

HISTOMORPHOLOGICAL PECULIARITIES OF THE TONGUE OF INDIAN DROMEDARY CAMEL (*Camelus dromedarius*)

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ABSTRACT

The present study was conducted on 10 tongues of recently dead adult camels (*Camelus dromedarius*), irrespective to age and sex, who were free from any pathological condition of tongue. Histologically, the tongue of camel consisted of mucosa, muscle layers, glands, blood vessels and nerves. The mucosa consisted of keratinised stratified squamous epithelium and lamina propria. Each papilla consisted of a central connective tissue core of lamina propria covered by keratinised stratified squamous epithelium. The keratinisation was more on the mechanical papillae as compared to gustatory papillae. The taste buds were present in the epithelium of the gustatory papillae. The filiform papillae were slender, elongated and sharp pointed structures. The lenticular papillae were round in shape and surrounded by a prominent papillary groove. The conical papillae were of 2 types. The small conical papilla was curved and blunt with a flat or rounded tip and large papilla was conical with a pointed tip. The fungiform papillae were small rounded button shaped and were of 2 types *viz.* dome shape and bud shape. Circumvallate papillae were large, rounded elongated structures. Each papilla was completely separated from thick annular fold by a deep gustatory groove. The lamina propria was composed of loosely interwoven collagen, reticular and elastic fibres, separating the epithelium from muscles. The bulk of tongue consisted of longitudinally, transversely and obliquely arranged intrinsic muscles which were essentially of striated type. Gustatory glands were associated with circumvallate papillae and were serous in nature. The glands of the root region and lateral margins of the torus were of mucous variety. The *lyssa* was composed of adipose tissue and striated muscle fibres.

Key words: Dromedary camel, histomorphology, tongue

The tongue assists in prehension, handles the movement of food during mastication and swallowing, dilates the airway during inspiration and is an organ of vocalisation in humans as well as in animals. The tongue is also used for grooming by licking the body coat and suckling in young ones. The tongue is an important sense organ, richly supplied with nerve endings for touch as well as with special endings for taste and chemical senses (Nonidez and Windle, 1953). The lingual structure is modified to play different abilities, for example feeding input, control and ingestion of nutrition molecules. The morphological appearance, prevalence, orientation and structure of lingual papillae are modified in accordance with the nutritional requirements, the types of nutritional particles accessible and the various environmental conditions (Farrag *et al*, 2022). It is a musculo - hydrostatic organ due to typical arrangement of longitudinal and transverse or oblique muscle fibres (Gilbert *et al*, 2007). The detailed description on the histology of tongue is meager.

Scarce work on the microscopic anatomy of tongue of dromedary camel evoked interest to undertake the present study

Materials and Methods

The present study was conducted on 10 tongues of recently dead adult camels (*Camelus dromedarius*), irrespective to age and sex, who were free from any pathological condition of tongue. For the histological studies, small pieces (2-3 mm size) of tongue were taken from the representative areas and were preserved either in 10% formalin or Zenker's solution or Bouin's fluid for 48 hrs, 12hrs and 18 hrs, respectively. The tissues were washed overnight in running tap water, dehydrated in ascending order of alcohol (50%, 70%, 90% and then Absolute I, II and III), cleared in cedar wood oil and finally impregnated with paraffin. Paraffin blocks were prepared, numbered and stored at 4°C in refrigerator. Sections of 6-8-micron thickness were made by rotary microtome then taken on albuminised slides and

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kept overnight in hot air oven at 36°C and finally staining for the lining epithelium, connective tissue, musculature and various papillae of the tongue.

Results and Discussion

The tongue of the camel is a musculo-membranous organ consisted of mucosa, muscle layers, glands, blood vessels and nerves. Mucosa covered the entire tongue and consisted of epithelium and lamina propria. The epithelium covering the tongue was keratinised stratified squamous epithelium composed of basal, spinosum, granulosum, lucidum and corneum layers which was in accordance with the findings of Qayyum and Beg (1975) in goat, Stinson and Calhoun (1993) in domestic animals, El-Sharaby *et al* (2012) in camel, Choudhury *et al* (2013) in musk deer, El-Bakary and Abumandour (2017) in Egyptian water buffalo and Alhasson *et al* (2024) in buffalo. The cells in the deep layer of epithelium were elongated and the nucleus was situated at the base of cell whereas, cells towards the surface became flat. The loss of nuclei with weakly stained by eosin, in the most superficial layer of the epithelium was also observed (Fig 1). The epithelium and stratum corneum layers were thicker on dorsal surface of tongue than the ventral surface. The findings were also supported by Dhingra and Barnwal (1980) in buffalo, Stinson and Calhoun (1993) in domestic animals and partially supported by El-Bakary and Abumandour (2017) in Egyptian water buffalo. The stratum corneum was thickest on all type of papilla.

The mean thickness of the tongue epithelium at the dorsal surface of the tip was $617.177 \pm 28.64 \mu\text{m}$, at the ventral surface of the tip was $462.622 \pm 17.801 \mu\text{m}$, at the torus $647.311 \pm 21.832 \mu\text{m}$ and at the root $356.332 \pm 28.259 \mu\text{m}$. The mean keratin thickness at the dorsal surface was $106.011 \pm 9.006 \mu\text{m}$, at the ventral surface of the tip was $43.235 \pm 1.850 \mu\text{m}$, at the torus was 188.373 ± 9.304 and at root was $116.825 \pm 6.998 \mu\text{m}$.

Papilla

The mucosa of dorsal surface and ventral margins of the tip was modified to form lingual papillae which were named according to their characteristic morphology *viz.* filiform, lenticular, conical, fungiform and circumvallate papillae. These papillae were classified into 2 groups according to their function *viz.* mechanical papillae and gustatory papillae which were also suggested by Eerdunchaolu *et al* (2001) in Bactrian camel, Farrag *et al* (2022) in water buffalo and Alhasson *et al* (2024) in buffalo.

Mechanical Papilla

Mechanical papillae were covered with a much thicker layer of keratin. The filiform, lenticular and conical papillae were mechanical papillae. Similar findings were noticed by Eerdunchaolu *et al* (2001) in Bactrian camel.

Filiform papillae

Filiform papillae were the dominant type of papillae on the tongue (Fig 2). These were slender, elongated, sharp pointed structures consisting of a central connective tissue core covered by keratinised stratified squamous epithelium, which was in conformity with the findings of Dellmann (2006) in domestic animals and contrary with the findings of Dhingra and Barnwal (1980) in buffalo according to which it did not possess any connective tissue core. The primary connective tissue core gave rise to several small secondary papillae but these did not extend up to the tip of the papillae, which was also reported by Labh and Mitra (1975) in goat, Lahkar *et al* (1992) in giraffe and Trautmann and Fiebiger (2002) in domestic animals. The epithelial coat was raised into a single keratinised apex. The filiform papillae were taller and thicker towards the *fossa linguae* and their height and thickness decreased towards the lingual apex. The lamina propria was also present in these small secondary papillae but did not extend up to the tip of the papillae. The epithelial coat was raised into a single large keratinised cone and covered by a highly keratinised epithelium as also mentioned by Qayyum *et al* (1988) in camel, Lahkar *et al* (1992) in giraffe and Dellmann (2006) in domestic animals.

The mean length of filiform papillae was $904.473 \pm 63.162 \mu\text{m}$, mean breadth was $351.375 \pm 29.064 \mu\text{m}$ and mean keratin thickness was $84.111 \pm 7.444 \mu\text{m}$.

Lenticular papillae

The lenticular papillae were round in shape and were covered by stratified squamous epithelium with a thick layer of *stratum corneum* (Fig 3) which was in agreement with the observation of Lahkar *et al* (1992) for the tongue of a giraffe. The papillae were surrounded by a prominent papillary groove. The connective tissue core was dense with secondary projections and consisted of collagen fibres, reticular fibres, blood vessels and nerves which was in congruence with the findings of Dhingra and Barnwal (1980) in buffalo.

The mean length of the lenticular papillae was 4196.857 ± 249.291 , breadth was 1797.847 ± 199.622 and keratin thickness was $84.111 \pm 7.444 \mu\text{m}$.

Table 1. Thickness of epithelium of different regions of tongue (in micron).

S. No.	At root		At <i>Torus linguae</i>		At Ventral of Tip		At Dorsal of Tip	
	Epithelium	Keratin	Epithelium	Keratin	Epithelium	Keratin	Epithelium	Keratin
1.	391.920	132.445	616.267	195.606	542.909	49.653	683.694	120.537
2.	404.442	114.647	610.901	198.121	544.896	40.083	605.063	116.564
3.	524.748	171.235	651.66	199.324	471.941	34.312	697.785	154.391
4.	294.749	101.273	574.336	147.58	432.044	51.836	720.596	137.7
5.	410.661	121.310	708.325	211.484	446.043	40.853	613.164	96.511
6.	258.820	104.802	744.904	226.485	433.221	36.654	697.383	110.652
7.	266.882	102.192	711.7	213.604	397.377	41.609	546.362	76.723
8.	275.802	106.863	707.322	204.131	521.83	47.441	460.819	67.658
9.	391.257	125.021	548.506	140.291	413.694	41.609	527.997	86.041
10.	344.043	88.462	599.192	147.11	422.268	48.309	618.908	93.338
Mean	356.332	116.825	647.311	188.373	462.622	43.235	617.177	106.011
SD	89.363	22.098	69.040	29.422	56.293	5.8505	90.573	28.479
SE	28.259	6.988	21.832	9.304	17.801	1.850	28.641	9.006

Table 2. Length, width and thickness of keratin of filiform, lenticular and conical papillae (mechanical papillae) of tongue (in micron).

S. No.	Filliform papillae			Lenticular papillae			Conical papillae		
	Length	Width	Thickness of keratine	Length	Width	Thickness of keratine	Length	Width	Thickness of keratine
1.	805.078	253.029	54.251	4684.293	852.177	122.757	3220.193	1217.827	352.906
2.	1218.197	493.756	99.2	3179.056	1381.516	308.018	3150.465	1451.601	296.424
3.	955.51	217.213	93.338	3440.371	2077.514	146.236	4081.198	2320.307	240.037
4.	815.042	352.219	122.106	5138.751	2189.499	409.445	7228.575	4936.584	364.946
5.	650.346	224.071	72.261	3699.068	2312.078	186.23	4580.254	3816.802	179.257
6.	774.708	346.19	54.949	4735.745	942.231	131.875	3084.049	2014.903	213.142
7.	594.743	356.829	76.633	3585.616	1742.425	624.278	2864.551	2297.15	108.375
8.	825.263	265.385	65.367	4072.754	2456.013	179.265	4112.544	1915.732	183.834
9.	1092.185	404.827	104.371	5342.635	2478.236	456.156	5269.733	2966.423	274.493
10.	1313.661	600.237	98.64	4090.285	1546.783	257.254	4185.875	2657.493	231.818
Mean	904.473	351.375	84.111	4196.857	1797.847	282.151	4177.744	2559.482	244.523
SD	199.738	91.908	23.540	788.329	631.260	176.911	1395.011	1186.404	84.636
SE	63.162	29.064	7.444	249.291	199.622	55.944	441.141	375.174	26.764

Conical Papillae

The surface of conical papillae was covered by stratified squamous epithelium with a coat of keratin (Fig 4), which was in uniformity with the findings of Labh and Mitra (1975) in goat and Lahkar *et al* (1992) in giraffe. The connective tissue core was present below the epithelium. It consisted of collagen fibres and reticular fibres. The connective tissue core carried numerous low secondary papillae which was also reported by Labh and Mitra (1975) in goat. The conical papillae were of 2 types depending upon their shape and size i.e. small conical and large conical. In small

conical papillae, connective tissue core was short cylindrical, curved and blunt with a flat or rounded tip which was in close agreement with the observation of Dhingra and Barnwal (1980) in buffalo tongue. In large papilla, the connective tissue core was conical with a pointed keratinised process. The giant conical papillae in the goat were greatly enlarged (Labh and Mitra, 1975). Most of them had a blunt conical dermal core but in some it was short and cylindrical (Fig 4).

The mean length was $4177.744 \pm 441.141 \mu\text{m}$, breadth was $2559.482 \pm 375.174 \mu\text{m}$ and keratin thickness of the conical papillae was $244.523 \pm 26.764 \mu\text{m}$.

Table 3. Length, width and thickness of keratin of fungiform and circumvallet papillae (gustatory papillae) of tongue (in micron).

S. No.	Fugiform papillae			Circumvalate papillae			
	Length	Width	Thickness of keratine	Median wall		Lateral wall	
				Thickness of Epithelium	Thickness of keratine	Thickness of Epithelium	Thickness of keratine
1.	2247.763	1475.272	259.981	142.324	28.465	349.049	41.609
2.	1853.536	1188.88	209.735	163.92	22.33	357.585	24.262
3.	2831.975	1751.359	497.862	164.131	22.33	264.261	22.33
4.	2201.819	1475.272	593.431	153.717	24.826	285.79	22.638
5.	1429.798	964.322	370.146	194.986	28.465	292.473	20.553
6.	2096.786	1195.467	416.422	165.873	44.737	286.177	29.422
7.	2021.251	1233.377	33.701	208.045	34.211	344.375	30.689
8.	2367.801	2414.987	51.836	155.864	32.015	282.169	19.158
9.	3248.545	3397.71	93.708	159.053	35.793	243.943	22.484
10.	1578.114	1841.301	94.883	102.395	23.538	173.165	29.773
Mean	904.473	351.375	84.111	161.030	29.671	287.898	26.291
SD	199.738	91.908	23.540	20.786	7.250	40.116	7.016
SE	63.162	29.064	7.444	6.5733	2.292	12.685	2.218

Table 4. Length and width of taste buds (In Micron).

S. No.	Length	Width
1.	158.311	101.239
2.	153.311	75.906
3.	153.107	93.338
4.	154.189	81.621
5.	150.023	80.726
6.	175.292	85.678
7.	143.173	83.633
8.	136.766	81.749
9.	149.792	75.906
10.	119.15	90.627
Mean	149.311	85.042
SD	10.635	8.202
SE	3.3632	2.593
Correlation	0.013	

Gustatory Papilla

In gustatory papillae, keratin layer was comparatively thin and taste buds were present. The fungiform and circumvallate papillae were gustatory papillae. Eerdunchaolu *et al* (2001) had similar finding in Bactrian camel.

Fungiform Papilla

The fungiform papillae were small rounded button-shaped structures with rounded free top which was supported by a short cylindrical neck. Similar findings were seen by Dhingra and Barnwal (1980) in buffalo but they also observed narrow and

shallow trench around the papilla which was not encountered in the dromedary tongue in present study. The fungiform papillae were of 2 types on the basis of morphological differences in shape, i.e. dome shaped and bud shaped. The epithelium covering the papilla on the top was very thin with a very thin keratin coat, which was in agreement with the report of Dhingra and Barnwal (1980) in buffalo and Dellmann (2006) in domestic animals but in disagreement with the findings of Labh and Mitra (1967) in goat. The taste buds were present in the epithelium of the upper surface of these papillae, which resembled with the finding of Eerdunchaolu *et al* (2001) in Bactrian camel and Dellmann (2006) in domestic animals but contradictory with the observations of Labh and Mitra (1967) in goat. The number of taste buds was very less, which was supported by Trautmann and Fiebiger (2002) and Dellmann (2006) in cattle and horses. The side walls of the papillae were devoid of taste buds. The connective tissue core was consisted of collagen fibres and reticular fibres which simulated the findings of Dellmann (2006) in domestic animals. The fungiform papillae present on the ventral surface of tip of tongue were comparatively small with thinner epithelium and keratin coat and devoid of taste buds which was not in harmony with the observations of Labh and Mitra (1967) in goat. No secondary papillae were present in the papillae of on the ventral surface (Fig 5).

The mean length of fungiform papilla was $2187.739 \pm 63.162 \mu\text{m}$, breadth was $1693.794 \pm 29.064 \mu\text{m}$ and keratin thickness was $262.170 \pm 7.444 \mu\text{m}$.

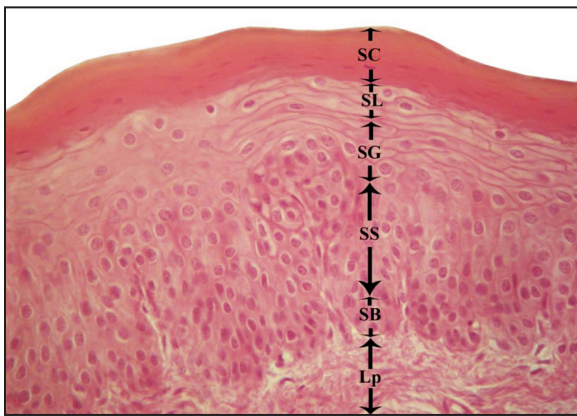


Fig 1. Photomicrograph of dorsal surface of tongue of camel showing different layers of epithelium. SC - Stratum corneum, SL - Stratum lucidum SG - Stratum granulosum, SS - Stratum spinosum, SB - Stratum basal, Lp - Lamina propria. (H & E stain, 400X).

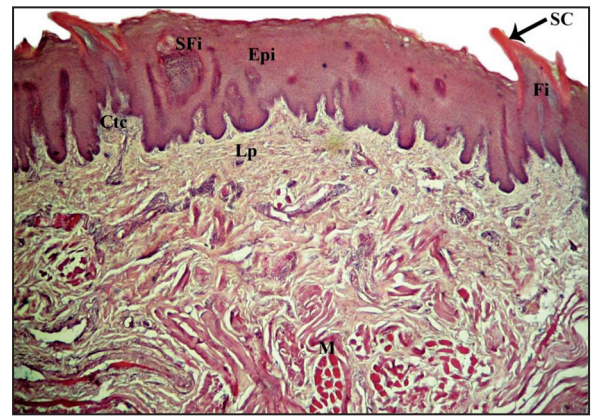


Fig 2. Photomicrograph of dorsal surface of tongue of camel showing filiform papillae. Fi - Filiform papilla, SFi - Secondary filiform papilla, Ctc - Connective tissue core, Epi - Epithelium, Lp - Lamina propria, M - Muscles, SC - Stratum corneum. (H & E stain, 40X).

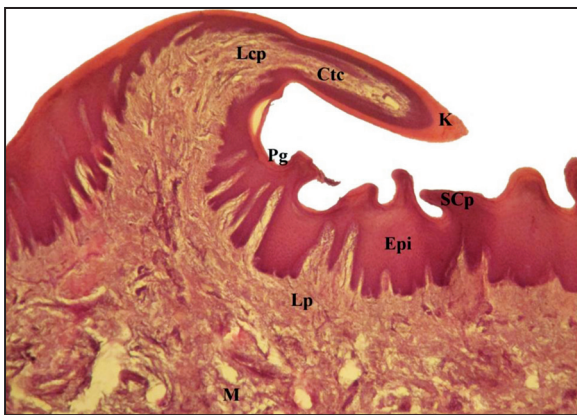


Fig 3. Photomicrograph of dorsal surface of tongue of camel showing lenticular papilla. Lcp - Lenticular papilla, Ctc - Connective tissue core, K - Keratin, Epi - Epithelium, Lp - Lamina propria, M - Muscles, Scp - Small conical papilla, Pg - Papillary groove. (H & E stain, 40X).

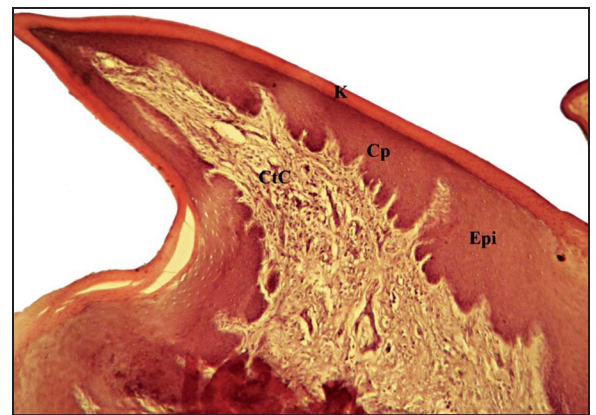


Fig 4. Photomicrograph of dorsal surface of tongue of camel showing large conical papilla. Cp - Conical papilla, Ctc - Connective tissue core, K - Keratin, Epi - Epithelium. (H & E stain, 100X).

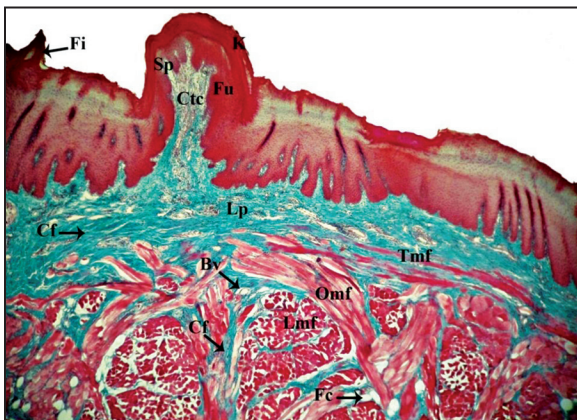


Fig 5. Photomicrograph of dorsal surface of tongue of camel showing bud shaped fungiform papilla. Fu - Fungiform papilla, Ctc - Connective tissue core, K - Keratin, Cf - Collagen fibres, Lp - Lamina propria, Lmf - Longitudinal muscle fibre, Tmf - Transverse muscle fibre, Omf - Oblique muscle fibre, Fc - Fat cell, Bv - Blood vessel. (Masson's Trichrome stain, 40X).

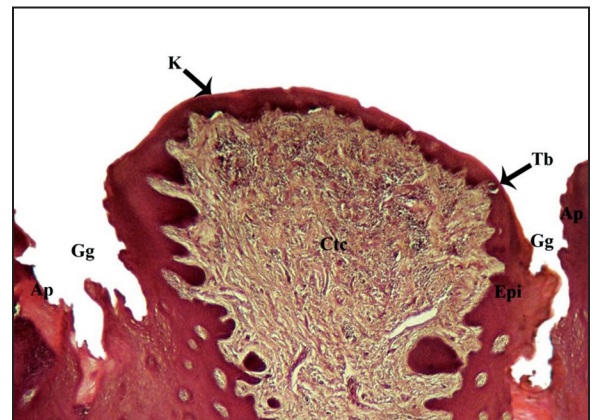


Fig 6. Photomicrograph of dorsal surface of tongue of camel showing a longitudinal section of circumvallate papilla. Ctc - Connective tissue core, K - Keratin, Tb - Taste bud, Epi - Epithelium, Ap - Annular pad, Gg - Gustatory groove. (H & E stain, 100X).

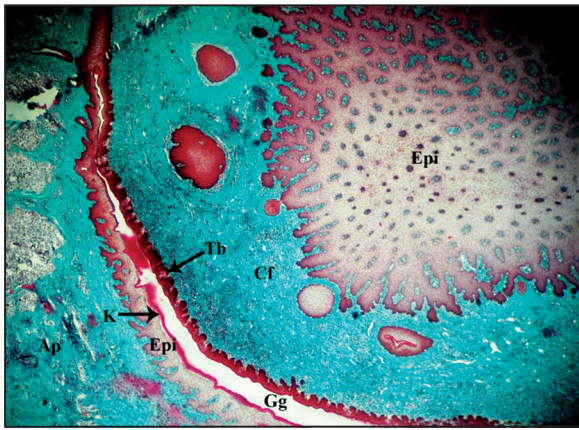


Fig 7. Photomicrograph of dorsal surface of tongue of camel showing transverse section of circumvallate papilla. Cf - Collagen fibre, K - Keratin, Tb - Taste bud, Epi - Epithelium, Ap - Annular pad, Gg - Gustatory groove. (Masson's Trichrom stain, 40X).



Fig 8. Photomicrograph of dorsal surface of tongue of camel showing transverse section of circumvallate papilla. Rf - Reticular fibres, K - Keratin, TB - Taste bud, Epi - Epithelium, Ap - Annular pad, Gg - Gustatory groove. (Gomori's stain for reticulum, 40X).

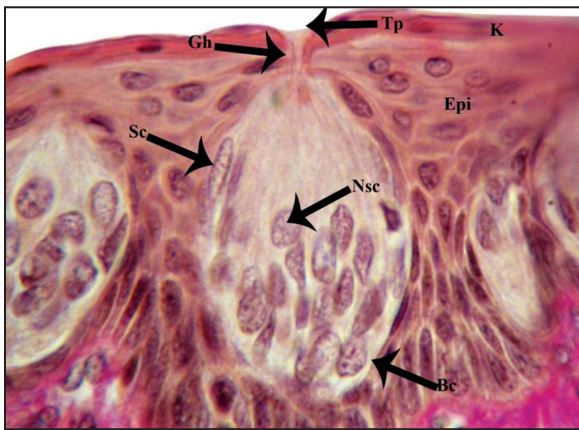


Fig 9. Photomicrograph of epithelium of circumvallate papilla of camel showing taste bud. Tp - Taste pore, Sc - Support cells, Bc - Basal cell, Nsc - Neuro-sensory cells, Gh - Gustatory hair, Epi - Epithelium, K - Keratin. (Van Geison's stain, 1000X).

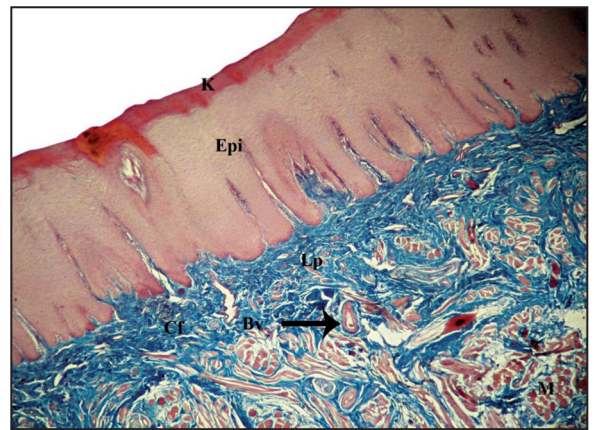


Fig 10. Photomicrograph of the tongue of camel showing different layers of the tongue. Epi - Epithelium, Lp - lamina propria, Cf - collagen fibres, M - Muscle layer, K - Keratin, BV - Blood vessel. (Selective demonstration of different connective tissue fibres stained by Silver & Orcin, 100X).

Circumvallate papillae

Circumvallate papillae were large, rounded elongated structures. Each papilla was completely separated from thick annular fold by a deep gustatory groove, an epithelial lined cleft or moat which was in consonance with the reports of Labh and Mitra (1967) in goat, Dhingra and Barnwal (1980) in buffalo, Trautmann and Fiebiger (2002) and Dellmann (2006) in domestic animals. The papillae were lined with moderately keratinised stratified squamous epithelium. The epithelium of papillary surface was less keratinised as compared to that of the surrounding annular pad which was in congruence with the observations of El-Sharaby *et al* (2012) in camel. Numerous small or large elongated taste buds were observed along the entire length of epithelium

of papillary surface of the gustatory groove; which was in accordance with the findings of Trautmann and Fiebiger (2002) in horse, ruminants and swine and El-Sharaby *et al* (2012) in camel. No taste buds were found on dorsal surface of papillae and in the lateral walls of the groove, which was in conformity with the findings of Trautmann and Fiebiger (2002) in domestic animals. However, according to El-Sharaby *et al* (2014) taste buds were located in the medial and lateral epithelium of both primary and secondary grooves as well as in the dome epithelium in dog. The connective tissue core consisted of collagen and reticular fibres present under the epithelium. The core of connective tissue extended into the epithelium at few places and forming the secondary papillae, which was also reported by Labh and Mitra (1967) in goat and

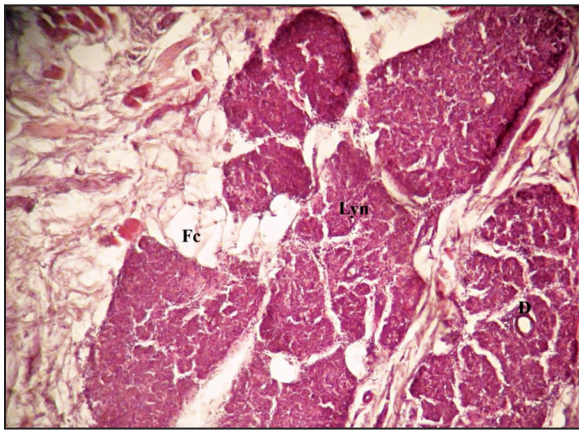


Fig 11. Photomicrograph of root of the tongue of camel showing lymph nodes. Lyn - Lymph node, D - Duct of lymph node, Fc- Fat cells. (H & E stain, 100X).

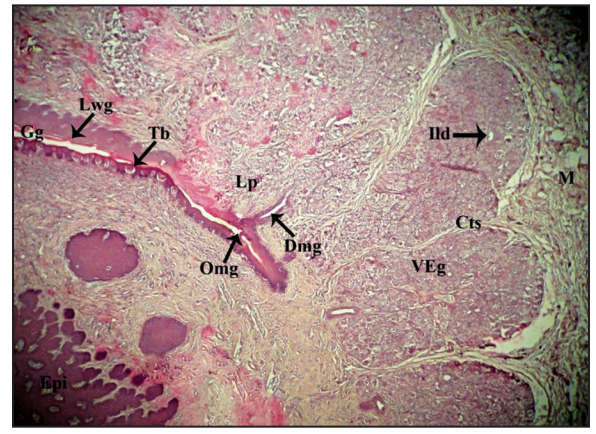


Fig 12. Photomicrograph of circumvallate papilla of the tongue of camel showing Von Ebner's glands. VEG - Von Ebner's gland, Cts - Connective tissue septum, Lp - Lamina propria, M - Muscle layer, Tb - Taste bud, Gg - Gustatory groove, Lwg - Lateral wall of gustatory groove, Epi - Epithelium, Ild - Intra lobular duct of the gland, Dmg - Duct of mucous gland, Omg - Opening of mucous gland in gustatory groove. (H & E stain, 40X).

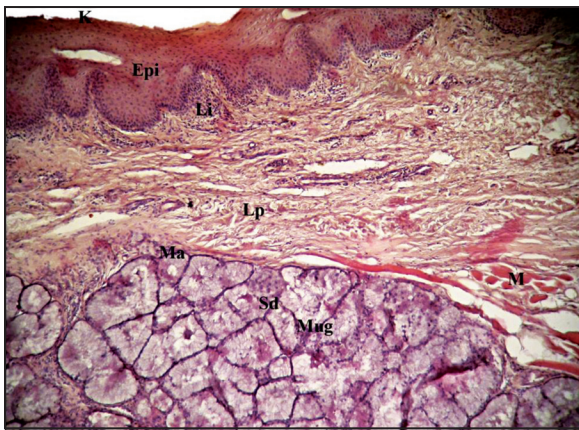


Fig 13. Photomicrograph of tongue of camel showing mucous glands. Mug - Mucous gland, Lp - Lamina propria, Epi - Epithelium, Li - Lymphatic infiltration, K - Keratin, M - Muscle fibres, Ma - Mucous acini, Sd - Serous demilune. (H & E stain, 40X).

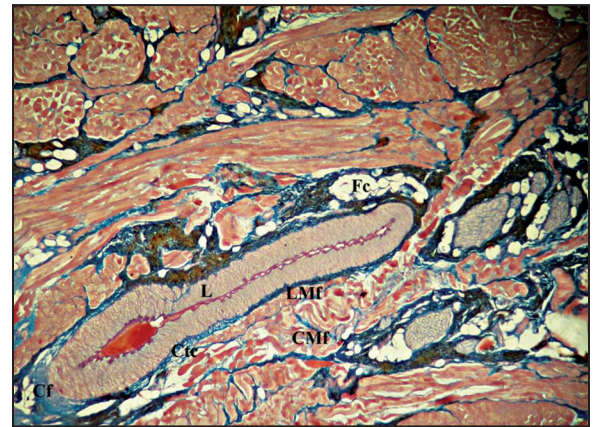


Fig 14. Photomicrograph of tongue of camel showing transverse section of lyssa. L - Lyssa, Ctc - Connective tissue capsule, LMF - Longitudinal muscle fibres, CMF - Circular muscle fibres, Fc - Fat cells, Cf - Collagen fibres. (Selective demonstration of different connective tissue fibres by Silver & Orcin, 40X).

Trautmann and Fiebiger (2002) in domestic animal. The openings of the lingual glands were also observed in the lateral wall of the gustatory groove, which was also favoured by Dellmann (2006) in domestic animals and El-Sharaby *et al* (2012) in camel (Figs 6, 7 and 8).

The mean keratin thickness of medial wall was $29.671 \pm 2.292 \mu\text{m}$, at lateral wall was $26.291 \pm 2.218 \mu\text{m}$, mean thickness of epithelium of medial wall was $161.030 \pm 6.573 \mu\text{m}$ and at lateral wall was $287.898 \pm 12.685 \mu\text{m}$.

Taste buds

The taste buds were ovoid or spindle shape structures present along the entire length of the epithelium of the medial wall of the circumvallate papillae gustatory groove and the epithelium of the upper surface of the fungiform papillae which was in congruence with the observations of Dhingra and

Barnwal (1980) in buffalo and El-Sharaby *et al* (2012) in camel. These were arranged in single layer and occupied the entire thickness of the epithelium. These were extended from the lamina propria to a little opening, the taste pore, on the free epithelial surface. The long axis of taste bud was vertical to the surface (Figs 6, 7 and 8).

Each taste bud consisted of 3 types of cells, *viz.* basal cells, supporting cells and neuro-epithelial sensory cells or gustatory cell. The basal cells were arranged at the base of taste buds. The supporting cells were arranged like the sticks of a barrel and formed an outer envelope for the bud. The gustatory

cells occupied the central portion of the bud; these were spindle-shaped and possessed a large spherical nucleus near the middle of the cell. The gustatory cells extended the microvilli or fine gustatory hair into the taste pore. These observations were in conformity with the findings of Trautmann and Fiebiger (2002) in domestic animals (Fig 9).

The mean height of taste buds was $149.311 \pm 3.3632 \mu\text{m}$ in and mean width was $85.042 \pm 2.593 \mu\text{m}$.

Lamina Propria

The lamina propria was a large layer of connective tissue which separated the innermost layer of epithelial cells from the muscle tissue. It was extended in the epithelium in a variable pattern to form connective tissue core of papillae and intermingled with the striated muscle fibres which was also confirmed by Deore *et al* (2002) in goat. It was composed of loosely interwoven collagen fibres, reticular fibres and elastic fibres along with the connective tissue cells (Fig 2, 5, 13). This observation was simulated with the findings of Dhingra and Barnwal (1980) and Alhasson *et al* (2024) in buffalo. The collagen and reticular fibres were abundant but elastic fibres were very few which was in agreement with Ramayya *et al* (2000) in goat. Lingual glands were present in the lamina propria which was also described by the Stinson and Calhoun (1993) in domestic animals, Lahkar *et al* (1992) in giraffe and El-Sharaby *et al* (2012) in camel. The lamina propria was highly vascular containing arteries, capillaries and veins which was in harmony with the observation of Jain (1975) in goat (Fig 5 and 10). Large lymph nodes were observed in lamina propria of the root of the tongue which was also investigated by Zidan and Pabst (2020) in camel (Fig 11). Small nodules were also seen in the lamina propria just below the epithelium and in some areas, it was in the form of diffused lymphatic tissue. Large numbers of fat cells were also observed in the lamina propria which was also reported by Trautmann and Fiebiger (2002) in domestic animals.

Muscles

The bulk of the tongue consisted of intrinsic muscles which were essentially of striated type found beneath the lamina propria, which was in conformity with the observations of Dhingra and Barnwal (1980) in buffalo, Stinson and Calhoun (1993) and Trautmann and Fiebiger (2002) in domestic animals, Choudhury *et al* (2013) in musk deer and El-Bakary and Abumandour (2017) in Egyptian water buffalo.

The muscular mass consisted of longitudinally, transversely and obliquely arranged bundles of striated muscles fibres which interlaced with each other which were in consonance with the reports of Jain (1975) in goat, Dhingra and Barnwal (1980), Alhasson *et al* (2024) in buffalo and Stinson and Calhoun (1993) in domestic animals. Large amount of adipose tissue and numerous blood vessels were present between the muscle fibres, which simulated to the findings of Dhingra and Barnwal (1980) in buffalo and Trautmann and Fiebiger (2002) in domestic animals. In between the muscle fibres, collagen fibres were also present (Fig 2, 5, 10).

Lingual Glands

The lingual glands were of 2 types, *viz.* gustatory and mucous variety.

Gustatory Glands or Von Ebner's glands

Gustatory glands were associated with circumvallate papillae. These were serous in nature and arranged in lobes, which was also reported by Dhingra and Barnwal (1980) in buffalo, Lahkar *et al* (1992) in giraffe, Narasimhan *et al* (1999) in goat and Biradar and Ramkrishna (2000) in sheep. The glands were partially located in the lamina propria and the muscular layer, which was in consonance with the observation of Dhingra and Barnwal (1980) in buffalo. The latter extended between the lobes and partially covering the same. Each lobe consisted of several lobules. Thin connective tissue septa containing collagen and reticular fibres divided the lobes into lobules, this was in uniformity with the findings of Parida and Das (1991) in domestic ruminants. Each lobule consisted of several secretory units, the serous acini. Each acinus was spherical in shape and lined by tall columnar epithelium with basal nuclei which simulated the observations of Parida and Das (1991) in domestic ruminants but according to Narasimhan *et al* (1999) the acini were lined by pyramidal cells with indistinct cell boundaries in goat. The apical portion of each cell was filled with secretory granules. The cells rested on the basement membrane. The myo-epithelial cells with elongated nuclei were present in between the basement membranes of the acini partially in agreement with the findings of Stinson and Calhoun (1993) in domestic animals. The serous demilunes were also observed in between the serous acini (Fig 12).

Mucous Glands

The glands of the root region and lateral margins of the torus linguae were of mucous variety

with occasional serous demilunes which was in close agreement with the reports of Qayyum and Beg (1975) and Narasimhan *et al* (1999) in goat. The glands were of the acinar type and oval in shape and the acini showed large lumen lined by the pyramidal cells, which was not in agreement with the reports of Parida and Das (1991) in domestic ruminants according to which the mucous acini were more rectangular than spherical in shape and the acinar cells were cuboidal to columnar. The nucleus was rounded and situated at the base of the cell. The acini were densely packed. In between the acini myoepithelial cells with elongated nuclei were observed (Fig 13).

The intralobular and interlobular ducts were lined with simple cuboidal epithelium. The epithelium of the interlobular ducts was lined by two layered cuboidal epithelia. Terminal ducts of serous gland opened on the outer wall of the gustatory groove of the circumvallate papillae. The terminal ducts of the mucous glands opened directly on the dorsum of the tongue. The glands were absent in the tip region. These findings were in harmony with the findings of Narasimhan *et al* (1999) in goat.

Lyssa

The lyssa of the camel was highly vascular, resembled with the finding of Sultana *et al* (2017) in dog. Transverse section showed that the lyssa was composed of adipose tissue and striated muscle fibre which was also observed by Sultana *et al* (2017) in dog. It was enclosed by a dense connective tissue capsule formed mainly of collagen fibres which was also supported by Sultana *et al* (2017) in dog. The connective tissue capsule was surrounded by longitudinal and circular muscle fibres. The body of lyssa was elongated and consisted of adipose tissue and isolated striated muscle fibres and collagen fibres were found in between the adipose tissue. In the cranial third of the lyssa, a pyramidal rod formed by the adipose tissue and encircled by a fine capsule of connective tissue was observed. This rod was attached to the ventral edge of the lyssa, also favoured by Besoluk *et al* (2006) in dog and cat and Sultana *et al* (2017) in dog. In caudal part, body was divided in small - small parts and enclosed by the connective tissue separately (Fig 14).

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