# A comparative histological and histochemical study of colon in goat (*Capra hircus*) and sheep *Ovis aries*

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**Abstract**
This study aimed to comparative the histomorphometry structure of colon in sheep and goat. Seven samples from each animal, the specimens for histological and histochemical study were taken from different regions from each of the portion of colon (ascending, descending and transverse). The colon wall was composed of four tunicae; mucosa, submucosa, muscularis and serosa. The mucosa showed three different layers; the lining epithelium, the muscularis mucosa, and the lamina propria containing Lieberkühn crypts. The epithelium lined the mucosal folds and was composed of simple columnar epithelia with goblet cells. Goblet cells had been globular-shaped, unorganized mucus which were dispersed among the rows of epithelium cells and Lieberkühn crypts. The colon's mucosa was identified by the presence of long-shaped folds that were grouped in a zigzag arrangement in sheep and leaf-shape mucosal folds make up the mucosal surface in goats. Sheep have simpler, tubular, straight, unbranched glands in their colon epithelium than goats. Goats have intestinal glands at the lamina muscularis, while sheep have aggregated lymphatic nodules near the lamina muscularis. The goblet cells in the lining epithelium with Lieberkühn crypts of goat and sheep had robust positive reactions to both periodic acid Schiff stain and Alcian blue, whereas all research animals showed negative reactions with Alcian blue. The submucosa is made up of dense, connective tissue that contains nerves and blood vessels. The muscularis externia was made up of inner circular layer and outer longitudinal layer. In certain colon locations, the outer layer's smooth muscle layers had non-continuous, altered thickenings that were primarily localized into three flat bands, or taeniae coli. In sheep, the tunica serosa was made up of collagen and elastic fibers; in goats consists of only collagen fibers, the adventitia; loose connective tissue in certain areas of the colon of goat and sheep. These tunicae were thicker in sheep colon than in goat colon. Conclusions: Animals undergo several modifications as a result of evolution in order to adapt to their surroundings. Every species has distinct characteristics that aid in their survival and allow them to eat a variety of foods.

**Keywords:** colon, sheep, goat, histological, histochemical

## Introduction

Goats are found all over the world since they are amongst the livestock animals that can adapt to a wide range of environmental circumstances. Goats may live on a small plot of land and in a variety of agroclimatic conditions with a diverse range of vegetation. They may transform low-quality fibrous along with other feedstuffs into extremely nutrient-dense milk and meat (1,2). The milk, skin, and wool from the goat and sheep production, which will also be a major source of income for the state government (3). Goats generally browsers (weeds, bushes), more independent, inquisitive, and skilled escape artists; goats require more copper since they consume leaves, shrubs, and weeds. are inherently curious and self-reliant animals, sheep are grazers, and consume grass (4). They prefer to consume leaves, twigs, and weeds over grass, making them browsers rather than grazers. They are great at cleaning overgrown terrain because of their browsing behavior, but they also need specialized fencing and dietary strategies. In most regions, both species breed seasonally; for spring births, breeding usually takes place in the fall. Planning breeding initiatives and getting ready for the ensuing phases of intense care require an understanding of these natural cycles (5,6). Domestic sheep and goats have ancient and closely related livestock that are both ruminants. However, they differ in behaviors (sheep flock, whereas goats browse) (7). (8) said they sheep and goat are frequently raised in similar harsh environments and have provided vital products for humanity for millennia. Goats often have short hair, straight tails facing up, and beards; sheep, on the other hand, usually grow wool, have no beards, and have tails pointing down (9). Goats, Browsers; foliage, plants, higher-quality food, and lighter fiber. A higher passage rate results in a lower need for; lot of lymphoid tissue, a lot of mucous (10. The gastrointestinal system of sheep is essential for the storage and digestion by microbes of feed, which is necessary for meeting energy needs and preserving bodily functions. Different functional capacities are imparted to certain segments of the gastrointestinal system by their structural and functional abilities (11-13). For productive performance, such as optimal development with high-quality milk and meat production, the gastrointestinal tract's optimal health and effective functioning abilities are essential (14). Comparative studies across animals are crucial, with a particular emphasis on their structures. These studies help to more fully comprehend the evolutionary process overall by demonstrating the degree of similarity and difference between species in terms of functionality and composition. However, in order to comprehend the relationships between eating patterns and metabolic requirements.

## Materials and method

**Ethical approval**

Every operation was carried out in accordance with the Animal Care and Use Committee of the College of Veterinary Medicine at AL-Muthanna University's section of histology and anatomy.

**Animals**: Seven colon samples were taken from each healthy male adult goat (*Capra hircus*) and ram (*Ovis aries*) that weighed between 100 and 120 kg and were killed at the AL-Muthanna butcher between two and three years of age. The colon was removed from the colic junction to the start of the sacculation at the colo-rectal junction. The intestinal tract has been separated and dissected away from its connections through the dorsal abdominal wall during the collection phase, which ran from October 2025 until January 2026. Six specimens (0.7-0.8 cm) from various colon segments ascending (centripetal, central, and centrifugal), transverse, and descending were prepared with normal saline and subsequently preserved in 10% formalin during 48 hours above room temperature. Hematoxylin and Eosin (H&E) was used for histological characteristics, Masson's trichrome was used for muscle and collagen fibers, and Verhoef was used for elastic fibers, periodic acid Schiff and Alcian blue for carbohydrates (15).

**Statistical Analysis;** One-way evaluation of variance, ANOVA, tests were used to assess the study at 1% significant levels. Social science statistical techniques were used to process and regulate the data (16).

## Results and discussion

Sheep and goats have the same colon wall composition; mucosa, sub-mucosa, muscularis and serosa (Fig.1-3), while the thickness of those layers varies (Table 1). Because goats eat more green material that is high in cell solubles, their colon plays a comparatively larger function. Sheep's colon is mostly specialized to break down fibrous leftovers from grass (17). The colon's mucosa was identified by the presence of long-shaped folds that were grouped in a zigzag arrangement in sheep and leaf-shape mucosal folds make up the mucosal surface in goats. These folds may improve the surface area available for absorption, A single layer of taller columnar epithelial cells including goblet cells that secrete mucus border these creases. Basal nuclei are seen in the epithelial cells. The goblet cells feature a small, spherical nucleus in the lower section and a large, mucinous granule-filled upper part (Fig.2,4,5) as this study is similar to (17,18). However, mucosa in the colon of both sheep and goats lacks villi or plicae. Instead, the mucosa is composed of a simple columnar epithelial layer that contains goblet cells that secrete mucus and columnar cells that have long, oval, strongly basophilic nuclei (Fig.3,6,7) are similar in other ruminants (17,19). The lumen, which is composed of several cell types such as goblet cells as well as absorptive columnar cells, is lined with a thin basement membrane which supports the basic columnar epithelium (Fig. 4,5,8-12). These results in sheep were in line with (19). Mucosal epithelium and generated mucus coating those organs are crucial for providing a physical barrier from pathogen or microorganism invasion, that could be harmful to the ductal tissue parenchyma (7,20).

The intestinal glands, which are simple tubular, straight, unbranched glands composed primarily of goblet cells and a small number of columnar cells, are found in the loose connective tissue that forms the lamina propria. Numerous mucus secretion cells surround feces globules with a mucous coating that shields the epithelium and aids their release, as reported by (19,21). The proximal colon possessed more Lieberkühn crypts that the other sections, as shown by the histogram (1,2), and also a greater number of goblet cells, also the colon in sheep had more number than that in goat (Histogram 3); this result is in line with (5). Lipid absorbing and the provision of an obstacle that is selectively permeable against different antigens to regulate interactions among the body and the external environment were the main functions of this epithelium. The height of the epithelium rose during the protective immune reaction.

Smooth muscle fibers are arranged longitudinally in the muscularis mucosa, which is thicker in sheep than in goats (Table 1). It creates the mucosa's outer border that the digestive system is moved and combined by the muscular mucosa (1,22). According to Table 1, there were non-significant ($p<0.05$) changes between the thickness of the mucosa in the colon section between sheep and goats. This could be because of the nutritional similarities. Conversely, the amount and sources of dietary fiber have an impact on the gastrointestinal tract mucosa's morphology, including villous height, goblet cell count, and crypt depth. These alterations have an indirect impact on animal growth, which has an impact on intestinal cell proliferation (2,23-27). Sheep have more goblet cells because of slower digesta transit or because their diet contains more bulkier fiber (Histogram 3), which results in thicker mucus for lubrication, more noticeable lymphoid aggregates, thicker walls, deeper crypts linked to higher epithelial turnover, more noticeable mucosal folds and stronger muscularis externa, increased mucus production, more thorough immune monitoring, and thicker muscularis externa (more mixing, slower digesta passage).

The submucosa beneath the mucosa is made up of loose connective tissue, but it lacks lymphatic nodules and glands in the colon (Fig.2,3). Sheep's colon submucosa was thicker than goats' (Table 1), which is consistent with what they found in camelus dromedaries (10,21). When compared to the identical parts of goats, thickness of muscular sheep was greater (Table 1). This finding contradicts the findings of (3), This is in contrast to the study conducted by (23), which found lymphoid aggregation in alpaca. Gut-related lymphoid tissues have only been seen in ileocecal patches, although they have been seen in ruminants, dogs (7, 28-31).

The muscularis layer is composed of two layers of smooth muscle fibers: an external longitudinal layer with loose connective tissue and an inside circular layer with greater thickness (Fig. 1,2,6). The statistical study showed that the muscularis thickness varied significantly across the colon (Table 1). These tunica's role in the intestine's contractions implies that the colon's movements were a little quicker than those of the other parts in order to facilitate the digestion and absorption of the intestine's contents. The outer layer of the colon was divided into three distinct bands, which are referred to as taeniae coli in sheep. (5,24) revealed that the large intestine's haustra, or sacculation's, are created by taenia coli contractions or tonus. Moreover, a tiny amount of loose connective tissue, called the serosa layer contained blood vessels, nerves, and a few tiny elastics, thickness of muscular sheep was greater. This finding contradicts the findings of (4), who said that the thickness of the muscularis in the colon of cattle was 2380±16µm, which may be connected to the location and function of the large intestine. Buffering and fecal material ejection from this area were linked to muscularis thickening (25,26), layers of the thick muscle; usage is less than that of sheep in regard to body weight. Nutrients are more efficiently extracted by their digestive system. Sheep will not eat rough, inferior veggies, although they can use them. Their bodies were smaller than those of most sheep breeds. Goats also eat less than sheep, benefit from inadequate and meager nourishment, digest fibers, like coarse turf, are better adapted for arid places, are resilient to harsh settings, and produce a lot. A number of non-food extraterrestrial things are consumed by sheep that are allowed to roam freely and search for meals. These indigestible foreign materials cause a range of histopathological changes in the intestinal walls of sheep. The layers of smooth muscle make up the lamina muscularis. Sheep had the greatest elasticity in this lamina muscularis, while goats had the least. Sheep's ascending colon contains Taeniae coli, while goats do not. The wall puckers as a result, creating sacculation that expand effective surface area. Their synchronized contraction facilitates the mixing of microbial populations with fibrous ingesta. Their contraction facilitates ingesta mixing and movement in the direction of the distal colon. They help with the contents' gradual propulsion, which is essential for fermentation. Because sheep rely more on foregut fermentation than hindgut fermentation, taeniae coli are not as common or functionally important in ruminants as they are in horses (2,17,23).
The goblet cells of the intestinal glands and epithelial surface exhibit a robust response to PAS of the colon (Fig. 9). This indication revealed a neutral mucus that makes it easier for feces to move through, but the columnar cell's response to PAS was poor. Additionally, the colon epithelium was stained by PAS, and intestinal glands and goblet cells have been found to be PAS positive (Fig.9,11). This study, however, contradicts (22), which found the Lieberkühn crypts exhibited a prevalence of acidic muco-polysaccharides. This discrepancy could be attributed to the quality of the food. Goblet cells release mucus that reacts favorably to alcian blue and includes high concentrations of acidic mucopolysaccharides. Because their mucus includes carbohydrate-rich glycoproteins which react with PAS stain, goblet cells in the goat colon mucosa were PAS-positive (Fig.9,11). According to histochemical data, the goblet cells' quantity and composition varied among the study animals in the colon's sections, exhibiting high mucous secretion and a greater number in goblet cells compared to the proximal colon (Fig.9,11). This outcome is consistent with a camelid observation (13,21). The goblet cells' mucin staining intensity varied from negative, weak, moderate, and strong with periodic acid Schiff, Alcian blue pH 2.5, and paired Alcian blue-periodic acid Schiff (Fig.9,11). The composition of secreted mucins and the content of intestinal goblet cells in sheep and goats are thought to be similar to those in mammals. The production of secretory vesicles containing neutral, and acidic, glycoproteins (23,27,28) indicates that the composition of the glycoconjugate of the goblet cells varies depending on the species and the intestinal region. Secretory granules in the colon's columnar cells reacted poorly with alcian blue stain and strongly with periodic acid Schiff. Neutral mucins have been linked to absorption of readily digested materials, including short-chain fatty acids and disaccharides. Maintaining an impartial setting on luminal surface is thought to create an ecological niche for the bacteria that produce particular vitamins or digesting enzymes.

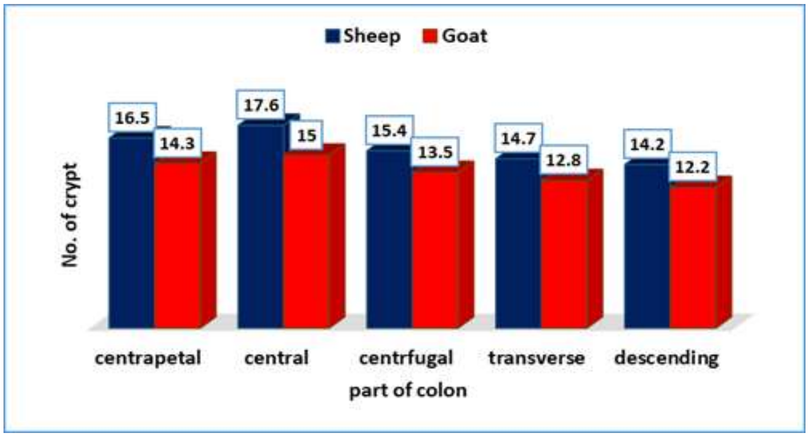
**Table, (1):** Measurements wall layers of parts of colon in sheep and goat, µm

| Tunics / Part | Mucosa | Submucosa | Muscularis | Serosa |
|---|---|---|---|---|
| Centripetal flexure of ascending colon in sheep | 655.1±1.1a | 186.7±0.5b | 496.1±0.7c | 65±0.5e |
| In goat | 615.3±0.9a | 172.0±0.6b | 490.5±1.4c | 59.3±0.2e |
| Central flexure of ascending colon in sheep | 670.10±0.6a | 196.0±0.5b | 525.0±0.1c | 66.4±0.3e |
| In goat | 655.1± 0.7a | 182.3± 0.5b | 507.5±0.4c | 61.8±0.2e |
| Centrifugal flexure of ascending colon in sheep | 603.1±1.1a | 172.2±0.6b | 460.5±0.8c | 59.0±0.4e |
| In goat | 582.9 ±0.7a | 166±0.3b | 451.1±0.3c | 57.7±0.3e |
| Transverse colon in sheep | 573.1±1.1a | 162.2±0.6b | 450.5±0.5d | 57.0±0.1e |
| In goat | 553.9 ±0.8 a | 156±0.4b | 442.1±0.7d | 54.7±0.3e |

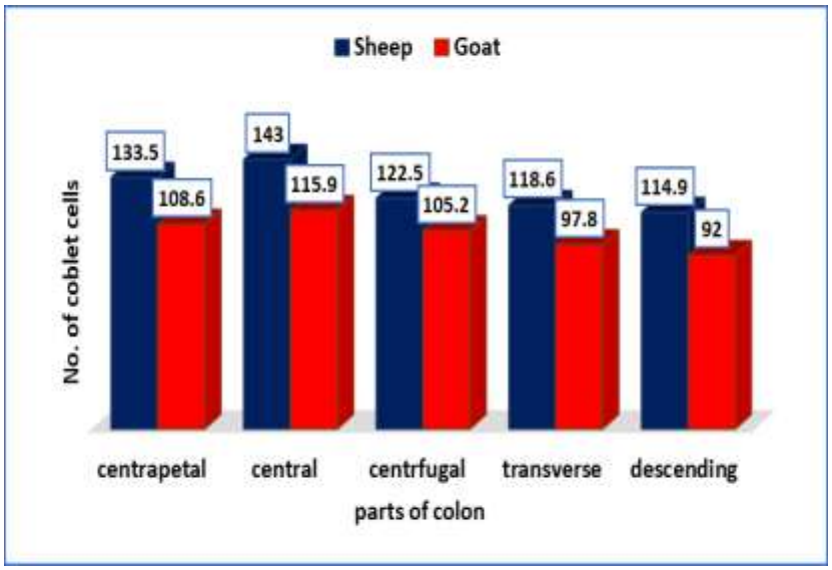
| | | | | |
|---|---|---|---|---|
| Descending colon in sheep<br>In goat | 533.1±1.1a<br>513.9 ±0.5 a | 152.2±0.6b<br>142±0.3b | 440.5±0.8d<br>431.1±0.6d | 55.0±0.4e<br>51.7±0.6e |

Values in small letters in one column denote to significant differences (P>0.01)

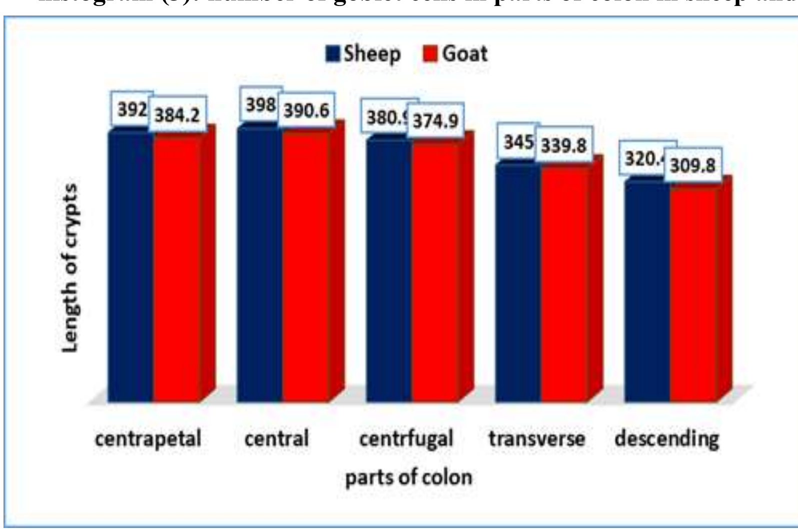
**histogram (1): Measurements length of crypt in parts of colon in sheep and goat, (μm )**




**histogram (2): number of crypt in parts of colon in sheep and goat,**




**histogram (3): number of goblet cells in parts of colon in sheep and goat,**



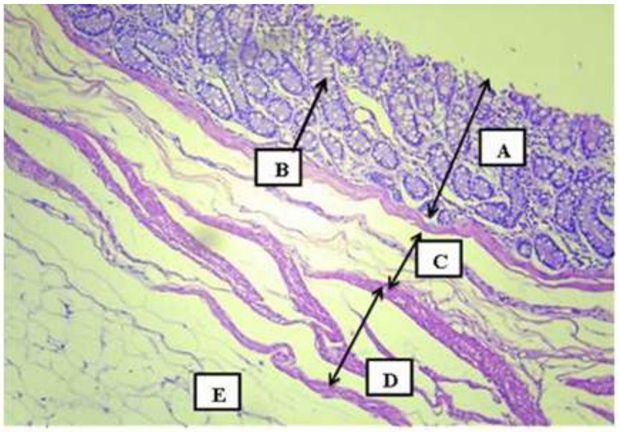



**Fig. (1) :** Longitudinal microscopic section of the colon of goat, mucosa (A), goblet cells (B), submucosa (C), muscularis externa (D), serosa (E), H&E Stain 40X

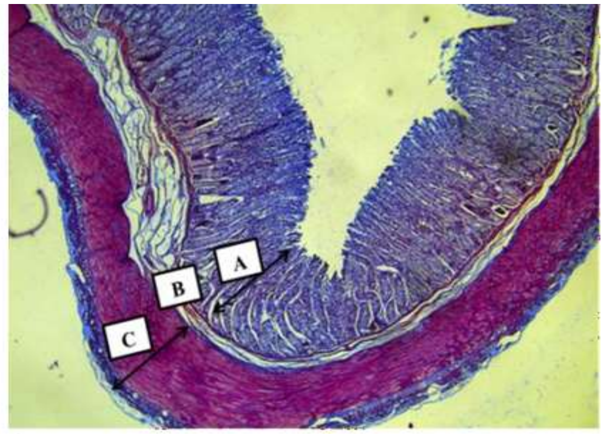



**Fig. (2):** Longitudinal microscopic section of the colon in sheep, mucosa (A), submucosa (B), muscularis externa (C), **Masson Stain 4X**

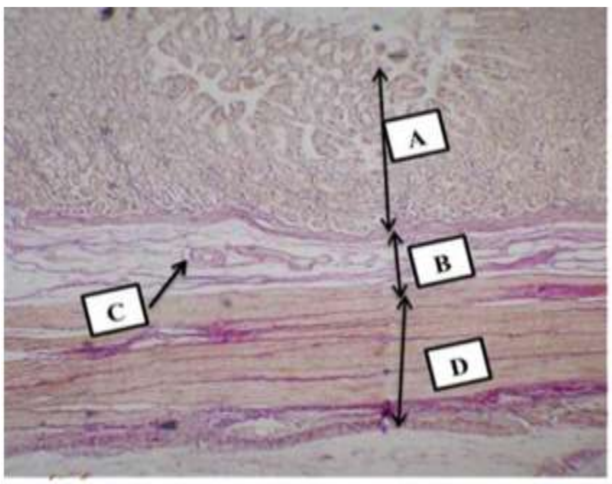



**Fig. (3):** Longitudinal microscopic section of the colon in goat, mucosa (A), submucosa (B), blood vessels (C), muscularis externa (D), **Verhoeffs' Stain 4X**

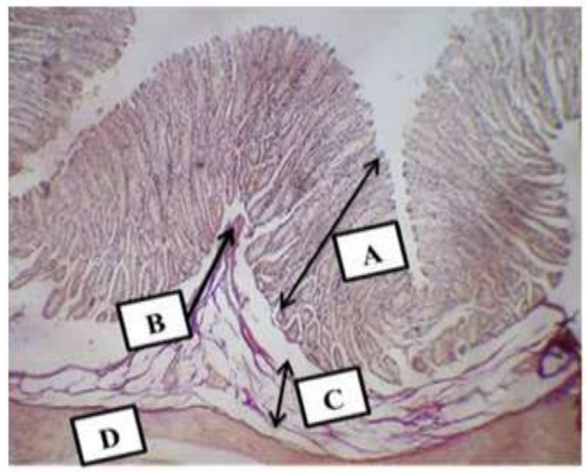



**Fig. (4):** Longitudinal microscopic section of the colon in sheep, mucosa (A), mucosal folds are long (B), submucosa (C), muscularis externa (D), **Verhoeffs' Stain 4X**

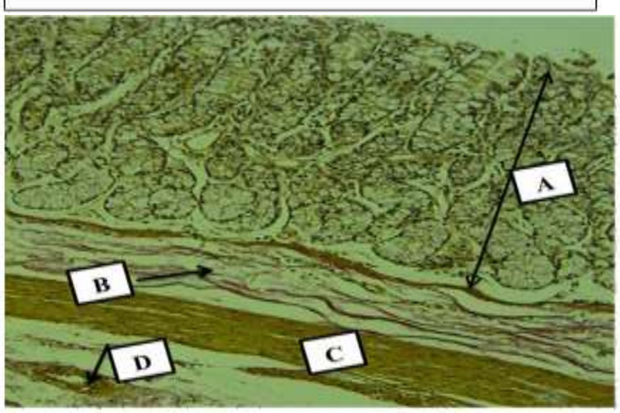



**Fig. (5):** Longitudinal microscopic section of the colon in sheep, mucosa (A), connective tissue in submucosa (B), muscularis externa (C), blood vessels (D), **AB Stain 100X**

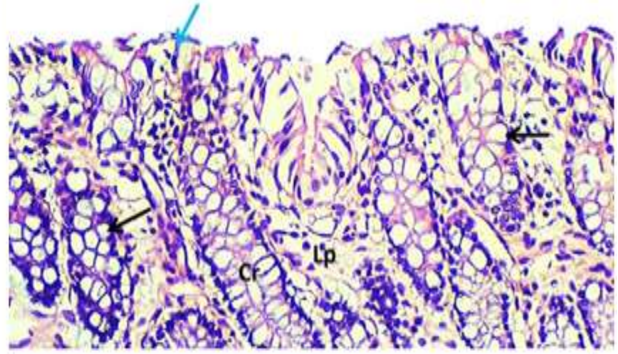



**Fig. (6) :** Cross section of colon in goat show: epithelium (blue arrow), lamina propria (LP), crypt of Liberhan (Cr), goblet cell (G). H&E stain. X200.

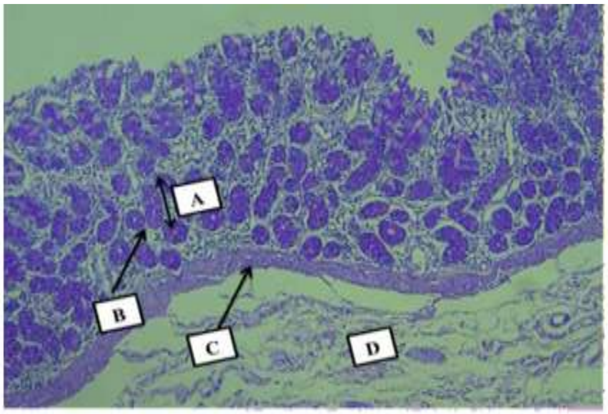



**Fig. (9):** Longitudinal microscopic section of the colon in goat, crypts (A), goblet cells (B), muscularis mucosa (C), connective tissue (D), **PAS Stain 100X**

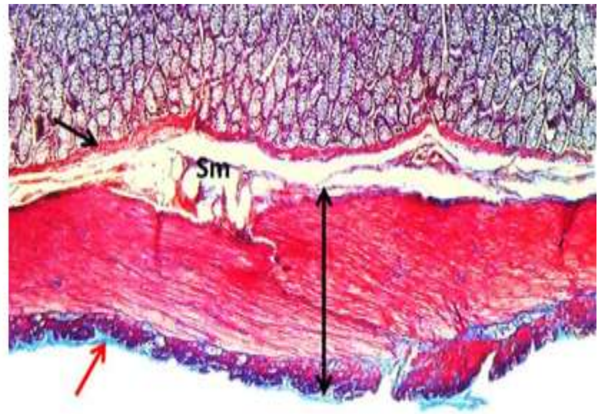



**Fig. (10):** Cross section of colon in sheep: muscularis mucosa (black arrow), submucosa (Sm), muscularis (double head arrow), serosa (red arrow). Masson trichrom. X40.

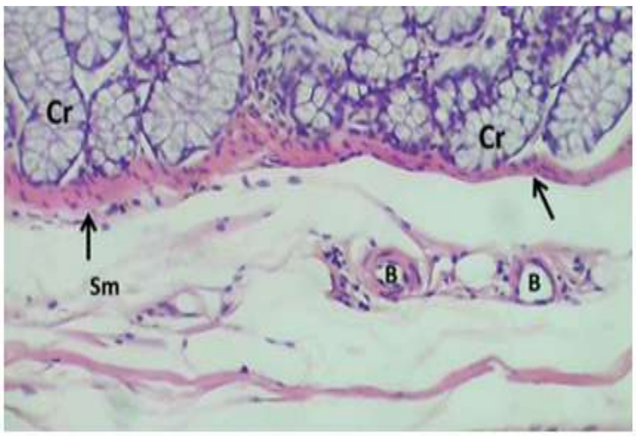



**Fig. (7):** Cross histological section of colon in goat show: crypt of liberkhan (Cr), muscularis mucosa (black arrow), tunica submucosa (Sm), blood supply (B). H&E stain. X200.

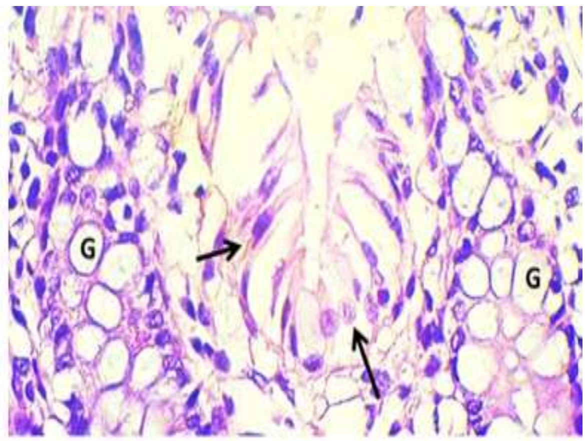



**Fig. (8)** Cross histological section of colon in local sheep show: simple columnar cell (black arrow), goblet ell (G). H&E stain. X400.

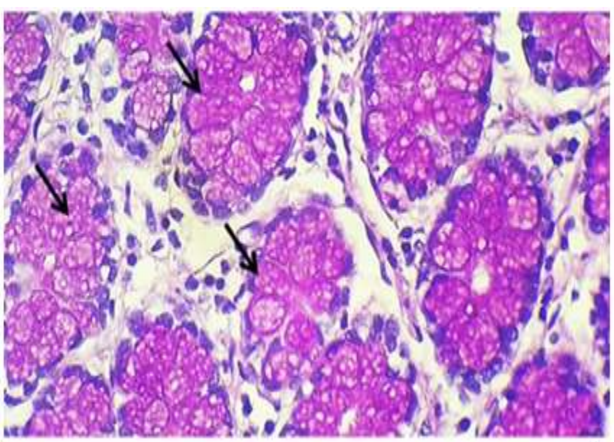


**Fig. (11):** Cross section of colon in sheep show: with high magnification this figure show strong reaction for periodic acid shif stain with the goblet cell (black arrow). PAS-AB stain.

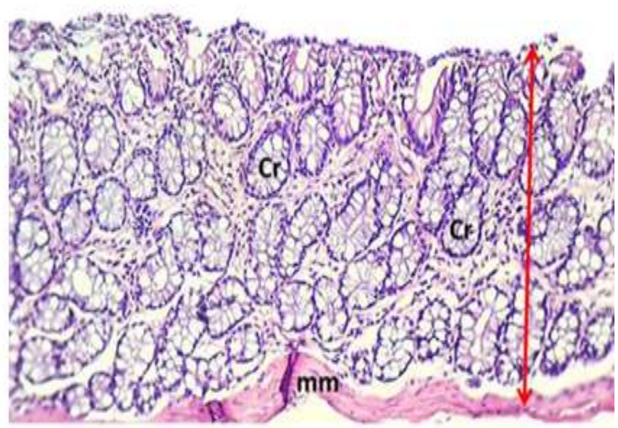



**Fig. (12):** Cross section of colon in sheep show: mucosa (Red arrow), crypt (Cr), muscularis mucosa (mm). H@E stain. X200.

## Conclusion

Although goats and sheep are considered small ruminants, their dietary habits and preferences differ significantly due to differences in feeding behavior and digestive physiology. This study examined variations between species in histomorphometry and histochemical characteristics of the colon. The information now available will be useful in identifying any colon modifications. The basic features of ruminant large intestine architecture, such as a simple columnar epithelium with many goblet cells, established crypts of Lieberkühn, as well as a typical two-layered muscularis externa, are shared by sheep and goats, according to a comparison of their colon histological structures. However, their digestive physiology and feeding patterns are reflected in clear quantitative disparities. Because they are mostly grazers, sheep have longer colons, tougher intestinal walls, deeper crypts, greater goblet cells, and more widespread lymphoid tissue adaptations that facilitate enhanced fermentation, slower digesta transit, and better mucosal protection. Goats, on the other hand, exhibit somewhat thinner walls, less goblet cells, fewer lymphoid aggregation, as well as shallower crypts, all of which are indicative of a quicker passing rate and a diet made up of less fibrous, more selective material. Overall, the two species' ecological feeding patterns and digestion needs are correlated with small but constant differences, even if the fundamental histological organization is intact.

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