 5-9.

Leopold, G., 1978. the economic importance of the one-humped camel. Urban and Schwarzenberg, Munich.

Mannar, M.C., Venkayya, D., Narayan, D., Rangaswami, M.C., 1956. functional individuality of the quarters of the udder of the dairy cows. J. Dairy Sci., 9, P, 186-192.

Musaad, A., Faye, B., Abu-Nikhela, A., 2013. Lactation curve of dairy camels in an intensive system. Trop. Anim. Health Prod., 45 (4) P, 1039-1046.

Musinga, M., Kimenye, D., Kivolonzi, P., 2008. The camel milk industry in Kenya. Results of a study commissioned by SNV to explore the potential of camel milk from Isiolo District to access sustainable formal markets. Fin. Rep. Res. Mobilizat. Center., P, 1-75.

Nagpal, A.K., Patil, N.V., 2012. performance of lactating dromedary camels maintained on different energy ration under arid ecosystem. J. camel Prac. Res., 19, (2) P, 229-233.

Nagy, P., Skidmore, J.A., Juhasz, J., 2013. use of assisted reproduction for the improvement of milk production in dairy camels (Camelus dromedaries). Anim. Rep. Sci., 136, P, 205-210.

Ohari, S.P., Joshi, B.K., 1961. composition of camel milk. Ind. Vet. J., 38 (a), P, 514-516, 38 (b), P, 604-606.

Pash, R.H., Qureshi, A.S., Khamas, W.A., 2013. a survey of camel production in three different ecological zones of Pakistan. Int. J. Agric. Biol., 15, P, 62-68.

Qureshi, M.H., 1986. the camel. A paper presented at FAO seminar on camel production and health, oct 20-23, Kuwait.

Raghvendar, S., Shukla, S.K., Sahani, M.S., Bhakat, C., 2005. chemical and physico-chemical properties of camel milk at different stages of lactation. In: saving the camel and peoples livelihoods: building a multi-stakeholder platform for the conservation of the camel in Rajasthan. Proc. Internat. Conf. held on Nov 23-25, 2004, LPPS, Sadri, Rajasthan, India.

Rao, C.K., 1974. scheme for the improvement of Indian camels: to what extent camels are milked and what the approximate yield is. Mimeo. Item No. 12, P, 3.

Raziq, A., Younas, M., Kakar, M.A., 2008. camel-a potential dairy animal in difficult environments. Pak. J. Agri. Sci., 45 (2), P, 263-267.

Raziq, A., Younas, M., Khan, M.S., Iqbal, A., 2011. milk production potential as affected by parity and age in the kohi dromedary camel. J. camel Prac. Res., 7, (2) P: 1-4.

Reta, D., Mekonnen, H.M., 2002. study on milk off take from Issa type dromedaries under pastoral environmental conditions in and around Dire Dawa, Ethiopia. J. Revue de Med. Veter.

Saleh, M.S., Mobarak, A.M., Fouad, S.M., 1971. Radiological, Anatomical and histological studies of the mammary gland of the one-humped camel (Camelus dromedaries). Zbl. Vet. Med., A, 18, P, 347-352.

Schwartz, H.J., 1992. productive performance and productivity of dromedaries (Camelus dromedaries) Anim. Res. Dev., 35, P, 85-98.

Schwartz, H.J., Dioli, M., 1992. the one-humped camels (Camelus dromedarius) in Eastern of Africa. A pictorial guide to diseases, health care and management. Verlag Josef Margraf, Berlin, Germany., P, 91-94.

Simpkin, S.P., Rowlinson, P., Tullu, D., Lesorogol, P., 1997. camel calf suckling behavior and milk yield estimation studies in Kenya. J. Camel Parc. Res., 4, P, 235-239.

Simpkin, S.P., 1998. traditional camel management methods in kenya with a special reference to milk production. In: Bonnet, P. (ed) dromedaries and camel, milking animals. Actes Du Colloque, 24-26 October, Nouakchott, Mauritanie, Montipellier, France, CIRAD., P, 67-68.

Smuts, M.M.S., Bezuidenhout, A.J., 1987. Anatomy of Dromedary, 1st edition, Clarendon press, Oxford university, Oxford, New York., P, 230.

Tezera, G., 1998. characterization of camel husbandry practice and camel milk and meat utilization in Shinille and Jijiga zone of Somali national regional state, MSc thesis. Alemaya Univ. Agr., Dire Dawa, Ethiopia.

Tibary, A., Anouassi, A., 2000. Lactation and udder diseases. In: Skidmore, J.A. and Adams, G.P. (eds): resent advances in camelid reproduction. Publ. Inter. Vet. Inform. Serv. (www.ivis.org).

Wardeh, M.F., 2004. classification of the dromedary camels. J. Camel Science 1, ACSAD-Damascus., P, 1-7.

Wardeh, M.F., Al-Mustafa, M., 1990. camel breed types in the Arab countries north and west Africa. Proc Arab symp. Of camel husbandry and diseases and methods of their control, March 24-26, 1990, Alger, Algeria., P, 105.

Wernery, U., 2006. camel milk, the white gold of the desert. J. Camel Prac. Res., 13, p, 15-26.

Wernery, U., Juhasz, J., Nagy, P., 2004. milk yield performance of dromedaries with an automatic bucket milking machine. J. Camel Prac. Res. 11, p, 51-57.

Wilson, R.T., 1984. the camel. London, Longman., P. 153-154.

www. welt. de/wissenschaft/article., 2013. Dromedar statt Kuh-Kamelmilch aus Holland.

Yagil, R., 1982. Camels and camel milk. FAO Animal production and Health Paper Nr. 26, Rome, Italy., P. 14-19.

Yagil, R., Etzion, Z., 1983. Lactation in drought areas. In: Shual. Development in ecological and environmental quality., 11, P, 22-30.

Yagil, R., Creveld, V., Abu-Rkaib, G., Merin, U., 1999. milk let-down in camels. J. camel. Prac. Res., 6, P, 27-29.

Yaqoop, M., Nawaz, H,. 2007. potential of Pakistani camel for dairy and other uses-review article. Anim. Sci. J., 78, P, 467-475.

Zayeed, A.A., Magdub, A.B., Shareha, A.M., El-sheikh, A., Manzally, M., 1991. Camels in the Arab world. Conference, 1st edition. Univ.Omar El-Mukhtar, Tripoli, Libya., P, 115.