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ORIGINAL ARTICLE

Light Microscopic Studies on the Abomasum of Goat (*Capra hircus*)

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Abstract

The abomasums was lined by simple columnar epithelium in cardiac, fundic and pyloric regions including torus pyloricus. The glands of all the regions were uniformly simple branched tubular having varying number of mucous neck cells, chief, parietal and endocrine cells. The surface epithelial and glandular cells showed varying affinities for glycogen, acid and neutral mucopolysaccharides and Alcianophilic reaction. The endocrine cells were distributed maximally in the fundic gland region. Lymphoid aggregations were observed only in torus pyloricus region. Abomaso-duodenal junction was characterized by appearance of villi lined by simple columnar epithelium.

Keywords: Abomasum, Cardiac, Fundic, Pyloric region, Torus pyloricus, Endocrine cells, Goat.

1. Introduction

Abomasum being glandular in nature plays an important role in preparation of ingested food for digestion by action of gastric juices. The aggregated lymphoid nodules area has been discovered as a special immune structure only in abomasum of Bactrian camels and there was a close relationship between its degree of development, anatomical characteristics and age (Zhang *et al*., 2012). The histological structure of compound stomach has been reported earlier in goat (Chungath *et al*., 1985). An attempt has been made to explore histomorphological and histochemical architecture of abomasum with emphasis on distribution of endocrine cells during present study in goats.

2. Material and Methods

The present study was conducted on abomasum of 10 young goats of either sex of local mixed breed. The tissues were collected from different regions of the abomasum including torus pyloricus and abomaso-duodenal junction. The tissues were fixed in 10 % neutral buffered formalin and paraffin sections of 5-6 µ were stained with routine Harris' hematoxylin and eosin stain for demonstration of morphostructural characteristics, Gomori's method for reticulum, Weigert's method for elastic fibres, McManus' PAS method for glycogen, PAS-Alcian blue method for mucosubstances (pH 2.5), Alcian blue method for mucosubstances (Luna, 1968), Crossman's trichrome stain for collagen fibres (Crossman, 1937) and Fontana method for enterochromaffin cells (Humason, 1966).

3. Results and Discussion

The abomasum of goat was true stomach and divided into cardiac, fundic and pyloric regions. All the regions presented elevations in mucosa called as gastric areas which were separated from each other by gastric pits.

3.1 Cardiac Region

This region present close to the omasum showed simple columnar epithelium. The nuclei of columnar cells were elongated and pushed towards the basal portion (Fig 1). However, towards the pits these cells were having round to oval nuclei. The cytoplasm of these cells was finely granular and eosinophilic. The goblet cells of the surface epithelium showed the strong PAS positive reaction (Fig 2). At places, small vacuolated areas were also observed may be due to washing of mucus during the processing of tissue. These cells were also positive for acidic and neutral mucopolysaccharides with the predominance of later. However, the concentration of acidic mucopolysaccharide was more towards the gastric pits. These cells also presented strong positive reaction for Alcian blue.

The lamina propria mucosae was having very small amount of loose irregular connective tissue along with fine reticular and collagen fibres. The majority of the portion was occupied by the cardiac glands which –

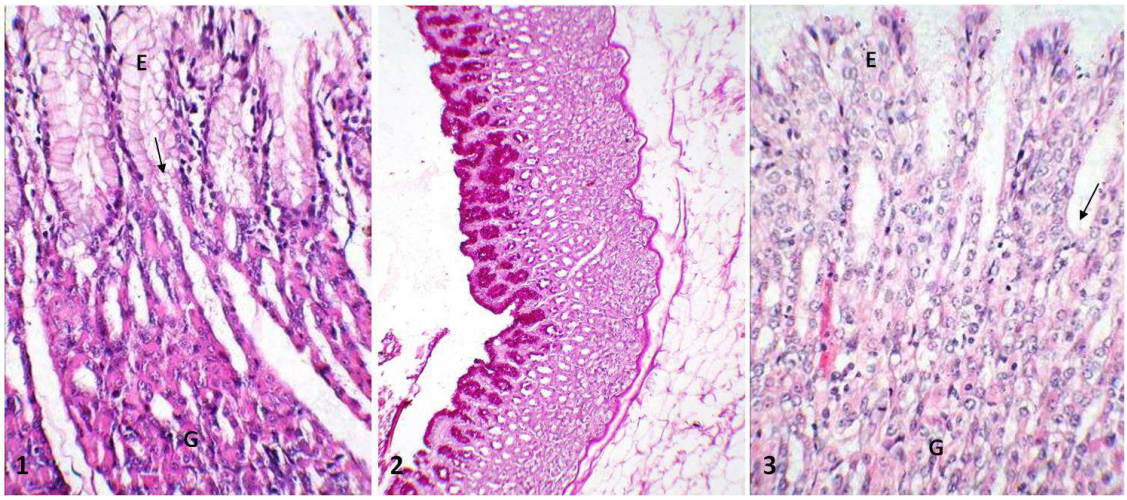

Fig 1: Photomicrograph showing cardiac gland region of abomasum. Note the simple columnar epithelium (E) and the cardiac glands (G). H and E x 400.

Fig 2: Photomicrograph of cardiac gland region showing strong PAS positive reactions in epithelium. McManus' PAS x 100.

Fig 3: Photomicrograph of fundic region of abomasum showing simple columnar epithelium (E) of gastric folds, gastric pits (↑) and fundic glands (G). H and E x 400.

were simple, branched and tubular in nature as reported in cattle (Aage *et al*., 2007). However, Kalita and Chandramouly (1997) in buffaloes reported that these glands were coiled, branched and compound tubular glands. The cardiac glands extended approximately 0.5 mm wide in the sheep (Sommervillie, 1956). Lamina muscularis mucosae was thin uniform layer and generally oriented in a single layer. The tunica submucosa was having a loose irregular connective tissue.

3.2 Fundic Region

Its mucosa having gastric areas was lined by simple columnar epithelium having large number of goblet cells (Fig 3). The round to oval nuclei was less basophilic and showed irregular distribution of fine chromatin material. The nucleoli one or more in number were centric or eccentric in position. The epithelial height of surface epithelial cells decreased towards the gastric pits. These cells showed presence of PAS positive material only in the supranuclear portion towards the luminal surface. This reactivity was comparatively more towards the base of gastric pits. These cells were strongly positive for the acidic as well as neutral mucopolysaccharides with the predominance of neutral mucopolysaccharides. The neutral mucopolysaccharides predominated towards the gastric areas whereas towards the pits, a few cells having more acidic mucopolysaccharides were also observed (Fig 4). Alcianophilic reaction was very strong in the surface epithelial cells, but was localized in the supranuclear position (Fig 5).

The lamina propria mucosae was having very less loose irregular connective tissue and it extended in between the folds of epithelium of the gastric areas. The fine elastic fibres extended towards the gastric pits. Few collagen fibres, fine blood capillaries and a few lymphoid cells were also present. Majority of lamina propria mucosae was occupied by the glands. The fundic glands were simple, branched tubular type (Fig 3) and were divided into neck, body and the blind end or fundus region. These glands were the specific glands and mainly four cell types were present distributing in varying numbers in various regions. In the neck, predominantly mucous neck cells and parietal cells were present as reported in buffalo (Malik and Parkash, 1977), cattle (Aage *et al*., 2007) and camel (Raji, 2011). However, these cells were not observed in buffalo (Chandramouly and Rao, 1984) and goat (Hill, 1951).

In the body, parietal and few chief cells were present, whereas in the basal part clusters of chief cells, a few parietal cells and argentaffin cells were observed (Figs 6, 7). The mucous neck cells were cuboidal to pyramidal in shape having flat nuclei placed towards the basal portion of the cells. The cytoplasm appeared vacuolated and showed PAS positive reaction towards the luminal surface. The surface cells and mucous neck cells produced a protective layer of mucin that lined the internal surface of the stomach and may reduced autodigestive activities from injuring the gastric mucosa (Samuelson, 2007). The mucous neck cells showed almost equal distribution of acidic and the neutral mucopolysaccharides with slightly more -

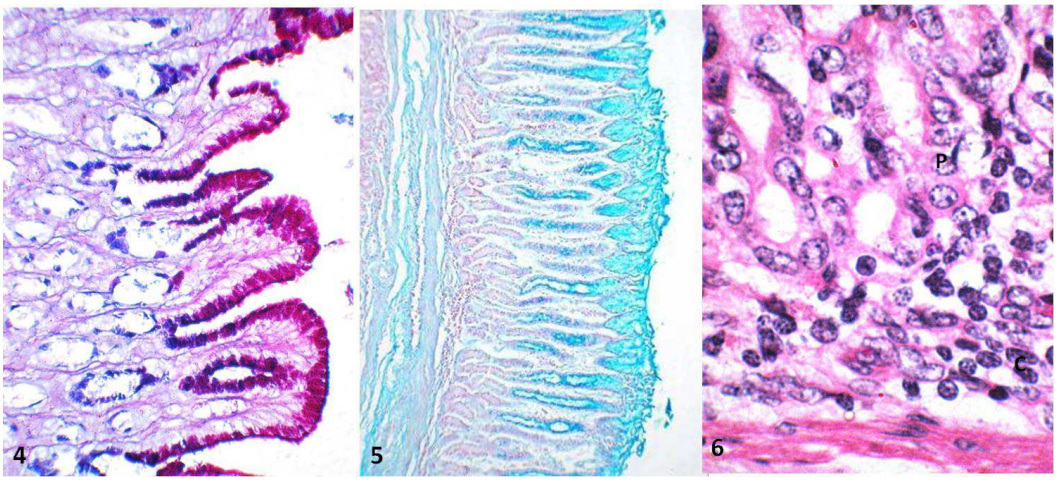

Fig 4: Photomicrograph of fundic part of abomasum at higher magnification showing the predominance of neutral mucopolysaccharides (red colour) in the surface epithelial cells, a mixed distribution of acidic (blue colour) and neutral mucopolysaccharides in the gastric pits and the basic reaction in the mucous neck cells. PAS-AB stain x 400.

Fig 5: Photomicrograph of fundic part of abomasum showing the Alcianophilic reaction in the surface epithelium and in the neck region of fundic glands. Alcian blue stain x 400.

Fig 6: Photomicrograph of the basal portion of the fundic gland showing clusters of chief cells (C) and few parietal cells (P). H and E x 1000.

tendency of the former. The mucous neck cells also showed strong Alcianophilic reaction indicating presence of hyaluronic acid, weakly sulfated mucopolysaccharides and sialomucins. The reaction was stronger as compared to that of PAS and PAS-Alcian blue reaction. The parietal and chief cells did not exhibit positive reaction.

Parietal cells were wedged in between the mucous neck cells and these cells were present along with chief cells in the body and towards the base of the fundic glands (Fig 6). Their nuclei were round and the chromatin material was aggregated irregularly in smaller clumps towards the inner nuclear membrane. One or more nucleoli were centric or eccentric in position. The cytoplasm was finely granular, homogeneous and strongly eosinophilic. The basal surface of these cells protruded towards the outer surface. Generally size of parietal cells was larger than that of chief cells. Two types of mature and immature parietal cells with vesicular nuclei have been reported in cattle (Aage *et al*., 2007).

Chief cells were less in the body but these were present in clusters in the fundus portion (Fig 6). The round to oval nuclei was of varying size. These cells possessed one nucleolus which was generally eccentric in position. The cytoplasm of these cells was slightly basophilic. Similar observations were made in buffalo (Malik and Parkash, 1977). These formed the largest group of cells in goat which were also recorded in canine (Ritchie *et al*., 1966) and buffalo (Chandramouly and Rao, 1984) but in pig the number of parietal cells was more than chief cells (Roy, 1974). These cells contained numerous secretory granules rich in proenzyme pepsinogen and have been referred as zymogen granules and thus these cells were called zymogen cells (Samuelson, 2007).

The argentaffin cells, smaller in dimension were present in between the parietal and chief cells in the body and basal part of the fundic glands. The concentration of these cells was more towards basal portion (Fig 7). Their nuclei were small and round to oval in shape. These nuclei were dark due to condensation of chromatin material. Cytoplasm of these cells contained small brown granules (Fig 7). These cells could not be demonstrated in cardiac and pyloric glands. This was in contrast to these being more in the fundus than in cardia, with very few in pylorus of sheep (Oomori *et al*., 1980) and were found abundantly in cardiac and pyloric regions of horse (Kitamura *et al*., 1984). The number of argentaffin cells of the pyloric glands was less than in fundic region in bovine (Kitamura *et al*., 1985). Some of these cells were involved in amine precursor uptake and decarboxylation and can be referred as amine precursor uptake and decarboxylation (APUD) cells (Samuelson, 2007).

The tunica submucosa had loose irregular connective tissue along with collagen, reticular and few elastic fibres. Concentration of collagen fibres increased in the submucosa especially towards the tunica muscularis. The blood vessels showed elastic fibres especially towards the tunica intima. Large

amount of fatty tissue was also observed. At places, nerve bundles in the form of submucosal nerve plexus were also observed. The tunica muscularis had a thicker inner circular, middle longitudinal and a circular or oblique outer layer. Fine nerve bundles or myenteric plexus was present in between the middle and outer layers of smooth muscles. A few elastic fibres penetrated the fasciculi of tunica muscularis. Tunica serosa was thick having mesothelium and loose irregular connective tissue.

3.3 Pyloric Region

This region was lined by simple columnar epithelium having large number of goblet cells (Fig 8). The height of the epithelial cells was almost same extending from the gastric folds to the gastric pits. The goblet cells were strongly PAS positive showing the presence of glycogen mainly localized in the supranuclear portion (Fig 9). These cells also showed strong positive reaction for acidic and neutral mucopolysaccharides. The upper portion of the epithelium of pyloric mucosa showed predominance of neutral mucopolysaccharides (Fig 10). In the middle of the extent of the epithelium, the acidic and neutral mucopolysaccharides were distributed almost equally whereas towards the gastric pits there was predominance of the acidic mucopolysaccharides. These goblet cells were also strongly positive for the Alcianophilic reaction.

The lamina propria mucosae was comparatively more as compared to the fundic region. The pyloric glands were of simple branched tubular type as reported in cattle (Aage *et al*., 2007). The glandular acini were mucous in nature and showed strong positive reaction for PAS. The reaction was localized in the supra as well as infranuclear portion. The pyloric glands close to the gastric pits showed almost equal distribution of acidic and neutral mucopolysaccharides (Fig 11). The neutral mucopolysaccharides were mainly localized in the infranuclear portion whereas the acidic mucopolysaccharides were concentrated towards the luminal surface of glandular acini. The pyloric glands in the basal portion had mainly the acidic mucopolysaccharides. The lamina muscularis mucosae were thicker and had 2-3 layers of smooth muscles oriented longitudinally.

Tunica submucosa was formed of loose irregular connective tissue having large amount of fatty tissue, collagen fibres, reticular fibres and the large number of blood capillaries and small blood vessels. The rest of features were similar to those of fundic region.

3.4 Torus Pyloricus

The mucosa of the torus pyloricus was highly folded having gastric folds and pits. The surface epithelium was simple columnar (Fig 12). The columnar shaped cells had oval to elongated nuclei which were vertically oriented towards the gastric fold and were pushed towards the base of the cell towards the gastric pits. The cytoplasm was finely granular and strongly eosinophilic. The surface cells were strongly PAS positive for glycogen and neutral mucopolysaccharides especially towards supranuclear portion (Fig 13). Few cells towards the gastric pits had acidic mucopolysaccharides. These cells also showed a weak Alcianophilic reaction.

The lamina propria mucosae was comparatively larger having loose irregular connective tissue which surrounded the clusters of glandular acini. Large amount of lymphocytes in the form of lymphoid aggregations were also observed. The simple branched tubular and coiled glands were PAS positive with predominance of acidic mucopolysaccharides. Only very less quantity of neutral mucopolysaccharides was present. In contrast, these glands showed comparatively stronger Alcianophilic reaction as compared to the surface epithelial cells. The lamina muscularis mucosae were thicker and were comprised of many cell layers.

Tunica submucosa was similar to that of pyloric region. Tunica muscularis presented several layers of which the innermost was obliquely placed and it was interrupted and not continuous, middle circular layer and outer longitudinal layer. Large amount of fatty tissue was present in between the fasciculi of innermost layer of tunica muscularis. This layer presented muscle fibres in various directions. Tunica serosa was thicker having loose irregular connective tissue, adipose tissue, few blood vessels and the mesothelium.

3.5 Abomaso-Duodenal Junction

The junction was characterized by modification of simple columnar epithelium of gastric pits into simple columnar epithelium lining the villi of duodenum (Fig 14). The abomasal portion was having features as described earlier; whereas, the epithelial cells of duodenal villi were large columnar shaped having round to oval lightly basophilic nuclei located towards the basal portion. The cytoplasm was strongly eosinophilic especially towards the luminal border. Those cells weakly positive for the glycogen showed PAS reaction only towards the supranuclear portion. Some of these cells showed strong positive reaction for the neutral and weakly sulfated mucopolysaccharides. The lamina propria mucosae were having large number of connective tissue cells along with few reticular, collagen and elastic fibres. Its majority of portion was occupied by intestinal glands or crypts of Lieberkuhn. Lamina muscularis mucosae was thin and interrupted -

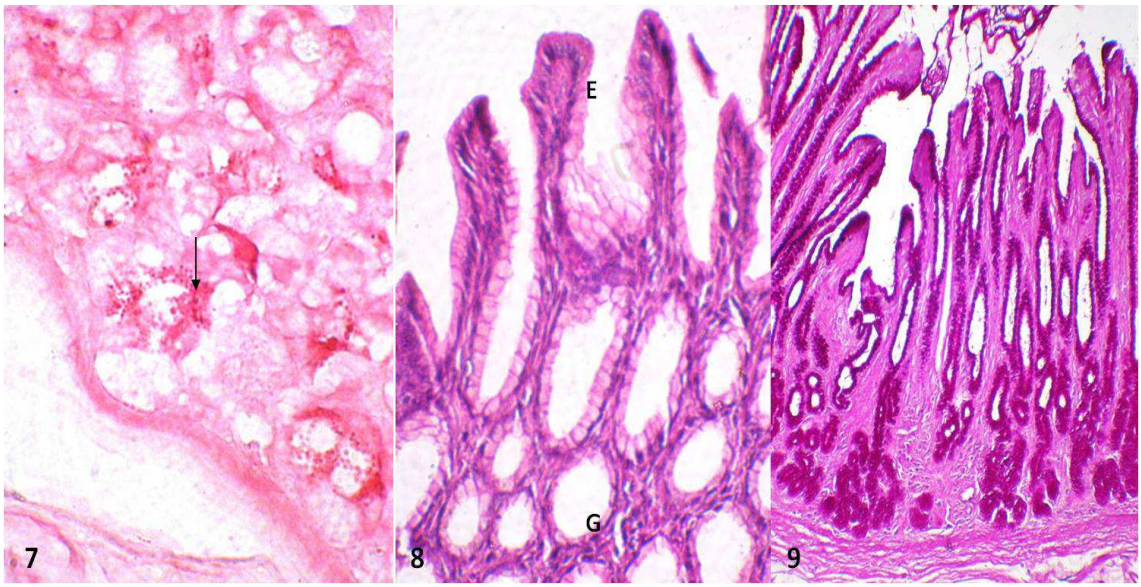

Fig 7: Photomicrograph of the basal portion of the fundic gland at higher magnification. Note the fine granules (↑) present in the endocrine cells. Fontana method x 1000.

Fig 8: Photomicrograph of the pyloric region of abomasum showing the simple columnar epithelium (E) and the pyloric glands (G). H and E x 400.

Fig 9: Photomicrograph showing the presence of PAS positive reaction in the surface epithelium and the pyloric glands. McManus PAS x 100.

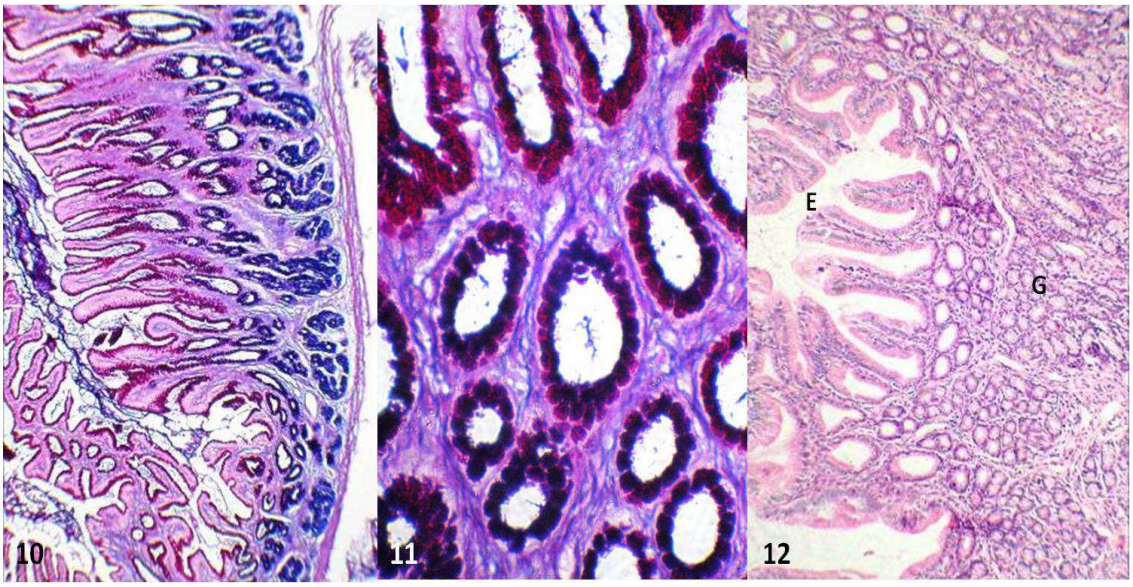

Fig 10: Photomicrograph showing the presence of acidic (blue) and neutral (red) mucopolysaccharides in the surface epithelium and the pyloric glands. PAS-AB stain x 100.

Fig 11: Photomicrograph of superficially placed pyloric glands showing mixed distribution of acidic and neutral mucopolysaccharides. PAS-AB stain x 400.

Fig 12: Photomicrograph of torus pyloricus showing folded mucosa having simple columnar epithelium (E) and the glands (G). H and E x 100.

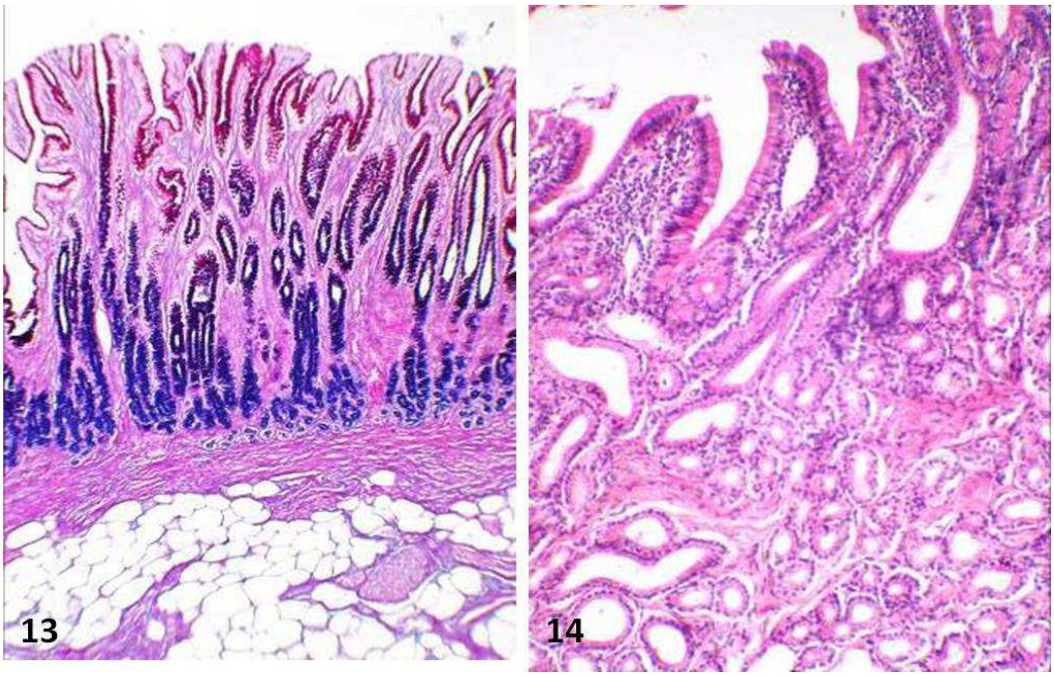

Fig 13: Photomicrograph of torus pyloricus showing presence of neutral (red) and acidic (blue) mucopolysaccharides in the epithelium and in the pyloric glands. PAS-AB stain x 100.

Fig 14: Photomicrograph of abomasoduodenal junction. H and E x 100.

allowing the continuation of crypts of Lieberkuhn and submucosal or Brunner's glands. Intestinal glands were strongly positive for the acidic and only very less concentration for the neutral one. Brunner's glands were mainly positive for the acidic mucopolysaccharides. Some of the glandular acini were positive for glycogen. Tunica muscularis presented three layers, an inner longitudinal, middle circular and outer oblique layer. Tunica serosa was having mesothelium and large amount of connective tissue, few fine blood vessels and nerve bundles.

4. Conclusion

The cardiac, fundic and pyloric regions of abomasums presented gastric folds and pits lined by simple columnar epithelium. All the regions had simple branched tubular glands with varying numbers of cell types in lamina propria mucosae. The cells of surface epithelium and glands showed varying concentrations of glycogen, acidic, neutral and weakly sulfated mucopolysaccharides, sialomucins and hyaluronic acid. Endocrine cells could be demonstrated mainly in fundic region whereas small isolated aggregations of lymphoid tissue were localized in torus pyloricus. These findings may be utilized by physiologists and endocrinologists to plan different experiments to explore their functional significance.

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