

Characteristics of Dorsal Lingual Papillae of Zavot Cattle

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Abstract: Reared for milk and meat production, the Zavot cattle breed, which is grazed on grassland in summer and fed on fodder in winter, is a cattle breed native to the East Anatolian region of Turkey. The objective of the study was to investigate the localization and histological features of the lingual papillae on the dorsal surface of the Zavot cattle tongue by light and scanning electron microscopy and to compare the findings with those of related ruminants. Tissue samples were harvested from the apex, body and root of the tongues and were examined by light and scanning electron microscopy. Histologically, there were five types of papillae on the dorsal surface of the tongue, namely filiform, fungiform, circumvallate, lenticular and conical papillae. Filiform papillae had different structure on the apex and body of the tongue. On the body of the tongue each main papilla was accompanied by 1-3 secondary papillae. However, there was not any secondary papilla on the main papilla at the apex of the tongue. The taste pores were seen at the free surface of the fungiform papillae. Round to oval in shape circumvallate papillae were arranged twine and irregularly in two lines at the caudo-lateral region of the torus linguae. Lenticular papillae which were round or conical-like shape limited on the torus linguae. Conical papillae were distributed mainly on the lingual root. Tips of the conical papillae were covered with a thick layer of keratin. Variety of the distribution and morphological and histological characteristics of the lingual papillae in Zavot cattle related to be kind of diet and feeding habits.

Key words: Lingual papillae, zavot cattle, light microscopy, scanning electron microscopy, dorsal surface

INTRODUCTION

The Zavot breed, which is grazed on grassland in summer and fed on fodder in winter, is a cattle breed native to the East Anatolian region of Turkey. Zavot cattle have evolved as a result of a cross between the Simmental and Brown Swiss and their colour varies from grey to white. Reared for milk and meat production, Zavot cattle are at the risk of extinction. They are known to be resistant to the harsh winter conditions of East Anatolia.

The tongue is extensible and this muscular organ has a primary role in feeding, namely, in the stages of prehension, chewing and the swallowing of food. Although, they differ in characteristics, existence and distribution among animal species, lingual papillae are classified as gustatory and mechanical papillae. Gustatory papillae with taste buds are fungiform papillae, circumvallate papillae and foliate papillae. Mechanical papillae include lenticular papillae, conical papillae and filiform papillae (Eurell *et al.*, 2006).

Various light and scanning electron microscopic investigations have been reported on the distribution, structure and existence of lingual papillae in various ruminant species and breeds, including cattle (Steflik *et al.*, 1983; Chamorro *et al.*, 1986; De Paz Cabello *et al.*, 1988; Scala *et al.*, 1995; Kobayashi *et al.*, 2005), buffalo (Scala *et al.*, 1993), the one-humped camel (Qayyum *et al.*, 1998), Bactrian camel (Eerdunchaolu *et al.*, 2001), Egyptian camel (Korany and Bachir, 2004), Jamunapari goat (Kumar *et al.*, 1998), Rocky mountain goat (Kobayashi *et al.*, 2005), Saanen goat (Kurtul and Atalgin, 2008), Red Skoto goat (Igbokwe and Okolie, 2009), Akkaraman sheep (Unsal *et al.*, 2003), Mehraban lamb (Tadjalli and Pazhoomand, 2004), lesser mouse deer (Agungprijono *et al.*, 1995) and mutjac deer (Zheng and Kobayashi, 2006). However, there is no previous study on the lingual papillae of Zavot cattle, which is an important cattle breed for east Anatolia.

Hence, the aim of the study was to investigate the localization and histological features of lingual papillae on

the Zavot cattle tongue by light and scanning electron microscopy and to compare the findings with those reported in related ruminants.

MATERIALS AND METHODS

Animals and tissue collection: For this study, tongues of 5-years-old healthy male Zavot cattle ($n = 2$) taken from the slaughterhouse were used. Tissue samples were harvested from the dorsal surface of the apex, body and root of the tongues.

Light microscopy: Some of the samples were fixed in 10% formaldehyde for 24 h at room temperature and then subjected to routine tissue processing, before embedded in paraffin. Tissue blocks were cut into 5-6 μm thick sections on a microtome. The sections were stained with Mallory's trichrome staining (Crossmonn, 1937). The slides were examined by light microscope (Olympus BX51, Japan) and photographed (DP 71, Olympus, Japan).

Scanning electron microscopy: Tissue samples were rinsed in saline. Then, they were fixed in FAA (10% Formaldehyde-5% Acetic Acid-85% Alcohol) solution. After dehydrated and infiltrated with Hexamethyldisilazane (HMDS), the samples were mounted on copper stubs. Subsequently, tissue samples were observed under the scanning electron microscope (EVO50, Zeiss, Germany).

RESULTS

The Zavot cattle tongue was 30-35 cm in length and was divided into three regions, namely, the apex, body and root. The torus linguae and fossa linguae were at the anterior of the root. There was not a median groove on the apex of the tongue (Fig. 1). Histologically, there were five types of papillae: filiform, fungiform, circumvallate, lenticular and conical papillae on the dorsal surface of the tongue.

Filiform papillae: Filiform papillae, which completely covered the anterior half of the tongue surface and showed a distribution of regular caudal orientation, differed in structure on the apex and body of the tongue. The height of the filiform papillae were 1.8 mm on the apex (Fig. 2a), but decreased to 1 mm on the body (Fig. 2b) of the tongue. These papillae were robust and ridge-like on the apex of the tongue. Longitudinal grooves ran from the base to the tip of these papillae (Fig. 2a). It was observed that towards the body of the tongue, the surface of these papillae became smooth, displayed a dorsoventral

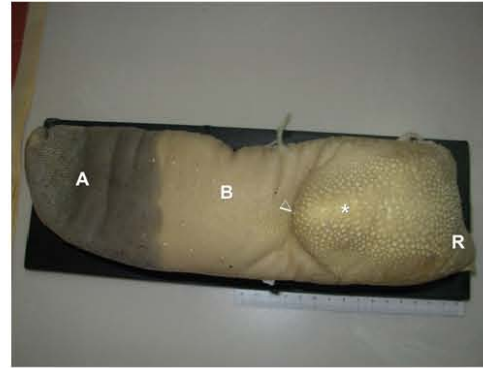


Fig. 1: Macroscopic observation of the tongue of the Zavot cattle. Apex (A), Body (B) and Root (R) of the tongue. Torus linguae (asterisk) and fossa linguae (arrowhead)

flattened and tongue-like shape and showed a caudally oriented distribution when compared to the apex of the tongue (Fig. 2b). On the body of the tongue, each main papilla was accompanied by 1-3 secondary papillae, which were 100-200 μm in height and spiral to unicorn horn-like in shape on the antero-lateral side of its base (Fig. 2b). However, there was not any secondary papilla on the main papilla at the apex of the tongue (Fig. 2a). The surfaces of the filiform papillae were covered with distinct stratified scales (Fig. 3b).

In light microscopic investigations, it was seen that filiform papillae were lined with thick keratinized stratified squamous epithelium supported with a connective tissue core (Fig. 2c).

Fungiform papillae: Fungiform papillae were distributed among filiform papillae on two-thirds of the dorsal surface and especially, on the lateral margins of the tongue. The diameter of the small and round fungiform papillae was about 1.2 mm. Each papilla was surrounded by a prominent groove (Fig. 3a). The taste pores were seen at the free surface of the papillae. These pores were 20-30 μm in diameter and were covered with a protective squamous flange. The surfaces of the papillae were covered with stratified scales (Fig. 3b).

Light microscopy showed that fungiform papillae were surrounded by thick cornified epithelial cells with the presence of a few taste buds on their tops (Fig. 3c).

Circumvallate papillae: Circumvallate papillae were arranged irregularly and as two intertwined lines at the caudo-lateral region of the torus linguae. There were 26 papillae on the two lines and they were about 2 mm in diameter. The papillae were encircled by a papillary

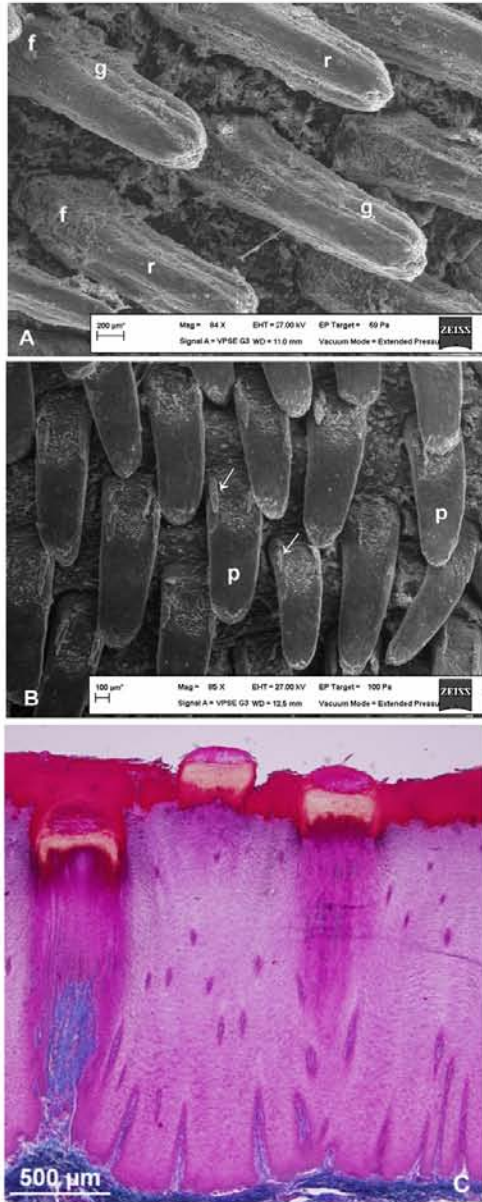


Fig. 2: a): Scanning electron micrograph showing robust filiform papillae (f) on the apex of the tongue. g: longitudinal grooves, r: ridge, b): Scanning electron micrograph showing tongue-like filiform papillae (p) on the body of the tongue. Unicorn horn-like secondary papilla (arrows) projected from the base of the main papilla, c): Light micrograph showing histological features of filiform papillae, which are covered with thick keratinized epithelium. Mallory's trichrome staining

groove and an annular pad of the surrounding lingual mucosa. There were cap-like reliefs on the annular pad.

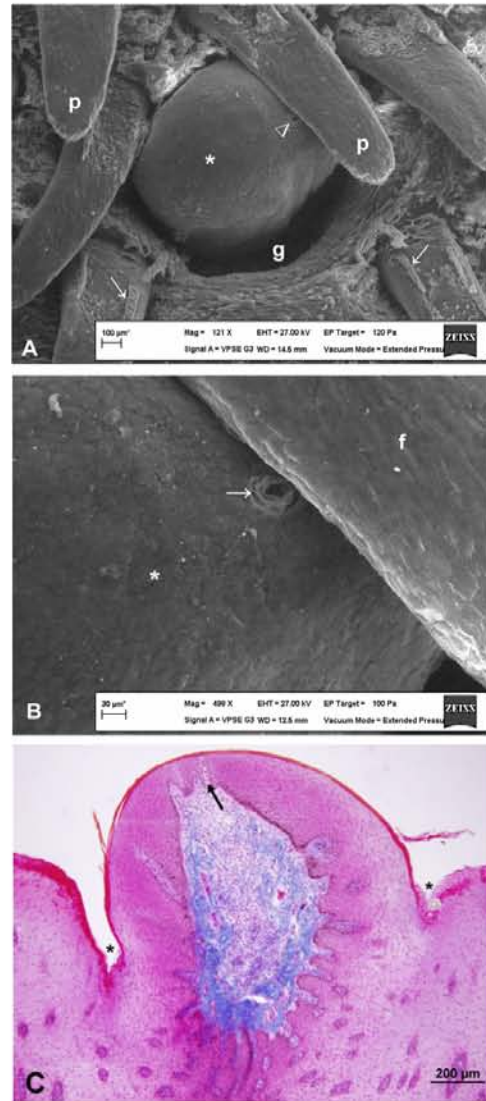


Fig. 3: a): Scanning electron micrograph showing a fungiform papilla (asterisk) on the body of the tongue. Surrounding groove (g) and a taste pore (arrowhead) on the dorsal surface of a fungiform papilla are indicated. p: filiform papilla, arrows: unicorn horn-like secondary papilla, b): Detail of the taste pore showing protection by a squamous flange (arrow) and filiform (f) and fungiform (asterisk) papillary surface showing stratified scales, c): Light micrograph of a sagittal section of a fungiform papilla located on the body of the tongue. A taste bud (arrow) is found at its top in the epithelium. Asterisk: groove. Mallory's trichrome staining

Round to oval-shaped circumvallate papillae were protruded towards the surface of the tongue.

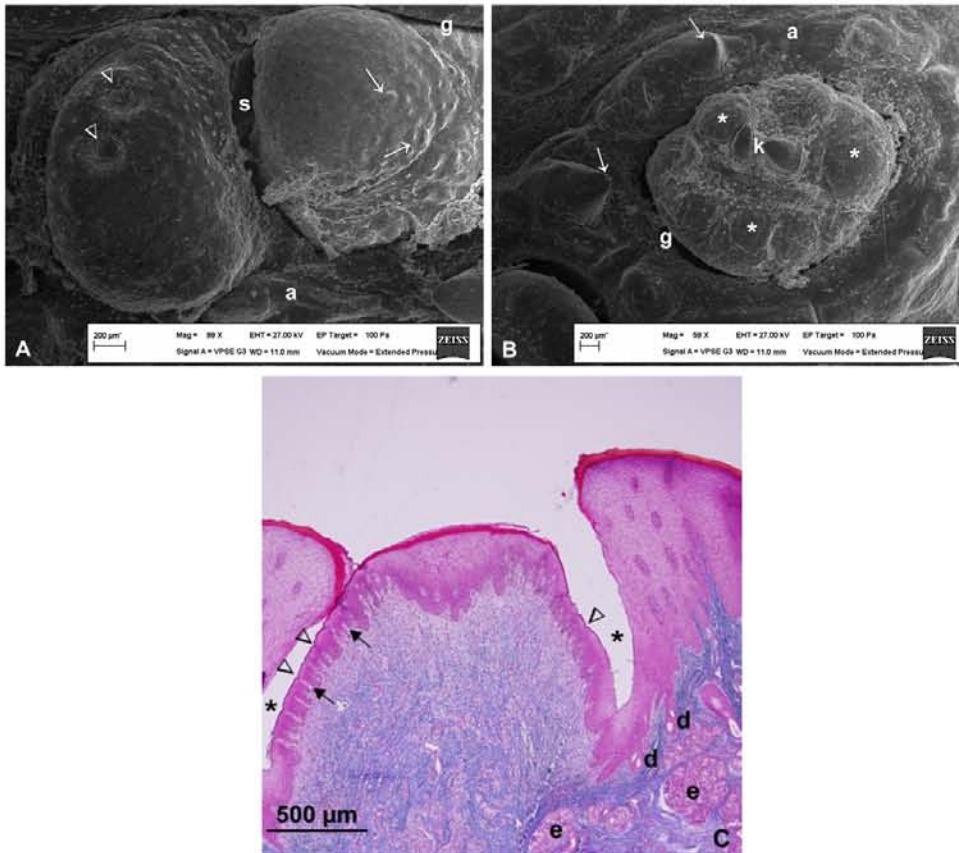


Fig. 4: a): Scanning electron micrograph showing twin circumvallate papillae surrounded by one primary papillary groove (g) and annular pad (a) and separated from another by a secondary papillary groove (s). Arrows: Numerous blisters on the papillary surface, Arrow heads: depressions on the papillary surface, b): Scanning electron micrograph showing a circumvallate papilla with bulging surface together with conical projections. g: papillary groove, a: annular pad, k: conical projection, arrows: cap-like relief, asterisk: ridge on the papillary surface, c): Light micrograph of a sagittal section of a circumvallate papilla. Numerous taste buds (arrows) and small indentations (arrowheads) in their openings are distributed in the epithelium on the side of the circumvallate papilla. Excretory channels (d) of the Ebner glands (e) present in the lamina propria are opening to the base of the grooves (asterisk). Mallory's trichrome staining

Occasionally, two papillae together were surrounded by only one primary groove and annular pad. Two papillae were separated by a secondary groove. Small blisters were seen less on the free surface of the papillae and more on the groove side (Fig. 4a). Furthermore, the surfaces of some papillae were convex and had a small conical ridge in the middle (Fig. 4b).

Light microscopy revealed that the cornified cell layer was rather slender on the papillary surface, while it almost disappeared in the grooves. Numerous taste buds were situated on the groove side of the epithelial cell layer. The pore areas of the taste buds displayed a wavy appearance with accentuation of the groove side, resulting from the dentation of the epithelial layer. Excretory channels of the serous type Ebner glands opened to the papillary grooves (Fig. 4c).

Lenticular papillae: Round or conical-like lenticular papillae were limited to the torus linguae. The largest of these papillae were localized medianly at the anterior region of the torus linguae. The conical-like types of these papillae, which had a mean diameter of 2-3 mm and were localized caudally, were less protruding from the lingual surface and the rostral parts were more compressed. A distinctive papillary groove, which lined the papillary body, was observed. This groove was deeper in the caudal region (Fig. 5a).

In light microscopy, the lenticular papillae were observed to be covered with thick keratinized stratified squamous epithelium (Fig. 5b).

Conical papillae: Conical papillae differed from lenticular papillae in shape and size. Their diameter was 1 mm at the

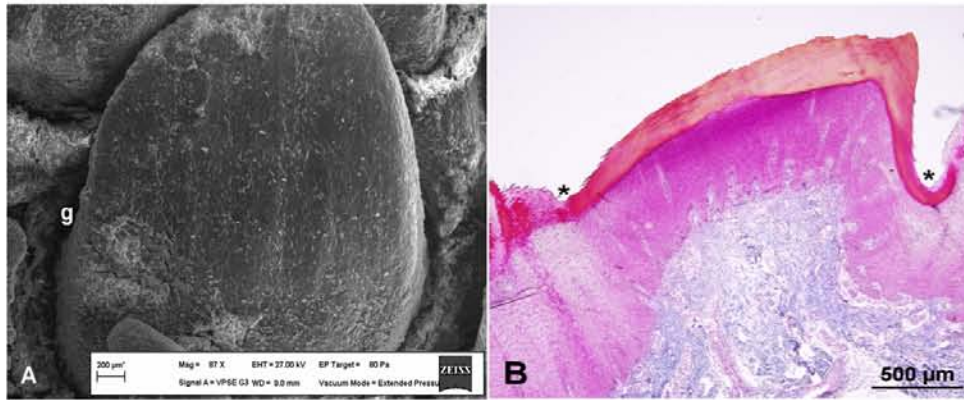


Fig. 5: a): Scanning electron micrograph showing a lenticular papilla. g: papillary groove, b): Light micrograph showing the histology of a lenticular papilla. Caudal groove of a conical type lenticular papilla with very thick cornified epithelial layer is deeper compared to the rostral part. asterisk: groove. Mallory's trichrome staining

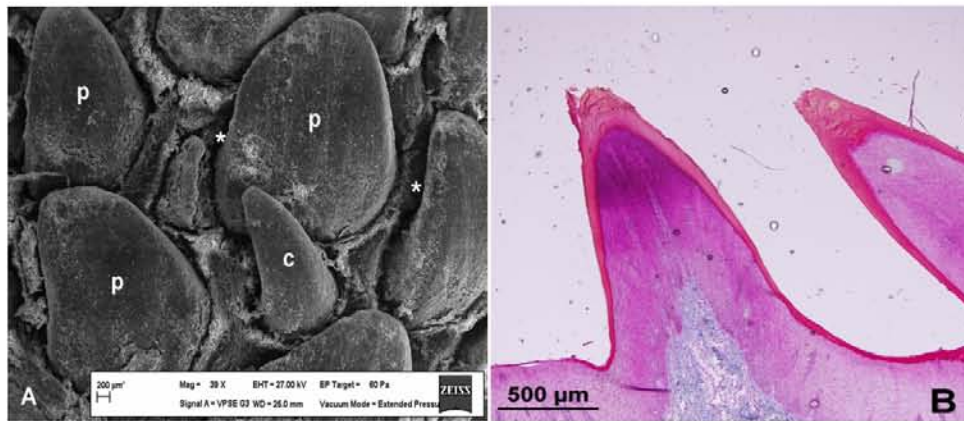


Fig. 6: a): Scanning electron micrograph showing a conical papilla (c) on the sideward of the torus linguae between the lenticular papilla (p). asterisk: papillary groove, b): Light micrograph showing the structure of a conical papilla

base and 100 µm (ordinary conical) at the top. Their height was about 1-2 mm. These papillae were distributed mainly on the lingual root, in other words, the posterior region of the torus linguae and were less in number on the lateral side of the torus linguae (Fig. 6a). The distribution of conical papillae started from the root of the tongue and extended caudally. The papillae had a smooth surface.

Light microscopy revealed that the tips of the papillae were covered with a thick layer of keratin (Fig. 6b).

DISCUSSION

The dorsal surface of the tongue in Zavot cattle was examined by light and scanning electron microscopy. Accordingly, in the present study, filiform, conical and lenticular papillae were distinguished as mechanical papillae and fungiform and circumvallate papillae were distinguished as gustatory papillae. Although,

Chamorro *et al.* (1986) reported the presence of foliate papillae in cattle, these were absent on the dorsal surface of the Zavot cattle tongue, as reported by Kobayashi *et al.* (2005).

Filiform papillae have a mechanical function, which gives the tongue a grating quality. While Steflik *et al.* (1983) and De Paz Cabello *et al.* (1988) noted the presence of filiform papillae, Scala *et al.* (1995) reported filiform papillae not to exist in the cattle tongue. Regional differences were determined in both the size and the structure of these papillae in the Zavot cattle tongue. Filiform papillae have a caudal orientation and are arranged regularly at the anterior half of the dorsal surface of the tongue. Filiform papillae were reported to be conical in shape, with a sharp tip pointed backwards, in cattle (Steflik *et al.*, 1983), the one-humped camel (Qayyum *et al.*, 1998), Jamunapari goat (Kumar *et al.*, 1998), Saanen goat (Kurtul and Atalgin, 2008) and

Merhaban lamb (Tadjalli and Pazhoomand, 2004), while, they were reported as tongue-like in cattle (De Paz Cabello *et al.*, 1988; Kobayashi *et al.*, 2005) and leaf-like in the Bactrian camel (Eerdunchaolu *et al.*, 2001), Egyptian camel (Korany and Bachir, 2004) and lesser mouse deer (Agungpriyono *et al.*, 1995). The shape of filiform papillae varied from robust to ridge-like in the apex and was tongue-like in the body of the Zavot cattle tongue. The existence of secondary papillae on filiform papillae was reported in the Bactrian camel (Eerdunchaolu *et al.*, 2001), Jamunapari goat (Kumar *et al.*, 1998), Saanen goat (Kurtul and Atalgin, 2008), Mehraban lamb (Tadjalli and Pazhoomand, 2004) and lesser mouse deer (Agungpriyono *et al.*, 1995), while secondary papillae were not reported in the one-humped camel (Qayyum *et al.*, 1998) and Egyptian camel (Korany and Bachir, 2004). Secondary papillae on filiform papillae were observed on the body of the tongue but not on the apex of the Zavot cattle tongue. The number of secondary papillae was 2-4 in the Bactrian camel (Eerdunchaolu *et al.*, 2001), 6-8 in the Jamunapari goat (Kumar *et al.*, 1998), 3-6 in the Saanen goat (Kurtul and Atalgin, 2008), 4-8 in the Mehraban lamb (Unsal *et al.*, 2003) and 2-3 in the lesser mouse deer (Agungpriyono *et al.*, 1995). The number of secondary papillae in Zavot cattle is very similar to that in the Bactrian camel (Eerdunchaolu *et al.*, 2001) and lesser mouse deer (Agungpriyono *et al.*, 1995), in that it varied from 1-3. In cattle (De Paz Cabello *et al.*, 1988) the papillary surface was reported to be smooth without stratified scales, while in Zavot cattle it was rough with distinct stratified scales as in the Jamunapari goat (Kumar *et al.*, 1998) and Saanen goat (Kurtul and Atalgin, 2008). Longitudinal grooves, which may provide a prehension mechanism to hold feed more tightly (Yamada *et al.*, 1983) were seen on the filiform papillae of the Zavot cattle tongue, similar to that of the Bactrian camel (Eerdunchaolu *et al.*, 2001) and lesser mouse deer (Agungpriyono *et al.*, 1995). Thick keratinized stratified squamous epithelium lining filiform papillae in the Zavot breed resembled that of cattle (Steflik *et al.*, 1983) and the Bactrian camel (Eerdunchaolu *et al.*, 2001).

Small and round fungiform papillae were scattered among the filiform papillae on the dorsal surface of the Zavot cattle tongue. The papillary surface showed stratified scales in Zavot cattle, similar to those in cattle (Chamorro *et al.*, 1986), the Saanen goat (Kurtul and Atalgin, 2008) and the Mehraban lamb (Tadjalli and Pazhoomand, 2004). The presence of taste buds on the free surface of fungiform papillae was observed in Zavot cattle, similar to cattle (Chamorro *et al.*, 1986), the Bactrian camel (Eerdunchaolu *et al.*, 2001), one-humped camel

(Qayyum *et al.*, 1998), Akkaraman sheep (Unsal *et al.*, 2003), lesser mouse deer (Agungpriyono *et al.*, 1995) and mutjac deer (Zheng and Kobayashi, 2006). However, in the Egyptian camel (Korany and Bachir, 2004), Jamunapari goat (Kumar *et al.*, 1998) and Saanen goat (Kurtul and Atalgin, 2008) fungiform papillae were without taste buds. Barone (1976), suggested that because of the absence of taste buds in fungiform papillae, these papillae have only a mechanical function in some animal species. Therefore, the taste buds present in fungiform papillae in the Zavot cattle tongue have gustatory function.

The number of circumvallate papillae was reported to be 15 or more in cattle (Kobayashi *et al.*, 2005), 15-18 in buffalo (Scala *et al.*, 1993), 12-16 in the Bactrian camel (Eerdunchaolu *et al.*, 2001), 9-12 in the one-humped camel (Qayyum *et al.*, 1998), 5 in the lesser mouse deer (Agungpriyono *et al.*, 1995) and 10 or more in the mutjac deer (Zheng and Kobayashi, 2006). Twenty-six circumvallate papillae were observed on both lines at the caudolateral region of the torus linguae in the Zavot cattle tongue, similar to the Saanen goat (Kurtul and Atalgin, 2008). Circumvallate papillae of Zavot cattle were lined by a papillary groove and an annular pad surrounded with lingual mucosa, resembling that of cattle (De Paz Cabello *et al.*, 1988), buffalo (Scala *et al.*, 1993), the Bactrian camel (Eerdunchaolu *et al.*, 2001), one-humped camel (Qayyum *et al.*, 1998), Jamunapari goat (Kumar *et al.*, 1998), Saanen goat (Kurtul and Atalgin, 2008) and Mehraban lamb (Tadjalli and Pazhoomand, 2004). It was suggested that the annular pad regulates the access and retention of saliva in the groove by means of smooth muscle (Chamorro *et al.*, 1986). The free surface of circumvallate papillae was irregular in Zavot cattle, as in the Bactrian camel (Eerdunchaolu *et al.*, 2001), Egyptian camel (Korany and Bachir, 2004) and Saanen goat (Kurtul and Atalgin, 2008), while it was smooth in buffalo (Scala *et al.*, 1993), the one-humped camel (Qayyum *et al.*, 1998) and Jamunapari goat (Kumar *et al.*, 1998). Agungpriyono *et al.* (1995) and Korany and Bachir (2004) reported the existence of taste buds only in the epithelium of the lateral parts of the circumvallate papillae in the lesser mouse deer and Egyptian camel, respectively. Numerous taste buds were situated on the epithelium of the groove side of circumvallate papillae in the Zavot cattle, similar to the lesser mouse deer (Agungpriyono *et al.*, 1995) and Egyptian camel (Korany and Bachir, 2004). Furthermore, Chamorro *et al.* (1986) reported the presence of taste buds in the epithelium of the dorsal and lateral parts of circumvallate papillae in cattle.

Lenticular papillae, as mechanical papillae, were reported to be distributed only on the torus linguae of the Zavot cattle tongue, as in cattle (De Paz Cabello *et al.*,

1988), the Bacterian camel (Eerdunchaolu *et al.*, 2001), Egyptian camel (Korany and Bachir, 2004), Saanen goat (Kurtul and Atalgin, 2008) and Mehraban lamb (Tadjalli and Pazhoomand, 2004), while they were determined not to exist in the one-humped camel (Qayyum *et al.*, 1998), lesser mouse deer (Agungpriyono *et al.*, 1995) and mutjac deer (Zheng and Kobayashi, 2006). Lenticular papillae in Zavot cattle had a papillary groove, similar to that reported in the Saanen goat (Kurtul and Atalgin, 2008) and Mehraban lamb (Tadjalli and Pazhoomand, 2004). However, it was determined that this groove was deeper in the caudal region of the torus linguae.

Conical papillae are mechanically effective in the repeated mastication of grass in the mouth of ruminants (Zheng and Kobayashi, 2006). Conical papillae were reported not to exist in the Bacterian camel (Eerdunchaolu *et al.*, 2001), one-humped camel (Qayyum *et al.*, 1998), Egyptian camel (Korany and Bachir, 2004), lesser mouse deer (Agungpriyono *et al.*, 1995) and mutjac deer (Zheng and Kobayashi, 2006). In Zavot cattle, these papillae were located particularly on the posterior region of the torus linguae, while in the buffalo, Mehraban lamb and Jamunapari goat they were situated on the lateral area of the torus linguae.

CONCLUSION

The differences determined in the distribution and morphological and histological characteristics of lingual papillae in the Zavot breed, which is grazed on grassland in summer and fed on fodder in winter, were considered to be related to diet and feeding habits. The characteristics of the lingual papillae on the dorsal surface of the Zavot cattle tongue were similar to those reported in the Bacterian camel and Saanen goat.

REFERENCES

- Agungpriyono, S., J. Yamada, N. Kitamura, C. Nisa, K. Sigit and Y. Yamamoto, 1995. Morphology of the dorsal lingual papillae in the lesser mouse deer, *Tragulus javanicus*. *J. Anat.*, 187: 635-640. PMID: 8586562.
- Barone, R., 1976. Anatomie comparee des mammiferes domestiques. Vol. 3. Splanchnologie, Lyon: Laboratoire anatomie, Ecole Nationale Veterinaria.
- Chammorro, C.A., P. De Paz Cabello, J. Sandoval and F. Fernandez, 1986. Comparative scanning electron microscopic study of the lingual papillae in two species of domestic mammals (*Equus caballus* and *Bostaurus*). I. Gustatory papillae. *Acta Anat.*, 125: 83-87. PMID: 3953255.
- Crossmorn, G., 1937. A modification of Mallory's connective tissue stain with a discussion of the principals involved. *Anat. Rec.*, 69: 33-38.
- De Paz Cabello, P., C.A. Chammorro, J. Sandoval and F. Fernandez, 1988. Comparative scanning electron microscopic study of the lingual papillae in two species of domestic mammals (*Equus caballus* and *Bostaurus*). II. Mechanical papillae. *Acta Anat.*, 132: 120-123. PMID: 3414356.
- Eerdunchaolu, E., K. Takehana, E. Yamamoto, A. Kobayashi, G. Cao, U.H. Baiyin and P. Tangkawattana, 2001. Characteristics of dorsal lingual papillae of the Bactrian camel (*Camelus bactrianus*). *Anat. Histol. Embryol.*, 30: 147-151. PMID: 11447938.
- Eurell, J.A., B.L. Frappier and H. Dellmann, 2006. Textbook of Veterinary Histology. Philadelphia. 6th Edn. Lea and Febiger, pp: 174-175.
- Igbokwe, C.O. and C. Okolie, 2009. The morphological observations of some lingual papillae in the prenatal and prepuberal stages of Red Sokoto goats (*Capra hircus*). *Int. J. Morphol.*, 27 (1): 145-150.
- Kobayashi, K., H. Jachowiak, H. Frankowiak, K. Yoshimura, M. Kumakura and K. Kobayashi, 2005. Comparative morphological study on the tongue and lingual papillae of horses (Perissodactyla) and selected ruminantia (Artiodactyla). *Ital. J. Anat. Embryol.*, 110: 55-63. PMID: 16101021.
- Korany, N.S. and M.H. Bachir, 2004. Morphofunctional study of different tongue papillae in ruminants and rodentia (a scanning electron microscopic and histological studies). *Cairo Dental J.*, 20 (2): 215-220.
- Kumar, P., S. Kumar and S. Singh, 1998. Tongue papillae in the goat: A scanning electron microscopic study. *Anat. Histol. Embryol.*, 27: 355-357. PMID: 9972641.
- Kurtul, I. and S.H. Atalgin, 2008. Scanning electron microscopic study on the structure of the lingual papillae of the Saanen goat. *Small Rum. Res.*, 80: 52-56. DOI: 10.1016/j.smallrumres.2008.09.003.
- Qayyum, M.A., J.A. Fatani and A.M. Mohajir, 1998. Scanning electron microscopic study of the lingual papillae of the one humped camel, *Camelus dromedarius*. *J. Anat.*, 160: 21-26. PMID: 3253256.
- Scala, G., N. Mirabella and G.V. Pelagalli, 1995. Etude morphofonctionnelle des papillas linguales chez le boeuf (*Bos taurus*). *Anat. Histol. Embryol.*, 24: 101-105.
- Scala, G., G.V. Pelagalli, A. Vittoria and P. Girolamo, 1993. Etude morphostructurale des papillas linguales chez le buffalo (*Bubalis bubalis*). *Anat. Histol. Embryol.*, 22: 264-272.

- Steflik, D.E., B.B. Singh, R.V. McKinney and J.L. Boshell, 1983. Correlated TEM, SEM and histological observations of the filiform papillae of the cow tongue. *Acta Anat.*, 117: 21-30. PMID: 6195885.
- Tadjalli, M. and R. Pazhoomand, 2004. Tongue papilla in lambs: A scanning electron microscopic study. *Small Rum. Res.*, 54: 157-164.
- Unsal, S., A. Aktunsek, I. Celik and E. Sur, 2003. The number and distribution of fungiform papillae and taste buds in the tongue of young and adult Akkaraman sheep. *Rev. Med. Vet.*, 154 (11): 709-714.
- Yamada, J., N. Calingasan, N. Kitamura and T. Yamashita, 1983. Comparative scanning electron microscopic study of the lingual filiform papillae of some domestic animals. *Philippine J. Vet. Med.*, 22: 1-6.
- Zheng, J. and K. Kobayashi, 2006. Comparative morphological study on the lingual papillae and their Connective Tissue Cores (CTC) in reeves' muntjac deer (*Muntiacus reevesi*). *Ann. Anat.*, 188: 555-564. DOI: 10.1016/j.aanat.2006.05.014.