AATCC Review

30 January 2026: Received
12 March 2026: Revised
13 April 2026: Accepted
22 April 2026: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Cytoarchitectural characterization of the adult porcine liver of the Jammu region

Haneet Singh, Jasvinder Singh Sasan*, Shalini Suri, Kamal Sarma, Lovish Sethi and Shivangi Bhardwaj

Division of Veterinary Anatomy, Faculty of Veterinary Science & Animal Husbandry, SKUAST-Jammu, 181102 India

ABSTRACT

The present study aimed to describe the histomorphological features of the porcine liver due to its importance in veterinary medicine, biomedical research, and its relevance as a comparative model for human studies. Histologically, pig liver was covered by a mesothelial layer and a well-developed Glisson's capsule composed predominantly of collagen fibers, which extend into the parenchyma forming prominent interlobular septa. The most distinctive feature was well-defined classical hepatic lobules, polygonal to hexagonal in outline, with a centrally located central vein and portal triads at the periphery. Hepatocytes were polygonal in shape, arranged in radiating plates, and exhibited occasional binucleation. The hepatic sinusoids were lined by endothelial and Kupffer cells. Portal triads, consisted of portal vein, hepatic artery, and bile ductules. Overall, the study demonstrated a highly organized liver architecture in pigs, characterized by distinct lobulation and well-developed connective tissue septa, reflecting structural adaptations for efficient metabolic, circulatory, and biliary functions.

Keywords: *Glisson's capsule, Hepatocyte, Liver, Pig, Portal triad.*

Introduction

In our country, the total number of livestock is 535.78 million, with pigs accounting for 9.06 million (01.70%) (Livestock Census 2019). Although India has a large pig population, the production of swine is not fully developed (Chauhan *et al* 2016). Pigs have great potential to provide quick economic benefits to farmers because of their efficient feeding, early maturity, and short generation time (Banerjee 1998). Pigs are also of interest in biomedical research because they are similar to humans in their body structure, function, and disease processes. They are widely used in various scientific fields, such as immunology, organ transplantation, heart disease, and wound healing (Wang *et al* 2023).

The liver is both structurally and functionally complex, second only to the brain in complexity (Malarkay *et al* 2005). It has many important roles, such as efficient uptake of amino acids, carbohydrates, bile acids, cholesterol, proteins, lipids, and vitamins (Burt and Day 2002). It also helps in removing waste, producing clotting factors, fibrinogen, albumin, and other proteins, fighting infections, breaking down toxins, processing drugs, and supporting the body's ability to produce blood cells (Eurell and Frappier 2006). Understanding the liver's anatomy is crucial for interpreting these processes.

Understanding the histoarchitecture of the porcine liver is vital for explaining its metabolic, synthetic, and detoxification functions, as well as for accurate diagnosis of hepatic disorders.

Corresponding Author: **Jasvinder Singh Sasan*

DOI: https://doi.org/10.21276/AATCCReview.2026.14.02.86

Such detailed information on the porcine liver from the Jammu region is scarce. In view of this, the present study was undertaken to examine the histoarchitecture of the porcine liver of the Jammu region with the aim of providing a comprehensive description of its microscopic structure. The findings of this study are expected to serve as valuable baseline data for veterinary diagnostics, toxicological and pharmacological research, comparative hepatology, and educational purposes, and support the use of the pig as a reliable experimental model for human liver studies.

Materials and methods

Collection of samples: Liver of apparently healthy adult (1-1.5 years) pigs (irrespective of sex) were collected from slaughter houses in and around Jammu City of union territory of Jammu & Kashmir. Age was estimated by examining the dentition. Ten (N=10) samples were collected.

Histological and Histochemical studies: Immediately after collection, the samples were cleaned with running water and brought to the laboratory. Tissue samples (2 mm size) were preserved in 10% Neutral Buffered Formalin (NBF) solution. These tissues samples were processed for paraffin block preparation by alcohol-benzene schedule (Luna 1968). Tissue sections of 5 µm thickness were obtained from these blocks on clean glass slides with the help of rotary microtome. The sections were then subjected to various histological methods as detailed hereunder.

1. Haematoxylin & Eosin for routine histomorphology
2. Van Gieson's method for collagen fibers
3. Gomori's method for reticulum

Results and discussion

Studying and discussing the histomorphology of the swine liver is important for multiple fields such as veterinary medicine, biomedical research, animal production, and education. Understanding the liver's microscopic structure helps interpret its function, diagnose diseases, and apply that knowledge to both animal and human health.

Capsule

The liver of pig in present study was covered by visceral peritoneal mesothelial cells (Fig. 1) similar to the findings of Eurell and Frappier (2006). Beneath this layer was connective tissue capsule known as Glisson's capsule (Fig. 1) which was similar to the findings of Bacha and Bacha (2000), Young *et al* (2014) and Liebich (2019) in domestic animals, Bharathkumar (2018) in pig, Biswas *et al* (2018) in Ghungroo pig, Kalita *et al* (2019) in Mizo local pig, Debroy *et al* (2021) in Mizoram local pig and Singh *et al* (2025) in porcine liver.

The capsule, in present study, was mainly composed of collagen fibers (Fig. 2) with few elastic fibers along with reticular fibers. Few fibroblasts and fibrocytes were also present in the capsule (Fig. 1). These findings were in accordance to the findings of Singh *et al* (2025) in pig liver. However, Bharatkumar (2018) reported that capsule of pig liver was devoid of reticular fibers. Presence of collagen fibers in the capsule provides strength and structural support to the liver whereas fibroblasts are responsible for producing extracellular matrix (Young *et al* 2014). In present study, the connective tissue fibers from the capsule extended into the parenchyma of liver and dividing into numerous hexagonal lobules (Fig. 3) which was in accordance to the observations by Bharatkumar (2018) and Singh *et al* (2025) in pig. Kuehnel (2023) observed polygonal liver lobules in pig whereas Sivakumar *et al* (2023) reported polyhedral shaped lobules in the liver of indigenous pigs of Tamil Nadu. In present study, each lobule was distinctly separated by thick connective tissue septa rich in collagenous fibers (Fig. 4) as earlier reported by Endo *et al* (2000) in two-humped camel and Sasan *et al* (2017) in pig. Bacha and Bacha (2000) observed that of all the domestic species, the porcine liver had the greatest amount of interlobular connective tissue. In other species, the structural lobules were not as clearly defined. Aughey and Frye (2001) also mentioned that the classic lobule is most clearly visualized in the liver of pig due to abundant connective tissue. This is not the case in the other domestic animals, except under pathological conditions such as cirrhosis.

Lobulation

Histological study of lobule system in pig liver including classical hepatic lobule, portal lobule and liver acinus is essential for understanding both the normal liver function and pathophysiology of hepatic diseases in pigs. Each lobular model provides a unique structural and functional perspective that gives a comprehensive understanding of liver architecture and physiology.

The most striking significant feature of the pig liver was its exceptionally well-defined classical hepatic lobule which formed anatomical structural unit of the liver and was present throughout the parenchyma of liver (Fig. 3). Distinct lobulation was also reported in two-humped camel (Endo *et al* 2000) and pig (Sasan *et al* 2017). In present study, hepatic lobule appeared polygonal/hexagonal in outline, centered around a centrally located central vein. It was similar to the findings of Biswas *et al* (2018) in Ghungroo pig, Kalita *et al* (2019) in Mizo local pig, Debroy *et al* (2021) in Zovawk (Mizoram local pig) and Sivakumar *et al* (2023) in indigenous pigs of Tamil Nadu. Eberlova *et al* (2020) reported pentagonal hepatic lobules in porcine liver. Hepatocytes were arranged in radial plates or cords extending from the central vein towards the periphery. These cords were separated by hepatic sinusoids (Fig. 5). The lobular boundaries were outlined by prominent connective tissue septa as earlier observed by Aughey and Frye (2001) and Lada *et al* (2020) in pig. Eurell and Frappier (2006) reported that among all the domestic species, the porcine liver had the greatest amount of interlobular connective tissue. Sethi (2020) observed that hepatic lobule was easily recognized in Bakerwali goat whereas in non-descript goats the interlobular connective tissue was minimal making it difficult to recognized the hepatic lobules. Portal triads was seen located at the periphery of each lobule which was similar to the findings of Singh *et al* (2025) in pig. Each portal triad was composed of branch of portal vein, hepatic artery and bile ductules (Fig. 6). Similar findings were made by Aughey and Frye (2001) in pig.

Portal lobule was organized as a triangular region defined by three adjacent central veins with centrally located portal triad. Portal triad was supported by connective tissue as reported by Eurell and Frappier (2006). Histologically, this unit emphasized the biliary drainage territory (Ross and Pawlina 2016).

The functional liver acinar concept was described for the first time by Rappaport and Wilson (1958) in human. As per this concept, liver parenchyma was divided into three concentric zones. In present study, liver acinus was a diamond shaped area bounded by two central veins at opposite poles and two adjacent portal triads. Young *et al* (2014) described liver acinus as berry-shaped unit of liver parenchyma centered on portal tract whereas Ross and Pawline (2016) describe liver acinus as lozenge-shaped. The acinus was subdivided into three zones based on the proximity to the vascular supply (Fig. 7) similar to the findings of Young *et al* (2014). In current study, zone 1 (periportal) was located closest to the portal triads. This zone showed densest arrangement of hepatocytes. The hepatocytes received excellent nutrient and oxygen supply and these cells were first to exposed to toxins entering into the liver. The second zone was zone 2 (intermediate) which were intermediate in activity and zone 3 (centrilobular) bordered the central vein with least supplied with nutrients and oxygen. According to Young *et al* (2014), hepatocytes in these zones had different metabolic functions. Vrtkova (2014) in Prestice Black-Pied breed of pig reported that the size and density of hepatocytes were not uniformly distributed in different regions of the liver in relation to the hepatic vasculature. In current study, the hepatocytes of zone 3 were darker stained. According to Ross and Pawline (2016), cells in zone 1 were the first to receive oxygen, nutrients, and toxins from the sinusoidal blood and the first to show morphologic changes after bile duct occlusion. These cells were also the last to die if circulation is impaired and the first to regenerate. However, cells in zone 3 are the first to show ischemic necrosis in situations of reduced perfusion and the first to show fat accumulation. They are the last to respond to toxic sub stances and bile stasis.

Parenchyma

Pig liver consisted of both parenchymal and non-parenchymal cells. Hepatocytes were the parenchymal cells whereas non-parenchymal cells included the Kupffer cells (specialized hepatic macrophages), Ito cells (stellate liver cells or fat storing cells), bile duct epithelium, and leukocytes.

Similar observations were made by Elghoul *et al* (2023) in liver of young domesticated pig.

Hepatocytes

In the present study, the liver parenchyma of pig was predominantly composed of hepatocytes, in agreement with the findings of Singh *et al* (2025) in pig. Hepatocytes represented the principal functional cells of the liver, responsible for a wide range of metabolic, synthetic, detoxification, and secretory activities essential for maintaining homeostasis (Liebich 2019).
Morphologically, hepatocytes were observed as polygonal epithelial cells with abundant eosinophilic, finely granular cytoplasm and large, centrally located round nuclei (Fig. 8). These features were consistent with the descriptions of Endo *et al* (2000) in the two-humped camel, and Bharathkumar (2018) and Singh *et al* (2025) in pig. The eosinophilic cytoplasm corresponded to the high content of mitochondria, while the fine basophilic granularity was attributed to free ribosomes and rough endoplasmic reticulum, reflecting the hepatocyte's intense involvement in protein synthesis (Young *et al* 2014). Banks (1993) reported that the morphological characteristics of hepatocytes were influenced by the physiological state of the animal at the time of sampling. In fasted animals, hepatocytes appeared smaller, with a turbid cytoplasm and indistinct cellular boundaries. Following feeding, the hepatocytes became enlarged, with well-defined cell borders and abundant glycogen accumulation, resulting in a foamy cytoplasmic appearance.
In different domestic animals, hepatocyte shape varied from being hexagonal in sheep and goat to polygonal in cattle (Madhan and Raju, 2014), and cuboidal to polyhedral in buffalo (Rashad *et al* 2017). The polygonal shape in pig may facilitate close packing and maximizes contact with sinusoids and bile canaliculi, optimizing metabolic exchange and bile secretion. White (1973) noted that hepatocyte size and nuclear morphology could vary depending on nutritional status, time post-feeding, and fixation method that influenced metabolic state and glycogen content.
Occasional cytoplasmic vacuolation were observed in some hepatocytes (Fig. 8). Young *et al* (2014) reported that in well-nourished individuals, hepatocytes store significant quantities of glycogen and process large quantities of lipid, both of which are partially removed during routine histological preparations, leaving irregular unstained areas, within the cytoplasm. Nuclei were round with distinct nuclear membranes, prominent nucleoli, and peripheral heterochromatin (Fig. 8), reflecting active transcription and metabolic function. Each hepatocyte displayed three distinct surfaces: the intercellular contact surface, the surface facing the space of Disse, and the bile canalicular surface. Similar observation was made by Liebich (2019) in domestic animals. The binucleated hepatocytes occurred occasionally in the current study, aligns with the findings of Sasan *et al* (2017) and Young *et al* (2014), who described binucleation as a common physiological feature in normal pig liver. Rashad *et al* (2017) also noted binucleated hepatocytes toward portal areas in buffalo. Binucleation represents a mechanism of polyploidy associated with increased metabolic capacity and regenerative potential. Liebich (2019) reported that hepatocytes through amitosis may contain two or more nuclei, depending on the functional status of the cell. The cytoplasmic staining intensity of hepatocytes varied from deeply eosinophilic to pale pink, reflecting nutritional and functional states.
Hepatocytes were arranged in radiating plates or hepatic cords, typically one to two cells thick, extending from the central vein toward the lobular periphery, as described by Leeson and Leeson (1976). Kalita *et al* (2019) reported similar single-cell thick hepatic cords in the Mizo local pig. This arrangement ensured efficient exchange of metabolites between hepatocytes and sinusoidal blood. The hepatic cords anastomosed to form a network enclosing hepatic sinusoid, similar to observations by Aughey and Frye (2001) in pig. Biswas *et al* (2018) described a comparable branching, anastomosing plate arrangement in the Ghungroo pig, forming a sponge-like parenchymal architecture that facilitates optimal perfusion and nutrient exchange. At the periphery of each lobule, hepatocytes adjacent to the portal triad formed a distinct boundary termed the limiting plate. The area between the limiting plate and the connective tissue of the portal tract constituted the space of Mall, which may act as a transitional region for lymphatic drainage and exchange between parenchyma and portal connective tissue (Singh *et al* 2025).
Fine reticular fibers formed a delicate supporting meshwork around hepatic cords, encircling individual hepatocytes (Fig. 9), as earlier reported by Eurell and Frappier (2006) in ruminants and Bharathkumar (2018) and Kalita *et al* (2019) in pig. This reticular framework provides structural integrity and maintained the architecture of hepatic plates during blood flow and mechanical stress (Young *et al* 2014). Treuting *et al* (2018) also demonstrated a similar reticulin network in mouse, rat, and human liver, while Bamaniya *et al* (2020) reported a widespread distribution of reticular fibers in Marwari goat liver. In contrast to our findings, Eurell and Frappier (2006) in domestic animals also reported presence of collagenous fibers around each hepatocyte.
Bile canaliculi were identified as expanded intercellular channels between adjacent hepatocytes, serving as the initial conduits for bile flow toward the interlobular bile ducts. Young *et al* (2014) reported that bile synthesized by hepatocytes is secreted into canaliculi which were fine channels formed by the plasma membrane of adjacent hepatocytes. These structures, occasionally observed by Leeson and Leeson (1976), were critical for the excretion of bile and metabolic waste products. Their strategic placement between hepatocytes enables direct secretion of bile components synthesized within the cell, thus linking hepatocellular function with the biliary excretory system. These findings were in concurrence with findings of Eurell and Frappier (2006) in domestic animals.
Overall, the hepatocyte morphology and arrangement observed in the current study closely aligned with previous reports across mammalian species and reflected a highly organized structural and functional design optimized for metabolic efficiency, detoxification, and bile production.

Central vein and sinusoids

The histomorphological organization of the central vein and hepatic sinusoids plays a pivotal role in maintaining the structural and functional integrity of the porcine liver. These components collectively support hepatic microcirculation, facilitate metabolic exchange, and enable efficient detoxification, thereby ensuring overall metabolic homeostasis in the organism.
Central vein, also referred to as terminal hepatic venule or centrilobular vein (Malarkey *et al* 2005), represents a key structural element of the hepatic lobule in the porcine liver.

Its histological characteristics closely resembled those of other mammalian species, including humans. Each hepatic lobule was organized around a centrally positioned central vein lined by a single layer of simple squamous endothelial cells resting on a thin basement membrane, consistent with earlier descriptions in pigs (Singh *et al* 2025). In some lobules of indigenous pigs of Tamil Nadu, the occurrence of two central veins within a single lobule has been reported (Sivakumar *et al* 2023). In present study, the vessel wall was supported by a delicate network of collagenous and reticular fibers that provided structural support. Central vein exhibited a wide and clear lumen, functioning as the primary drainage channel for blood within the lobule. However, collapsed lumen was noticed in ruminants (Madhan and Raju 2014). The central veins communicated directly with sublobular veins at the periphery of the lobules and communicated directly with sinusoids. This was similar to the findings of Eurell and Frappier (2006) in cattle. Sublobular veins joined to form progressively larger veins that eventually formed the hepatic veins, which drains directly into the caudal vena cava. Similar observation was reported by Singh *et al* (2025) in pig.

Although pigs displayed some species-specific differences in lobular organization, the microanatomy of hepatic sinusoids was very much similar to that of other mammals, including humans. The hepatic sinusoids of pig liver in current study were specialized blood capillaries, located between hepatic cords that communicated with the central vein. Similar observation was made by Biswas *et al* (2018) and Singh *et al* (2025) in pig. Mak and Shin (2020) reported that, in humans and dogs, the hepatic sinusoids drained exclusively into the central veins. In contrast, in rats, the sinusoidal outflow occurred both into the central veins as well as directly into the larger sublobular veins (Bhunchet and Wake 1998; Elias and Popper 1955; Lamers *et al* 1999). They formed an extensive network of irregular, anastomosing vascular channels that connected portal venules at the lobule periphery to the central vein. Their lumen was typically wide and irregular which frequently communicated with each other via spaces in between hepatocytes and cords through a perisinusoidal space. This ramifying arrangement ensured that hepatocytes have at least one surface adjacent to a sinusoid. Centrilobular sinusoids exhibited a relatively straight course, whereas the periportal sinusoids appeared more tortuous, consistent with the observations of Wisse *et al* (1983).

Sinusoids were lined by endothelial cells and stellate macrophages (Kupffer cells) as earlier reported by Biswas *et al* (2018) and Bharathkumar (2018) in pig. The endothelial cells were flattened with attenuated cytoplasm and condensed nuclei, readily distinguishing them from hepatocytes (Fig. 10). A narrow gap between the endothelial cells of sinusoids and the hepatocyte surfaces was observed which was known as perisinusoidal space (of Disse). Similar observation was made by Bharathkumar (2018) in pig. The space of Disse served as the principal conduit for bidirectional exchange of materials between the sinusoidal blood and the hepatic parenchyma. It also provided a pathway for paracrine signaling between liver sinusoidal endothelial cells and hepatocytes (Mak and Shin 2020). Extensions of hepatocytes projected into the perisinusoidal space, presumably to enhance metabolic exchange and facilitate close contact between hepatocytes and circulating blood plasma (Mak and Shin 2020). The sinusoidal framework was further supported by a delicate meshwork of reticular fibers that preserved the integrity and organization of the hepatic parenchyma.

Portal triad

In the current study, the portal triads were located at the junctions between three or more hepatic lobules, consistent with the classical hepatic lobular architecture. Each portal triad comprised a branch of the portal vein, a hepatic arteriole, and a bile ductule, all embedded within a connective tissue framework. Among these structures, the portal vein was observed to be the largest in diameter, a feature typical of mammalian livers (Fig. 6). Similar structural organization of the portal triad has been reported by Bacha and Bacha (2000) in domestic animals, confirming the conserved histological pattern of hepatic microanatomy across species. The portal vein and hepatic artery together constituted the dual vascular supply of the liver (Malarkey *et al* 2005). The portal vein supplied about 70% of the blood flow and 40% of the oxygen while the hepatic artery supplied 30% of the flow and 60% of the oxygen (Burt and Day 2002). The structural features of the portal triad observed in the present study, therefore, aligned well with previously described hepatic architecture in domestic species.

Portal vein

In the current study, the portal vein, which primarily transported nutrient-rich blood from the intestines and associated visceral organs to the liver, was lined by a simple squamous endothelial layer. This observation was consistent with the findings of Sasan *et al* (2017) and Singh *et al* (2025) in the porcine liver. The lumen of the portal vein in the current study appeared irregular in outline. Histologically, the tunica media of the portal vein was relatively thin and composed of smooth muscle fibers interspersed with bundles of collagenous fibers, providing moderate contractile and structural support. The tunica adventitia consisted of multiple layers of collagenous and elastic fibers that provided structural support to the vessel.

Hepatic arteriole

The hepatic artery provided oxygenated blood to the liver parenchyma. In the current study, the hepatic arterioles were characterized by relatively small lumina and a distinctly thick tunica media. The tunica media consisted of three to five concentric layers of smooth muscle fibers, correlating with the size of the arteriole. Occasionally, more than one hepatic arteriole was observed in close association with a single bile ductule within the portal triad region, suggesting a close functional and anatomical relationship between the vascular and biliary components. These observations were consistent with previous reports in pigs, as documented by Singh *et al* (2025). The thick-walled structure of the hepatic arterioles, compared to the portal vein, underscores their role in delivering oxygen rich blood under higher pressure, thereby ensuring adequate oxygenation of hepatocytes.

Bile ductule

Bile was observed to flow through the bile canaliculi toward the periphery of the classic hepatic lobule. Within the portal areas, bile ductules of varying size and shape were identified. The smaller bile ductules were lined by low cuboidal to high cuboidal epithelial cells, while the larger ductules exhibited a simple columnar epithelial lining. The epithelial cells were generally oval in shape, with basally located nuclei. In larger bile ducts, the lining epithelium consisted predominantly of columnar cells, with occasional goblet cells interspersed among them, consistent with observations reported by Bacha and Bacha (2000) in domestic animals.

The presence of prominent apical blebs on the luminal surface of the epithelial cells (Fig. 11) indicated active secretory activity and corroborate with the findings of Sethi (2020) in goats.

LIST OF FIGURES

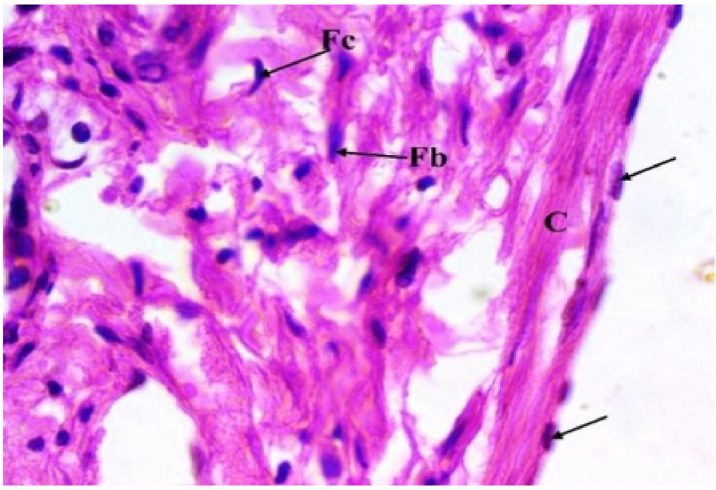

Fig. 1: ***Photomicrograph of pig liver showing Glisson's capsule (C) beneath simple squamous epithelium (arrow). Connective tissue included both fibroblasts (Fb) and fibrocytes (Fc). x1000 H&E stain***

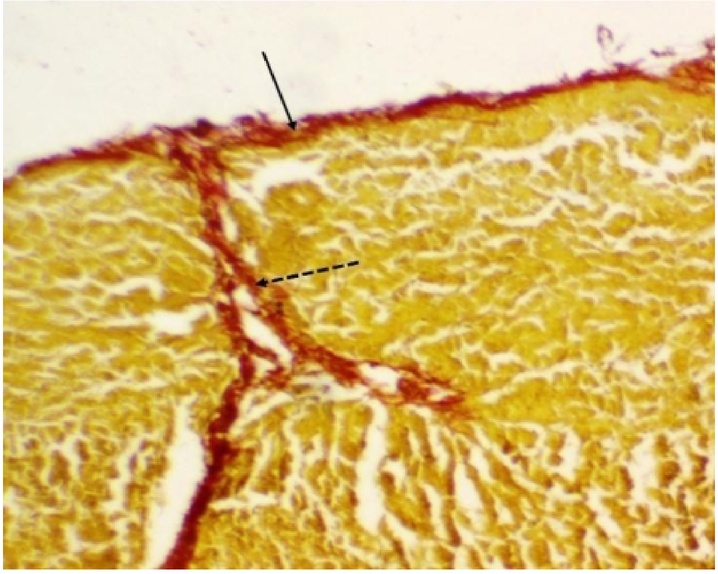

Fig. 2: ***Photomicrograph of pig liver showing presence of collagen fibers (arrow) in the capsule. Collagen fibers extended into parenchyma to divide it into lobules (dotted arrow). x100 Van Gieson's method***

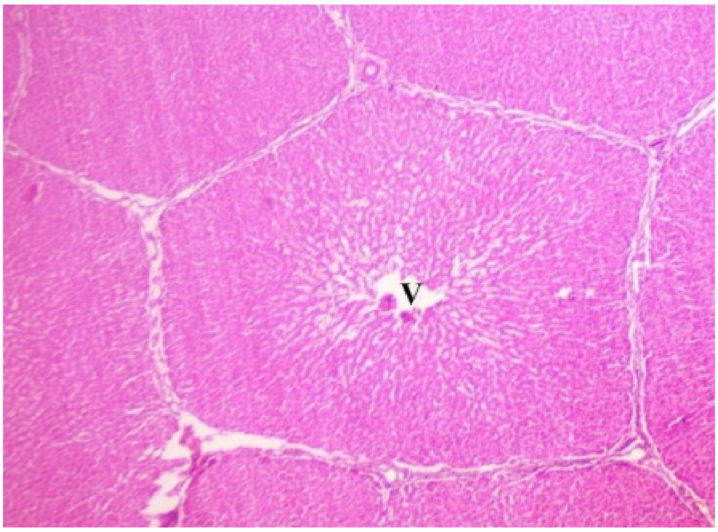

Fig. 3: ***Photomicrograph of pig liver showing well-defined classical hepatic lobule with centrally located central vein (V). x40 H&E stain***

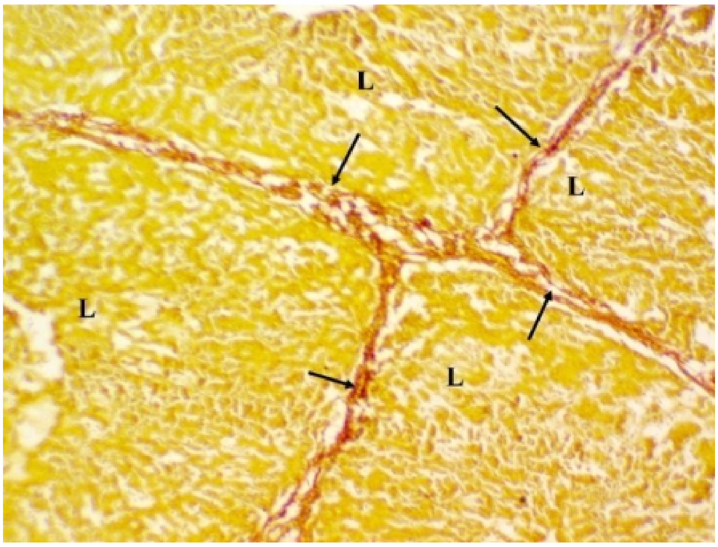

Fig. 4: ***Photomicrograph of pig liver showing prominent connective tissue septa (arrow) rich in collagen fibers forming boundary of hepatic lobules (L). x100 Van Gieson's method***

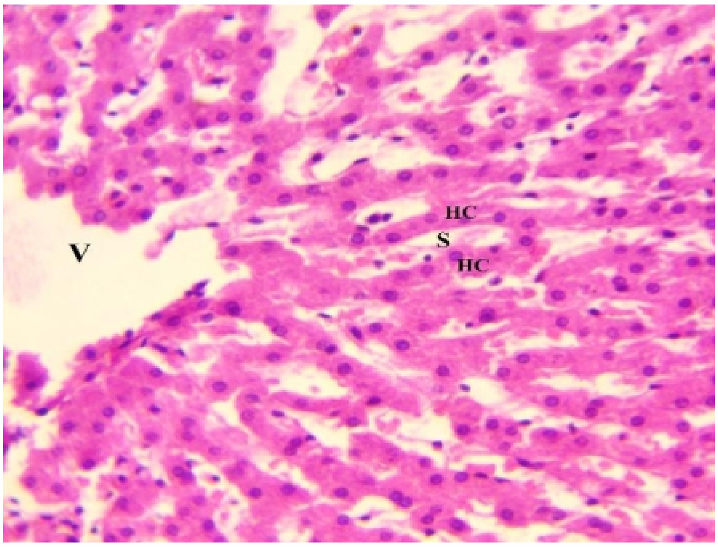

Fig. 5: ***Photomicrograph of pig liver showing central vein (V) and hepatocytes arranged in hepatic cords (HC). Hepatic cords were separated by sinusoids (S). x400 H&E stain***

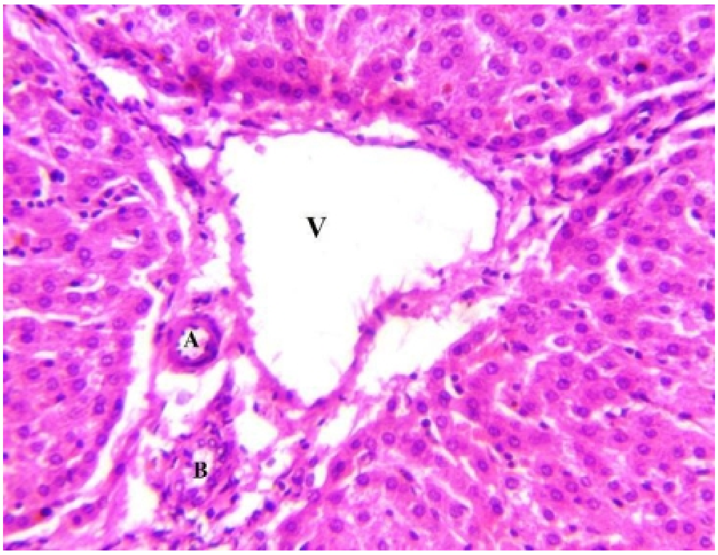

Fig. 6: ***Photomicrograph of pig liver showing portal triad area containing portal vein (V), hepatic artery (A) and bile ductule (B). x400 H&E stain***

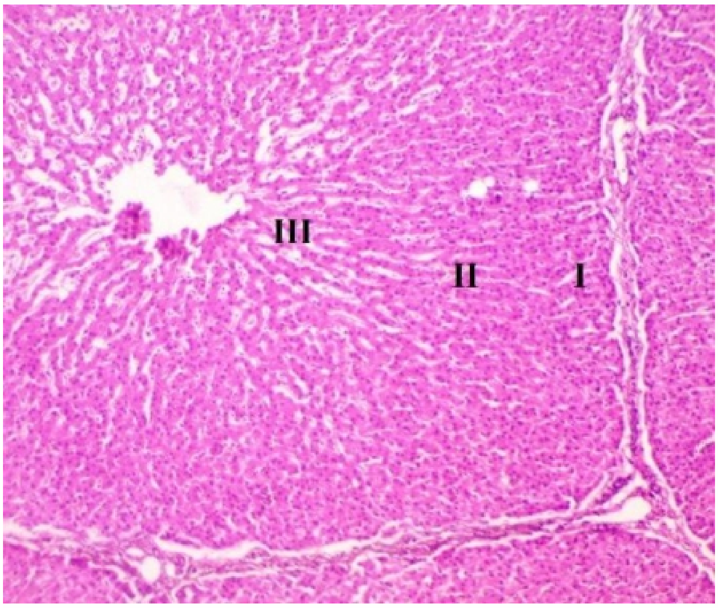

Fig. 7: ***Photomicrograph of pig liver showing zone I (periportal), zone II (intermediate) and zone III (centrilobular) of liver acinus. Zone I showed dense arrangement of hepatocytes. x100 H&E stain***

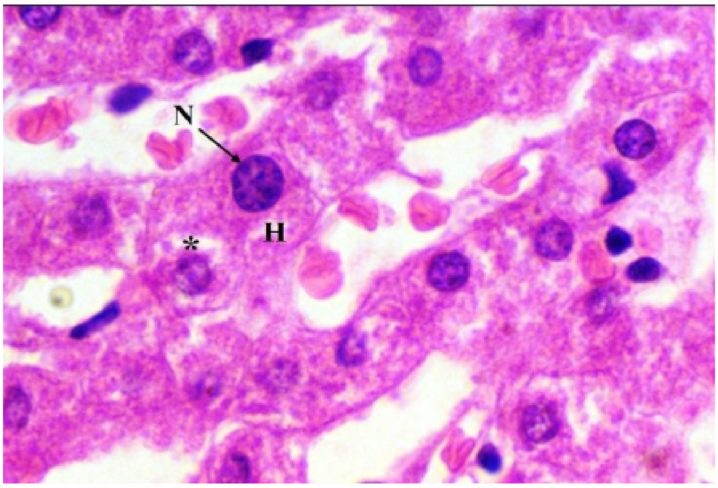

Fig. 8: ***Photomicrograph of pig liver showing hepatocytes (H) with central round nucleus (N). Nucleus showing well-defined peripheral heterochromatin. Cytoplasmic vacuolations (*) are visible in few hepatocytes. x1000 H&E stain***

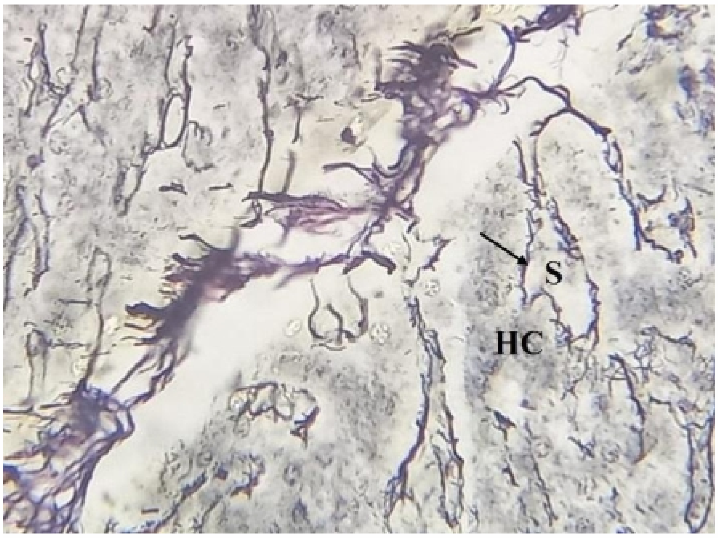

Fig. 9: ***Photomicrograph of pig liver showing presence of reticular fibers (arrow) around hepatic cords (HC). Sinusoids (S) are also prominent. x400 Gomori's method***

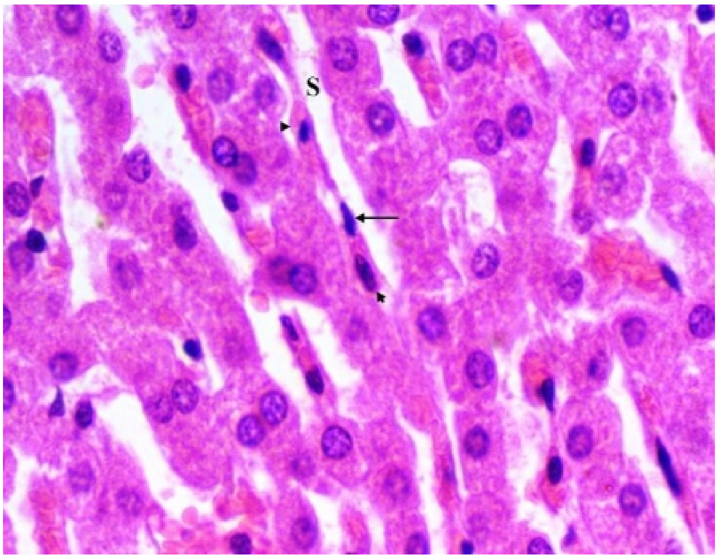

Fig. 10: ***Photomicrograph of pig liver showing endothelial cells (arrow) with flattened nucleus lining sinusoid (S). Ito cells (arrow head) were seen in peri-sinusoidal space. x1000 H&E stain***

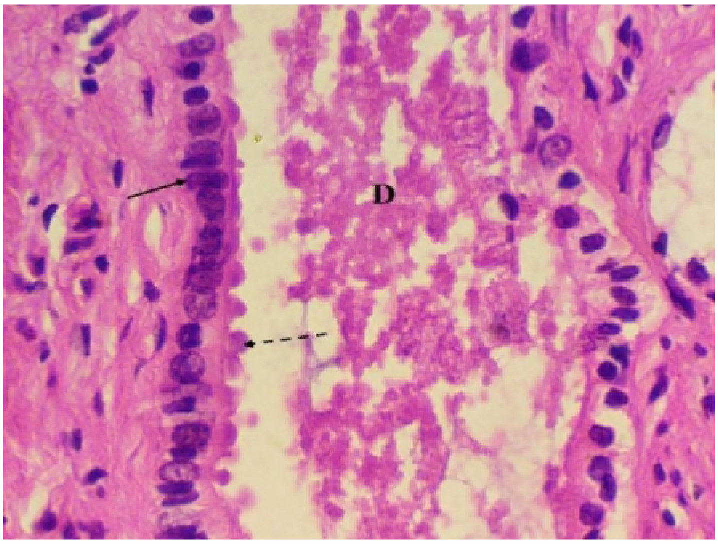

Fig. 11: ***Photomicrograph of pig liver showing larger bile ductule (D) lined by columnar epithelium (arrow) and filled with secretions. Apical blebs (dotted arrow) were prominent. x1000 H&E stain***

Conclusions

The present study demonstrated that the porcine liver exhibited clearly defined classical hepatic lobules, portal lobules, and liver acini with well-developed Glisson's capsule and abundant interlobular connective tissue, and. Hepatocytes were arranged in radiating plates around a prominent central vein and showed characteristic polygonal morphology with occasional binucleation, reflecting high metabolic and regenerative capacity. Overall, the study confirms that the porcine liver possessed distinctive structural, supporting its significance in veterinary diagnostics, comparative anatomy, biomedical research, and experimental hepatology.

Conflicts of interest: The authors declare that there is no conflict of interest.

References

1. Aughey, E., & Frye, F. L. (2001). Comparative Veterinary Histology with Clinical Correlates. Manson Publishing/The Veterinary Press, pp: 124.
2. Bacha, W. J., & Bacha, L. M. (2000). Color Atlas of Veterinary Histology. 2nd edn., Lippincott Williams & Wilkins, pp: 120-121.
3. Bamaniya, M., Mathur, R., Joshi, S., Singh, K. N., Kumar, M., Vishen, A., & Gharu, S. (2020). Histological studies on the liver of Marwari Goat (Capra hircus). Journal of Entomology and Zoology Studies, 8(2), 25-27.
4. Banerjee, G. C. (1998). A textbook of Animal Husbandry. 8th Edn. Oxford and IBH publishing Co. Pvt. Ltd. New Delhi: 54-55.
5. Banks, W. J. (2007). Text Book of Applied Veterinary Histology. 4th edn. Baltimore: Williams & Wilkins, pp: 362-72.
6. Bharathkumar, M. L. (2018). Histology, histochemistry and ultrastructure of heart, liver and pancreas in pigs (Sus scrofa domesticus). Ph.D thesis submitted to Karnataka Veterinary Animal and Fisheries Sciences University, Bidar.
7. Bhunchet, E., & Wake, K. (1998). The portal lobule in rat liver fibrosis: A re-evaluation of the liver unit. Hepatology, 27, 481-487.
8. Biswas, P., Ray, S., Das, P., Saren, S., Shee, A., Banerjee, A., & Islam, M. M. (2018). Gross anatomical and histomorphological studies on liver with ramification of portal vein and hepatic artery in Ghungroo pig. International Journal of Current Microbiology and Applied Sciences, 7(6), 2955-2965.
9. Burt, A. D., & Day, C. P. (2002). Pathophysiology of the liver. In: MacSween RNM, Burt AD, Portmann BC, Ishak KG, Scheuer PJ and Anthony PP (Eds) Pathology of liver, Churchill Livingstone, New York, pp: 67-105.
10. Chauhan, A., Patel, B. H. M., Maury, R., Kumar, S., Shukla, S., & Kumar, S. (2016). Pig production system as a source of livelihood in Indian scenario: An overview. International Journal of Science Environment and Technology, 5, 2089-96.
11. Debroy, S., Kalita, P. C., Kalita, A., Choudhary, O. P., Doley, P. J., Paul, A., & Sarkar, R. (2021). Anatomy of the Liver of Mizoram Local Pig (Zovawk). Indian Journal of Animal Research, DOI: 10.18805/IJAR.B-4447.
12. Eberlova, L., Maleckova, A., Mik Patrik, M. A., Tonar, Z., Jirik, M., Mirka, H., Palek, R., Leupen Sarah, B. A., & Liska, V. (2020). Porcine liver anatomy applied to biomedicine. Science Direct, 250, 70-79.
13. Elghoul, M., Kandyle, R., & Abumandour, M. M. A. (2023). Microscopic focus on the different hepatic cells of the young domesticated pig (Sus suidae). Alexandria Journal of Veterinary Sciences, 76(2), 1-5.
14. Elias, H., & Popper, H. (1955). Venous distribution in livers; comparison in man and experimental animals and application to the morphogenesis of cirrhosis. A.M.A. Archives of Pathology, 59, 332-340.
15. Endo, H., Gui-fang, C., Dugarsuren, B., Erdemtu, B., Manglai, D., & Hayashi, Y. (2000). On the morphology of the liver in the two humped camel (Camelus bactrianus). Anatomia Histologia Embryologia, 29, 243-46.
16. Eurell, J. A., & Frappier, B. L. (2006). Dellmann's Textbook of Veterinary Histology. Blackwell Publishing, 6th Edn. 201-206.
17. Kalita, P., Kalita, A., Doley, P., Choudhary, O., Das, H., & Debroy, S. (2019). Liver and Pancreas of Mizo Local Pig (Zovawk): A Histomorphological and Histochemical Analysis. International Journal of Livestock Research, 9(1), 150-156.
18. Kuehnel, W. (2023). Color Atlas of Cytology, Histology, and Microscopic Anatomy. 4th edn., Thieme Stuttgart NewYork, pp: 318-329.
19. Lada, E., Anna, M., Patrik, M., Zbynek, T., Miroslav, J., Hynek, M., Richard, P., Sarah, L., & Vaclav, L. (2020). Porcine liver anatomy applied to biomedicine. Journal of Surgical Research, 250, 70-79.
20. Lamers, W. H., Vermeulen, J. L., Hakvoort, T. B., & Moorman, A. F. (1999). Expression pattern of glutamine synthetase marks transition from collecting into conducting hepatic veins. The Journal of Histochemistry and Cytochemistry, 47, 1507-1512.
21. Leeson, C. R., & Leeson, T. S. (1976). Asian Edition Histology. 3rd edition, W.B. Saunders Co. Philadelphia, London, pp: 376-382.
22. Liebich, H. G. (2019). Veterinary Histology of Domestic Mammals and Birds. 5th edn., 5m Publishing, pp: 226-235.
23. Livestock Census. (2019). Department of Animal Husbandry & Dairying under Ministry of Fisheries, Animal Husbandry & Dairying.
24. Luna, L. G. (1968). Manual of histological staining methods of Armed Forces Institute of Pathology. 3rd Edn, McGraw Hill Book Company, New York, pp 34-157.
25. Madhan, K. E., & Raju, S. (2014). Comparative histology of human and cow, goat and sheep liver. Journal of Surgical Academia, 4(1), 10-13.
26. Mak, K. M., & Shin, D. W. (2020). Hepatic sinusoids versus central veins: Structures, markers, angiocrines, and roles in liver regeneration and homeostasis. The Anatomical Records, 304, 1661-1691.
27. Malarkey, D. E., Johnson, K., Ryan, L., Boorman, G., & Maronpot, R. R. (2005). New Insights into Functional Aspects of Liver Morphology. Toxicological Pathology, 33(1), 27-34.
28. Rappaport, A. M., & Wilson, W. D. (1958). The structural and functional unit in the human liver (liver acinus). The Anatomical Records, 130, 673e689.
29. Rashad, E., El-Haback, H. A., Rabou, M. I. A., Hussein, S., & Khalifa, E. F. (2017). Gross anatomy and morphology of Egyptian water buffalo's liver (Bubalus Bubalis) with reference to some histochemical and immunohistochemical evaluation. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 8(3), 45-60.
30. Ross, M. H., & Pawlina, W. (2016). Histology: a text and atlas: with correlated cell and molecular biology. 7th Edn. Wolters Kluwer, pp: 626-640.
31. Sasan, J. S., Sharma, A., Sarma, K., Suri, S., & Malik, M. R. (2017). A quantitative histological study of the liver of pig (Sus scrofa). Indian Veterinary Journal, 94(04), 14-16.
32. Sethi, L. (2020). Anatomical studies on the liver of adult Bakerwali and non-descript goats of Jammu region- a comparative study. M.V.Sc Thesis submitted to SKUAST-Jammu.
33. Singh, K., Uppal, V., Bansal, N., Gupta, A., & Pathak, D. (2025). Characterizing morphological heterogeneity in porcine hepatocytes. Indian Journal of Animal Sciences, 95(2), 136–143.
34. Sivakumar, S. A., Kannan, T. A., Basha, S. H., & Ramesh, G. (2023). Histological and micrometrical observation on the liver of indigenous pig of Tamil Nadu. The Pharma Innovation Journal, 12(9), 264-267.
35. Treuting, P. M., Dintzis, S. M., & Montine, K. S. (2018). Comparative anatomy and histology: A Mouse, Rat, and Human Atlas. 2nd edn., Elsevier, pp: 233-238.
36. Vrtkova, I. (2015). Genetic admixture analysis in prestice black-pied pigs. Archives Animal Breeding, 58, 115e121.
37. Wang, L., Piao, Y., Guo, F., Wei, J., Chen, Y., Dai, X., & Zhang, X. (2023). Current progress of pig models for liver cancer research. Biomedicine & Pharmacotherapy, 165, 115256.
38. White, E. G. (1973). Some observations on the liver of the pig: The hepatic lobule and liver cell during post-natal growth. Animal Pathology, 24, 15-18.
39. Wisse, E., De Zanger, R. B., Jacobs, R., & McCuskey, R. S. (1983). Scanning electron microscope observations on the structure of portal veins, sinusoids and central veins in rat liver. Scanning Electron Microscopy, 111, 1441-1452.
40. Young, B., O'Dowd, G., & Woodford, P. (2014). Wheater's Functional Histology A Text and Color Atlas. 6th edn., Churchill Livingstone, pp: 66-73, 276-283.