RESEARCH ARTICLE

STEREOMICROSCOPIC AND SCANNING ELECTRON MICROSCOPIC OBSERVATIONS OF THE FORESTOMACH MUCOSA OF AKKARAMAN SHEEP FED WITH STRAW-CONCENTRATE DIET

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ABSTRACT

This research was conducted to observe the mucosal surface of the forestomach components of seven Akkaraman sheep fed with straw-concentrate diet using stereomicroscopy and SEM. The samples were obtained from the animals fed 60% straw and 40% concentrate, and slaughtered in a local slaughterhouse. The results revealed that the ruminal papillae were present on all of the surface of the rumen except the ruminal pila. Their shape varied considerably in shape and size from a short lingual to a long and wide leaf-like forms. Some papilla showed asymmetrical doubled-apices. The cells in the ruminal mucosa were mostly intermediate-type cells. Occasionally, their shapes resembled balloon-type cells. Reticular cristas in the reticulum and omasal lamina in the omasum were also displayed clearly, but certain papilla types and their peculiarities were not eminent at macroscopical level. At microscopical level, there were papilla- type structures present on the omasal lamina. They had smooth surface, mostly possessing one, occasionally double ridges. The epithelial scrap layer formed by the horny cells was eminent, indicating regeneration of the papilla. The results have shown the characteristics of the animals fed with straw-concentrate diet.

Keywords: Intermediate type eaters, sheep, forestomach components, SEM

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INTRODUCTION

Sheep in Türkiye is raised mostly in nonagricultural areas, grasslands, and pastures, contributing to economy through transforming natural vegetation to yields such as meat, milk and wool. Likewise, Akkaraman sheep has an important place within the sheep population in Türkiye, comprising 45.8% of all population (Akçapınar, 2000).

Ruminants digest herbaceous feed through microbial fermentation in their forestomachs. This is augmented by mucosal duplications which differ greatly in shape in accordance with their feeding habits, providing common digestive ability. Several studies have documented gross and ultra structural nature of the mucosa of the forestomachs in ruminants (Loe et al., 1959; Yamamoto, 1998; Steele et al., 2009; Swan and Groenewald, 2000). They have classified them into three categories with regard to the feeding preferences: grazers, concentrate selectors, and intermediate type eaters (Hofmann, 1989). Domesticated ruminants belong either to grazers or to the intermediate type eaters. Grazers digest usually low-quality roughage, particularly different kinds of grass; on the other hand, the intermediate type eaters choose leaves and young plants with high energy content, if present (Hofmann, 1989).

Different feeding habits profoundly affect anatomical peculiarities of the mucosal duplications of the forestomachs, which is related directly to the passage rates of digesta in the gastrointestinal tract, with the longest duration times recorded in the grazers (Hofmann and Schnorr, 1982). Grazers have a larger rumen and a smaller omasal orifice than intermediate types and concentrate selectors (Hofmann, 1989). Animals that belong to the last two groups can send food directly into the abomasum through bypassing forestomach via the reticular groove (Hofmann, 1989). These indicate adaptations of the motility patterns in the forestomachs whith regards to feeding type.

The rumen epithelial barrier is a critical component of the immune system in ruminants (Penner et al., 2011). The destruction of the rumen mucosa, i.e. necrosis, is an important problem in animals fed with concentrated feed (Liu et al., 2013). However, little is known about the true molecular causes underlying this. Changes in ruminal epithelial barrier function, mRNA and tight junction (TJ) proteins in protein expression during concentrated diet feeding have been reported (Liu et al., 2013). In the current intensive ruminant production system, the use of a highly concentrated diet is used to maximize energy intake and improve milk production, or to increase daily weight gain. However, highly fermentable diets put animals at risk. Fast fermentable non-structural carbohydrates increase the rate of fermentation process of acid production. Acid accumulation in the rumen reveals the possibility of impairment in ruminal epithelial barrier function and its exposure to toxins (Beauchemin et al., 2008). The cellular structure of the rumen epithelium is complex. Damages in this section can be viewed histologically and by scanning electron microscopy (Steele et al., 2009).

High grain (HG) feeding shows a strongly disrupted epithelial barrier. Multiple systemic symptoms such as the development of rumenitis and liver abscess caused by the HG diet also show ruminal epithelial cellular damage and changes in TJ protein (Liu et al., 2013). It was reported that the number of papillae increased significantly in the concentrate-fed groups compared to those fed with hay. It was reported that the number of papillae per cm2 was 48 in the group fed with concentrated feed in 4 weeks, and 38 papillae were detected in animals fed with hay. On the other hand, it has been reported that the number of papillae per cm2 of mucosa increases as the duration of concentrate feeding increases among the groups fed concentrate (Gäbel et al., 1987). It has been stated that papillae are under the influence of diet change and feeding time. It has been reported that the shape of the papilla also changes depending on the diet. Small, finger-shaped papillae were observed in the hay-fed group, while large, leaf and tongue-shaped cornified papillae were observed in animals fed with concentrated feed (Ahmed et al., 2013).

Generally, the development and growth of ruminal papillae has been reported to be highly dietary. Mechanical and chemical stimuli, short-chain fatty acids, the age of the animal and the time of weaning were found to be directly related to the size and shape of the papilla (Anderson et al., 1987; Franco et al., 1992; Zitnan et al., 1999; Swan and Groenewald, 2000; Ahmed et al., 2013). It has been reported that papillae are the largest and most concentrated in the ventral wall of the rumen, in the parts that are most exposed to food. The number of papillae per cm2 of mucosa has been observed to increase significantly in concentrated feeding compared to straw feeding. As the concentrate-feeding time gradually increases, the papillae ruminis take the shape of leaves and elongate (Gäbel et al., 1987; Ahmed et al., 2013). It has also been shown that the development of papillae is dependent on short-chain fatty acids (especially SCFA, mainly butyric and to a lesser extent propionic acids) originating from feed ingredients (Brownlee, 1956).

When the average length and width of papilla ruminis were compared between the concentrate and hay-fed groups, it was observed that the length and width of the papilla ruminis in the concentrate-fed group were strikingly higher (Ahmed et al., 2013). Scanning electron microscope findings; in the images of the rumen papillae, indentations and dead keratinized cells along the surface were more prominent in animals fed with concentrated feed than in hay feeding. Deep cellular damage and parakeratosis were found in rumen papillae surface cells for goats fed with concentrated feed. Rumen papillae sections, nuclei, mitochondria and intercellular connections were normal during hay diet. In goats fed with concentrated feed, cellular necrosis and cellular erosion were seen in all cell layers. The HG diet was reported to cause serious deterioration in the ruminal epithelium during nutrition, especially in subacute ruminal acidosis when cell erosion (parakeratosis) was detected with prominent epithelial cellular damage (Liu et al., 2013). Also, in such cases where the rumen epithelium was disrupted, the layer became permeable to endotoxin and this can cause liver abscesses, laminitis, and inflammatory responses (Steele et al., 2009).

Morphologically, rich deep ridges and indentations were observed in SEM images of rumen papillae from all cattle. Heterogeneous microflora, including abundant bacteria and protozoa, were detected in deep ridges and indentations, especially in the diet based on roughage. At additional magnification, keratinized squamous cells of the stratum corneum layer were evident in the HG diet. Desquamation of dead keratinized cells was evident, while microbial flora decreased (Steele et al., 2009).

Studies have revealed adaptations of the mucosal morphology of the forestomachs in different ruminant species due to both feeding habits and seasonal and regional changes (Flatt et al., 1958), including sheep (Scot and Gardner, 1973) and cattle and goats (Yamamoto et al., 1993). Moreover, mucosal papilla of the forestomachs has been shown to vary greatly, depending on age, feeding type, and region (Habel, 1975; Franco et al., 1992; Banks, 1993; Dyce et al., 2010). Reversable alterations can also be seen in the morphology and function of rumen epithelia within 1-3 weeks of food change (Gäbel et al., 1987; Anderson et al., 2013). In relation with that, this study aimed at revealing the possible morphological relationship between the structures of the mucosal morphology of the forestomachs and feed stuffs in Akkaraman sheep fed with straw-concentrate diet.

MATERIALS AND METHODS

Seven female and adult Akkaraman sheep, a national Turkish breed, were used in the study. The animals were fed 60% straw and 40% concentrate during the period between October and February. The samples taken from the ventral portion of the forestomach for stereomicroscopic and SEM examinations were processed at Gazi University, Ankara, Türkiye. For SEM examination, samples were placed into 3% glutaraldehyde with phosphate buffer (pH: 7.3). After rinsing in buffer, tissues were post-fixed in 1% osmium tetraoxide (OsO4) at 37 °C for 1.5 hours. After post-fixation, tissues were placed in 3N HCl at 60 °C for 20 minutes to remove the extracellular mucus from the surface of the tissue. Tissue samples were passed alcohol and amyl acetate series and dried with critical-point-dryer. Specimens were coated with gold and observed a Jeol JVM 5000 SEM at 5-15 kv (JSM 6390LV, JEOL, Germany).

RESULTS

The mucosal surface of the forestomach of the Akkaraman sheep was not smooth, expanding into a large area by numerous papillae which varied considerably in shape and size in the various sacs and compartments.

Ruminal papillae were densely distributed eminently all over the ruminal surface except the ruminal pillars and nearby, where they were reduced both in number and length. They were light brown in color, varying profoundly with regard to a location, from a short lingual to long and wide leaf-like forms (Figure 1). Occasionally, some of the papillae showed asymmetrical doubled apices (Figure 1). The short lingual type of the papillae were located mostly dorsally, while long and wide leaf-like papillae were present cranioventrally on the cranial cecal sac. The latter contained two types of grooves in different length

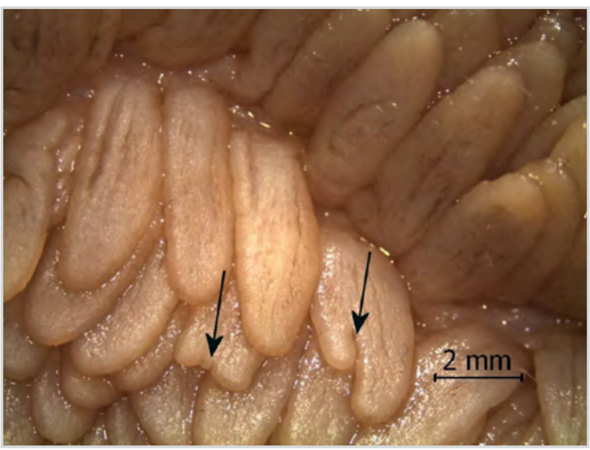

Figure 1 Stereomicroscope view of the rumen papilla in the ventral part of the rumen (Scale 2 mm). Arrows: asymmetrical doubled-apices

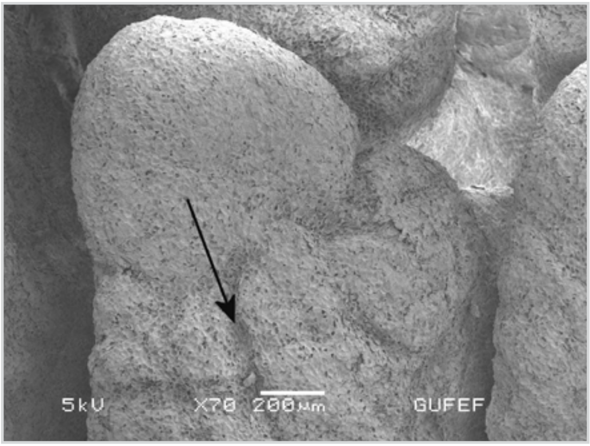

Figure 2 View of ruminal papilla, x35 scale, bar: 200µm. Arrow: primary groove

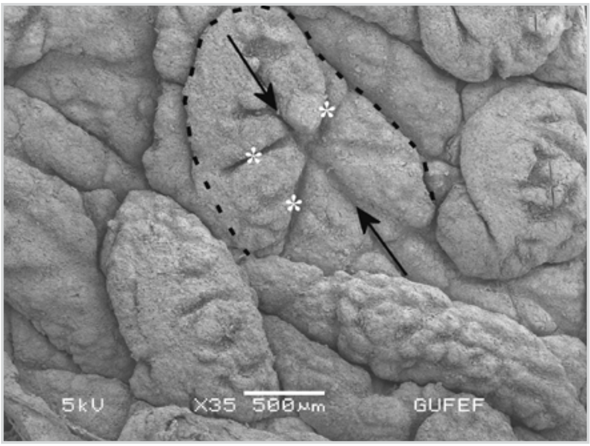

Figure 3 Shallow grooves on the ruminal papilla. x50, scale, bar: 500µm. Arrows: primary groove, asterisk: secondary groove, dotted line: papilla ruminis

and largeness (Figure 2); the primary groove lied centrally throughout the length of the papilla, and the small secondary groove intersecting the primary one (Figure 3).

Short tongue-shaped papillae were mostly found in the dorsal and lateral wall of the rumen (Figure 4), while long and wide leaf-like papillae were seen in the ventral part (Figure 1). In the samples taken from the lateral wall of the rumen, few grooves were observed on the rumen papillae. On the other hand, primary very deep grooves and 4-6 secondary grooves were detected on those of the ventral wall. The grooves on the ventral wall of the rumen of the animals fed the intermediate type were wrinkled in shape.

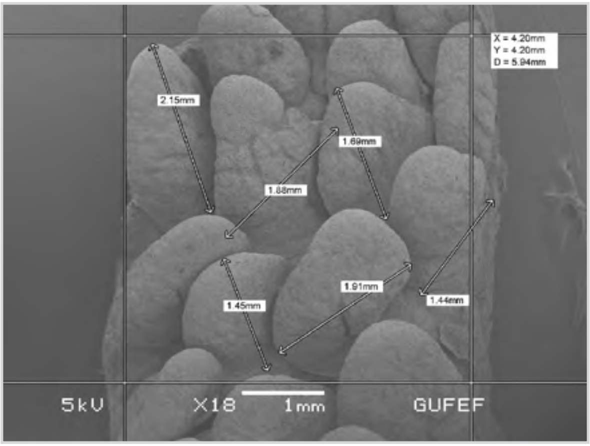

Figure 4 Short tongue-shaped papillae in the dorsal and lateral wall of the rumen

Cell debris and necroses were detected in the papillae at 200 magnification in the samples taken from the ventral wall of the rumen. Keratinized squamous cells, very intense in number appeared on the surface and edges of the grooves. Necrotic cell debris was found to be mostly quadrilateral, pentagonal, and hexagonal polygonal. The margins of these squamous cell debris ranged from 18 to 35 micrometers (Figure 5).

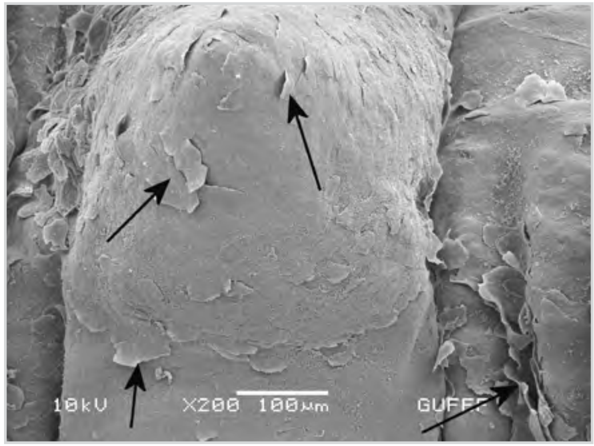

Figure 5 Cell debris and necroses in the ventral wall of the rumen. Arrows: Cell debris and necroses

At 2500 magnification, a granular view was seen on the ruminal surface (Figure 6). It was due to the presence of the cytoplasmic ridges lying around. Polygonal cells were observed on all the inner surface of the rumen. The ruminal papillae located on the inner dorsal surface of the rumen, were settled sparsely, showing no grooves at all. They, instead, had ridges.

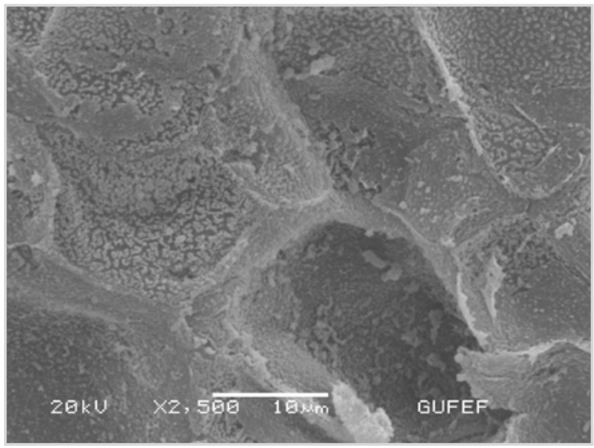

Figure 6 Cytoplasmic ridges of rumen (asterisk), x2500, scale bar: 10µm, arrows: bacterial colony

Reticular cristas in the reticulum and omasal lamina in the omasum were shown clearly. They were seen grossly, but some of the papilla types and their peculiarities were not eminent at macroscopical level. At microscopical level, there were papilla type structures present on the omasal lamina. They had smooth surface, mostly possessing one (Figure 7), occasionally double ridges (Figure 8). The epithelial scrap layer formed by the horny cells was eminent (Figure 9), indicating regeneration of the papilla.

SEM images showed intermediary balloon-type cells on the rumen surface at 1000 magnification.

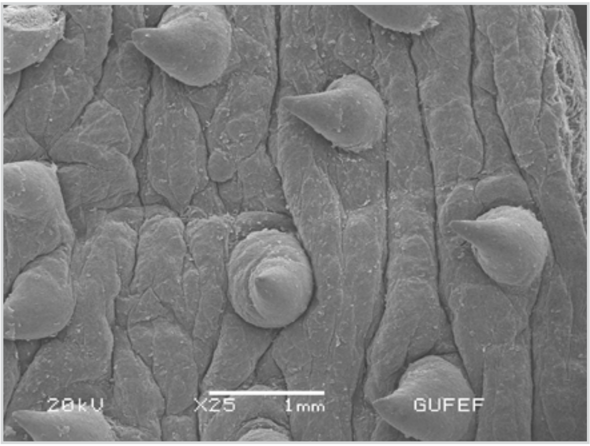

Figure 7 Papilla-type structures of omasal lamina, x25, scale bar: 1mm

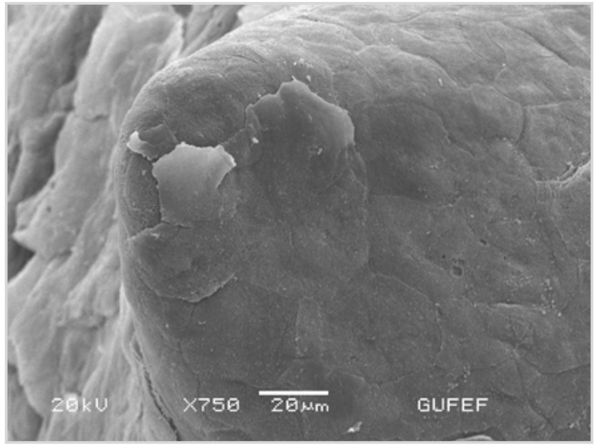

Figure 9 The epithelial scrap layer of omasal lamina. x750, scale bar: 20µm

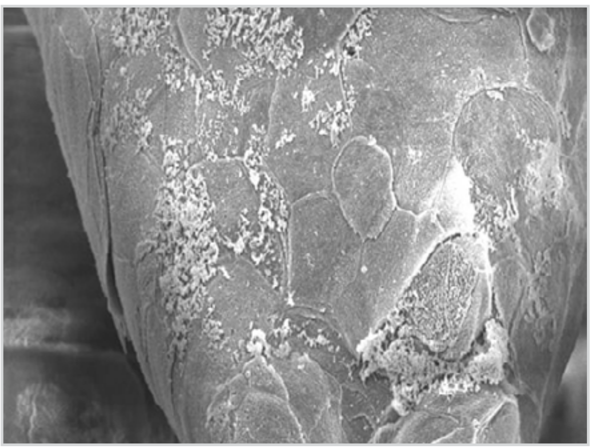

Figure 8 View double ridges of omasal lamina, x1000, scale bar: 10 µm

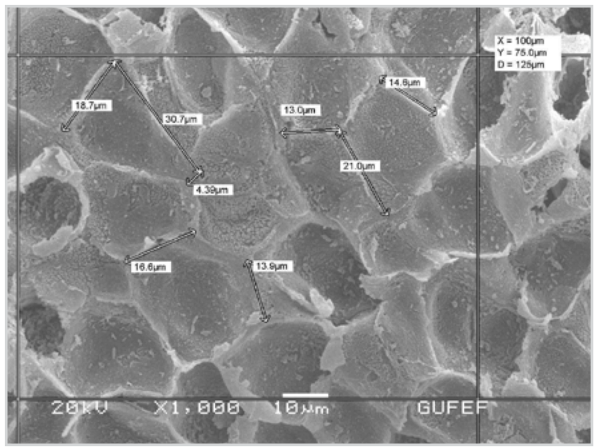

Figure 10 Intermediary baloon-type cells on the ruminal surface x1000, scale bar: 10µm.

Cells were generally observed as pentagonal-hexagonal types. It was determined that each edge ranged from 35 µm to 3.3 µm. The edges were found to be generally unequal in length (Figure 10).

DISCUSSION AND CONCLUSION

At SEM observation, they were determined to function basically as surface enhancement (Tamate et al., 1979; Anderson et al., 1987) to lie in similar fashion, but being various topographically in numbers and shape. These differences on papilla development have been shown partly to be related to a feeding habit (Loe et al., 1959; Sander et al., 1959; Weyrauch and Schnorr, 1979; Dyce et al., 2010; Ahmed et al., 2013), just as found in our results. Lipid acids, particularly butyric and propiyonic acids have been reported to play a very essential role in mucosal development with this variation range (Sander et al., 1959). They have been indicated to exert their role exclusively by both causing structural differences and augmenting absorbtion (Sander et al., 1959; McGilliard et al., 1965). This study, which was conducted in animals known to have nutritional status, revealed broad variations, particularly in the rumen, as compared to the literature. Especially symmetrical and unsymmetrical bifurcations and characteristic grooves were noted in the end parts of the papilla ruminis.

The results of a study (Scott and Gardner, 1973) that the entire surface of the rumen is covered with polygonal cells, are compatible with our findings, and polygonal cell types - especially hexagonal - were observed in our study. Scott (1973) mentioned that cell borders are seen clearly, and this clarity is present in our study.

Garcia et al. (2012) has reported in their study that the ruminal wall is seen as a smooth surface, indicating no evidence of keratinization or desquamation; this view is not in agreement with our study. This literature has stated that the cells, their outline, and the boundaries between the cells are clear, which is consistent with our study.

Along with our results, most researchers (Penner et al., 2011; Ajmed et al., 2013) have reported that there is cellular necrosis, parakeratosis and cell debris observed in papilla ruminis of animals fed with concentrate feed. Yet, a study (Scott and Gardner, 1973; Penner et al., 2011; Ahmed et al., 2013) has stated that this shedding is a feature of the ruminal epithelium, and that this spill is normal. In our study, and in most literature, necrotic cell debris was observed in the epithelial cells of the papilla ruminis of animals fed with concentrated feed and intermediary type. These results are contrary to those of that literature with the exception of normal cell death. Finally, Steele et al. (2011) (Supplemental Material 1, Supplemental Figure S1, A and B) mentioned that heterogeneous microflora including bacteria and protozoa were seen in SEM images, especially in hay-based nutrition, which was also observed in our study, as displayed in Figure 6.

Hofmann (1989) has categorized ruminants with regard to stomachs' morphology into three types, concentrate-fed (CS), intermediate type eaters (IM), and grazers (GR). This study has focused on the mucosal peculiarities of the IM animals fed concentrates along with straw rich in cellulose. Literature (Hofmann, 1989) has indicated that mucosal changes in animals fed different ratios occur mostly in the rumen and reticulum. Since this study has used IM animals only, no comparison has been done. The ruminal papillae have been observed to scatter evenly in the rumen, just as reported by the literature (Ahmed et al., 2013). Hofmann (1989) has shown that the presence of the ruminal papilla, even on the ruminal surface of the ruminoreticular plica and lacking on the reticular plica, are characteristics of the CS animals. Interestingly, no ruminal papilla was present on the plicas of the IM animals used in this study.

Tamate et al. (1979) have defined primary and secondary grooves on the ruminal papilla in sheep. Yamamoto et al. (1994) and Scott and Gardner (1973) have also mentioned these structures. Our study has likewise determined the primary and secondary grooves while the secondary ones being shallow in shape. These grooves are due likely to the longer stay of the concentrates in this area. Except on the cranial and ventral aspects of the cranial blind sac, the fact that these grooves are shallow and less present (Figure 3) is most probably because of the feeding habit.

Ahmed et al. (2013) reported that the number of grooves on papilla ruminis was one in straw-fed animals, but the number of grooves and depth increased as the animal feed rate increased. The results of our study are compatible with this publication in that that the presence of primary and secondary grooves in the intermediatefeeding habits and the depth of the grooves are moderate. Additionaly, certain papillas have been found to comprise two grooves parallel to each other and equal, without differentiating between primary and secondary. Ahmed et al. (2013) stated that the papilla ruminis form small, flattened tongues in the animals of the same type of ration in their study, and our study shows that the findings are the same as in this study. Mahes et al. (2014) have found smaller pointed and blunt projections like the secondary papillas between large and small intense papillae on the ventral wall of the rumen in our study. This type of secondary papilla has not been observed in our study. The color of the ruminal papillae was light brown. This study revealed that changes in colour of the papillae were diet-dependent. Ahmed et al. (2013) reported papillae from hay-fed sheep or sheep fed concentrate were light brown in colour. However, papillae with dark brown colour were observed in 6 and 12 weeks concentrate-fed groups. Interestingly, 4 weeks concentrate-fed group showed papillae with both light and dark brown colours. These data are consistent with the results of our study. The scarcely present omasal papilla ending blindly seen on the omasal lamina are usually observed in grass-roughage eaters (GR) animals (Yamamoto et al., 1998). They have also been determined in this study. Subepithelial connective tissue in sheep has been shown to possess several papillar prominences (Tamate et al., 1979; Yamamoto et al., 1993). These structures are less present in Japanese serow (Yamamoto et al., 1998). Presence of these papilla-type structures is also determined in our study (Figure 4). Cytologically, Schnorr and Vollmerhaus (1967) and Hofmann and Schnorr (1982) have defined the keratinized cells as flattened, baloon and intermediate- type cells. The cells seen in our study were mostly intermediate-type. Occasionaly, they were in resemblance with balloon-type cells.

Consequently, this paper observed the mucosal surface of the forestomach components of seven Akkaraman sheep fed on an intermediate- type feeding, using stereomicroscopy and SEM. The ruminal papillae present on all of the surface of the rumen except the ruminal pila, varied considerably in shape and size, some of which possessing asymetrical doubled-apices. The cells in the ruminal mucosa were mostly intermediate-type cells. Certain papilla types on the reticulum and omasum were not eminent at macroscopical level, if present, comprising mostly one, occasionally double ridges. The epithelial scrap layer formed by the horny cells was eminent, indicating regeneration of the papilla. The results have indicated the characteristics of the animals fed on intermediate- type feeding.

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CONFLICT OF INTEREST

The authors declare no conflict of interest for the present study.

CONTRIBUTIONS

Concept – ŞHA; Design – ŞHA; Supervision – ŞHA; Resources - ŞHA; Materials – ŞHA, IK; Data Collection and/or Processing – ŞHA, IK; Analysis and/or Interpretation – ŞHA, IK; Literature Search – ŞHA, IK, LT; Writing Manuscript – ŞHA, IK, LT; Critical Review – ŞHA, IK, LT.

REFERENCES

Ahmed RS, Martens H, Muelling C. 2013. Scanning electron microscopical and morphometrical studies on ruminal papillae of sheep fed on concentrates. JAS, 3(2), 111-23.

Akçapınar H. 2000. Koyunyetiştiriciliği (pp.106-107). Ankara-Türkiye: İsmat Press.

Anderson K, Nagaraja T, Morrill J. 1987. Ruminal metabolic development in calves weaned conventionally or early. J. Dairy Sci, 70(5), 1000-5.

Banks W. 1993. Applied Veterinary Histology (Third edition, pp. 326-359). St Louis, USA: Mosby, Inc.

Beauchemin K, Eriksen L, Nørgaard P, Rode L. 2008. Salivary secretion during meals in lactating dairy cattle. J Dairy Sci, 1(5), 2077-81.

Brownlee A. 1956. The development of rumen papillae in cattle fed on different diets. Br Vet J, 112, 369-75.

Dyce K, Sack W, Wensing C. 2010. Textbook of Veterinary Anatomy (4th edition, pp. 71-78).

Flatt W, Warner R, Loosli J. 1958. Influence of purified materials on the development of the ruminant stomach. J Dairy Sci, 41(11), 1593-600.

Franco A, Regodon S, Robina A, Redondo E. 1992.

Histomorphometric analysis of the rumen of sheep during development. Am J Vet Res, 53(7), 1209-17.

Gäbel G, Martens H, Sündermann M, Galfi P. 1987. The effect of diet, intraruminal pH and osmolarity on sodium, chloride and magnesium absorption from the temporarily isolated and washed reticulo-rumen of sheep. Q J Exp Physiol, 72(4), 501-11.

García A, Masot J, Franco A, Gázquez A, Redondo E. 2012. Histomorphometric and immunohistochemical study of the goat rumen during prenatal development. Anat Rec, 295(5), 776-85.

Habel R. 1975. Ruminant digestive system. Sisson and Grossman's the Anatomy of the Domestic Animals, 1, 861-915.

Hofmann RR, Schnorr B. 1982. Die funktionelle Morphologie des Wiederkäuer-Magens: Schleimhaut und Versorgungsbahnen. Enke.

Hofmann RR. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia, 78(4), 443-57.

Liu JH, Xu TT, Liu YJ, Zhu WY, Mao SY. 2013. A high-grain diet causes massive disruption of ruminal epithelial tight junctions in goats. Am J Physiol Regul Integr Comp Physiol, 305(3), R232-R241.

Loe WC, Stallcup O, Colvin H. 1959. Effect of various diets on the rumen development of dairy calves. JDS, 395-395. Amer Dairy Science Assoc 1111 N Dunlap Ave, Savoy, IL 61874.

Mahesh R, Singh G, Kumar P. 2014. Light and scanning electron microscopic studies on the rumen of goat (Capra hircus). Vet Res Int, 2, 74-80.

McGilliard A, Jacobson N, Sutton J. 1965. Physiological development of the ruminant stomach. In Dougherty RW, et al (Eds.), Physiology of Digestion in the Ruminant (pp. 39-50). Washington, USA: Butterworths.

Penner G, Steele M, Aschenbach J, McBride B. 2011. Ruminant Nutrition Symposium: Molecular adaptation of ruminal epithelia to highly fermentable diets. J Anim Sci, 9(4), 1108-19.

Sander E, Warner R, Harrison H, Loosli J. 1959. The stimulatory effect of sodium butyrate and sodium propionate on the development of rumen mucosa in the young calf. J Dairy Sci, 42(9), 1600-5.

Schnorr B, Vollmerhaus B. 1967. Die Feinstruktur des Pansenepithels von Ziege und Rind (Zweite Mitteilung zur funktionellen Morphologie der Vormägen der Hauswiederkäuer). Zentralblatt für Veterinärmedizin Reihe A, 14(9), 789-818.

Scott A, Gardner IC. 1973. Papillar form in the forestomach of the sheep. J Anat, 116(2), 255.

Steele A, Croom J, Kahler M, AlZahal O, Hook S, Plaizier K, et al.". 2011. Bovine rumen epithelium undergoes rapid structural adaptations during grain-induced subacute ruminal acidosis. Am J Physiol Regul Integr Comp Physiol 300, 1515–23.

Swan GE, Groenewald HB. 2000. Morphological changes associated with the development of the rumino-reticulum in growing lambs fed different rations. Onderstepoort J Vet Res, 67, 105-14.

Tamate H, Shiomura Y, Sakata T. 1979. Scanning Electron Microscopic Observation of the Sheep Ruminal Mucosa at its Epithelium-Connective. Tohoku J Agric Res, 30(2), 87-95.

Weyrauch K, Schnorr B. 1979. Der Papillarkörper der vormagenschleimhaut bei Schaf und Ziege. Anat Histol Embryol, 8(3), 248-61.

Yamamoto Y, Atoji Y, Agungpriyono S, Suzuki Y. 1998. Morphological study of the forestomach of the Japanese serow (Capricomiscrispus). Anat Histol Embryol, 27(2), 73-81.

Yamamoto Y, Kitamura N, Yamada J, Andren A, Yamashita T. 1994. Morphological study of the surface structure of the omasal laminae in cattle, sheep and goats. AnatHistolEmbryol, 23(2), 166-76.

Yamamoto Y, Kitamura N, Yamada J, Yamashita T. 1993. Three-dimensional architecture of the subepithelial connective tissue in the omasal laminae of sheep and cattle. Cells Tissues Organs, 146 (4), 238-43.

Zitnan R, Voigt J, Wegner J, Breves G, Schröder B, Winckler C, et al. 1999. Morphological and functional development of the rumen in the calf: Influence of the time of weaning. 1. Morphological development of rumen mucosa. Archiv fur Tierernahrung, 52(4), 351-62.

OPSERVACIJE SLUZNICE PREDŽELUCA KOD AKKARAMAN OVCE PREHRANJIVANE SLAMOM I KONCENTRATOM KORIŠTENJEM STEREOMIKROSKOPIJE I SKENIRAJUĆE ELEKTRONSKE MIKROSKOPIJE

SAŽETAK

Istraživanje je provedeno sa ciljem evaluacije površine sluznice komponenti predželuca korištenjem stereomikroskopije i SEM-a kod sedam ovaca soja Akkaraman hranjenih sa slamom i koncentratom. Uzorci su dobijeni od životinja koje su hranjene sa 60% slame i 40% koncentrata, zaklanih u lokalnoj klaonici. Rezultati su pokazali da su na cijeloj površini buraga bile prisutne ruminalne papile, osim u području pila. Njihov oblik je znatno varirao veličinom i oblikom, od kratkih lingualnih do dugih i širokih u obliku lista. Neke papile su imale asimetrične duple vrhove. Ćelije sluznice buraga su većinom bile intermedijarnog tipa. Mjestimično im je oblik ličio ćelijama balonastog tipa. Jasno su prikazane i retikularne kriste u kapuri i lamina omasuma, s tim da pojedini tipovi papila sa svojim osobitostima nisu bili izraženi na makroskopskoj razini. Na mikroskopskoj razini su u lamini omasuma postojale strukture tipa papila koje su imale glatku površinu i jedan, ponegdje dva grebena. Sloj oljuštenog epitela kojeg čine ćelije u obliku roga je bio upadljiv ukazujući na regeneraciju papila. Rezultati pokazuju karakteristike životinja koje se hrane slamom i koncentratom.

Ključne riječi: Intermedijarni tip jedača, ovce, komponente predželuca, SEM.