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Change in Udder Measurements Traits during Lactation and Its Relationship with Milk Yield in Dairy Camel (Camelus Dromedaries)

Abdelgadir Musaad[1]*, Bernard Faye[2], Ahmed Khalil[3], Moez Ayadi[4,5] and Riyadh S. Aljumaah[4].

[1] *Conservation and Genetic Improvement Center, Saudi Arabia, Al-Kharj, 11942.*faisalmus99@yahoo.com
[2] *UMR SELMET, CIRAD-ES, Campus International de Baillarguet, TA-C/112A, 34398 Montpellier, France*
[3] *Department of Animal Production, College of Agricultural Studies, University of Science & Technology, Sudan.*
[4] *Department of Animal Production, College of Food and Agriculture Sciences ,King Saud University, P.O. Box 2460, Riyadh 11451, Saudi Arabia*
[5] *Département de Biotechnologie Animale, Institut Supérieur de Biotechnologie de Beja, Université de Jendouba, B.P. 382, Av. Habib Bourguiba, 9000 Beja, Tunisia.*

Abstract: *A total of 77 multiparous dromedary camels were used to evaluate the change of udder morphology traits after a machine milking and to study the evolution of udder traits during early (wk10), mid (wk22) and late (wk 40) stage of lactation. The measurements were taken directly before and after milking. On average the length, height, depth and circumference of the udder were 43.6±4.9, 106.9±7.7, 43.8±4.6, 97.1±6.3 cm respectively. The teat length front and rear, diameter and distance between teats were 4.85±1.85, 5.09±1.85, 3.43±1.05, 8.92±1.92 cm respectively before milking. Udder length and height did not change before and after milking while udder depth and circumference showed significant decrease after milking. Otherwise, high significant difference was observed in front teat length and diameter and distance between teats before and after milking. Front teat length significantly increased after milking while, teat diameter and distance between teats showed significantly decreased. Udder depth, udder circumference and distance between teats positively correlated with milk yield and affected significantly ($p<0.05$) by stage of lactation and showed highest value at mid stage of lactation: 46.1±4.2, 99.9±5.3, 9.6±1.8 respectively. Teat length and diameter did not change during lactation. Total milk yield reaches the highest value at mid stage of lactation while, there were no differences appearing between early and late stage of lactation. Three types of udder were identified, smallest udder with the smaller teats, medium udder with long teats and biggest udder with medium teats. Udder depth, circumference, teat diameter and distance between teats differed significantly among all types. Teat length and total milk yield showed no differences between type 1 and type 2. Udder and teats measurement changes during milking and stage of lactation increase our standing for selection lactating camels and improving camel machine milking efficiency.*

Keywords: *camels, lactation stage, milk yield, udder measurements.*

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I. Introduction

The udder is a very important organ of dairy animal and their physiological and conformational characteristics are linked to their dairy performances (Kominakis et al., 2009). The udder dimensions and morphology were added in selection programs of ewe (De la Fuente, 1996), buffalo (Prasad et al., 2910) and cow (Seykora and McDaniel, 1985). Furthermore, the age and lactation could affect considerably mammary gland (Kausar et al, 2001). In general appearance, lactating camels are characterized by well–developed udder and prominent milk vein (Al-Ani 2004). Some data on camel udder morphometric proved to have an impact on milk yield, and the morphologic change before and after hand milking may indicates potential in milk secretion under extensive production system (Eisaet al 2010). However, few studies investigated the change of udder morphology in dairy camels after machine milking (Ayadi et al., 2015; Nagy et al., 2016). Udder morphology has been recognized as one of the main factors affecting the ability of machine milking of dairy camels (Shehadeh and Abdul-Aziz, 2014; Caja et al., 2011).External udder measurements could give us an idea about the storage capacity of the udder and may offer first elements that could be used as additional parameters (Ayadi et al., 2013: Atigui et al., 2016), since they are more susceptible to injuries. The evaluation of udder morphology during lactation can be significant for obtaining a positive genetic response in the milkability of dairy camel

(Ayadi et al., 2013). Udder morphology determines several aspects of machine milking and manageability (time of milking, falling off clusters, and difficulty of calves for suckling). There is general agreement that machine milking could affect the udder health of animals. The teats are the most stressed part of the udder, because milking changes their condition (Hillerton et al., 2002). There are a number of factors in milking that influence the condition of the teats such as vacuum level, pulsation rate, and the teat cups. The use of the high working vacuum level can cause irritation in mammary tissues, congestion and oedema of the teat tissue, especially at the teat end, and influence teat diameter (Hamann et al., 1993; Rasmussen and Madsen, 2000; Mein et al., 2001). Increase of teats diameters immediately after milking (indicator of congestion of teats) was observed in dairy cows milked by 50 kPa (Hamann et al., 1993). Little is known about the effect of vacuum levels on teat changes and udder health of dairy camels (Ayadi et al., 2015).The objective of this study was (i) to evaluate the change of udder morphology traits after a machine milking and (ii) to study the evolution of udder traits throughout lactation, and its relationship with milk yield in dairy dromedary camel maintained under intensive condition.

II. Materials And Methods

1. Animals and their management

A total of 77 multiparous dromedary camels (7-10 years old) from Al-Turath Al-Saudi Company, large – scale camel dairy farm (180 km northeast of Jeddah, from KSA) situated at 22˚.97 ″N and 39˚.91″ E latitude were used in this experiment.

All calves suckled their dams freely until 40 days of age. Subsequently, they were on partial suckling regime all the night for 20days when their dam were machine milked once daily. Therefore, all calves allowed suckling, leave one hour after machine milking until they were completely weaned at five months of age. Daily diet of camel calves consisted of 1 kg concentrate and 1.5 kg of alfalfa. The lactating camels were supplemented with 5 kg of commercial concentrate pellets (WAFI®, ARASCO) besides 3 kg of alfalfa per head in addition to continuous water supply. Multiparous dromedary camels were used to study the evaluation of udder morphology traits throughout lactation.

Camels were machine milked twice a day (06:00and 16:00h) in a double-tunnel milking parlour equipped with low-pipeline milking stalls (Agripadana Podova, Italy Company, Riyadh, Saudi Arabia), electronic pulsators and listed measurable milk recording system allowing reliable and continued collection of milk yield data of individual camels. The weight of the milking cluster and the diameter of the mouthpiece liners were 1.6kg and 25mm, respectively. The milking machine was set at 45 kPa, 60 pulsations/min, and 60:40 pulsation ratio. The milking routine included: milk let-down (without calves suckling); udder preparation (teat and udder washing and drying), machine milking and machine striping milk.

2. Experimental procedures

Two hundred eight multiparous lactating dromedary camels of the Al-Awarik breed (Faye et al., 2011) at early (wk=10; n = 77), mid (wk=24; n = 67) and late lactation (wk=40; n = 64) were included in the data set, with similar parities and ages randomly selected from the herd. Camels were kept in barns all the time in intensive farming system. Each of the experimental selected females was identified by plastic ear tag with numerical No. A record for each she-camel such as, calving date and daily milk yield was compiled. Udder and teat morphology traits for all camels were measured before and after morning milking at first, mid and late lactation. All camels had clinically health udders. At the start of experiment all camels were diagnosed free of mastitis by California mastitis test (CMT).

3. Udder morphology

Measurements of udder and teat morphology were taken in milking parlour two times directly before routine pre–milking treatment and directly after removal of milking cluster. The following measurements were done according to Ayadi et al. (2013):

- Udder depth (UD)= distance between abdominal wall at the base of the udder and the base of teat;
- Udder height (UH)= distance from ground to the base of the front and rear teat;
- Udder circumference (UC) measured by matching the tape throw around the udder from suspensory ligament between four quarters.
- Udder length (UL) = distance between front and rear attachment of the udder;
- Teat length (TL) = distance between the base and the tip of the teat;
- Teat diameter (TD) measured with the calliper at the middle point.
- Distance between teats (DBT) =distance between the rear and front teat from middle point by the right side.

4. Daily milk yield

Individual milk yields from morning and evening milking were measured using cylinders recorders attached with the milking machine for each cluster.

5. Statistical analysis

Udder measurement and milk yield changes (mean and SD) were reported at early, mid and late lactation stage. Pearson correlations between different udder and teat parameters were calculated. The effect of udder and teat morphology traits and milk yield were examined by ANOVA procedure. The types of udder based on their multiple measurements, were determined by using Hierarchical Classification Analysis (HCA) on Ward distance applied on a matrix including 208 camels' measures during three lactation stages and 7 columns (teat and udder measurements). Relationships between type of udder and milk yield was determined by ANOVA. Data from the present study were analysed by using XLSTAT software (2012, 02 version Addinsoft©).

III. Results

1. General description of udder and teats traits

The udder length, udder height, udder depth and udder circumference were 43.6±4.9, 106.9±7.7, 43.8±4.6, and 97.1±6.3 cm respectively. The teat length front and rear were4.85±1.85 cm, 5.09±1.85 cm respectively and teat diameter and distance between teats before milking were 3.43±1.05 cm, 8.92±1.92 cm respectively. Udder length and height did not change before and after milking while significant changes ($p < 0.00l$) in udder depth and circumference were observed (table 1). Elsewhere high significant difference ($p < 0.00l$) was observed in front teat length and diameter and distance between teat before and after milking while the rear teat length showed no difference. Regarding lactation stage (table 2), udder depth and circumference showed lowest value at the first stage of lactation and increased up to mid stage of lactation then decreased slightly at the end of lactation. Teat length and diameter did not differ along all lactation stage while distance between teats gave the significant highest value at mid stage of lactation. In addition, lactation stage significantly affected udder depth, udder circumference and distance between teat before and after milking ($p < 0.00l$).

2. Correlation between milk yield and udder traits

Milk yield was positively correlated ($p<0.05$) with udder depth, circumference and distance between teats at mid stage of lactation. Positive correlation was found also between teat length and teat diameter at mid and late stage of lactation ($p < 0.0001$), and positive correlation ($p<0.0001$) were found between udder depth and length and circumference at mid and late stage. The correlation between udder height and milk yield was negative. Significant positive correlation was observed between teat length and teat diameter at all stages of lactation ($p<0.0001$). There was also highly negative correlation between teat length and udder height as well as there was negative correlation between teats parameters and udder height. Significant positive correlation $p \leq 0.05$ was observed between udder length, udder depth, udder circumference, teat length and distance between teats at the mid stage of lactation (table 5), while teat length, udder length, udder circumference and udder depth correlated with total milk yield ($p < 0.05$) at the mid stage of lactation respectively (table 5). Teat diameter was highly correlated ($p \leq 0.0001$) with teats length in front and rear teats all along the stages of lactation.

3. Udder types

Cluster analysis of 208udders and teats measurement (early lactation n = 77, mid lactation n = 67, late lactation n = 64) grouped udders with the similar shape. As a result, three types of udders were identified (fig.1):

- Type 1: udders appearing with medium udder height and short udder depth, length and circumference in addition of medium teat length and small teat diameter and short distance between teats. It's corresponding to the smallest udder with the smaller teats;
- Type 2: camels with large udder height, medium udder length, depth and circumference with large teat length and diameter and medium distance between teats. It's corresponding to medium udder with long teats;
- Type 3: camels having lowest udder with biggest udder length and short teat length with big distance between teats. It's corresponding to biggest udder with relatively medium teats. Udder depth, circumference, teat diameter and distance between teats differed significantly among all types. Teat length and total milk yield showed no differences between type 1 and type 2 (table 3).

IV. Discussion

Morphological characterizations of udder and teats in dairy camel have taken a deal of attention and to its relationship with milk production, machine milkability and manageability. There was a great variation in udder and teat size and length in camel which is attributed to many factors such as camel type, stage of lactation, parity, and udder health (Zayeed et al. 1991).Udder measurements reported in table 1 were higher than those reported by Atiguiet al (2016) for Maghrebi camel's intensive system and Eisa et al (2010) for Arabi-Lahwee camels in semi intensive system. Our camels have particularly large udder length and small udder depth compared to values reported by Moez et al (2016).This may be attributed to methodology and camel breed. Moreover, udder and teats measurements are closely to the same value reported by Ayadi et al (2013) at late stage of lactation in the same conditions.

Teats measurement reported in the present study before milking showed lower values than those reported by Atiguiet al. (2016) for Maghrebi camels managed in intensive system in Tunisia, and teat diameters have lower values in comparison to the results reported by Nagy et al (2015). The diameter slightly decreased in its size during and after milking in agreement with Nagy et al. (2015).Udder depth and circumference showed significant differences before and after milking as well as front teat length, diameter and distance between teats while there is no significant change for rear teat length which had higher values than the front similarly to result obtained by Nagy et al (2015). Those authors reported that the size of teats decreased after milking, and changes in front quarter were more obvious than in the back. This is the reason of more milk received from the back–quarter (Yagil, 1982). Eisa et al (2010) reported similar results with significant decrease ($p \leq 0.01$) for teat length, diameter, udder depth and circumference. Juhasz et al (2008) stated that the teat underwent significant size changes during milking and the length increased by 50 % in intensive machine milked camels.

Atigui et al (2015) testaments some of clusters liner parameters to avoid too much elongated teats during milking. Iveta et al (2013) reported various changes in teats morphology in the dairy cow caused by milking machine and recommended ultrasonography method for accurate investigations as Ayadi (2015) achieved on camel. From their side, Muammer et al (2005) reported no significant correlation between udder heights before and after milking while they found significant decrease in distance between front teat and significant decrease in teat length in brown Swiss cows.

Udder depth and circumference were significantly changed during lactation and reached their higher values at the mid stage of lactation. This is due to the increasing of milk production and cisternal size corresponding in camel to the lactation peak which occurs as a plateau between the 3th and 5thmonth of lactation (Musaad et al., 2013).Both in camel (Atigui, 2016) and cow (Gerardo et al., 2004) larger milk production is related to a bigger udder size. Otherwise, there are no significant change for udder height and length in accordance with the results obtained by Maria et al (2011) in Suffolk sheep. There are no significant changes in the teat traits except the distance between teats during lactation contrary to finding reported by Sadeghi et al (2016) in Indian goats. There are several other factors that influence udder morphology, particularly genotype, lactation stage, lactation rank and breeding system (Milerskiet al., 2006). Interestingly and even though the camel udder is specialized milk organ, there is very few authors who have studied the modification occurring in the udder and teats throughout lactation period. Yet, these studies are essential to improve camel dairy production. The association of these changes with different milking frequencies, parity, breeds, milking machine parameters and udder health is also of high importance and have to be investigated in the future.

Cluster analysis identified three types of udder according to udder and teats measurement. These 3 types can be observed within the same breed reflecting the high within-breed variability as reported by Eisa et al (2010) in Arabi-lahwee camels in Eastern Sudan. These testify also the potential of genetic selection within a specific breed. From their part, shag et al., (2011) classified Sudanese camels into 10 types based to udder and teats size (large, medium, rudimentary). Sandor et al (2006) reported that udder type in sheep had only small effect on milk yield and linked its importance to machine milking. Such phenotypic description can be useful for selected lactating camels and set appropriate parameters of milking machine.

Relationships among udder and teats and milk yield, as summarized in table 5, indicated that selection of lactating camels with greater distance between teat, greater udder depth and circumference would result in higher milk production. Similar finding was also reported by Ayadi et al (2013) and Eisa et al (2010). Prasad et al (2010) reported also positive correlation between udder measurements and milk yield in buffaloes. Positive correlation was also observed between teat length and teat diameter reflecting that only one single teat measurement could be included in the selection schemes.

Positive correlation between inter-teats distance, teat diameter and udder circumference indicated positive relationship of teat dimension with udder capacity. The high positive correlations among teat measurement indicated the importance’s of the teats in the selection of lactating camels. The correlations of teat length, teat diameter, distance between teats, udder depth, udder circumference and milk yield with udder height were all negative that means highest udder corresponding with small udder.

V. Conclusion

The present study confirmed that the udder measurements were the main selection markers for camel milkability. Such udder traits must be monitored in the objective of building a linear scoring of udder morphology as suggested by Ayadi et al., (2015).Such scoring could be very useful in genetic selection programme for improving milking machine. However, the links with udder health is necessary in further studies especially by looking impact on mastitis incidence which is main cause of culling in dairy camels.

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References

[1]. **Atigui**, M., Marnet, P. G., Harrabi, H., Bessalah, S., Khorchani, T., & Hammadi, M. (2016). Relationship between external and internal udder and teat measurements of machine milked dromedary camels. Tropical animal health and production, 48(5), 935-942.

[2]. **Ayadi**, M., R. S. Aljumaah, A. Musaad, E. M. Samara, M. M. Abelrahman, M. A. Alshaikh, S. KSaleh and B. Faye. 2013. Relationship between udder morphology traits, alveolar and cisternal milk compartments and machine milking performances of dairy camels (Camelusdromedarius). Spanish Journal of Agricultural Research, 11(1): 790-797.

[3]. **Ayadi**, M., Aljumaah, R. S., Samara, E. M., Faye, B., & Caja, G. (2016). A proposal of linear assessment scheme for the udder of dairy camels (Camelus dromedarius L.). Tropical animal health and production, 48(5), 927-933.

[4]. **Ayadi** M., Aljumaah R., Samara S., Faye B., Caja G., 2015. Udder typology of Arabian dairy camels and proposal of a linear scoring system for assessing their udder traits for machine milking, In: Proc. of 4th Conference of ISOCARD,"Silk Road Camel: The Camelids, Main Stakes For Sustainable Development", June 8-12, 2015 Almaty, Kazakhstan, Konuspayeva G. (Ed.), Special Issue of Scientific and Practical Journal Veterinariya #2 (42) 2015, oral communication, 110-112

[5]. **Caja,** G., Ayadi, M., & Knight, C. H. (2004). Changes in cisternal compartment based on stage of lactation and time since milk ejection in the udder of dairy cows. Journal of dairy science, 87(8), 2409-2415.

[6]. **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. In Book of Abstracts of the 62nd Annual Meeting of EAAP (p. 363). August 29th – September. Stavanger, Norway.

[7]. **De la Fuente**, L. F., Fernandez, G., & San Primitivo, F. (1996). A linear evaluation system for udder traits of dairy ewes. Livestock Production Science, 45(2), 171-178.

[8]. **Eisa**, M.O., Ishag, I.A., Abu-Nikhaila, A.M., 2010 Anote on the relationship between udder morphometric and milk yield of Lahween camel (camelus dromedaries). Livest. Res. Rural Development. 22,(10).

[9]. **Falah**,K., AL-Ain 2004 book, camel management and Disease, first edition 2004.

[10]. **Faye** B., Abdallah H., Almathen F., Harzallah B., Al-MutairiS., 2011. Camel biodiversity. Camel phenotypes in the Kingdom of Saudi Arabia. Camel Breeding, Protection and Improvement Center, project UTF/SAU/021/SAU, FAO publ., Riyadh (Saudi Arabia), 78 p.

[11]. **HILLERTON**, J. E., Pankey, J. W., & Pankey, P. (2002). Effect of over-milking on teat condition. Journal of Dairy Research, 69(1), 81-84.

[12]. **Ishag,** I.A., Eisa, M.O., Ahmed. M.K.A., 2011. Phenotypic characterization of Sudanese camels (camelus dromedaries). Livest. Res. Rur. Dev., 22(10), On –line edition (www.irrd .org/irrd23/4/isha23099.htm)

[13]. **Juhasz,** J., & Nagy, P. (2008, July). Challenges in the development of a large-scale milking system for dromedary camels. In Proceedings of the WBC/ICAR 2008 Satellite Meeting on Camelid Reproduction (pp. 84-87)..

[14]. **Kominakis**, A. P., Papavasiliou, D., & Rogdakis, E. (2009). Relationships among udder characteristics, milk yield and, non-yield traits in Frizarta dairy sheep. Small Ruminant Research, 84(1), 82-88.

[15]. **Marne**t P. G, Atigui. M, Hammadi. M. Developing mechanical milking of camels? The way to proceed. 4th conference of ISOCARD,Silk Road Camel: the camelids, main stakes for sustainable devolopment June 8-12, 2015 Almaty, Kazakhstan, 131-133.

[16]. **Martínez**, M. E., Calderón, C., de la Barra, R., de la Fuente, L. F., & Gonzalo, C. (2011). Udder morphological traits and milk yield of Chilota and Suffolk Down sheep breeds. Chilean Journal of Agricultural Research, 71(1), 90.

[17]. **Milerski,** M., Margetín, M., Capistrák, A., Apolen, D., Spanik, J., & Oravcová, M. (2006). Relationships between external and internal udder measurements and the linear scores for udder morphology traits in dairy sheep. Czech Journal of Animal Science, 51(9), 383.

[18]. **Musaad** A., Faye B., Abu-Nikhela A., 2013. Lactation curves of dairy camels in an intensive system. Trop. Anim. Health Prod., 4, 1039–1046

[19]. **Nagy**, P., Keresztes, M., Reiczigel, J., Juhasz, J.2015 .Evaluation of udder and teat shape and size in lactating dromedary camels (camelus dromedaries). 4th conference of ISOCARD,Silk Road Camel: the camelids, main stakes for sustanaible devolopment June 8-12, 2015 Almaty, Kazakhstan, 134-135.

[20]. **Prasad**, R. M. V., Sudhakar, K., Raghava, R. E., Ramesh, G. B., & Mahender, M. (2010). Studies on the udder and teat morphology and their relationship with milk yield in Murrah buffaloes. Livestock Research for Rural Development, 22(1), 2010.

[21]. **Sadeghi**, S., Rafat, S. A., Moghadam, G., & Janmohammadi, H. (2016). Measuring of Udder Morphological Characteristics among Crossbred and Pure Sheep Breeds. Iranian Journal of Applied Animal Science, 6(2), 343-348.

[22]. S**andor** Kukovics, Andras Molnar, MariaAbraham, Timea Nemeth and IstvanKomlosi, 2006. Effects of udder traits on the milk yield of sheep. Arch. Tierz., Dummerstorf 49 (2). 165-175.

[23]. **Sarwar**. R. Kausar A. and C.S.Hayat. 2001 gross and microscopic anatomy of mammary gland of dromedaries under different physiological condition Pakistan.Vet.j.21 (4): 2001.

[24]. **Szencziova** I., Strapak P., Stadnik L., Duchacek J., Beran J. 2013. Relationship of udder and teat morphology to milking characteristic and udder health determined by ultrasonographic examinations in dairy cows. Annals of Animal Science, Vol .13. No.4, 783-795, DOI: 10.2478/aoas-2013-0053.

[25]. **Seykora,** A. J., & McDaniel, B. T. (1985). Udder and Teat Morphology Related to Mastitis Resistance: A Review1. Journal of Dairy Science, 68(8), 2087-2093.

[26]. **Shehadeh** K., Abdelaziz F., 2014. The challenge of machine milking in dromedary camel. Scientific Journal of Review. 3(12)1004-1017.

[27]. **Tilki**, M., İNAL, Ş., Colak, M., & Garip, M. (2005). Relationships between milk yield and udder measurements in Brown Swiss cows. Turkish Journal of Veterinary and Animal Sciences, 29(1), 75-81.

[28]. **Zayeed**, A.A., Magdub, A.B., Shareha, A.M., El-sheikh. A., Manzally, M., 1991.Camels in Arab world. Conference, 1st edition. Univ. Omer El- Mukhtar, Tripoli, Libya. P, 115.

Table (1): Estimated udder and teats measurement (cm) before and after milking in dromedaries camels.

Traits	Number	Before milking	After milking	P	SE
Udder depth	416	43 ± 4.9 ^{a}	40.5± 4.8 ^{b}	< 0.0001	0.469
Udder circumference	416	97.1 ± 6.3 ^{a}	93.7 ± 5.9 ^{b}	< 0.0001	0.603
Udder height	416	106.9 ± 7.7	-	-	-
Udder length	416	43.6 ± 4.9	-	-	-
Teat length front	416	4.58 ± 1.85 ^{a}	5.42 ± 1.73 ^{b}	< 0.0001	0.121
Teat length rear	416	5.09 ± 1.58	5.32 ± 1.73	0.099	0.176
Teat diameter front	416	3.43 ± 1.05 ^{a}	3.06 ± 0.86 ^{b}	< 0.0001	0.095
Distance between teats	416	8.92 ± 1.92 ^{a}	7.96 ± 1.6 ^{b}	< 0.0001	0.174

Different letters within a line indicate significant difference ($p \leq 0.0001$)

Table (2): Mean udder and teat measurements (cm) before milking and total milk yield (kg) according to stage of lactation in dromedaries' camels.

Traits		Mean ± SD			
Number	N= 77	N= 67	N= 64		
Stage of lactation (week)	10 wk	22 wk	40 wk	Stage [1]	Stage ×BA[2]
Udder height	108.8±7.9	104.5±8.0	107.4±6.4	0.003	-
Udder depth	40.9 ±4.1^{a}	46.1±4.2 ^{b}	44.9 ±3.9 ^{b}	<0.0001	0.383
Udder length	43.2±4.8	43.7±3.0	44.4 ± 4.8	0.235	-
Udder circumference	95.4±7.8 ^{a}	99.9±5.3^{b}	96.4 ± 4.1 ^{a}	<0.0001	0.267
Teat length front	5.0±1.9	4.6 ± 1.9	4.9 ± 1.8	0.751	0.617
Teat length rare	5.1±1.8	4.8±1.9	5.1 ± 1.8	0.416	0.935
Teat diameter front	3.4±1.3	3.5±0.9	3.4 ± 0.9	0.933	0.964
Distance between teat	8.8 ± 2.0 ^{a}	9.6 ±1.8^{b}	8.3 ± 1.7 ^{a}	<0.0001	0.561
Total milk yield	4.9 ± 1.7 ^{a}	6.01 ± 2.3 ^{b}	4.2 ± 1.7 ^{a}	<0.0001	-

Different letters within a line indicate significant difference ($p \leq 0.0001$)

[1] Effect of lactation stage. [2] interaction between stage of lactation and before and after milking measurements.

Table (3): udder and teat measurement (cm) and milk daily milk yield (kg/d) related with different udder types.

Traits	Mean ± SD			
	Number	Type 1	Type 2	Type 3
Udder height	208	106.8±5.6 ^{ab}	108.5±7.8 ^{a}	103.0±7.3 ^{b}
Udder depth before milking	208	39.6 ±4.4^{a}	44.3±4.2 ^{b}	45.3±4.7 ^{c}
Udder length	208	40.3±7.6 ^{a}	44.2±4.3 ^{b}	44.4±3.3 ^{b}
Udder circumference before milking	208	89.8±7.7 ^{a}	97.7±5.2 ^{b}	100.8±4.2 ^{c}
Teat length front	208	4.9 ±2.3 ^{a}	7.0 ± 2.0 ^{b}	4.2±1.1 ^{a}
Teat length rear	208	4.9 ± 1.7 ^{a}	7.5 ± 1.8 ^{b}	4.4 ± 1.2 ^{a}
Teat diameter front	208	2.6 ± 0.8 ^{a}	3.3 ± 0.8 ^{b}	4.5± 1.0 ^{c}
Distance between teats	208	6.6 ± 1.2 ^{a}	9.1 ± 1.7 ^{b}	10.0 ± 1.7 ^{c}
Total milk yield	208	4.4 ± 1.4 ^{a}	4.9 ± 1.8 ^{a}	6.0 ± 2.7 ^{b}

Different letters within a line indicate significant difference ($p \leq 0.0001$)

Table (4): Correlation matrix between the different measurements of teats and udder traits and milk yield at early stage of lactation (77).

	MYM	MYE	TMY	UH	UD	UL	CP	TLF	TLR	TDF	TDR	DT
MYM		.54***	.84***	-.01	0.16	0.1467	0.13	0.18	0.20	0.26*	-.02	.26*
MYE	.54***		0.91***	-.19	0.10	0.01	0.09	0.15	0.22	0.10	-0.01	0.11
TMY	.84***	0.90***		-0.13	0.15	0.08	0.13	0.19	0.24*	0.18	-0.012	0.20
UH	-0.01	-0.19	-0.13		0.27*	0.04	0.01	-0.16	-0.23*	-0.09	-0.05	0.04
UD	0.17	0.11	0.15	0.27*		0.19	0.04	0.30*	0.25	0.04	-0.14	0.12
UL	0.15	0.01	0.08	0.04	0.21		0.39**	-0.11	0.03	0.37**	0.23*	0.12
CP	0.14	0.09	0.13	0.002	0.04	0.39**		-0.09	0.07	0.51***	0.26*	0.26
TLF	0.19	0.15	0.19	-0.16	0.30*	-0.11	-0.09		0.94***	0.35	0.03	0.06*
TLR	0.20	0.21	0.23*	-0.23*	0.25*	0.03	0.08	0.94***		0.43***	0.08	0.10
TDF	0.25*	0.07	0.18	-0.10	0.04	0.37**	0.51***	0.35	0.43***		0.46***	0.33
TDR	-0.02	-0.01	-0.01	-0.04	-0.14	0.23*	0.26*	0.02	0.08	0.46***		-.25**
DT	0.25*	0.11	0.19	0.04	0.12	0.12	0.25	0.06*	0.10	0.33	-0.25**	

UH: udder height; UD: udder depth ; UL: udder length; CP: udder circumference ; TLF: teat length front ; TLR: teat length rear ; TDF: teat diameter front ; TDR: teat diameter rear ; DT: distance between teat ; TMY: total milk yield: MYE: milk yield evening ; MYM: milk yield morning * $P \leq 0.05$; ** $P \leq 0.005$; *** $P \leq 0.0001$

Table (5): Correlation matrix between the different measurements of teats and udder traits and milk yield at mid stage of lactation (67).

	MYM	MYE	TMY	UH	UD	UL	CP	TLF	TLR	TDF	TDR	DT
MYM		0.71***	.92***	-0.01	0.21	0.24*	0.29*	0.29*	0.24*	0.25*	0.22	0.27*
MYE	.70***		0.93***	-0.01	0.25*	0.34**	0.19	0.18	0.11	0.07	0.09	0.32*
TMY	.91***	0.93***		-0.01	0.25*	0.32*	0.26*	0.25*	0.19	0.17	0.17	0.32*
UH	-0.01	-0.01	-0.01		-0.15	0.13	-0.24*	-0.38**	-0.32*	-0.29*	-0.34**	-0.05
UD	0.20	0.26*	0.25*	-0.16		0.40**	0.61***	0.37**	0.28*	0.39**	0.32*	.47***
UL	0.24*	0.35**	0.32*	0.13	0.41**		0.28*	0.02	0.02	-0.08	-0.01	0.29*
CP	0.29*	0.19	0.26*	-0.24	0.62***	0.28		0.31*	0.22	0.48***	0.47***	.44***
TLF	0.29*	0.18	0.26*	-0.38**	0.37**	0.02	0.31*		0.82***	0.74***	0.61***	0.14
TLR	0.25*	0.11	0.19	-0.32*	0.28*	0.02	0.22	0.82***		0.69***	0.51***	-0.01
TDF	0.25*	0.07	0.17	-0.29*	0.39**	-0.08	0.48***	0.74***	0.69***		.77***	0.23
TDR	0.22	0.09	0.17	-0.34**	0.32*	-0.012	0.47***	0.62***	0.51***	0.77***		0.22
DT	0.27*	0.32	0.32*	-0.05	.47***	0.29*	0.44***	0.14	-0.01	0.23	0.22	

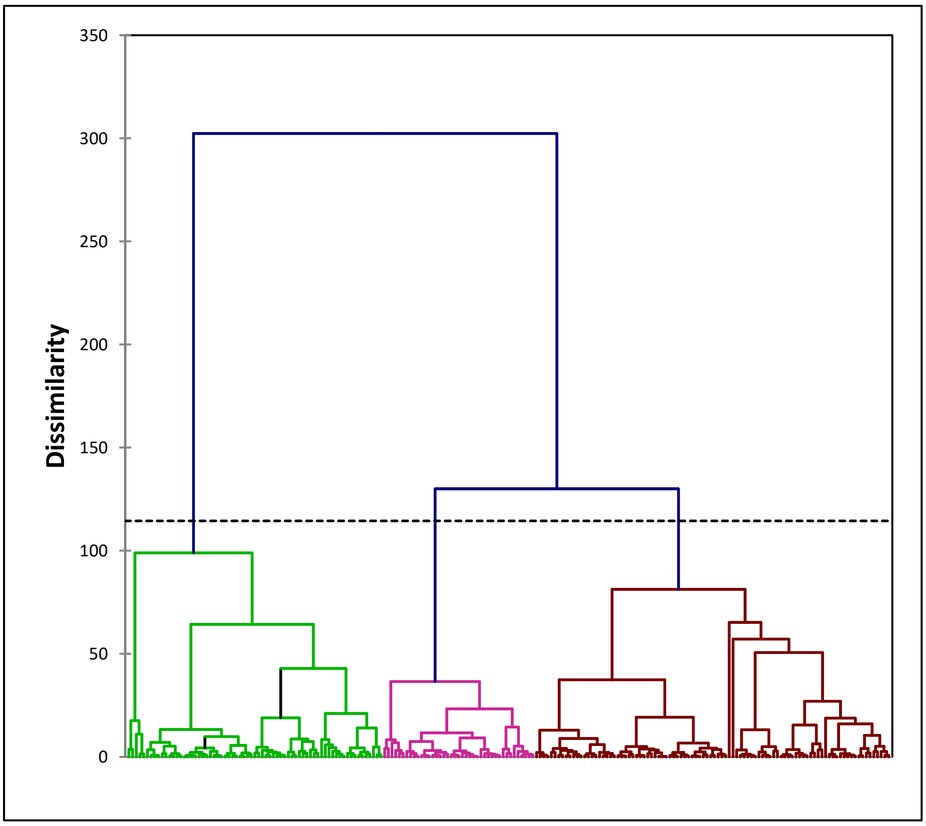
UH: udder height; UD: udder depth ; UL: udder length; CP: udder circumference ; TLF: teat length front ; TLR: teat length rear ; TDF: teat diameter front ; TDR: teat diameter rear ; DT: distance between teat ; TMY: total milk yield: MYE: milk yield evening ; MYM: milk yield morning * P≤ 0.05 ; ** P≤0.005 ; ***P≤0.0001

Table (6): Correlation matrix between the different measurements of teats and udder traits and milk yield at late stage of lactation (64).

	MYM	MYE	TMY	UH	UD	UL	CP	TLF	TLR	TDF	TDR	DT
MYM		0.50***	.86***	-0.14	0.12	-0.03	0.23	0.15	0.001	0.04	-0.06	0.02
MYE	0.50***		0.87***	-0.08	0.21	0.14	0.22	0.19	0.22	0.06	-0.14	-0.12
TMY	0.85***	0.87***		-0.13	0.19	0.07	0.25*	0.20	0.13	0.06	-0.12	-0.06
UH	-0.14	-0.09	-0.13		0.12	0.09	-0.01	-0.36**	-0.27*	-0.22	-0.02	-0.02
UD	0.19	0.21	0.19	0.12		0.56***	0.25*	0.31*	0.24	0.29*	-0.02	0.02
UL	-0.03	0.14	0.07	0.09	0.56***		0.21	0.12	0.12	0.23	0.10	-0.19
CP	0.22	0.23	0.26*	-0.01	0.25*	0.21		0.21	0.31*	0.40**	0.22	0.19
TLF	0.15	0.19	0.20	-0.36**	0.31*	0.09	0.20		0.79***	.62***	0.34*	0.33*
TLR	0.001	0.22	0.13	-0.27*	0.25	0.13	0.31*	0.79***		.57***	0.33*	0.15
TDF	0.04	0.06	0.06	-0.22	0.29	0.23	0.41**	0.62***	.57***		0.58***	0.43**
TDR	-0.06	-0.14	-0.12	-0.02	-0.02	0.10	0.22	0.34*	0.33*	.58***		0.33*
DT	0.02	-0.12	-0.06	-0.02	0.02	-0.18	0.12	0.33*	0.15	0.42**	0.33*	

UH: udder height; UD: udder depth ; UL: udder length; CP: udder circumference ; TLF: teat length front ; TLR: teat length rear ; TDF: teat diameter front ; TDR: teat diameter rear ; DT: distance between teat ; TMY: total milk yield: MYE: milk yield evening ; MYM: milk yield morning * P≤ 0.05 ; ** P≤0.005 ; ***P≤0.0001

Figure (1) Dendrogram of hierarchical classification of the 208 udder and teats measurement during three stages showing three type of udders (74.26 % of variances explained)



Abdelgadir Musaad Mustafa "Change In udder Measurements Traits during Lactation and Its Relationship with Milk Yield in Dairy Camel (Camelus Dromedaries)." IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) 10.12 (2017): 76-83.