Research Article

Macro and Microscopical Features of Productive and Nonproductive Mammary Gland of Local Arabian She-Camel in Al Muthanna Governorate

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Abstract | Camel milk plays important source of protein, vitamins and other nanocomponents. The camel's daily milk production shows a variation in milking frequency, which is affected by environments, feeding, stage of lactation, breed, species and diseases of the udder . Moreover, she-camels also shows fluctuating in the lactation length from 9 to 18 months. This study intends to investigate the macro and microscopical features of local Arabian she-camel's productive and nonproductive mammary glands (SCPMG & SCN-PMG). Sixteen mammary gland samples and its teats (8 SCPMG and 8 SCN-PMG) were collected from Al Muthanna abattoir. Gross examination, and full description were done and recorded. The samples were dissected and kept in a 10 % neutral buffered formalin. All samples were processed by histological technique and stained with Haematoxylin and Eosin. This study showed that SC's udder appeared with four quarters, covered by brown to solid black tint skin. Both conical and cylindrical shapes of teat were observed, which constituted 75%& 25% and 37.5% & 62.5% for SCPMG & SCN-PMG), respectively. Microscopical examination of teats revealed two streak canals lined by a stratified squamous keratinized epithelium. Furstenberg's Rosettes were vertically located as ridges at teat internal streak canal end mucosa. The number of Furstenberg's Rosettes ranged from 11 to 15 and 9 to 11 in SCPMG and SCN-PMG, respectively. Mammary gland parenchyma revealed an arrangement of lobules separated by interlobular connective tissue. Each lobule comprised a group of alveoli surrounded by interalveolar connective tissue. In SCPMG, less connective tissue was seen in between a large number of alveoli, which were lined by simple columnar epithelium; vice versa, more connective tissue and few alveoli lined by flattened epithelium were seen in the SCN-PMG. In conclusion, this study showed the presence of large anatomical and histological variations in the she-camel's udder reliant on the physiological state.

Keywords | Conical teat, cylindrical teat, Dromedary, Furstenberg's Rosettes, Histology, Mammary gland.

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INTRODUCTION

The Arabian camel (dromedary) is one of the vital animals living in the arid and semiarid areas of Africa and Asia, especially the Arabian peninsula (El Khasmi & Faye, 2019). It can produce a large amount of milk in severe environments from poor feed compared to other dairy animal species (El Khasmi & Faye, 2019; Abdul Al-Hussein et al., 2020). There is increasing attention toward camel milk because of its nutritional values and unique composition

with significant health benefits (Al haj & Al Kanhal, 2010; Alexandraki et al., 2016). She-camels are known as tough to milking and ejection of milk without udder pre-stimulation (Calf or/ exogenous oxytocin/manual) due to the accumulation of 90% of milk in the alveolar compartment of the udder (Kaskou, 2018). The anatomical and histological structures of the udder and teat impact the milking process and milk yield, considering the volume and values (Atigua, 2014). Different shapes of udders (pear, globular, and pendulous) and teats (conical and cylindrical) were reported previously in She-camels (Wernery, 2006; Ayadi et al., 2015). Manual or machine milking of she-camel is different from other dairy animals, and a high percentage of bimodality (41.9%) has been reported by (Atigua et al., 2014). She reported three types of milk flow during the milking process of she-camel (Type 1, Type 2, and Type 3) depending on the udder's topology.

She-camel can be milked every hour due to its ability to refill its udder about one hour after complete milking by hand (Yagil et al., 1999). Initiation of milk ejection in she-camel occurs after 1.5 minutes of calf suckling (Yagil et al., 1999; Costa & Reinemann, 2003; Wernery, 2006), leading to sudden swelling of the teats. The researchers interpret these observations that she-camel's udder has no gland cistern because of the transfer of milk alveoli to the teat cistern directly after teat swelling. This observation shortened the milking time of she-camels (Yagil et al., 1998; Costa & Reinemann, 2004; Wernery et al., 2004). In addition to all the above observations, teat and udder morphology has been associated with the incidence of mastitis (Alsalihi et al., 2017). Accordingly, knowing the udder's anatomical and histological features help in understanding the ability of dromedaries to resist mastitis. Few studies have focused on studying the gross and physiological characteristics of the udder of dromedaries she-camel (Kausar et al., 2001; Eisa et al., 2010; Ishag et al., 2011; Atigui et al., 2016). In Iraq, there is a paucity of studies related to gross and histology of Arabian she-camel's udder during different physiological states. Hence, this study aimed to investigate the gross and histological features of the lactating and non-lactating mammary gland of dromedary she-camel.

MATERIALS AND METHODS

The study was approved by animal ethical and research committee /College of veterinary Medicine /Al Muthanna University 2022-2021(code: 21-22).

Sixteen samples of mammary glands and their teats (8 non-lactating and 8 lactating she-camels) were collected from Al Muthanna abattoir from December 2021 to March 2022. The external anatomy of mammary glands was studied during the pre-slaughtering preparation period of the animal. The samples were removed directly from the slaughtered animal. The teats and pieces from the gland were cut and soaked in 10% neutral buffered formalin. Each sample was trimmed into small specimens involving the teat canal, teat cistern, gland cistern, parenchyma, and both teat and gland skin. The samples were transferred to the anatomy laboratory/ College of Veterinary Medicine/ Al Muthanna University and processed routinely by histological technique. Forty eight hours, following fixation of the samples, dehydration was done using arising grades of ethyl alcohol (50-100%), then cleared using xylene (2 changes). Afterwards, samples were embedded in melted paraffin wax (59 ° C), blocked and sectioned with an ordinary microtome (3-6 micrometer thickness). Lastly, sectioned were stained by Hematoxylin and Eosin stain and examined under a light microscope. All sections were examined in magnification (X4, X10, X20, X40). Furthermore, images were acquired by Leica image analyzer (Bancroft and Gamble, 2008). All samples were routinely processed by histological technique, sectioned at 5-6 µm, stained with Haematoxylin and Eosin, and examined under light microscopy connected with a camera and Image analyzer (Leica).

RESULTS

Gross examination revealed that dromedary she-camel had four quarters; two front and two hind, each with its teat (Figure 1).

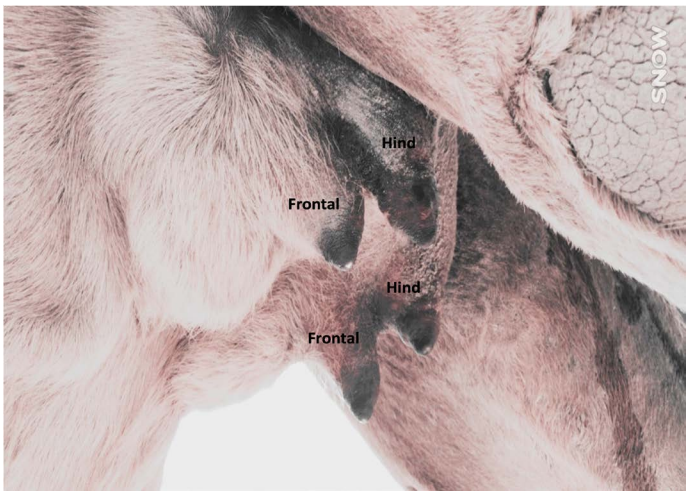

Figure 1: Shows the four quarters (two front and two hinds) of dromedary she-camel udder; each with its teat showed brown to tint black color

Teats revealed both conical and cylindrical shapes (Figure 2 & 3) constituted ("6/8" 75% and "2/ 8" 25%) and ("3/8" 37.5% and "5/8" 62.5" out of 8) for lactating and non-lactating she-camel glands respectively. The skin of the teats was brown to black tinge. The teat's diameter ranged (from

1.03 cm - 3.03 cm) and (2.25-5.75 cm) for non-lactating and lactating udders. The teat's lengths were (2.0 -7.9 cm) and (3.35-9.5 cm) for non-lactating and lactating glands, respectively. At the same time, the teat's depths were (18.5-25 cm) and (29-42cm) for non-lactating and lactating she-camels glands, respectively.

Figure 2 & 3: Show conical and cylindrical shapes of teats

The teat's diameter ranged (from 1.03 cm - 3.03 cm) and (2.25-5.75 cm) for non-lactating and lactating she-camels glands. The teat's lengths were (2.0 -7.9 cm) and (3.35-9.5 cm) for non-lactating and lactating she-camels glands, respectively. At the same time, the teat's depths were (18.5-25 cm) and (29-42cm) for non-lactating and lactating she-camels glands, respectively.

Microscopical examination of the teats revealed two streak canals lined by a stratified squamous keratinized epithelium. This lining was thicker in lactating glands compared to non-lactating. A variation was also observed in the luminal width of the teat streak canal comprised a wider diameter for lactating than non-lactating gland. The submucosa layer of the teats was also thicker in lactating than the non-lactating glands. Furstenberg's Rosettes were vertically located as ridges at the teat internal streak canal end mucosa. The number of Furstenberg's Rosettes ranged from 11 to 15 and 9 to 11 in lactating and non-lactating glands, respectively (Figure 4). The skin layer of the teat was devoid of hair follicles except at the base teat. Additionally, hair follicles were related to sebaceous glands. The sweat glands were also seen with a less coiled and wide acinous element that formed the part of the excretory duct.

Examination of udder sections revealed pseudo-stratified columnar epithelium and the simple cuboidal epithelium lining the cranial and caudal glands cisterns. A group of alveoli was found in the submucosa of the gland cistern surrounded by aggregation of dense irregular connective tissue.

Mammary gland parenchyma revealed an arrangement of lobules separated by interlobular connective tissue. Each lobule comprised a group of alveoli surrounded by interalveolar connective tissue. In lactating she-camel, less connective tissue was seen between many alveoli lined by simple columnar epithelium (Figure 5). Vice versa, more connective tissue, and a few alveoli were lined by flattened tissue epithelium, which were seen in the non-lactating gland (Figure 6).

Figure 4: Shows: I. Furstenberg's Rosettes in the SCN-PMG and teat cistern (H&E/ X 4). II. White and black illustration (drawing by Banen Najeh Rehim) to show the two streak canals) (SCN-PMG: She-camel non-productive mammary gland)

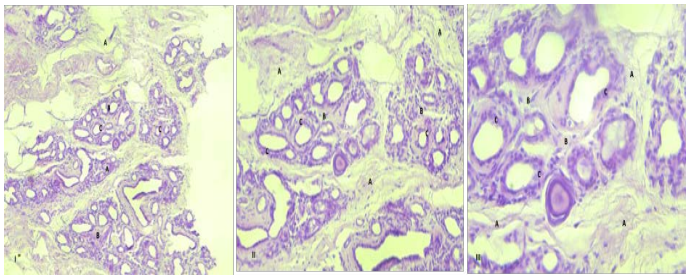

Figure 5: Parenchyma of the SCPMG showing active mammary gland and glandular tissue. A. Inter-lobular connective tissue, B. Inter-alveolar connective tissue, C. Alveolar epithelium. (H&E / I. X4, II. X10, III. X40). (SCPMG: she-camel productive mammary glands)

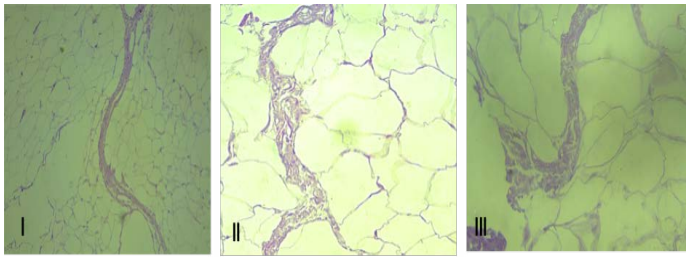

Figure 6: Parenchyma of the SCN-PMG showing non-active glandular tissue (More connective tissue and a few alveoli lined by flattened epithelium). (H&E/ I. X4, II. X10, III. X 40). (SCN-PMG: She-camel nonproductive mammary glands)

DISCUSSION

The current study showed that dromedary she-camel had four quarters; two front and two hinds, each with its teat. The skin of the teats was brown to black tinge. The results of this study revealed two shapes of teats, the conical and

cylindrical, nearly similar to those described in dromedaries in previous studies (Schwartz and Dioli, 1992; Atigui et al., 2014 ; Ayadi et al., 2016; Rizk et al., 2017). Previous studies reported three different teat shapes, the funnel/conic shapes that appeared in both mature and immature animals: cylindrical and irregular/ bottled. In the current study, the percentages of teats with a conical shape were 75% & 37.5 for lactating and non-lactating she-camel, respectively. In comparison, the percentages of teats with cylindrical shapes were 25% & 62.5 for lactating and non-lactating she-camel, respectively. These results are consistent with a previous study (Tilki et al., 2005) that showed the effect of teat shape on cow milk yield.

Moreover, it is compatible with prior studies by other authors that reported a large variation in morphology and size of teats and udder on dairy she-camels. They also mentioned that the teats changed markedly according to the physiological state and became noticeably round at the tip (Eisa et al., 2010; Atigui, 2014; Nagy et al., 2015; Ayadi et al., 2016; Musaad et al., 2017; Atigui et al., 2021).

This study also focused on the teat's diameter, length, and depth and showed variations in their measurements between the lactating and non-lactating she-camels. These results agree with observations reported by other authors that found variations in the udder and teats measurements. They approved that the large irregular bottle-shaped teats lead to difficulties in milking and increase the risk of mastitis, accompanied by difficulties in suckling the newly born calf (Atigui et al., 2021). Moreover, the other researchers found that the morphometrical data of teat length at maturity increased twice the size 7.95±0.01 cm of immature she-camel 3..23±0.26cm (Kausar et al., 2001). Moreover, studies showed that the teat circumference at apex and midpoints decreased significantly ($P< 0.05$) in non-lactating compared with lactating camels. These changes might be due to tissue reconstitution under hormonal or other biochemical processes during the involution period with a loss of parenchyma. The variation in the teats measurements might also be associated with the development and physiological changes occurring in maturity and lactation. However, the current study's finding disagrees with other researchers that reported the absence of considerable variations between the teats (Saleh et al., 1971).

The current study showed two streak canals lined by a stratified squamous keratinized epithelium. The variations were in the epithelium lining between the lactating (productive) and non-lactating glands (non -productive) and the number of Furstenberg's Rosettes. These observations are compatible with results reported previously by other researchers (Kausar et al., 2001; Rizk et al., 2017). Moreover, they are similar to those reported by (Nickerson, 1994) in Buffaloes that reported 10-14 Furstenberg's Rosettes. The Furstenberg's Rosettes is a mucosal fold of the streak canal lining at the end of the teat canal and acts as a pathogens barrier and deals with little resistance to milk leaving the teat and contains a population of leukocytes (Rizah et al., 2015).

The results of this study approved that mammary gland parenchyma was composed of a group of alveoli that made the lobule. There were variations in the constituents of alveoli and connective tissue depending on the animal's physiological state. These results are compatible with previous observations by other researchers (Kausar et al., 2001). They mentioned the alveoli epithelium lining variation depending on the physiological state. They also showed that the alveolar epithelium reached its maximum height during the lactation stage. However, alveolar number and size were reduced and replaced by connective tissue in the non-lactating stage. These results also agree with Banks, (1993), who mentioned that the actively lactating glands have much parenchyma and little connective tissue.

CONCLUSIONS AND RECOMMENDATIONS

This study approved numerous anatomical and histological variations in she-camel's udder, depending on the physiological state. The authors recommend a future comparative study between different lactation periods to investigate the highly milk productive period.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

FUNDING

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NOVELTY STATEMENT

A comparative histological study was done to investigate the histological changes of the lactating and non-lactating she-camel. The research support the field of camelids milk production to understand the mammary gland and

its physiology.

ABBREVIATIONS

Abbreviations	Full words
SCN-PMG	she-camel non-productive mammary glands)
SCPMG	she-camel productive mammary glands
SC	She-camels

AUTHOR CONTRIBUTIONS

All authors contributed equally in doing and writing this manuscript.

ETHICAL CONSIDERATION

The authors have no any ethical issues such as plagiarism, information fabrication, misconduct and/or falsification, permission to publish, duplicate publication and/or submission, and redundancy.

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