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MORPHOLOGY OF THE LINGUAL PAPILLAE OF BACTRIAN CAMEL (*Camelus bactrianus*)

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ABSTRACT

The lingual papillae of adult bactrian camel were studied using light and scanning electron microscopy (SEM). Five types of lingual papillae were found on the dorsal surface of the tongue. Two types of filiform papillae could be distinguished. The filiform papillae had a primary papilla and a few slender secondary papillae. Fungiform papillae were round in shape, and more densely distributed on the tip of the lingual apex. Only a few taste pores were recognisable on the free surface of the papillae. Conical papillae have a round base and a blunt tip without any projection. Lenticular papillae were positioned in a round or flat protrusion with the appearance of a papillae groove. Vallate papillae were encircled by a papillary groove and an annular pad of the surrounding lingual mucosa. Many taste buds were found in the papillary groove of the papillae. The taste buds, composed of several layers structure of appearing to be sponge shaped, looked like tree peony in shape. The irregular surface of all types of papillae revealed microplicae in the form of microridges and micropits.

Key words: Bactrian camel, lingual papillae, microridge, Scanning electron microscopy (SEM), tongue

The distribution of the different papillae on the surface of the tongue was characteristic of a genus and might even be distinctive for one species with regard to another. One of the elements that contributed most to the morphology, distribution and type of papillae is diet (Pastor *et al,* 2007). It was possible to speak of two types of papillae e.g., mechanical and gustatory. The former performed the functions of trapping and creating a frictional surface for food and were an important element for grooming functions. The latter were those which contained the taste pores connected to the sensory organs of taste, the taste buds (Pastor *et al,* 2007).

Much work had been published on the structures of the lingual surfaces in various animals. Scanning electron microscopic studies of the tongue papillae in domestic animals had been reported in cat (Boshell *et al,* 1982), dog (Holland *et al,* 1989; Ojima, 2001; Singh *et al,* 1980), pig (Chamorro *et al,* 1993, 1994; Kumar *et al,* 2004), goat (Kumar *et al,* 1998), lamb (Tadjalli and Pazhoomand, 2004), sheep (Emura *et al,* 2000), cow (Cabello *et al,* 1988; Scala *et al,* 1995; Steflik *et al,* 1983), buffalo (Scala *et al,* 1993), horse (Cabello *et al,* 1988; Pfeiffer *et al,* 2000), and camel (Eerdunchaolu *et al,* 2001; Qayyum *et al,* 1988). The present study had been envisaged to highlight the surface structure of the tongue papillae in bactrian camel and to describe the location of taste buds or pores on gustatory papillae.

Materials and Methods

The investigations were conducted on 5 tongues of adult bactrian camel (2 males and 3 female). The dissected tongues were fixed in 10% neutral formaldehyde. Tissues containing lingual papillae were dehydrated and embedded in paraffin. 5-μm-thick sections were stained with hematoxylin and eosin and prepared for observations under light microscope. Specimens bearing lingual papillae were cut with a razor blade and prefixed in 2.5% glutaraldehyde solution, rinsed with 0.1M phosphate buffer (pH 7.4), and posted-fixed with 1% osmium tetroxide at room temperature for 1 h. After rinsing in phosphate buffer, the specimens were dehydrated through a graded series of ethanol and soaked in the tertiary butyl alcohol for 2 hr. After critical-point drying and ion-sputter coating with gold, specimens were observed with a scanning electron microscope (JSM-680LA, Japan) at 20 Kv.

Results

In the present study on the lingual mucosa in bactrian camel 5 different types of papillae were found, viz., filiform, fungiform, conical, lenticular and vallate papillae.

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The apex and body of the tongue in bactrian camel were covered by 2 types of lingual papillae, i.e. filiform and fungiform papillae. No glands were seen in the apex and body of the tongue.

Filiform papillae

These papillae were densely distributed on the dorsal surface of the apex and body of tongue and the margins of the tongue except for the lingual radix zone. Two types could be clearly differentiated, long deplanate-shaped and conical-shaped filiform papillae (Figs 1, 2). Under light microscopy, the tips of two filiform papillae were covered with the thicker keratinised stratified squamous epithelium. There were no taste buds in endepidermis and no glandular organ in lamina propria (Figs 3, 4). The height of the papillae located on the apex of the tongue was 0.2 cm but increased to 0.5 cm in those that were on the body of the tongue. The long deplanate-shaped robust filiform papillae were distributed on the dorsum of the body of tongue, and their free ends were tilted towards back of the tongue. Two and three thin secondary papillae emerged at the base of papilla. The conical-shaped filiform were located on the dorsal surface of the apex and margins of the tongue. These filiform papillae were also inclined posteriorly. There was far distance between the papillae. A bulb-like structure was formed at the basal portion of the conical-shaped papilla. Sharp pointed tips emerged at the base of papilla between two and five secondary papillae and these tips appeared to be transformed into hard scales filiform keratinisation. Several layers of shingle-like flattened cells of a stratified squamous epithelium covered the surface (Fig 5). These cells provided a rough surface as dead cells from the superficial epithelial layer and were constantly shed. At higher magnification, a network pattern of microridges was seen, which was widely distributed on the interpapillar epithelial cell surfaces. The free surface of the filiform papillae, however, was devoid of distinct micropits but occupied by many microridges (Fig 6).

Fungiform papillae

These were distributed as small rounded bodies all over the anterior two thirds of the dorsum, especially the apex of the tongue and tip of the lingual apex. The surface of fungiform papillae was slightly projected or flat (Fig 2). Under light microscopy, the shape of fungiform papillae appeared to be nascent mushroom (Fig 7). Fungiform papillae were also sporadically observed on the root of the tongue. The papillae on the tip of the lingual apex were larger than those on the dorsal surface, ranging from 0.08 cm to 0.21 cm in diameter. These were attended by a crowd, but the others were scattered among the filiform papillae. Desquamation of the epithelial cells could be noted in most of the papillae. Fungiform papillae of the dorsum were heavily guarded by robust filiform papillae. Only a few taste buds or pores were recognisable on the free surface of the papillae. At higher magnification, a network pattern of microgroove was seen, which was widely distributed on the interpapillar epithelial cell surfaces. Cell boundaries were distinct on these surfaces. Generally, taste pores opened onto their surface and had no protective scales (Fig 8).

On the torus linguae of the tongue in bactrian camels 3 types of lingual papillae might be distinguished viz. vallate, conical and lenticular papillae.

Conical papillae

These papillae, found on the anterior part of the torus linguae, took the shape of a rostrally orientated cone with a blunt tip (Fig 9). A few of conical papillae were also found on the caudal area of the torus linguae. Under light microscopy, the conical papillae were covered with keratinised stratified squamous epithelium. No taste buds were recognisable on the free surface of the papillae. However, lingual glands were found in the muscle layers of these papillae (Fig 10). The superficial cells presented an irregular surface morphology, apparently due to cell sloughing and the presence of bacteria (Fig 11). Taste buds or pores could not be observed in any of these papillae, but lingual glands were located in the lamina propria of the papillae. Their surfaces were covered by microgrooves and pores could be observed.

Lenticular papillae

Lenticular papillae were located on the posterior part of the torus linguae. They differed from the conical papillae both in size and in shape. Thus, they emerged very little from the lingual surface, which appears more flattened. The papillae were positioned in a round or flat protrusion with the appearance of a papillae groove (Fig 12). The papillary groove was observed, which surrounded the papillary body and was deeper in the caudal than in the rostral part of the papilla. Under light microscopy, the lenticular papillae were covered with keratinised stratified squamous epithelium. No taste buds were recognisable on the free surface of the papillae. However, lingual glands were found in the muscle layers of these papillae (Fig 13). At increased

magnification the lenticular papillae revealed surfaces covered with microgrooves and pores (Fig 14).

Vallate papillae

These were arranged in a -pattern on the posterior part of the torus linguae with the apex of the pointed posteriorly. These round or oval shaped papillae present on either side towards the base of the torus linguae were encircled by a papillary groove and an annular pad of the surrounding lingual mucosa (Fig 15). In some cases, two and rarely three papillae were surrounded by a primary groove and an annular pad and were separated by a secondary groove. Under light microscopy, the top of mushroom-shaped vallate papillae were covered with thin cornified stratified squamous epithelium. Lateral walls were non-keratinising, and the taste buds in epithelium of lateral walls were relatively many in number (Fig 16). Light and dark cells were found in taste buds. In the torus linguae, serous gustatory glands associated with the vallate papillae were found in the lamina propria. The epithelial cells on the surface of the papilla were polygonal in shape. At higher magnification, the squamous cells displayed a complex pattern of microplicae, microridges and micropits (Fig 17). Microplicae of the adjacent squamous cells were separated by mucous membranes. Scanning electron microscopy revealed many taste buds in the papillary groove of the papillae. At higher magnification, taste buds were composed of several layers sponge shaped, structure looked like tree peony in shape (Fig 18).

Discussion

Observations of the dorsal surface of the tongue in bactrian camel under a scanning electron microscope made it possible to distinguish 2 types of gustatory papillae and 3 types of mechanical papillae. Mechanical papillae, e.g., filiform, conical and lenticular papillae, were the most numerous on the tongue of bactrian camels. Their function was transporting and swallowing of comminuted food to the pharynx. Gustatory papillae accommodated the sense of taste, as is the case of the fungiform and vallate papillae.

Filiform papillae

Two types of filiform papillae could be clearly differentiated e.g., long deplanate-shaped and conical-shaped filiform papillae. The length, fineness and density of filiform papillae at different location of the tongue, might function the stimulus of mechanical pressure, temperature and chemical substance. These filiform papillae in bactrian camel were directed caudally, which might play an important role in the prehension of food fragments, as reported in buffalo (Scala *et al,* 1993), goats (Kumar *et al,* 1998) and lambs (Tadjalli and Pazhoomand, 2004). The secondary papillae presented in bactrian camel had also been in goats (Qayyum *et al,* 1988), lambs (Tadjalli and Pazhoomand, 2004) and ox (Cabello *et al,* 1988). The papillary surface was rough in bactrian camel as reported in the goat (Qayyum *et al,* 1988) but smooth in the horse and ox (Cabello *et al,* 1988). The microplicae arranged in different patterns in bactrian camel had not been reported in other domestic animals except for the goat (Qayyum *et al,* 1988). The free surface of the filiform papillae, however, was devoid of distinct micropits but occupied by many microridges.

Conical and lenticular papillae

Conical and lenticular papillae of bactrian camel, from a morphological point of view, corresponded to their denomination. The location of the first, and their morphology and caudal inclination enabled us to attribute them a possible role in food prehension. Some conical papillae located on the anterior part of the torus linguae having tips inclined obliquely towards anterior aspect which might help stop quick swallowing of the food possily to allow rough food being chewed fully. Conical papillae with a basal groove reported in goat (Kumar *et al,* 1998) and cow (Cabello *et al,* 1988), were not observed in the present study on bactrian camel as reported in pig (Kumar *et al,* 2004). The conical papillae had a mechanical role in the transport of food mass and liquids towards the pharynx (Ojima *et al,* 1997). The lenticular papillae in bactrian camel, goat (Qayyum *et al,* 1988), ox (Cabello *et al,* 1988) and lamb (Tadjalli and Pazhoomand, 2004) were on the surface of torus linguae, which could serve as a complementary protection of the tongue surface. The papilla of bactrian camel was a circular and flat protuberance and different from the goat's phylliform lenticular papillae (Kumar *et al,* 1998). A papillary groove was observed in these papillae in bactrian camel similar to ox (Cabello *et al,* 1988) and lamb (Tadjalli and Pazhoomand, 2004). On the other hand, a scaly surface with channeled tracts in the conical and lenticular papillae which correspond to the surface of squamous cells is visible at high magnification.

Fungiform papillae

Dome-shaped fungiform papillae being separated from the filiform papillae by groove observed in bactrian camel was also reported in the

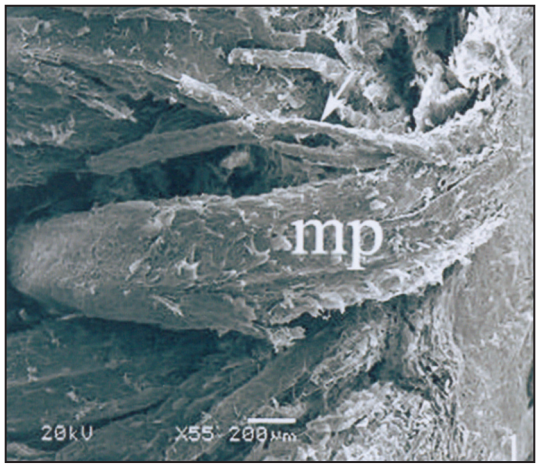

Fig 1. SEM micrograph of the long deplanate-shaped filiform papillae from the lingual body. The papillae consisted of a large main process (mp) and several slender accessory processes (arrow). Bar: 200 µm.

Fig 2. SEM showing the conical-shaped filiform papillae with distinct basal groove. Noted a fungiform papilla (Fu) surrounded by a shallow groove. Bar: 500 µm.

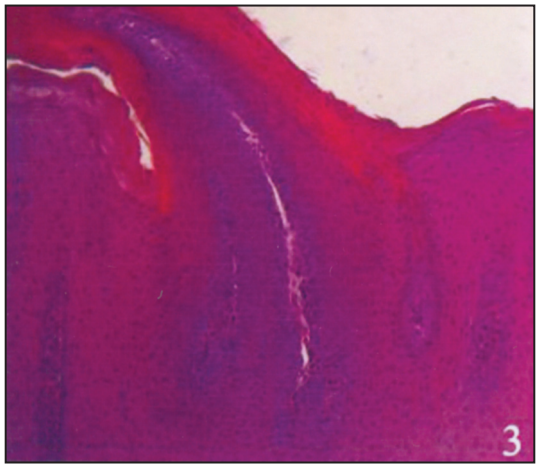

Fig 3. Light micrograph showing a leaf-shaped filiform papilla located the body of the tongue. The tip of the papilla was covered with thick keratinised stratified squamous epithelium. H&E staining. Bar: 100 µm.

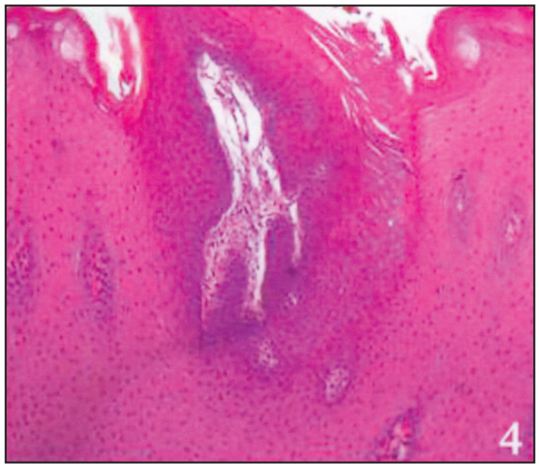

Fig 4. Light micrograph showing a conical-shaped filiform papilla located at the apex of the tongue. The tip of the papilla was covered with thick keratinised stratified squamous epithelium. H&E staining. Bar: 100 µm.

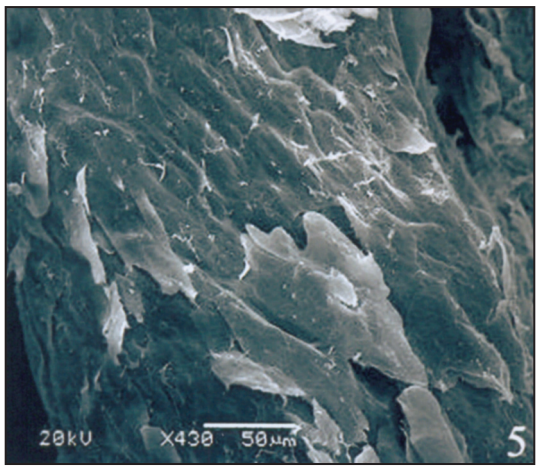

Fig 5. SEM micrograph of several layers of shingle-like flattened cells of a stratified squamous epithelium covered the surface of the conical-shaped filiform papillae. Bar: 50 µm.

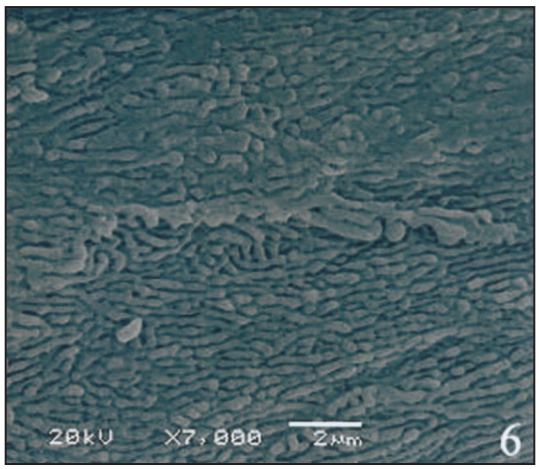

Fig 6. Higher magnification SEM micrograph of the upper surface of the long deplanate-shaped filiform papillae revealed microridges. Bar: 2 µm.

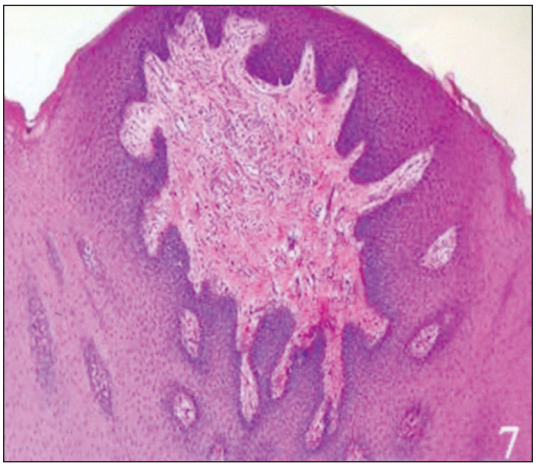

Fig 7. Light micrograph of a dome-shaped fungiform papilla. H&E staining. Bar: 100 µm

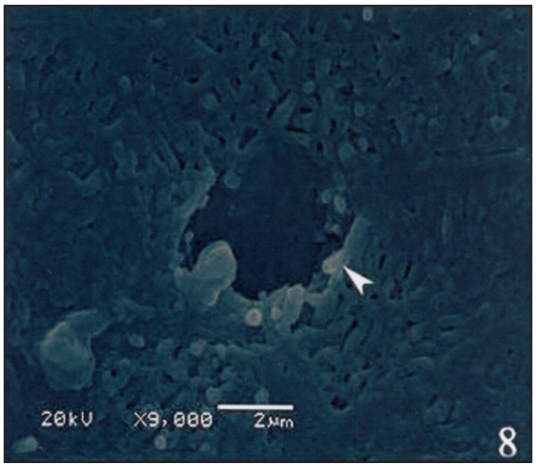

Fig 8. Higher magnification SEM micrograph of the upper surface of a rounded fungiform papilla revealed a pore (arrow heads) which act as taste buds. Bar: 2 µm.

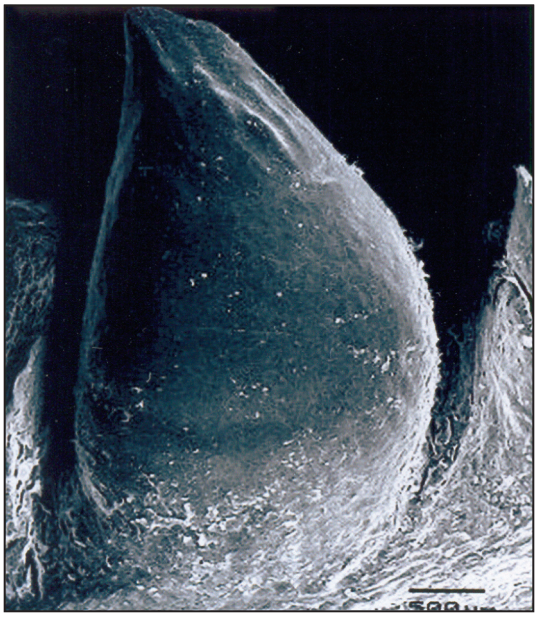

Fig 9. SEM micrograph of a conical papilla distributed on the lingual prominence. Bar: 500 µm.

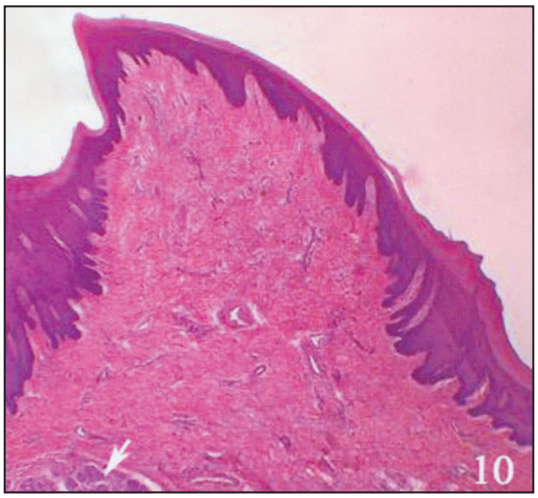

Fig 10. Light micrograph of a sagittal section of the conical papillae distributed on the torus linguae. Lingual glands (arrow) were distributed densely between the muscle layers. H&E staining. Bar: 100 µm.

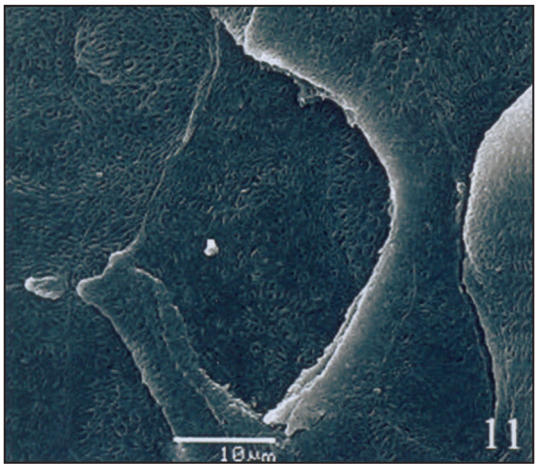

Fig11. Higher magnification SEM micrograph showing microplicae on the surface of conical papillae. Bar: 10 µm.

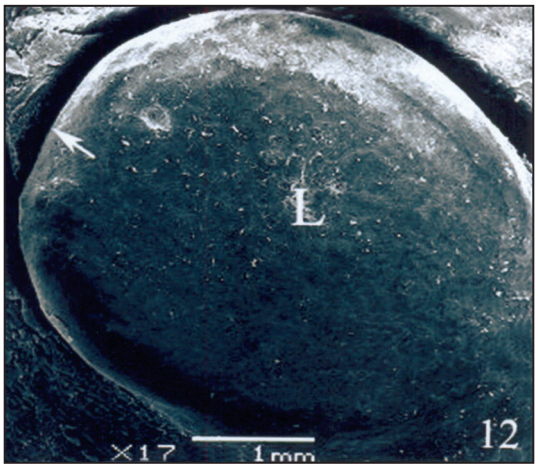

Fig 12. SEM showing lenticular papillae (L) with a papillary groove (arrow). Bar: 1000 µm

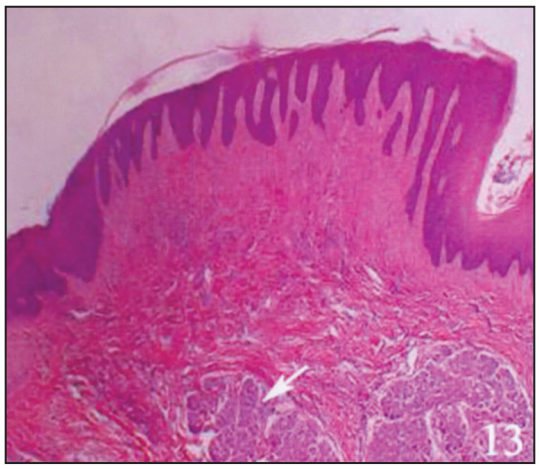

Fig 13. Light micrograph of a sagittal section of the lenticular papillae located on the torus linguae. Lingual glands (arrows) were distributed densely between the striated muscle layers. H&E staining. Bar: 100 µm.

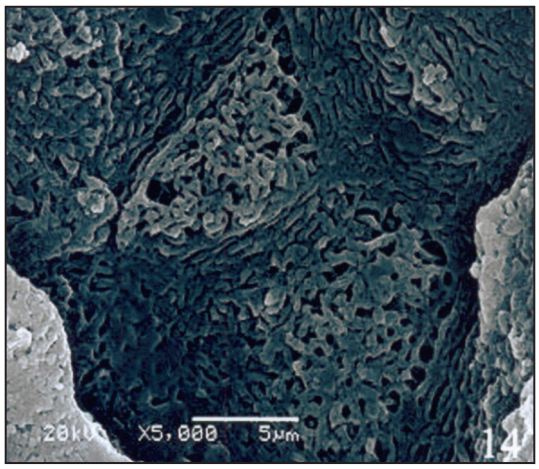

Fig 14. Higher magnification SEM micrograph revealed microplicae on the upper surface of lenticular papillae. Bar: 5 µm.

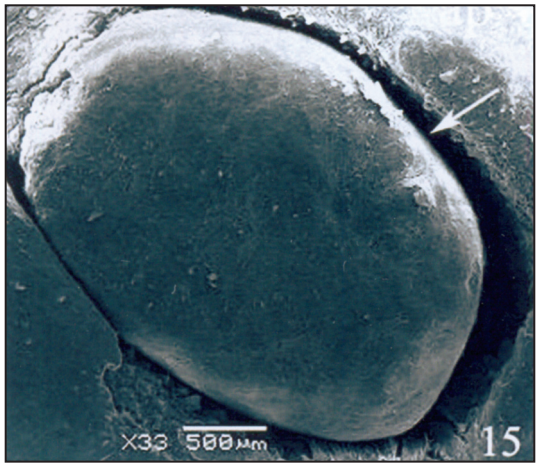

Fig 15. SEM micrograph of a vallate papilla. Noted the papillary groove (arrow) and the annular pad (ap) encircling the papillae. Bar: 500 µm.

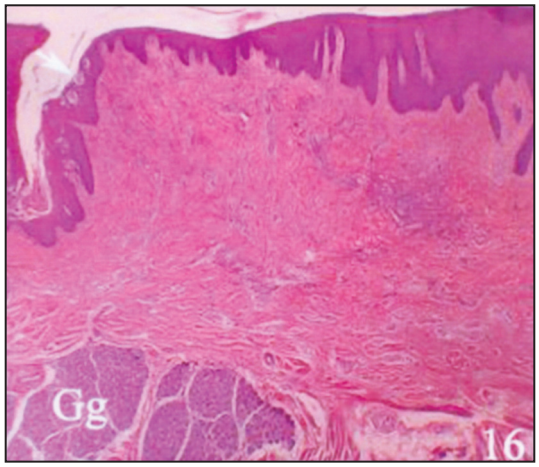

Fig 16. Light micrograph of a vallate papilla. Several taste buds were seen on the lateral wall of the papilla (arrow). Gustatory glands (Gg) were distributed densely between muscle layers. H&E staining. Bar: 400 µm.

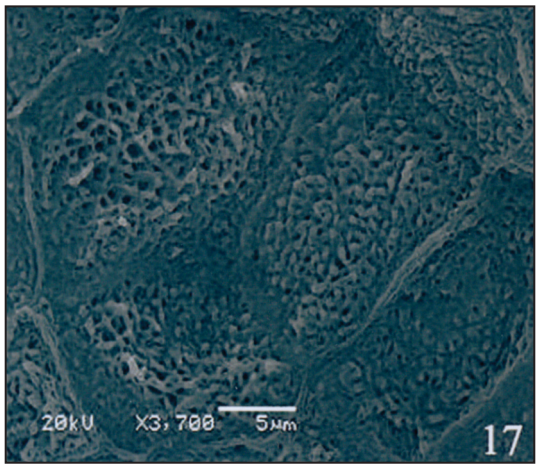

Fig 17. Higher magnification SEM micrograph showing microridges and micropits on the upper surface of vallate papillae. Bar: 5 µm.

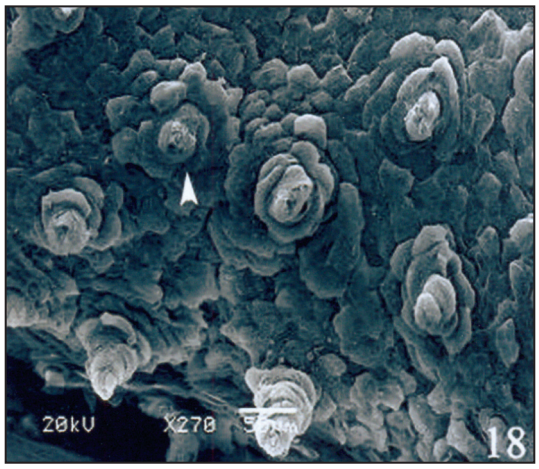

Fig 18. Higher magnification SEM micrograph of the papillary groove of a vallate papilla revealed numerous taste buds (arrow head). Bar: 5 µm

goat (Kumar *et al,* 1998), ox, horse (Chamorro *et al,* 1986) and one-humped camel (Qayyum *et al,* 1988). The taste bud of the bactrian camel was not very developed in the fungiform papillae (Yamamoto *et al,* 2001). The shortage of the taste buds perhaps had concerned a few kinds of food type and single flavour. The free surface of the papillae displayed only a few taste pores, which had also been reported in the ox and horse (Chamorro *et al,* 1986; Scala *et al,* 1995). However, no taste pores had been reported in the goat (Kumar *et al,* 1998). From these findings one might conclude that if taste pores were not present on the fungiform papillae, their mechanical function would be more important in bactrian camel than in the cow and horse. Fungiform papillae on the edge of the tongue tip were bigger than other spots. These characteristics might be helpful for the bactrian camel to distinguish edibility and taste of the food. When the food passed over it, the prominent fungiform papillae might distinguish the flavour of the food very quickly. Food enters the gutter of the vallate papillae and is detained there, perhaps enables to distinguish its flavour.

Vallate papillae

Vallate papillae in bactrian camel had a papillary groove and an annular pad as reported in the ox (Chamorro *et al,* 1986), one-humped camel (Qayyum *et al,* 1988), buffalo (Scala *et al,* 1993) and goat (Kumar *et al,* 1998). Occasionally a common vallium encircled the 2 or 3 vallate papillae as reported in the goat (Kumar *et al,* 1998). Some of vallate papillae of the asian black bear were composed by a primary papillae which was divided into several secondary papillae by intermediate grooves (Emura *et al,* 2001). The dorsal surfaces of the vallate papillae in the tiger were irregular (Emura *et al,* 2001). The surfaces of the vallate papillae in the silver fox were smooth (Jackowiak and Godynicki, 2004). In this study on bactrian camel, the surfaces of the vallate papillae were irregular. In this kind of papilla, the primary groove was prominent in bactrian camel, where the access and retention of saliva were easier. The groove was compressed by a thick annular pad. It is presumed that this pad regulated the access and retention of saliva in the groove by means of their smooth muscular fibres. Taste buds, being composed of several layers structure of appearing to be sponge shaped but looked like tree peony in shape had not been reported in other domestic animals. Taste pores opening onto that groove had a different morphology in each species. Equine taste pores were located in the primary, whereas in bactrian camel, the taste pores were closer to the papillary surface as reported in the cow (Chamorra *et al,* 1986). Considering the different localisation levels of the pores in the papillary grooves, the possible gustatory discrimination gradients still needed to be defined. The taste glands distributed in the lamina propria of the papillae and perhaps its continuing secretions were helpful to flush the circle ditch, eliminate the bacterium impurity and food debris, dissolve odorous material and benefitted for the taste bud to feel the stimulus of the different material (Cheng *et al,* 2003).

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