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Gross morphometrical studies of mammary gland in Kosali cow

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Abstract
The present study was conducted on mammary glands of thirty-six lactating and non-lactating/ non-pregnant Kosali cows divided into early, mid and late stages, respectively. The Kosali cows are reared on grazing and offered paddy straw only. While in urban and semi urban areas, this breed is rarely available, where it is reared in semi-intensive farming system offering dry fodder along with little concentrates. This breed is preferred in rural areas of Chhattisgarh due to its adaptability and heat tolerance as well as disease resistance. The mammary gland undergoes repeated cycles of structural development, functional differentiation and regression that are intimately associated with the specific physiology of the animal's growth and reproduction. All the observed gross morphometrical parameters of udder and teat of Kosali cows in present study were significantly higher in early lactation as compared to mid and late lactations and were significantly higher in early dry period as compared to mid and late dry periods. Further, they were significantly higher in lactating cows as compared to non-lactating/ non-pregnant cows in early, mid and late stages. The percentage decrease in all parameters between mid and late stages were higher as compared between early and mid stages in lactating as well as non-lactating/ non-pregnant Kosali cow.

Keywords: Gross morphometry, mammary gland, Kosali cow

Introduction
Kosali breed has been registered as the 36th breed of cattle in the year 2012 (Accession No.: INDIA_CATTLE_2600_KOSALI_03036) and it is the first breed from the Chhattisgarh. Its breeding tract lies in between 19.8 to 22.7 degrees north altitude and 80.3 to 83.6 degrees east longitude. Kosali breed is mainly concentrated in the central plain region (15 districts) of the C.G. state with 31.32 lakh estimated population and spread in 68.49 lakh hectare geographical area. These cows are small sized, draft purpose breed, possessing red coat colour, stumpy horn, horizontal ear (Jain *et al.*, 2017, 2018, 2019) [9,10,11]. The lactation yield ranges from 200 to 250 kg with average fat % from 3 to 4.5 (Sahu *et al.*, 2018b) [21].

The secretion of mammary gland provides passive immunity and nutrition to young ones, which enables them to survive in the new environment. It is also a nutritive support to human being at any age. It is also the second largest agricultural commodity next only to rice (Chaurasia *et al.*, 2018) [6]. The gross morphological study of mammary gland at different stages of lactation is very important to understand normal structure, to increase the background information in the physiology, reproduction, medicine, livestock production and management, genetics and pathology and to understand the mechanism of lactogenesis, galactopoisis and involution. Due to scarcity of literature for this newly established Kosali breed of cattle, present experiment has been undertaken to establish fundamental data on mammary gland of this breed. The outcome of this experiment will help to assess the milk production potential of this breed.

Materials and Methods
The gross morphological studies were conducted at Department of Veterinary Anatomy, College of Veterinary Science & A.H., Anjora, Durg (C.G.), Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Durg (C.G.). The experiment was conducted on mammary gland of thirty-six Kosali cows procured from central plain region of the Chhattisgarh. The samples were collected from animals immediately after death from farmers house, state veterinary hospitals etc. The different parameters of udder, teats and mammary lymph nodes were recorded with the help of weighing machine, Vernier calipers, thread and measuring tape. The data obtained from various parameters was analyzed by one way ANNOVA and independent

sample t-test statistical methods (Snedecor and Cochran, 1994) [24]. According to the earlier reports of Sahu *et al.* (2018a) [20] and Jain *et al.* (2019) [11], they were categorized into two groups (eighteen each) as lactating and nonlactating by ascertaining the status of mammary gland for stage of lactation and dry period as below:

Group I. Lactating stage - 18
- Early lactating stage (5 - 90 days) – 6.
- Mid lactating stage (Above 90 - 180 days) – 6.
- Late lactating stage (Above 180 - 230 days) – 6.

Group II. Nonlactating/ Non-pregnant stage – 18
- Early nonlactating/nonpregnant stage (Date of dry - 60 days) – 6.
- Mid nonlactating/nonpregnant stage (Above 60 - 120 days) – 6.
- Late nonlactating/nonpregnant stage (Above 120 - 190 days) – 6.

Results and Discussion

The mammary gland (Glandula mammary) of lactating and non-lactating/ non-pregnant Kosali cows comprised of four mammary unit (right and left front quarters and right and left rear quarters) and each mammary unit consisted of a body (Corpus mammae) and a teat (Papilla mammae). The right and left halves of the udder were separated by a median longitudinal intermammary groove (Sulcus intermammaricus) in both stages. These characters were similar to the findings of Sisson (1975) [23] in cow, Panchal and Vyas (2005) [15] in buffalo, Bragulla and Konig (2007) [4] in cow, Budras and Habel (2009) [5] in cow, Nickerson and Akers (2011) [14] in cow, ALsadi and Fadeal (2018) [1] in cow, Bhamburkar (2018) [3] in cow, Pandey *et al.* (2018) [16] in cow, Singh (2018) [22] in cow, Qureshi (2019) [19] in cow, Tataru *et al.* (2022) [25] in buffalo and Ghosh (2023) [7] in cow. The udder (Uber) of lactating Kosali cow was large and bowl shaped, whereas it was small and round shaped in non-lactating/ non-pregnant Kosali cows (Fig. 1). Similar findings were also confirmed by the Prasad *et al.* (2010) [18] in buffalo, Jain *et al.* (2018) [10] in cow, Basavaraj *et al.* (2019) [2] in cow and Poudel *et al.* (2022) [17] in buffalo.

The suspensory apparatus (Apparatus suspensorius mammarius) comprised of skin, superficial fascia or areolar subcutaneous tissue, coarse areolar or cordlike tissue, sub-pelvic tendon, superficial and deep layers of lateral suspensory ligament (Ligamentum suspensorium uberis lateralis) and median suspensory ligament (Ligamentum suspensorium uberis medialis) in both the groups (Fig. 2). These findings were in agreement with the earlier reports of Sisson (1975) [23], Panchal and Vyas (2005) [15], Bragulla and Konig (2007) [4], Budras and Habel (2009) [5] Nickerson and Akers (2011) [14], ALsadi and Fadeal (2018) [1], Bhamburkar (2018) [3], Pandey *et al.* (2018) [16], Singh (2018) [22], Tataru *et al.* (2022) [25] and Ghosh (2023) [7]. During sub-gross studies, it was noted that gland cistern or lactiferous sinus or udder cistern (Pars glandularis sinus lactiferi) of the both stages of Kosali cows opened into the teat cistern and allowed storage of milk. Annular fold or rosette of venous ring or cricoid ring was the constricted region between the teat cistern and the gland cistern in both the groups (Fig. 3). The organization of gland cistern and annular fold of Kosali cow was in accordance with the reports of Panchal and Vyas (2005) [15], Budras and Habel (2009) [5], ALsadi and Fadeal (2018) [1], Bhamburkar (2018) [3], Pandey *et al.* (2018) [16] and Tataru *et al.* (2022) [25]. Paired supra-mammary lymph nodes were present on the caudo-dorsal surface of each half of the mammary gland in both stages (Fig. 2). This statement was similar to the findings of Sisson (1975) [23], Panchal and Vyas (2005) [15] and Bhamburkar (2018) [3].

Data of observations of udder for weight, circumference, length at midline, maximum width, maximum depth, maximum lengths of right and left quarters, maximum widths of right and left quarters, thickness of skin, length of median suspensory ligament, maximum diameter of gland cistern, lengths and widths of right and left supra-mammary lymph nodes were significantly higher in early lactation as compared to mid and late lactations in lactating Kosali cow and were significantly higher in early dry period as compared to mid and late dry periods in non-lactating/ non-pregnant Kosali cow, further they were significantly higher in lactating cows as compared to non-lactating/ non-pregnant cows in early, mid and late stages (Table 1). The percentage decrease in the above parameters between mid and late stages (60%) were higher as compared between early and mid stages (40%) in lactating as well as non-lactating/ non-pregnant Kosali cow (Table 2).

Panchal and Vyas (2005) [15] in buffalo, ALsadi and Fadeal (2018) [1], Pandey *et al.* (2018) [16] and Qureshi (2020) [19] in cow observed higher weight of the udder as compared to present finding. Prasad *et al.* (2010) [18] observed higher length, width and depth of udder in buffalo, whereas Poudel *et al.* (2022) [17] recorded higher length and depth but similar width of udder in buffalo as compared to present finding. The weight, length, width and depth of udder were observed lower during present study, which indicated the lower milk production of Kosali cows. Maximum length and width of left quarters at the base of the udder were slightly higher as compared to right quarters in both stages. The length of median suspensory ligament could be assigned to weight bearing capacity of this ligament needed as per the mammary tissue development during different stages of mammogenesis during lactation. The size of gland cistern depicts the functional status of the compartments of the udder at different stages of lactation, the compartments were larger during peak stage of lactation and decreased in dimension in later stages. Length and width of supra-mammary lymph nodes were lower as compared to the earlier findings of Panchal and Vyas (2005) [15] in buffalo and Khoramian *et al.* (2015) [12] in cow. Length and width of left supra-mammary lymph node were slightly higher as compared to right supra-mammary lymph node in both the groups. Size of supra-mammary lymph nodes was greater in lactating Kosali cows as compared to non-lactating/ non-pregnant cows, which was responsible for more immunity against the mastitis (Table 1).

The teat (Papilla mammae) of Kosali cow was cylindrical or conical shaped in lactating Kosali cows and funnel or pear shaped in non-lactating/ non-pregnant Kosali cow. Teat orifice or papillary ostium (Ostium papillae) was rounded in both the groups (Fig. 1). These statements were similar to the findings of Prasad *et al.* (2010) [18] in buffalo, Nickerson and Akers (2011) [14] in cow, Jain *et al.* (2018) [10] in cow, Pandey *et al.* (2018) [16] in cow, Singh (2018) [22] in cow, Basavaraj *et al.* (2019) [2] in cow, Poudel *et al.* (2022) [17] in buffalo and Tataru *et al.* (2022) [25] in buffalo. Teat cistern or papillary sinus (Pars papillaris sinus lactiferi) of Kosali cow was a cavity within the teat and proximally it was continuous with the gland cistern and distally with the teat canal in both

stages. The organization of teat cistern of Kosali cow was in accordance with the reports of Panchal and Vyas (2005) [15], Budras and Habel (2009) [5], ALsadi and Fadeal (2018) [1], Bhamburkar (2018) [3] and Pandey *et al.* (2018) [16].

Furstenberg's rosette of both stages of Kosali cows was mucosal folds present between the teat cistern and teat canal and was involved in the local defence against mastitis. Teat canal or streak canal or papillary duct of both stages of Kosali cow was the external orifice of the gland, which allowed evacuation of the milk and kept closed by sphincter muscles and provided main barrier against intramammary infection. The keratin plugs more effectively sealed the teat canals in non-lactating/ non-pregnant stage as compared to lactating stage, which acts as a barrier for the pathogenic bacteria (Fig. 3). These statements were confirmed by Nickerson and Akers (2002) [13], Panchal and Vyas (2005) [15], Budras and Habel (2009) [5], ALsadi and Fadeal (2018) [1], Bhamburkar (2018) [3], Pandey *et al.* (2018) [16] and Qureshi (2019) [19]. Two numbers of simple but not anatomically complex supernumerary teats or accessory teats or polythelia or pseudo-teats without functional gland were observed near the right rear quarter teat of one late non-lactating/ non-pregnant stage of Kosali cow. This observation was in agreement with Panchal and Vyas (2005) [15] in buffalo, Nickerson and Akers (2011) [14] in cow, ALsadi and Fadeal (2018) [1] in cow, Pandey *et al.* (2018) [16] in cow and Hardwick *et al.* (2020) [8] in sheep.

Teat lengths of right and left front and rear quarters, teat diameters of right and left front and rear quarters (at base, at middle and near the tip), distance between front quarter teats, distance between rear quarter teats, distance between right front and rear quarter teats, distance between left front and rear quarter teats, maximum lengths of teat cistern of front and rear quarter teats and maximum lengths of teat canal of front and rear quarter teats were significantly higher in early lactation as compared to mid and late lactations in lactating Kosali cow and were significantly higher in early dry period as compared to mid and late periods in non-lactating/ non-pregnant Kosali cow, further they were significantly higher in lactating cows as compared to non-lactating/ non-pregnant cows in early, mid and late stages (Table 1). The percentage decrease in the above parameters between mid and late stages (60%) were higher as compared between early and mid stages (40%) in lactating as well as non-lactating/ non-lactating Kosali cow (Table 2).

Similar to the finding of Nickerson and Akers (2011) [14] in cow, in the present study the rear quarter teats were shorter and thicker than the front teats in lactating as well as non-lactating/ non-pregnant Kosali cows. Higher length of teat was noticed by Sisson (1975) [23] in cow, Prasad *et al.* (2010) [18] in buffalo, ALsadi and Fadeal (2018) [1] in cow, Bhamburkar (2018) [3] in cow and Singh (2018) [22] in cow; Poudel *et al.* (2022) [17] in buffalo and Tataru *et al.* (2022) [25] in buffalo. Prasad *et al.* (2010) [18] in buffalo, ALsadi and Fadeal (2018) [1] in cow and Poudel *et al.* (2022) [17] in buffalo recorded higher diameter of teat. The diameter of teat was greater in rear quarters as compared to front quarters, which indicated the higher capacity of rear quarters in Kosali cows. This statement was supported by earlier findings of Prasad *et al.* (2010) [18] and Nickerson and Akers (2011) [14]. The average value of the length and diameter of left quarter teats was slightly higher as compared to right quarter teats in both the groups. Distance between front teats was higher as compared to rear teats in both the groups. Distance between left front and rear quarter teats at base was slightly higher as compared to right front and rear quarter teats in both stages in both stages. Nickerson and Akers (2002) [13] observed higher length of teat canal as compared to present finding. The mean value of the maximum length of teat cistern and teat canal of front quarter teats was higher as compared to rear quarter teats in both the groups (Table 1).

All recorded gross anatomical parameters of mammary glands in early, mid and late lactating and non-lactating/ non-pregnant stages indicated that the gross anatomical development of the gland is directly related to the secretory activity of the gland.

Table 1: Mean±SE (kg or cm) gross parameters of mammary gland of lactating and non-lactating Kosali cows

S. No.	Parameters	Groups	Stages		
			Early	Mid	Late
1.	Weight of the udder (kg)	Lactating	$2.58 \pm 0.15^{a*}$	$2.13 \pm 0.13^{b*}$	$1.46 \pm 0.10^{c*}$
		Non lactating	1.12 ± 0.08^{a}	0.95 ± 0.05^{b}	0.69 ± 0.03^{c}
2.	Circumference of udder at the base (cm)	Lactating	$74.83 \pm 2.77^{a*}$	$68.81 \pm 1.82^{b*}$	$59.92 \pm 0.91^{c*}$
		Non lactating	49.08 ± 1.79^{a}	45.10 ± 0.78^{b}	39.25 ± 0.40^{c}
3.	Length of udder at the midline of the base (cm)	Lactating	$23.17 \pm 0.79^{a*}$	$20.83 \pm 0.55^{b*}$	$17.36 \pm 0.45^{c*}$
		Non lactating	16.99 ± 0.43^{a}	15.42 ± 0.41^{b}	13.04 ± 0.35^{c}
4.	Maximum width of udder at the base (cm)	Lactating	$19.49 \pm 0.45^{a*}$	$18.47 \pm 0.43^{b*}$	$16.92 \pm 0.32^{c*}$
		Non lactating	15.98 ± 0.23^{a}	14.73 ± 0.20^{b}	12.87 ± 0.10^{c}
5.	Maximum depth of the udder (cm)	Lactating	$11.03 \pm 0.09^{a*}$	$10.15 \pm 0.08^{b*}$	$8.83 \pm 0.06^{c*}$
		Non lactating	7.18 ± 0.05^{a}	6.39 ± 0.04^{b}	5.19 ± 0.03^{c}
6..	Maximum length of right quarters at the base (cm)	Lactating	$23.31 \pm 0.57^{a*}$	$21.09 \pm 0.53^{b*}$	$17.70 \pm 0.51^{c*}$
		Non lactating	17.08 ± 0.49^{a}	15.56 ± 0.47^{b}	13.25 ± 0.45^{c}
7.	Maximum length of left quarters at the base (cm)	Lactating	$23.82 \pm 0.63^{a*}$	$21.83 \pm 0.61^{b*}$	$18.79 \pm 0.58^{c*}$
		Non lactating	17.58 ± 0.56^{a}	16.35 ± 0.54^{b}	14.50 ± 0.52^{c}
8.	Maximum width of right quarters at the base (cm)	Lactating	$10.02 \pm 0.27^{a*}$	$8.99 \pm 0.25^{b*}$	$7.47 \pm 0.23^{c*}$
		Non lactating	7.12 ± 0.16^{a}	6.76 ± 0.13^{b}	6.21 ± 0.11^{c}
9.	Maximum width of left quarters at the base (cm)	Lactating	$11.50 \pm 0.32^{a*}$	$10.12 \pm 0.30^{b*}$	$7.97 \pm 0.26^{c*}$
		Non lactating	7.89 ± 0.17^{a}	7.25 ± 0.14^{b}	6.30 ± 0.10^{c}
10.	Thickness of skin at the base of udder (cm)	Lactating	$0.45 \pm 0.02^{a*}$	$0.41 \pm 0.01^{b*}$	$0.35 \pm 0.01^{c*}$
		Non lactating	0.34 ± 0.01^{a}	0.30 ± 0.01^{b}	0.24 ± 0.01^{c}
11.	Length of median suspensory ligament (cm)	Lactating	$23.02 \pm 0.72^{a*}$	$20.72 \pm 0.55^{b*}$	$17.32 \pm 0.30^{c*}$
		Non lactating	16.69 ± 0.23^{a}	15.23 ± 0.20^{b}	13.00 ± 0.10^{c}
12.	Maximum diameter of gland cistern (cm)	Lactating	$5.34 \pm 0.12^{a*}$	$4.19 \pm 0.06^{b*}$	$2.43 \pm 0.05^{c*}$
		Non lactating	1.71 ± 0.03^{a}	1.36 ± 0.02^{b}	0.84 ± 0.01^{c}
13.	Length of right supra-mammary lymph node (cm)	Lactating	$3.12 \pm 0.06^{a*}$	$2.81 \pm 0.05^{b*}$	$2.34 \pm 0.04^{c*}$
		Non lactating	1.90 ± 0.03^{a}	1.58 ± 0.02^{b}	1.09 ± 0.01^{c}

14.	Length of left supra-mammary lymph node (cm)	Lactating	5.01 ± 0.10^{a*}	4.70 ± 0.08^{b*}	4.23 ± 0.06^{c*}
		Non lactating	2.20 ± 0.04^{a}	1.96 ± 0.02^{b}	1.60 ± 0.01^{c}
15.	Width of right supra-mammary lymph node (cm)	Lactating	2.90 ± 0.02^{a*}	2.37 ± 0.02^{b*}	1.58 ± 0.02^{c*}
		Non lactating	1.47 ± 0.02^{a}	1.17 ± 0.01^{b}	0.71 ± 0.01^{c}
16.	Width of left supra-mammary lymph node (cm)	Lactating	3.25 ± 0.04^{a*}	3.05 ± 0.03^{b*}	2.75 ± 0.03^{c*}
		Non lactating	1.68 ± 0.02^{a}	1.38 ± 0.02^{b}	0.92 ± 0.01^{c}
17.	Length of right front quarter teat (cm)	Lactating	4.29 ± 0.08^{a*}	3.90 ± 0.07^{b*}	3.33 ± 0.05^{c*}
		Non lactating	2.15 ± 0.04^{a}	1.91 ± 0.03^{b}	1.55 ± 0.02^{c}
18.	Length of left front quarter teat (cm)	Lactating	4.49 ± 0.08^{a*}	4.10 ± 0.06^{b*}	3.52 ± 0.05^{c*}
		Non lactating	2.34 ± 0.04^{a}	2.10 ± 0.03^{b}	1.75 ± 0.02^{c}
19.	Length of right rear quarter teat (cm)	Lactating	3.73 ± 0.07^{a*}	3.40 ± 0.05^{b*}	2.91 ± 0.04^{c*}
		Non lactating	1.68 ± 0.03^{a}	1.42 ± 0.02^{b}	1.03 ± 0.01^{c}
20.	Length of left rear quarter teat (cm)	Lactating	3.98 ± 0.04^{a*}	3.63 ± 0.03^{b*}	3.10 ± 0.02^{c*}
		Non lactating	1.88 ± 0.01^{a}	1.63 ± 0.01^{b}	1.25 ± 0.01^{c}
21.	Diameter of right front quarter teat at base (cm)	Lactating	2.27 ± 0.04^{a*}	2.03 ± 0.03^{b*}	1.68 ± 0.02^{c*}
		Non lactating	1.59 ± 0.01^{a}	1.47 ± 0.01^{b}	1.29 ± 0.01^{c}
22.	Diameter of right front quarter teat at middle (cm)	Lactating	1.57 ± 0.02^{a*}	1.45 ± 0.01^{b*}	1.27 ± 0.01^{c*}
		Non lactating	1.22 ± 0.01^{a}	1.08 ± 0.01^{b}	0.87 ± 0.01^{c}
23.	Diameter of right front quarter teat near the tip (cm)	Lactating	1.05 ± 0.02^{a*}	0.97 ± 0.02^{b*}	0.85 ± 0.02^{c*}
		Non lactating	0.78 ± 0.01^{a}	0.74 ± 0.01^{b}	0.68 ± 0.01^{c}
24.	Diameter of left front quarter teat at base (cm)	Lactating	2.32 ± 0.04^{a*}	2.08 ± 0.03^{b*}	1.73 ± 0.02^{c*}
		Non lactating	1.63 ± 0.02^{a}	1.51 ± 0.01^{b}	1.33 ± 0.01^{c}
25.	Diameter of left front quarter teat at middle (cm)	Lactating	1.61 ± 0.02^{a*}	1.49 ± 0.02^{b*}	1.31 ± 0.02^{c*}
		Non lactating	1.24 ± 0.01^{a}	1.10 ± 0.01^{b}	0.89 ± 0.01^{c}
26.	Diameter of left front quarter teat near the tip (cm)	Lactating	1.09 ± 0.02^{a*}	1.00 ± 0.02^{b*}	0.87 ± 0.01^{c*}
		Non lactating	0.82 ± 0.01^{a}	0.78 ± 0.01^{b}	0.72 ± 0.01^{c}
27.	Diameter of right rear quarter teat at base (cm)	Lactating	2.51 ± 0.02^{a*}	2.27 ± 0.02^{b*}	1.91 ± 0.01^{c*}
		Non lactating	1.83 ± 0.02^{a}	1.70 ± 0.02^{b}	1.51 ± 0.01^{c}
28.	Diameter of right rear quarter teat at middle (cm)	Lactating	1.80 ± 0.04^{a*}	1.67 ± 0.03^{b*}	1.47 ± 0.02^{c*}
		Non lactating	1.42 ± 0.02^{a}	1.33 ± 0.01^{b}	1.20 ± 0.01^{c}
29.	Diameter of right rear quarter teat near the tip (cm)	Lactating	1.28 ± 0.01^{a*}	1.24 ± 0.01^{b*}	1.18 ± 0.01^{c*}
		Non lactating	0.90 ± 0.01^{a}	0.86 ± 0.01^{b}	0.80 ± 0.01^{c}
30.	Diameter of left rear quarter teat at base (cm)	Lactating	2.56 ± 0.04^{a*}	2.32 ± 0.03^{b*}	1.96 ± 0.03^{c*}
		Non lactating	1.87 ± 0.02^{a}	1.76 ± 0.02^{b}	1.59 ± 0.02^{c}
31.	Diameter of left rear quarter teat at middle (cm)	Lactating	1.85 ± 0.04^{a*}	1.72 ± 0.03^{b*}	1.53 ± 0.03^{c*}
		Non lactating	1.44 ± 0.03^{a}	1.35 ± 0.02^{b}	1.21 ± 0.01^{c}
32.	Diameter of left rear quarter teat near the tip (cm)	Lactating	1.33 ± 0.02^{a*}	1.29 ± 0.01^{b*}	1.23 ± 0.01^{c*}
		Non lactating	0.91 ± 0.01^{a}	0.87 ± 0.01^{b}	0.81 ± 0.01^{c}
33.	Distance between front quarter teats at base (cm)	Lactating	6.52 ± 0.08^{a*}	5.91 ± 0.06^{b*}	4.98 ± 0.05^{c*}
		Non lactating	4.56 ± 0.04^{a}	4.23 ± 0.03^{b}	3.75 ± 0.02^{c}
34.	Distance between rear quarter teats at base (cm)	Lactating	3.30 ± 0.04^{a*}	3.03 ± 0.03^{b*}	2.62 ± 0.03^{c*}
		Non lactating	2.57 ± 0.03^{a}	2.49 ± 0.02^{b}	2.37 ± 0.02^{c}
35.	Distance between right front and rear quarter teats at base (cm)	Lactating	5.62 ± 0.05^{a*}	5.45 ± 0.04^{b*}	5.20 ± 0.03^{c*}
		Non lactating	3.18 ± 0.02^{a}	3.12 ± 0.02^{b}	3.03 ± 0.02^{c}
36.	Distance between left front and rear quarter teats at base (cm)	Lactating	5.77 ± 0.06^{a*}	5.62 ± 0.05^{b*}	5.40 ± 0.04^{c*}
		Non lactating	3.36 ± 0.03^{a}	3.28 ± 0.02^{b}	3.16 ± 0.02^{c}
37.	Maximum length of teat cistern of front quarter teat (cm)	Lactating	2.80 ± 0.06^{a*}	2.53 ± 0.05^{b*}	2.12 ± 0.03^{c*}
		Non lactating	1.40 ± 0.03^{a}	1.04 ± 0.02^{b}	0.50 ± 0.01^{c}
38.	Maximum length of teat cistern of rear quarter teat (cm)	Lactating	2.30 ± 0.05^{a*}	2.05 ± 0.04^{b*}	1.68 ± 0.03^{c*}
		Non lactating	0.91 ± 0.02^{a}	0.71 ± 0.01^{b}	0.42 ± 0.01^{c}
39.	Maximum length of teat canal of front quarter teat (cm)	Lactating	1.22 ± 0.02^{a*}	1.04 ± 0.02^{b*}	0.78 ± 0.01^{c*}
		Non lactating	0.64 ± 0.01^{a}	0.47 ± 0.01^{b}	0.22 ± 0.01^{c}
40.	Maximum length of teat canal of rear quarter teat (cm)	Lactating	1.18 ± 0.02^{a*}	1.00 ± 0.01^{b*}	0.74 ± 0.01^{c*}
		Non lactating	0.59 ± 0.01^{a}	0.43 ± 0.01^{b}	0.19 ± 0.01^{c}

a, b, c in each row, means with different superscripts are significantly different (p<0.05)
* in each column, means with different superscripts are significantly different (p<0.05)

Table 2: Percentage decrease in different parameters between different stages of lactating and non-lactating Kosali cows

S. No.	Parameters	Groups	Percentage decrease between early and mid-stages	Percentage decrease between mid and late stages
1.	Weight of the udder (%)	Lactating	40.18	59.82
		Non lactating	39.53	60.47
2.	Circumference of udder at the base (%)	Lactating	40.38	59.62
		Non lactating	40.49	59.51
3.	Length of udder at the midline of base (%)	Lactating	40.28	59.72
		Non lactating	39.75	60.25
4.	Width of udder at the base (%)	Lactating	39.69	60.31
		Non lactating	40.19	59.81
5.	Maximum depth of the udder (%)	Lactating	40.00	60.00
		Non lactating	39.70	60.30
6.	Maximum length of right quarters at the base (%)	Lactating	39.57	60.43
		Non lactating	39.69	60.31
7.	Maximum length of left quarters at the base (%)	Lactating	39.56	60.44
		Non lactating	39.94	60.06
8.	Maximum width of right quarters at the base (%)	Lactating	40.39	59.61
		Non lactating	39.56	60.44
9.	Maximum width of left quarters at the base (%)	Lactating	39.09	60.91
		Non lactating	40.25	59.75
10.	Thickness of skin at the base of udder (%)	Lactating	40.00	60.00
		Non lactating	40.00	60.00
11.	Length of median suspensory ligament (%)	Lactating	40.35	59.65
		Non lactating	39.57	60.43
12.	Maximum diameter of gland cistern (%)	Lactating	39.52	60.48
		Non lactating	40.23	59.77
13.	Length of right supra-mammary lymph node (%)	Lactating	39.74	60.26
		Non lactating	39.51	60.49
14.	Length of left supra-mammary lymph node (%)	Lactating	39.74	60.26
		Non lactating	40.00	60.00
15.	Width of right supra-mammary lymph node (%)	Lactating	40.15	59.85
		Non lactating	39.47	60.53
16.	Width of left supra-mammary lymph node (%)	Lactating	40.00	60.00
		Non lactating	39.47	60.53
17.	Length of right front teat (%)	Lactating	40.63	59.38
		Non lactating	40.00	60.00
18.	Length of left front teat (%)	Lactating	40.21	59.79
		Non lactating	40.68	59.32
19.	Length of right rear teat (%)	Lactating	40.24	59.76
		Non lactating	40.00	60.00
20.	Length of left rear teat (%)	Lactating	39.77	60.23
		Non lactating	39.68	60.32
21.	Diameter of right front teat at base (%)	Lactating	40.68	59.32
		Non lactating	40.00	60.00
22.	Diameter of right front teat at middle (%)	Lactating	40.00	60.00
		Non lactating	40.00	60.00
23.	Diameter of right front teat near the tip (%)	Lactating	40.00	60.00
		Non lactating	40.00	60.00
24.	Diameter of left front teat at base (%)	Lactating	40.68	59.32
		Non lactating	40.00	60.00
25.	Diameter of left front teat at middle (%)	Lactating	40.00	60.00
		Non lactating	40.00	60.00
26.	Diameter of left front teat near the tip (%)	Lactating	40.91	59.09
		Non lactating	40.00	60.00
27.	Diameter of right rear teat at base (%)	Lactating	40.00	60.00
		Non lactating	40.63	59.38
28.	Diameter of right rear teat at middle (%)	Lactating	39.39	60.61
		Non lactating	40.91	59.09
29.	Diameter of right rear teat near the tip (%)	Lactating	40.00	60.00
		Non lactating	40.00	60.00
30.	Diameter of left rear teat at base (%)	Lactating	40.00	60.00
		Non lactating	39.29	60.71
31.	Diameter of left rear teat at middle (%)	Lactating	40.63	59.38
		Non lactating	39.13	60.87
32.	Diameter of left rear teat near the tip (%)	Lactating	40.00	60.00
		Non lactating	40.00	60.00
33.	Distance between front quarter teats at base (%)	Lactating	39.61	60.39
		Non lactating	40.74	59.26
34.	Distance between rear quarter teats at base (%)	Lactating	39.71	60.29
		Non lactating	40.00	60.00
35.	Distance between right front and rear quarter teats at base (%)	Lactating	40.48	59.52
		Non lactating	40.00	60.00
36.	Distance between left front and rear quarter teats at base (%)	Lactating	40.54	59.46
		Non lactating	40.00	60.00
37.	Maximum length of teat cistern of front quarter teat (%)	Lactating	39.71	60.29

		Non lactating	40.00	60.00
38.	Maximum length of teat cistern of rear quarter teat (%)	Lactating	40.32	59.68
		Non lactating	40.82	59.18
39.	Maximum length of teat canal of front quarter teat (%)	Lactating	40.91	59.09
		Non lactating	40.48	59.52
40.	Maximum length of teat canal of rear quarter teat (%)	Lactating	40.91	59.09
		Non lactating	40.00	60.00

Fig 1: Photograph of ventral view of mammary gland of early non-lactating stage of Kosali Cow showing, a. right fore quarter teat, b. left fore quarter teat, c. right hind quarter teat, d. left hind quarter teat, e. intermammary groove.

Fig 2: Photograph of dorsal view of mammary gland at mid lactating stage in Kosali cow showing, a. median suspensory ligament, b. lateral suspensory ligament, c. right supramammary lymph node, d. left supramammary lymph node.

Fig 3: Photograph of longitudinal section (sub-gross) of mammary gland of early lactating stage of Kosali Cow showing, a. streak canal, b. rosette of Furstenberg, c. teat cistern, d. annular fold, e. gland cistern, f. mammary parenchyma.

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