

MILK YIELD PERFORMANCE OF DROMEDARIES WITH AN AUTOMATIC BUCKET MILKING MACHINE

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ABSTRACT

Sixteen U.A.E. dromedaries were milked with an automatic bucket milking machine for twelve months. They produced a total of 21,959.9 kg of milk with a daily milk yield of 4.8 kg each. The milk production followed a typical lactation curve with the highest milk yield during the first months after parturition. Milk production was significantly dependent on how often the camels were milked per day and when milking started after parturition. It seems that camel calves can be removed from the dam without any negative effect on the milk yield.

A herringbone stand is suitable for milking dromedaries. Dromedaries entered the stand effortlessly without any sign of stress or discomfort. The automatic bucket milking machine using 25 mm silicon liners was accepted by all the 16 dromedaries without any problem. Machine stimulation was abandoned because it caused udder oedema and mastitis. Hand stimulation of two to three minutes was well accepted and duration was decreased after the first three months of milking. Milking was performed with a vacuum pressure of 36 - 40 kPa, a pulsation rate of 60:40 with 90 cycles per min.

Key words: Dromedary, milk yield performance, milking machine

The milk yield of camels is a controversial and highly disputed topic. In the scientific literature, daily milk yields have been reported between 3 and 40 L (Yagil, 1987; Ismail and Al-Mutairi, 1994 and Yagil, 2000). The great discrepancy is due to a variety of misunderstandings and misconceptions (Wernery, 2003). It is often not taken into account, that camel calves which graze with their dams for a year, will drink approximately 10 L per day even when the calves start to graze. All milk yield investigations have been conducted on manually milked dromedaries, and there are no reports available of milk yield performance of dromedaries with milking machine, although camels have been milked with a milking machine (Bonnet, 1994).

The aim of this study was to monitor the milk yield of 16 dromedaries over a period of one year after milking with an automatic bucket milking machine. It further describes the equipment of the milking machine and its use for milking dromedaries.

Materials and Methods

Dromedaries

Sixteen dromedaries between 10 to 15 years of age were moved together with their calves to the

stables of the Central Veterinary Research Laboratory (CVRL) in Dubai.

The dromedaries were kept in two groups in open pens. Group I consisted of 10 dromedaries which had calved five to seven months prior to milking, and Group II consisted of 6 camels which had calved six to eight weeks prior to milking. After the morning and afternoon milking, the calves were kept together with their dams for three hours to ensure a proper milk supply. As they grew older, the time spent with the dams was gradually reduced to one hour after each milking. All separated calves were kept in one holding pen where they also received additional feed. Complete weaning was done at approximately one year of age. The calf of one camel in Group II died two weeks after parturition, but the camel remained in the study.

Feed

After the morning milking, adult dromedaries received four kg of camel concentrate and four kg of fresh alfalfa hay daily and they were given Rhodes hay *ad libitum*. The camels also had free access to water and salt blocks. In addition to milk, the calves also received alfalfa hay, camel concentrate and Rhodes hay *ad libitum*.

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Milking stand

All dromedaries were milked in a herringbone-like milking stand designed by CVRL scientists with the help of engineers from UAE and Germany based companies (Adearest, Sharjah and Westfalia, Germany respectively). During milking, the milkers stood in a 25 cm deep pit which gave them easy access to the udders (Fig 1). Five dromedaries were milked simultaneously.

Milking machine

Milking was performed with a mobile bucket milking machine (Mobilek, Westfalia, Germany). Based on preliminary studies (Albrecht, 2003), the technical parameters used for this study were as follows: No machine stimulation, vacuum 36 to 40 kPa, pulsation rate 60:40 and 90 cycles per min.

Milking procedure

Milking was carried out twice daily at six in the morning and three in the afternoon during the week and only in the morning during weekends. A thorough examination of the udders was conducted prior to each milking and if any abnormality was detected (e.g. udder swelling, hardening or teat injury), milk samples from each quarter were aseptically collected for bacteriological examination and a California Mastitis Test (CMT).

Before milking, the udder was manually stimulated for two to five minutes by gentle massage of the udder and pulling the teats (Fig 2). Following manual stimulation, teats were cleaned with a disposable soft tissue containing a cleaning substance (Sowotaan Jumbo plus Profilac Dermapre, Westfalia, Germany) (Fig 3). After this procedure, clusters with silicon liners of 25 mm diameter were applied to the teats (Stimulor, Westfalia) (Fig 4). Following milking when the milk flow markedly decreased, the teat cups were removed and teats were dipped into a disinfectant solution (Profilacioderma, Westfalia, Germany).

When dromedaries were initially introduced into the study, manual stimulation alone failed to initiate milk ejection. Therefore the milk ejection reflex was initially induced either by allowing the calf to suckle for a few minutes, or by the intravenous injection of 8 IU oxytocin. When camels adapted to the milking procedure, manual stimulation alone was sufficient to induce the milk let-down.

Data collection and analysis

At each milking time, milk yield, stimulation time and milking time were recorded. The lactation period was divided into four periods, expressed in months from the time of parturition. Period one lasted from 1 to 6 months, period two from 7 to 12 months, period three from 13 to 18 months, and period four from 18 months onwards. Milk production was compared between the two groups of camels (Group I and II), and the four periods by analysis of variance for repeated measures. The difference between periods was tested by LSD (least significant difference) procedure. To test the effect of the calf on the milk yield, daily milk yield of nine dromedaries in Group I were compared 30 days before and 30 days after complete weaning by analysis of variance. Pearson correlation coefficient was calculated between milking time and milk yield both for the morning and the afternoon milking. Stimulation time between the first three months of milking and later on, was compared with analysis of variance (Townend, 2002).

Results

Over a period of several months 16 dromedaries which were milked with an automatic bucket milking machine produced 21,959.9 kg of milk with a daily milk yield of 4.8 kg each. Milk production was significantly lower when milked once a day in comparison to twice daily milking (mean $\pm$ SD; once a day: 3.3 kg $\pm$ 1.19; twice a day: 5.5 kg $\pm$ 1.75, $P < 0.001$, Table 1). Camels of Group II that were milked six to eight weeks after parturition, had a significantly higher average milk production than camels of Group I whereby calves were delivered five to seven months before the milking started (mean $\pm$ SD; Group I: 4.6 kg $\pm$ 1.83; Group II: 5.4 kg $\pm$ 1.94, $P < 0.001$, Table 1).

Milk production significantly decreased over time ($P < 0.001$). Camels in the first six months after parturition produced more milk than later on (mean $\pm$ SD; Period one: 5.4 kg $\pm$ 2.17). After the first six months, milk production remained stable until approximately 16 to 18 months after parturition (mean $\pm$ SD; Period two: 4.7 kg $\pm$ 1.78; Period three: 4.7 kg $\pm$ 1.88), when it declined (mean $\pm$ SD; Period four: 3.5 kg $\pm$ 1.17; Fig 5).

The calf of one camel from Group II died two weeks after parturition, but the camel continued lactating. Her milk production showed a similar pattern to other camels in the same group (Figure

6). In Group I, the average milk yield was the same during the 30-day period before (mean $\pm$ SD; 5.2 kg 1.92) compared with the 30-day period after (mean $\pm$ SD; 5.0 kg $\pm$ 1.75) complete weaning.

The average stimulation and milking times were 123.2 $\pm$ 84.4 and 126.9 $\pm$ 41.1 seconds, respectively in the morning and 130 $\pm$ 93.2 and 115 $\pm$ 38.2 seconds, respectively in the afternoon (mean $\pm$ SD). There was a significant correlation ($P < 0.001$) between milking time and milk yield both in the morning and in the afternoon (morning milking time: $R = 0.49$; afternoon milking time: $R = 0.45$). The changes in average morning stimulation and milking time throughout the months following parturition are shown in Fig 7. Stimulation time was significantly longer in the first three months of the milking compared with later (mean $\pm$ SD; morning stimulation time: first three months 193.3 $\pm$ 135.8 seconds, after the first three months 111.6 $\pm$ 65.6 seconds; afternoon stimulation time: 222.9 $\pm$ 124.4 seconds, after the first three months 115.7 $\pm$ 77.2 seconds; $P < 0.001$).

Discussion

This study has shown that camels can be managed well in a closed farm where they produce a high quality food product i.e., milk. Over a period of one year, 16 dromedaries were milked with an automatic bucket milking machine. Total milk produced was 21,959.9 kg with an average daily milk yield of 4.8 kg each. Although camels have been previously milked with a machine, this is the first time that the milk yield has been published. Comparable studies were conducted in different countries using hand-milking. In the literature the daily milk yield has been reported to range from 3 to 8 litres (Farah, 1994) to 40 L (Yagil, 1987). In Saudi Arabia, Ismail and Al Mutairi (1994) compared the daily milk yield of four different breeds. They produced 6.8 to 9.3 kg. Yasin and Wahid (1957), Rao (1974) and Knoess (1980), reported a daily milk yield of nine to 13 kg, 6.9 to 18.2 kg and 15 to 35 kg, respectively. With 4.8 kg of daily milk production, UAE camels are at the low end of the values reported in the literature. There are different

Table 1. Long-term total and daily average milk yield performance with an automatic milking machine in dromedaries with once and twice a day milking.

Camel	Group	Milking once a day			Milking twice a day			Entire milking period		
		Number of milking days	Total amount of milk (kg)	Daily average (kg)	Number of milking days	Total amount of milk (kg)	Daily average (kg)	Number of milking days	Total amount of milk (kg)	Daily average (kg)
1	I	104	489.0	4.7	233	1870.5	8.0	337	2359.5	7.0
2	I	114	362.0	3.2	245	1327.5	5.4	359	1689.5	4.7
3	I	88	253.5	2.9	165	771.0	4.7	253	1024.5	4.0
4	I	120	282.0	2.4	249	959.5	3.9	369	1241.5	3.4
5	I	113	336.0	3.0	238	1118.6	4.7	351	1454.6	4.1
6	I	109	356.0	3.3	224	1225.0	5.5	333	1581.0	4.7
7	I	117	347.5	3.0	259	1235.3	4.8	376	1582.8	4.2
8	I	115	419.5	3.6	251	1499.0	6.0	366	1918.5	5.2
9	I	61	127.0	2.1	116	405.8	3.5	177	532.8	3.0
10	I	79	253.0	3.2	180	863.5	4.8	259	1116.5	4.3
11	II	78	257.5	3.3	165	956.5	5.8	243	1214.0	5.0
12	II	82	305.5	3.7	163	1079.5	6.6	245	1385.0	5.7
13	II	71	241.5	3.4	138	853.5	6.2	209	1095.0	5.2
14	II	67	226.5	3.4	154	869.5	5.6	221	1096.0	5.0
15	II	74	323.3	4.4	168	1244.0	7.4	242	1567.3	6.5
16	II	76	250.5	3.3	154	851.0	5.5	230	1101.5	4.8
Total	Group I	1020	3225.5	3.2 ^{a*}	2160	11275.6	5.2 ^{b*}	3180	14501.1	4.6*
Total	Group II	448	1604.75	3.6 ^{a*}	942	5854	6.2 ^{b*}	1390	7458.75	5.4*
Total	All camels	1468	4830.25	3.4 ^a	3102	17129.6	5.7 ^b	4570	21959.85	5

* indicates significant difference between groups in the same column at $P < 0.001$ level.

a and b in superscript indicate significant difference in the same row at $P < 0.001$ level.



Fig 1. During the milking process the milkers are standing in a 25 cm deep pit.



Fig 2. Stimulation of the udder by hand prior to milking

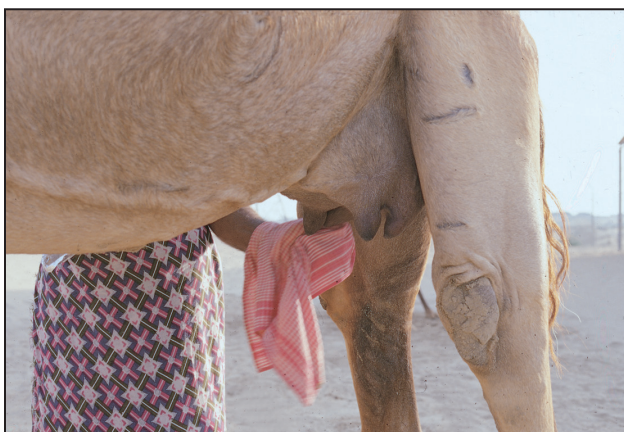


Fig 3. After stimulation and before milking the teats were thoroughly cleaned.

reasons for this. Firstly, our dromedaries were milked once a day during weekends, which reduces the total amount from 5.5 kg/d to 3.3 kg/d (Table 1). Secondly, daily average values provided in the literature usually include estimated quantity of milk consumed by the calves. Thirdly, UAE camels are bred for racing and not for milk production. In general, camels

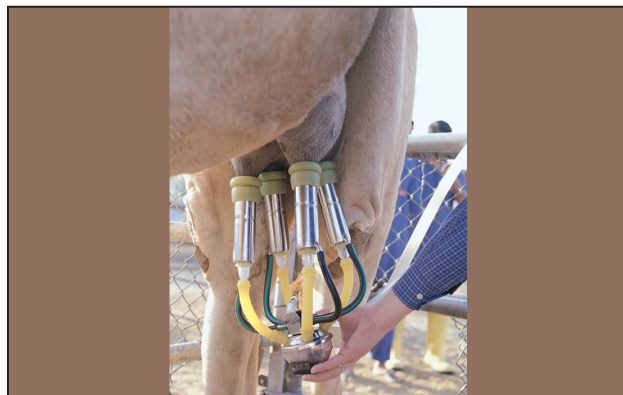


Fig 4. The silicon liners were applied to the teats.

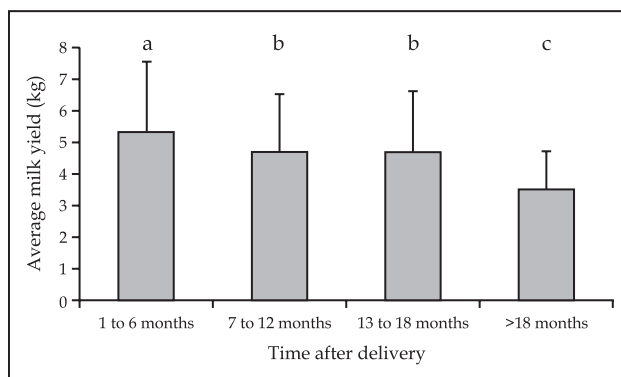


Fig 5. Average milk yield during four periods after parturition. Different letters above the columns indicate significant difference at $P < 0.001$ level. Error bars indicate standard deviation.

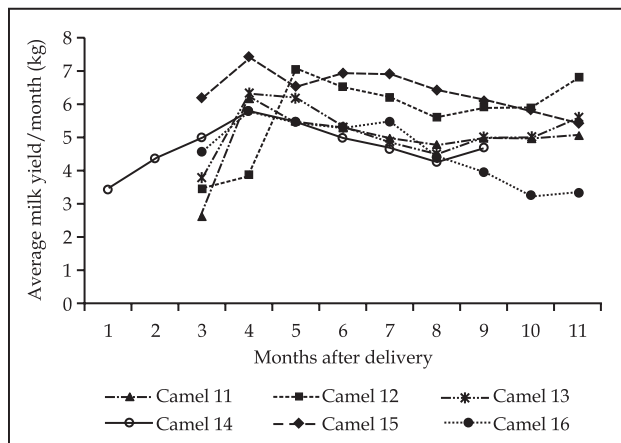


Fig 6. Average milk yield per month in Group II camels. Camel 14 (solid line and open circle) lost her calf but remained in milking. Its milk production shows a similar pattern as other camels in the group.

race for approximately 10 years before retiring to breeding farms. Here the milk is consumed by the offspring and the camel caretakers. Furthermore, our 16 experimental dromedaries had calved six to eight weeks (Group II) or five to seven months (Group I) before milking had commenced.

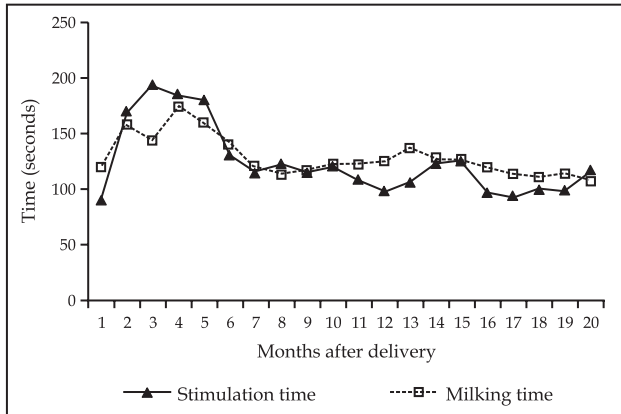


Fig 7. Average stimulation and milking time in the morning. Note the marked decrease both in stimulation and milking time six months after parturition.



Fig 8. A dromedary udder with very large teats makes automatic milking difficult.

The lactation curve of our dromedary herd followed a similar pattern as reported for dairy cows, whereby milk production significantly decreased with time. The highest average milk yield was recorded during the first six months, after which production remained stable until approximately 16 to 18 months after parturition, when it declined gradually. Karne (1998) observed that the daily milk production varied with the month of lactation, being high in the first seven months of lactation and declining during the last three months. A similar curve is reported by Hjort (1993) in Somalia and Karne (1998) in Kenya. However, their investigations were carried out between one to three months after delivery.

It was demonstrated that lactation in camels can last up to two years (Yagil, 2000). However, due to the low milk yield it might not be economical to continue milking after 1.5 years.

Milking was performed twice daily but only once at weekends. It is known that camels do not

‘store’ milk in the udder and should be milked several times a day to obtain a maximum milk yield (Yagil, 2000). Indeed, it has been suggested that camels should be milked by machine three or four times a day (Wernery, 2003). However, a study of milking frequency showed no advantage of three times a day milking over twice a day milking, with respect to daily yield (Karne, 1998).

The removal of calves immediately after parturition is a controversial issue and has so far never been practiced. One of our milking dromedaries lost its calf 14 days after parturition and the amount of milk this dam produced was similar to other dromedaries in Group II, which were kept with their calves. However, Bekele *et al* (2000) stated that camels, which have lost their calves, gave less milk. In our study we have also shown that complete weaning at approximately one year of age did not reduce the daily milk yield. From our study it seems that the removal of the calf has no negative effect on the milk yield, which could be of great advantage for the entire milking procedure.

The factors affecting the milk yield and quality are those common to all dairy animals: genetic potential, health care and nutrition. Dairy camels should receive a balanced supply of nutrients through their diet but very little is known about their requirements in general. Some work was conducted with racing dromedaries (Kohnke and Cluer, 1992) but virtually nothing is known for milk camels, consequently there is an urgent need to address this issue. In Kenya, dromedaries were able to maintain a daily milk yield between eight and 10 kg for the first seven months under a simple nomadic management system and consuming only natural vegetation. A cow dependent on forage from natural pasture produces five to six kg of milk per day (Karne, 1998). This demonstrates that dromedaries can produce more milk than cows of local breed under the same conditions. With improved nutrition it would be possible to raise the milk yield in camels, considerably, as shown by Moslah (1998).

Prior to this study, two different other designs of milking stands were evaluated: free-standing single stand (like a treatment stand, Albrecht, 2003) and tandem milking stand. Neither was as suitable as the presently used herringbone system. It requires much less space and from the outset, the dromedaries accepted it better, although they had never entered a milking stand before. The herringbone stand is an

optimal design with easy access for entry and exit. Because of the milk pit, the milkers had easy access to the udder without bending down. Only five stands were used but we are convinced that 12 stands on each side can easily be managed. It is also anticipated that camels can be fed a concentrate diet during the milking process. Camels are extremely intelligent (Davidson, 1980), and it is only a question of time before the first milking carousel is designed for dairy camels.

Machine stimulation of 300 cycles per minute for 40 seconds, proposed by Albrecht (2003), was tried but soon abandoned as it resulted in a high incidence of udder oedema and mastitis. At the beginning of milking, manual stimulation alone failed to let milk down, and therefore we needed to induce it either by allowing the calf to suckle or through oxytocin injection. After camels adapted to the technology, manual stimulation alone was sufficient. The milk let-down is of short duration and milking must, therefore, be conducted as quickly as possible. In camel rearing countries, camel owners are aware of this, and hand milking is carried out on both sides simultaneously by two milkers. The introduction of an automatic milking machine eliminates the necessity for double-sided milking. The duration of milking time was two to three minutes for each camel. The entire milking process with cleaning, stimulation, milking and teat dipping lasted between 4 to 7 minutes.

For the milking process we used liners made of silicon, which were soft and very suitable for camel teats (Albrecht, 2003). At the beginning of our study, we used different sizes of liners because of the different sizes of camel teats. The most suitable size available was 25 mm, which even fitted on very large teats, although with some difficulties (Fig 8). Because of the different anatomy of the camel teats compared to cattle (teats possess at least two teat canals each), in the future, different liner sizes and shape should be developed.

Much effort was put into experiments evaluating the optimal vacuum and pulsation rate. This is of paramount importance for the health of the udder. Albrecht (2003) used 90 cycles per minute with a pulsation rate of 60:40 and a vacuum pressure of 38 kPa. Using the same parameters, we also observed that our experimental dromedaries did not show any signs of stress or discomfort and had a low incidence of udder oedema or mastitis (Eberlein, 2004; in press).

This experiment shows that dromedaries can become good milk producers. If in the future, camel

milk is to be produced commercially, breeding of a milk camel should be a priority. Dromedaries become mature between four and five years, and their gestation period last approximately 13 months. Therefore by employing such techniques as artificial insemination and embryo transfer, both of which have already been used in breeding of camels for racing, this should be possible in the near future. Although, camel milk has been used for many centuries, camels have never been systematically selected solely for milk production and currently no large scale camel dairy enterprises exist.

If in the future, camel milk is being produced commercially, a milk camel with a uniform udder must be bred. This could permit the introduction of milking machines which would in turn encourage breeders to breed camels with standard-sized udders and teats. Moreover, milking machines will not only guarantee higher milk production and better milk hygiene (Eberlein, 2004 in press), but their introduction, and the consequent elevation of breeding camels for milk production to the status of a dairy industry, would also improve the social status of camel farmers.

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