Effect of vacuum level and pulsation rate on machine milking efficiency in lactating dromedary camels

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الملخص
تم استخدام عدد 14 ناقة وحيدة السنام في بداية الحلب (n=7;68±6 يوم حلب;1.0±5.2كغ/يوم) ونهاية الموسم (n=7;8±353 يوم حلب;1.2±3.6كغ/يوم) حيث تمت دراسة تأثير مستويات مختلفة من التفريغ (45 و 50 كيلوباسكال) ومعدل النبض (52 و60 نبضة/دقيقة) على كفاءة الحلب الالي في نظام الانتاج المكثف. تم حلب النوق مرتين في اليوم باستخدام اجهزة حلب ألى متنقلة. ثوابت كمية الحليب وتدفق الحليب تم تسجيلها بجهاز اللاكتوكوردر خلال حلبة الصباح. كمية الحليب و حليب التقطير و الحليب المتبقي تم قياسها في يومين مختلفين. مرحلة الحلب أثرت معنويا على صفات اجزاء الحليب وتدفقه خلال الحلب الآلي. وتبين ان مستوى التفريغ 50 كيلوباسكال ومعدل 60 نبضة/دقيقة لم تؤثر على النسب المئوية لكمية الحليب ولكن قللت معنويا نسبة حليب التقطير(15,2 إلى 5,9 %) الحليب المتبقي (44.1 إلى % 29,8). إن حلابة الابل على تفريغ 50 كيلو باسكال ومعدل 60 نبضة يؤدي الى امكانية الحصول على كمية حليب اكثر(0.41±3.15 كغ) وفي وقت حلابة اقل (0.21±3.70 دقيقة) وبمعدل تدفق اعلى (0.29±2.31كغ/دقيقة) في مرحلة الحلب الاولى. وعموما بينت نتائج الدراسة انه يمكن حلب الابل وحيدة السنام بكفاءة باستخدام تفريغ 50 كيلو باسكال ومعدل 60 نبضة. كما يجب اجراء دراسات مطولة على موسم الحليب وتأثير نظم الحلب الالي الموصى بها من خلال هذه الدراسة على صحة الضرع قبل تعميم النتائج.
الكلمات الرئيسية: ناقة وحيدة السنام ,الحلب الآلي, إنتاج الحليب, إفراز الحليب

Résumé
Quatorze dromadaire multipares en début (n = 7; 68±6 DIM ; 5.2±1.0 kg/j) et fin de lactation (n = 7; 353±8 DIM ; 3.6±1.2 kg/j) ont été utilisés pour étudier les effets à court terme du niveau de vide (45 à 50 kPa) et du taux de pulsation (52 et 60 pulsations/min) sur l'efficacité de la machine à traire en système intensif. Une machine à traire avec pots trayeurs et pulsateur électronique a été utilisée pour la traite deux fois par jour. Production et flux de lait ont été enregistrés par les compteurs de lait Lactocorder ®. À la traite du matin, les volumes de traites par la machine (MM), le lait égouttage machine (MSM) et le lait résiduel (RM) ont été enregistrés pendant deux jours différents. Le stade de lactation affecte significativement les fractions du lait et les flux de lait pendant la traite. Le niveau de vide de 50 kPa et un taux de pulsation de 60/min n'ont pas modifié le pourcentage de MM, mais a diminué (P<0,05) le MSM (de 15,2 à 5,9 %) et RM (de 44.1 à 29,8 %) pendant la lactation. La traite des chamelles à 50 kPa et 60 ppm ont permis d'extraire significativement plus de lait (3.15±0.41 kg) en moins de temps (min 3.70±0.21) et avec un de flux de lait plus élevé (2.31±0.29 kg/min) au début de la lactation. En conclusion, les dromadaires peuvent être traits efficacement à 50 kPa et 60 pulsations/min. Cependant, les effets à long terme sur la santé du pis doivent être étudiés avant de décider toute recommandation.
Mots clés : dromadaire, machine à traire, production de lait, cinétique d'éjection du lait.

Abstract
A total of 14 multiparous dromedary camels in first (n=7; 68±6 DIM; 5.2±1.0 kg/d) and late (n=7; 353±8 DIM; 3.6±1.2 kg/d) stage of lactation were used to study the short term effects

of vacuum level (45 and 50 kPa) and pulsation rate (52 and 60 pulsation/min) on machine milking efficiency under an intensive farming system. A portable milking machine with electronic pulsator was used to milk the camels twice daily. Milk yield and milk flows parameters were recorded by Lactocorder® milk meters. At a.m. milking, volumes of machine milk (MM), machine stripping milk (MSM) and residual milk (RM) were recorded in two different days. Stage of lactation affects significantly milk fraction and milk flow traits during machine milking. The 50 kPa vacuum level and 60 pulsations/min did not change the percentage of MM, but decreased (P<0.05) the MSM (from 15.2 to 5.9%) and RM (from 44.1 to 29.8%) during lactation. Milking camels at 50 kPa and 60 ppm were able to extract significantly more milk (3.15 ± 0.41 kg) in a shorter time (3.70 ± 0.21 min) with higher milk flows rate (2.31 ± 0.29 kg/min) at early stage of lactation. In conclusion, dromedary camels are readily to milk efficiently at 50 kPa and 60 pulsations/min. Long term effects on udder health should be studied before deciding any recommendation.

Keywords: Dromedary camels, machine milking, milk production, milk ejection kinetic.

1. Introduction

Nowadays there is an increasing interest in camel's milk for human nutrition due to its functional properties (Agrawal et al., 2003). As a result of market demand for commercial milk production, intensive dairy camels farms using modern machine milking have been recently created (Wernery et al., 2004; Hammadi et al., 2010; Ayadi et al., 2013). Despite the considerable number of studies that have been conducted on milking management of dairy ruminants, little information is available on machine milkability of dairy camels (Atigui et al., 2014).

Efficient milking are related to the good milkability of animal (degree to which animals can be machine milked). Milk partitioning, residual milk and milk flow traits during milking are generally used in dairy ruminants to evaluate machine milkability (Labussiere, 1988). Camels are known to be difficult to milk and many authors confirmed problems with disturbed milk ejection in this species (Ayadi et al., 2009; Atigui et al., 2014). Therefore, easily milked camels have a smaller proportion of machine striping milk (MSM) and residual milk (RM) than those that are harder to milk. It is well known that the volume of milk fraction during milking can be affected by the parameters of machine milking and characteristic of milking cluster (Labussiere, 1988). Few data are available about the effect of vacuum levels on milk flow traits during machine milking in dairy camels (Atigui et al., 2011).

The aim of this study was to compare the effect of machine milking at high and intermediate vacuum levels with different pulsations rates on machine milking efficiency. Milk partitioning during machine milking and the characteristics of milk emission were studied. The effect of lactation stage was also considered.

2. Materials and methods

2.1. Animals and their management

A total of 14 multiparous dromedary camels in first (n=7; 68 ± 6 DIM; 5.2 ± 1.0 kg/d) and late (n=7; 353 ± 8 DIM; 3.6 ± 1.2 kg/d) stage of lactation from conservation and genetic improvement center (Al-Kharj disctrict, Riyadh, Kingdom of Saudi Arabia) were used. The daily feeding routine for lactating camels includes ad libitum alfalfa hay and 2 kg/day/head of commercial pellets (Wafi®, ARASCO, Riyadh, Saudi Arabia). Camel had free access to fresh water. Lactating dromedary camels suckled their calves freely during the 1st month of lactation. Thereafter, the dams were introduced progressively to machine milking. Calves usually weaned at 12 month of age, leaving the dams to continue their lactation for another 6 months.

2.2. Milking routine

Camels were machine milked twice a day (06:30 and 15:30 h) in a single-tunnel milking parlour equipped with medium-pipeline (1.8 meters) milking stalls and electronic pulsator (BouMatic, Itak Company, Riyadh, Saudi Arabia). The weight of the milking cluster and the diameter of the mouthpiece liners were 1.9 kg and 25 mm, respectively. The milking machine was set at 45 kPa, 52 pulses/min, and 60:40 pulsation ratio. The milking routine included: milk let-down by calves (without suckling); udder preparation, machine milking and final stripping by the calf.

2.3. Milk fraction and milk flow traits

Two vacuum levels (45 and 50 kPa) and two pulsation rates (52 and 60 pulsation /min) was tested during 4 consecutive weeks (1 week for each treatment). Milk fractions at morning milking were recorded in two different days as follows: machine milk (MM; the quantity of milk that was taken after the setting of teat cups until milk flow dropped below 0.100 L/min), machine stripped milk (MSM; the amount of milk that was taken by udder stripping with hands without removing the teat cups) and residual milk (RM; the milk amount that was taken by machine milking after an i.m. injection of synthetic oxytocin (20IU/camel; Biocytocine, Laboratoires Biove, Arques, France)). Assessment of udder health was performed by California mastitis test (CMT). Milk flows rates were recorded in three different days by using two electronic mobile milk flow meters (Lactocorder®, WMB, Balgach, Swizerland) specially calibrated to low milk flow rate (<0.05 kg/min). The following milking traits were determined: milk yield (kg; total milk yield per head from the beginning to the end of the morning milking), total milking time (min; total milking time from attachment of the cluster till their removal), milk flow latency (min; time between the attachment of teat cups and milk flow of 0.250 kg/min), milk ejection time (min; time from milking cluster attachment till milk ejection occurs), average milk flow rate (kg/min; average milk flow rate during milk ejection time), peak milk flow rate (kg/min; peak milk flow rate during milk ejection time).The measurement of milk flow traits was made by the associated software lactopro® (version, 6.0.28). The lag time (min; time from cup attachment to the first drops of milk being observed) was also visually determined during the experimental periods.
Data were statistically analysed for least square means procedures using the proc Mixed of Statistical Analysis System (SAS version 9.1, SAS Inst. Inc., Cary, NC). The level for statistical significance was set at $P<0.05$.

3. Results and discussion

No subclinical mastitis was detected in any of the udders quarters during the experimental period as indicated by the CMT (<1). On average, daily milk yield were 5.19 ± 0.95 and 3.85 ± 1.00 kg/day at early and late stage of lactation, respectively. Stage of lactation affects significantly milk fraction and flow traits during machine milking. The MM and RM volumes did not fluctuate according to lactation period, while MSM was higher ($P<0.05$) in the early stage of lactation. Lag time was the shortest ($P<0.05$) for early lactation period. Nevertheless, milk ejection time (2.45 ± 0.31 min), total milking time (4.10 ± 0.32 min) and average milk flow rate (0.88 ± 0.22 kg/min) were not influenced by lactation periods. Milk partitioning and milk flow traits at different levels of vacuum and pulsation rate at early and late stage of lactation are shown in tables 1 and 2.
The average percentage of MSM (6%) obtained at late lactation in this study were higher than that reported in dairy camels (1%; Atigui et al., 2014) but lower than recorded in dairy ewes (19%; Such et al., 1999) and dairy goats (18%; Sinapis et al., 2000). However, RM recorded in our work was higher with those previously reported in dairy camels (20%; Kamoun, 1995) and dairy cows (15%; Tancin and Bruckmaier, 2001).

The 50 kPa vacuum levels and 60 pulsation rate did not change the percentage of MM, but decreased (P<0.05) the MSM (from 15.2 to 5.9%) and RM (from 43.2 to 29.8%) during lactation (Table 1 and 2). Our results disagree with those previously reported in dairy goats where percentage of MM decreased and MSM increased as a vacuum level increased (Sinapis et al., 2000).

Table 1: Milk partitioning and milk flow traits at different levels of vacuum and pulsation rate in dairy camels at early stage of lactation.

Vacuum level (kPa)	45		50	
Pulsation rate (ppm)	52	60	52	60
Milk fraction (kg)				
Machine milk yield	1.68 ± 0.39 [b]	1.89 ± 0.39 [b]	1.90 ± 0.40 [b]	3.15 ± 0.41 [a]
Machine stripping	0.37 ± 0.09 [a]	0.30 ± 0.08 [a]	0.30 ± 0.05 [a]	0.19 ± 0.05 [b]
Residual milk	1.63 ± 0.34 [a]	1.60 ± 0.34 [a]	1.47 ± 0.34 [ab]	1.16 ± 0.35 [b]
Milk emission				
Lag time (s)	1.93 ± 0.30	2.14 ± 0.32	1.82 ± 0.40	2.06 ± 0.40
Milk flow latency (min)	0.84 ± 0.10	0.76 ± 0.09	0.77 ± 0.09	0.68 ± 0.10
Milk ejection time (min)	2.23 ± 0.28	2.63 ± 0.30	2.03 ± 0.37	2.33 ± 0.40
Total milking time (min)	4.53 ± 0.42 [a]	4.16 ± 0.42 [ab]	3.94 ± 0.21 [ab]	3.70 ± 0.21 [b]
AFR (kg/min) [1]	0.71 ± 0.21	0.86 ± 0.18	0.86 ± 0.17	0.96 ± 0.17
PFR (kg/min) [2]	1.91 ± 0.28 [ab]	1.78 ± 0.31 [b]	1.61 ± 0.27 [b]	2.31 ± 0.28 [a]

[1:] Average milk flow rate
[2:] Peak milk flow rate
[abc:] Means in the same line with different letters were significantly different (P<0.05)

Milking camels at 50 kPa and 60 ppm were able to extract significantly more milk (3.15 ± 0.41 kg) in a shorter time (3.70 ± 0.21 min) with higher milk flows rate (2.31 ± 0.29 kg/min) at early stage of lactation . These results are similar to those recently reported in dairy camels in which milking at 48 kPa compared with 38 kPa increased milk yield and milk flow rate and decreased milking time (Attigui et al., 2011).

Table 2: Milk partitioning and milk flow traits at different levels of vacuum and pulsation rate in dairy camels at late stage of lactation.

Vacuum level (kPa)	45		50	
Pulsation rate (ppm)	52	60	52	60
Milk fraction (kg)				
Machine milk yield	1.92 ± 0.40	2.04 ± 0.40	2.10 ± 0.42	2.53 ± 0.42
Machine stripping	0.27 ± 0.08 [a]	0.17 ± 0.08 [b]	0.19 ± 0.08 [b]	0.15 ± 0.07 [b]
Residual milk	1.93 ± 0.33 [a]	1.43 ± 0.34 [ab]	1.36 ± 0.44 [ab]	1.14 ± 0.44 [b]
Milk emission				
Lag time (s)	2.93 ± 0.42	3.34 ± 0.42	3.42 ± 0.57	3.68 ± 0.57
Milk flow latency (min)	0.64 ± 0.08	0.51 ± 0.07	0.61 ± 0.08	0.56 ± 0.09
Milk ejection time (min)	2.74 ± 0.26	2.52 ± 0.29	2.46 ± 0.32	2.16 ± 0.40
Total milking time (min)	4.97 ± 0.42 [a]	4.29 ± 0.41 [ab]	4.19 ± 0.22 [ab]	3.84 ± 0.23 [b]
AFR (kg/min) [1]	0.59 ± 0.21 [b]	0.81 ± 0.21 [b]	0.81 ± 0.20 [b]	1.29 ± 0.19 [a]
PFR (kg/min) [2]	1.59 ± 0.30	1.34 ± 0.37	1.44 ± 0.32	1.91 ± 0.29

[1:] Average flow rate
[2:] Peak flow rate
[abc:] Means in the same line with different letters were significantly different (P<0.05).

Also, our finding agree with those previously obtained in dairy cows (Rasmussen and Madsen, 2000) and in dairy goats (Sinapis et al., 2000), but disagree in part with results of Caria et al. (2012) in dairy buffaloes where high vacuum level did not significantly affect the milk production. Vacuum level did not modify the lag time, at early and late stage of lactation, suggesting that 45 kPa is sufficient to open the teat sphincter and drain cisternal milk.

4. Conclusion

Milking camels at 50 kPa and 60 ppm resulted in milking greater milk amount in shorter time at early stage of lactation. Long term effects on udder health should be studied before its recommendation. The existing high retained amount of milk in the udder (30%) needs further investigation concerning methods to induce milk ejection during milking in dairy camels.

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