Influence of introducing machine milking on biothermal parameters of lactating camels (Camelus dromedarius)

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Abstract

The current study wanted to investigate the physiological suitability of using the machine milking in lactating camels by assessing several biothermal (thermophysiological and infraredd thermostaphical) parameters. These parameters were assessed on 3 consecutive days, immediately before, immediately after, and also 1 h after machine milking. The sample was composed of 12 multiparous dromedary camels at mid-lactation. The hypothesis of the current study was that introducing machine milking would produce noticeable effects on the physiological status of lactating camels. On the contrary, the obtained results revealed that machine milking had no effect (P>0.05) on average rectal (37.88±0.23°C) and vaginal temperatures (37.94±0.14°C), as well as respiratory (16.12±0.23 breath/min) and heart rates (56.78±1.89 beat/min). A significant decrease (P<0.001) in udder (-1.0°C) and teat (-1.6°C) surface temperatures, instead, was detected 1 h immediately after milking. Accordingly, this study provides a clear evidence that introducing machine milking has no effect on the homeothermic status of lactating camels.

Introduction

In Saudi Arabia, camel population is estimated to be made up of approximately 850,000 head, distributed in different parts of the country (Ministry of Agriculture, 2010). Daily camel milk produced by indigenous breeds ranges from 6 to 18 L/head (Aljumaah et al., 2011). Although dairy camel’s milk is traditionally used by nomadic people for human nutrition and therapeutic purposes (Agrawal et al., 2002), camel’s milk receives much attention. The particular interest in camel’s milk stems from the fact that dairy camels, unlike other farm animals, continue lactating even when encountering severe conditions in their natural environmental habitat (Aljumaah et al., 2011).

Milking management can be regarded as the most important and crucial step in the milk production chain. A considerable number of studies has been conducted on milking management of dairy cattle, sheep and goat, but comparatively little information is available on the milking management of dairy camels (Wernery et al., 2004; Ayadi et al., 2009; Hammad et al., 2010). Hand milking is the mostly used system in camels worldwide. However, as a result of market demand for commercial milk production, an intensive industrial system using modern machine milking has recently been adopted for dairy camels (Wernery et al., 2004).

Our previous study on lactating dairy camels showed that machine milking is used to improve the harvested milk quantity without altering the milk chemical composition of camels maintained under an intensive production system (Hammad et al., 2010). In this respect, it is a method more practical and efficient than hand milking. However, dams experienced some difficulties in adapting to the machine milking system.

As studies on the effect of introducing machine milking upon the physiological status of lactating camels are scarce, our aim was to bridge this gap. With this in mind, we evaluated the physiological suitability of using the machine milking in lactating dromedary camels by assessing several biothermal parameters immediately before, immediately after, and 1 h after machine milking.

Materials and methods

Animal and management

A total of 12 multiparous lactating dromedary camels [135±21 days in milk (DIM), 2.97±0.21 parity and 9.1±1.1 kg of daily milk yield] were used to conduct the present study in May 2011. All camels were identified by electronic ear tags (Shearwell Data Ltd., Minehead, UK), and housed together as groups under an intensive production system at Al-Watania agricultural farm stock (Al-Jouf district, Saudi Arabia). Camels were fed twice a day on alfalfa roughage and concentrates, while water was offered ad libitum. Daily ration per animal consisted of 13.5 kg of alfalfa hay [dry matter (DM), 92.2%; crude protein (CP), 21.8%; neutral detergent fibre (NDF), 26.7%; gross energy (GE), 4.36 Mcal/kg; on DM basis] and supplemented with 2 kg of a commercial concentrate [DM, 90.2%; metabolisable energy (ME), 2.9 Mcal/kg].

Under the current intensive system conditions, lactating camels after parturition suckled their calves freely for 2 months. Then, between the 2nd and the 12th month, camels were milked twice a day (at 5.00 a.m. and 5.00 p.m.) and suckled their calves for stripping. Calves were weaned at the 12th month of age, and camels were thereafter regularly milked until the 16th month.

Milking of camels in the present study was conducted using a down pipeline machine milking system (DEVALAL, Riyadh, Saudi Arabia). The milking machine was set at 45 kPa, 60 pulses/min, and 60:40 pulsation ratio, and equipped with recording jars. At each milking time, camels spent on average 7.5±0.3 min for an average milk yield of 4.6±1.1 kg.

Meteorological measurements

The ambient temperature (T_a) and relative
humidity (RH) were concurrently and continuously recorded at 15-min intervals using 2 data loggers (model H08-032-08; ONSET HOBO Data Loggers, Cape Cod, MA, USA), mounted inside the milking parlour at a height of approximately 2 m from the ground, and placed away from direct sources of heat, sunlight and water. A special data logging software (model BoxCar Pro 4; ONSET HOBO Data Loggers) was applied for programming the loggers and for data analysis. The temperature-humidity index (THI) was determined thereafter as described by West (1994) to estimate the environmental severity on the animals.

**Biothermal measurements**

In the current study, several biothermal (thermophysiological and infra-red thermographical) measurements were quantified for each lactating camel. Rectal (Tr) and vaginal (Tv) temperatures, respiratory (RR) and heart (HR) rates, as well as body, udder, teat and milk vein surface temperatures (Tv) were determined immediately before (pre-), immediately after (0 h post-) and 1 h after (1 h post) the evening milking (5.00 p.m.) on 3 consecutive days.

Measurements were recorded using a digital thermometer (ARTSANA, Grandate, Italy) measure to the nearest 0.1ºC for Tr and Tv. Meanwhile, camels’ RR and HR were recorded by placing the diaphragm of the stethoscope (3M Littmann® Classic II S.E. stethoscope; 3M, St. Paul, MN, USA) between the 9th and the 11th intercostal space, counting 10 breaths/beats, and then expressing the recorded time as number of breaths/beats per minute, respectively.

For dry surfaces, left side thermograms (infra-red thermographic images) of body, udder, teat (front and rear) and milk vein surfaces were obtained using a forward-looking and automatically calibrating infrared camera (VisIR-Ti200 infrared vision camera; Thermoteknix Systems Ltd., Cambridge, UK) placed perpendicular and approximately 150 cm (for body thermograms) or 50 cm (for udder, teat and milk vein thermograms) away from the camel’s surfaces. A body emissivity of 0.97 (Monteith and Unsworth, 1990) was used for all thermograms. The distance between the animal and the camera as well as the body emissivity was supplied for the camera to compensate for the effects of different radiation sources. The recording time between animals was kept to minimum. The camera used was equipped with 25° lens, 1.3 M pixel visible camera, an LCD touch screen. It also had a 7.5-13 m spectral range and a precision of ±0.1°C.

After capturing, thermograms were stored inside a 250 MB internal memory, readout and analysed using a special thermograms analysis programme (TherMonitor; Thermoteknix Systems Ltd.). For all thermograms, a rainbow colour scheme was chosen. A total of 148 thermograms was analysed in defined areas using the software functions. Afterwards, the software calculated the average, minimum, and maximum Tr within the defined areas. An example of udder, teat, and milk vein thermograms of lactating camels obtained at pre-, 0 h post- and 1 h post-milking is presented in Figure 1.

**Statistical analysis**

To determine the suitability of using the machine milking in camels, biothermal measurements before milking were regarded as control values, while those after milking were regarded as treatment values. Therefore, the influence of animal, times (pre-, 0 h post-, and 1 h post-milking) and their respective interactions were included in the statistical model. Data were statistically analysed using Proc. GLM, i.e., the general linear model procedure for analysis of variance (ANOVA) of the Statistical Analysis System (SAS, 2004). Means showing significant differences in ANOVA were tested using the PDIFF option. Differences between means were considered significant if the probability associated with the null hypothesis was <0.05. The degree of association between meteorological and biothermal measurements was analysed using the Proc. CORR, i.e., the correlation procedure of SAS, where the correlation coefficients (r) of Pearson were computed.

**Results and discussion**

**Thermal conditions**

Meteorological measurements conducted throughout the study are presented in Table 1. The results obtained exhibited time differ-
placement in the homeothermic status of lactating camels. Apart from some irrelevant increases, machine milking resulted to have no effect on average $T_r$ (37.88±0.23°C) and $T_v$ (37.94±0.14°C) as well as RR (16.12±0.23 breath/min) and HR (56.78±1.89 beat/min) (Table 2). These results are not in line with previous observations on dairy cows, where $T_r$ and $T_v$ temperatures decreased (-0.3°C to -1.0°C, P<0.05) after milking. Araki et al. (1984) reported a decrease in body (vaginal) temperature of dairy cattle immediately after milking and for several hours after animals were sent back to their pens. However, the authors attributed this decrease to the pre-milking udder wash or to the shade offered by the milking parlour. Moreover, Ben Younes et al. (2008) demonstrated that milking resulted in a decrease in udder as well as body (rectal and vaginal) temperatures of dairy cattle.

Machine milking produced prominent effects on the infra-red thermographical parameters of lactating camels. The infra-red thermography is a non-contact and non-invasive method that detects surface heat emitted as infrared radiation (Kunc et al., 2007). This technology has previously been used to study temperature patterns of udder and teat surface temperature in dairy cows (Hamann, 1985; Kunc et al., 2002; Vegricht et al., 2007), dairy ewes (Stelletta et al., 2007; Mala et al., 2009), dairy goats (Caruolo et al., 1990), and dairy camels (Ayadi et al., 2012). Immediately after machine milking, teat temperatures increased by +1.7 to +2.7°C in dairy cows (Eichel, 1992; Hillerton et al., 2002; Kunc et al., 2000, 2002), while they decreased by -0.71°C to -1.0°C in dairy ewes (Stelletta et al., 2007; Mala et al., 2009). Evidently, the infra-red thermographical measurements of lactating camels showed (P<0.05) time differences before and after milking (Table 2). A significant (P<0.05) decrease of udder (up to -1.0°C) and teat $T_t$ (up to -1.6°C) was detected at 0 h post- to 1 h post-milking, while body and milk vein $T_t$ decreased (P<0.05) only at 1 h post-milking (-1.2°C to -0.8°C, respectively) (Table 2). These results are in accordance with our previous observations on lactating camels (Ayadi et al., 2012), where teat $T_t$ decreased (-1.1°C) immediately after milking. Nevertheless, the discrepancy between our studies and those carried out on other dairy animals can partially be explained by the differences in the environmental thermal conditions, the age, the physiological status and the teat vasculatisation of the animals, the characteristics of the machine milking system, as well as the milking management (Araki et al., 1984; Eichel, 1992; Kunc et al., 2000, 2002; Hillerton et al., 2002; Stelletta et al., 2007).
2007; Ben Youness et al., 2008; Mala et al., 2009). Therefore, further studies are required to evaluate udder responses using different machine milking systems under different environmental conditions in dairy camels. Moreover, for the well-being of dairy camels, we believe that further research is necessary to determine the degree of association and the comparative reaction to both hand and machine milking in order to confirm whether machine milking is a more physiologically and efficiently suitable method for commercial milk production than hand milking in dairy camels. The observed decreases in all Ts parameters after milking could be a result of the milking process, because no pre-milking udder preparation was applied in the present study compared to dairy cows (Kunc et al., 2000). Nevertheless, Ts parameters were apparently more affected by Ta than the milking process. This response was emphasised when we calculated the gradient values (Ts-Ta) of the Ts parameters with their corresponding Ta (Figure 2). In lactating camels, all Ts-Ta values clearly exhibited positive values at 1 h post-milking but they did not at 0 h post-milking (Figure 2). In addition, the correlation coefficients between Ts and the measured Ta parameters revealed positive correlations (0.40<r<0.60). All in all, these results might indicate that Ta was decreasing when these thermograms were captured.

On the other hand, negative correlations (-0.50<r<-0.30) existed between Ts and the thermophysiological parameters. Although the camels used in the current study had an increase in their body temperature (Tr and Tv), the decrease of Ts might indicate that body temperature of lactating camels was insensitive to environmental conditions. Nevertheless, there is a growing body of evidence that fluctuations in the Ts thermal load could positively influence the circadian rhythm of body temperature in other large mammals inhabiting arid environments (Schmidt-Nielsen et al., 1957; Ostrowski et al., 2003; Piccione et al., 2007). The circadian rhythm of body temperature has been reported in cattle, sheep, and goats (Al-Haidary 2000, 2004, 2005; Piccione et al., 2002, 2003). However, no study that we are aware of attempted to describe the circadian rhythm of body temperatures of dairy camels. Therefore, determining the circadian rhythm of body temperature of lactating dairy camels is highly recommended in further investigations in order to effectively explain the results that we obtained.

## Conclusions

The present study sheds more light upon the physiologically suitability of using the machine milking in lactating camels. As demonstrated by the absence of any displacement in their homeothermic status, introducing machine milking has no effects on the thermophysiological parameters of lactating camels maintained under an intensive system. Simultaneously, machine milking decreased infra-red thermographical parameters of lactating camels.

Infra-red thermography can be a suitable tool for a non-invasive and non-contact evaluation of the udder responses to machine milking in dairy dromedary camels. Machine milking might be established as a physiologically suitable and an efficiently profitable method for commercial milk production in lactating dairy camels. Nevertheless, numerous aspects of investigations regarding the biothermal response of lactating camels should be undertaken to expand our knowledge of dairy camels’ thermophysiology.

### Table 2. Biothermal parameters of lactating camels (n=12) measured immediately before (pre-), immediately after (0 h post-) and 1 h after milking (1 h post-).

| Thermophysiology | Milking | SEM | P value |
|------------------|---------|-----|---------|
| Tr, °C | 37.81 | 0.23 | 0.14 |
| Ta, °C | 37.80 | 37.97 | 38.04 | 0.14 | 0.10 |
| RR, bpm | 15.80 | 16.25 | 16.33 | 0.14 | 0.10 |
| HR, bpm | 55.92 | 56.28 | 58.14 | 1.89 | 0.09 |
| Body Ts, °C | 33.14 | 32.75 | 31.99 | 0.13 | 0.00 |
| Udder Ts, °C | 36.12 | 35.12 | 33.91 | 0.24 | 0.00 |
| Teat Ts, °C | 35.55 | 33.95 | 33.92 | 0.15 | 0.00 |
| Milk vein Ts, °C | 35.35 | 35.30 | 34.51 | 0.13 | 0.00 |

Tr, rectal temperature; Ta, vaginal temperature; RR, respiratory rate; HR, heart rate; Ts, surface temperature. Mean values within the same row with different superscripts are significantly different at P<0.05.

### Figure 2. Mean body (a), udder (b), teat (c), and milk vein (d) surface temperatures (Ts) obtained from 12 lactating dairy camels at pre-, 0 h post-, and 1 h post-machine milking with their corresponding measured ambient temperature (Ta), expressed as gradient values (Ts-Ta).
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