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HISTOLOGICAL STUDIES ON THE EXOCRINE PORTION OF THE PANCREAS IN THE SAUDI CAMEL (*Camelus dromedarius*)

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ABSTRACT

The general features of the exocrine portion of the pancreas of the Saudi camel were studied microscopically. Specimens from 25 camels (*Camelus dromedarius*) of varying ages (2–12 years) and sexes were used. Microscopic results revealed that the pancreas of camel consists of a mixed endocrine and exocrine portion. It is covered with a thick capsule of connective tissue of collagenous, reticular, elastic fibres and blood vessels. The gland parenchyma is divided into lobules by the connective tissue septa, which extends septa from the internal surface of the capsule. These septa were abundant in adipose tissue and contained collagenous, elastic, reticular fibres, blood arteries, ducts, nerve fibres and ganglion cells. The acinar type predominated among the tubuloacinar secretory units. The excretory ducts started as centroacinar cells and formed intercalated, intralobular, interlobular and the main pancreatic ducts. In conclusion, the histology of the exocrine component of the pancreas in camels was similar to that of other domestic animals with a higher degree of acinar type and adipose tissue invaded the septa. However, uniquely, there were acinar cells in the connective tissue of the large ducts observed only in the present study.

Key words: Camel, exocrine, histology, pancreas

The one-humped camel (*Camelus dromedarius*) is an important farm animal in Saudi Arabia. Its morphological and physiological adaptations enable it to withstand harsh desert environments (Soliman, 2015). However, studies on its organ structure and function are not enough. Investigating its pancreas can enhance understanding its anatomy, physiology, behaviour and pathology. The pancreas is a mix of exocrine and endocrine glands that release digestive enzymes and hormones (Ghaji, 2018).

The exocrine pancreas produces digestive enzymes, including lipase, trypsin and amylase and secretes them into the gut to facilitate food digestion (Pandol, 2015; Wallig *et al,* 2024). Structurally, it is covered by a thin connective tissue capsule extending into septa, dividing the organ into lobules. It consists of secretory units and a duct system; the units are compound tubuloacinar, while the duct system is composed of the centroacinar cells, intercalated ducts, intralobular ducts, interlobular ducts, the main pancreatic duct that lead to the hepatopancreatic duct (Dellmann and Brown, 1981; Mostafa *et al,* 1983; Wheater *et al,* 1992; Motta *et al,* 1997; Jarrar and Faye, 2013; Young *et al,* 2013; Tsuchitani *et al,* 2016; Hafez and Zaghloul, 2017; Longnecker *et al,* 2023; Wallig *et al,* 2024).

The anatomy of the endocrine portion of dromedary camel pancreas has been adequately studied (Adeghate, 1997; Jarrar and Faye, 2013; Hafez *et al,* 2015; Hafez and Zaghloul, 2017; Althnaian *et al,* 2019; Abdellatif, 2020; Attai *et al,* 2022; Rashwan, 2023). Hence, the present investigation was aimed to study the histology of the exocrine portion with its duct system of pancreas of camel using different stains.

Materials and Methods

Sampling

The pancreatic specimens were taken from 25 one-humped camels (*Camelus dromedarius*) of both sexes from the Al Omran slaughterhouse in Al-Ahsa, Saudi Arabia. The animals were between 2-12 years old and the specimens appeared normal.

The ethics committee of King Faisal University approved the animal protocol, which was followed in all animal sample procedures.

Tissue preparation

Small pieces of the pancreas were collected immediately after slaughtering. Samples were taken from the body, right and left lobes. The tissue was

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cut into slices and put into 10% buffered formalin for fixation. The collected specimens were dehydrated in ascending alcohol grades, cleared in xylene and embedded in paraffin wax. Tissue blocks were sectioned at 4–5 µm and mounted onto glass slides coated with either chrome alum gelatin or albumin. The slides were then cleared in xylene, rehydrated in descending grades of alcohol, washed in distilled water and stained with Haematoxylin and Eosin stain for general histology, Masson trichrome for collagen, aldehyde fuchsin for elastic fibres and Gordon & Sweet's method for reticular fibres (Stevens and Bancroft, 1990). Stained slides were then examined and photographed by a light microscope (Leitz, Germany) connected to a digital camera (Leica DFC420, Germany).

Results

The pancreas of camel was found as a mixed exocrine and endocrine gland covered with a dense connective tissue capsule consisting of collagenous, reticular and elastic fibres, numerous nerve fibres, blood vessels and highly infiltrated with adipose tissue (Figs 1a and 1b).

Connective tissue fibres from the capsule's interior stretched into the gland parenchyma, creating septa that separated it into lobules (Figs 1b and 1c). These septa comprised adipose tissue, collagenous, elastic, reticular fibres, blood arteries, ducts, nerve fibres and ganglion cells (Figs 1c and 1d).

The exocrine portion

The exocrine portion was comprised of the secretory units and the excretory ducts.

Secretory units

Secretary units were tubuloacinar (Figs 2a and 2b), with the acinar portion more prominent (Fig 2a). The acini comprised 5-9 cells arranged around a small central lumen. The secretory epithelial cells were pyramidal with spherical basal nuclei and a narrow lumen in the centre (Fig 2a). The apical part of the cytoplasm contained secretory granules. The reticular connective tissue networks and basal laminae encircled the acini (Fig 2c). The connective tissue of the major ducts contained a few acinar cells. (Fig 2d).

Duct system

The duct system of the exocrine portion of the pancreas started as flattened centroacinar cells (Fig 3a). These centroacinar cells were continuous with small ducts termed the intercalated ducts that were lined with flattened to a simple low cuboidal epithelium and supported by a basal lamina. The intercalated ducts led to the intralobular ducts inside the lobules and were lined by simple cuboidal epithelium. The epithelium rested upon a basal lamina and was supported by bundles of collagenous fibres (Fig 3b). The intralobular ducts joined to form the interlobular ducts, which were lined by simple cuboidal to low columnar epithelial cells (Fig 3c). A basal lamina and thick dense connective tissue layer supported the cells (Figs 3c and 3d). The interlobular ducts led to the main pancreatic duct, which was lined by simple columnar epithelium and supported by a basal lamina and a thick connective tissue layer (Fig 3e). The main pancreatic duct possessed dense elastic fibres (Fig 3f), groups of acinar cells and small ducts within its connective tissue layer (Figs 2d and 3e). The main pancreatic duct communicated with the bile duct to form the hepatopancreatic duct.

Discussion

The present study has shown that the pancreas of camel was a mixed exocrine and endocrine gland. The pancreas was covered with a dense connective tissue capsule containing collagenous, reticular, elastic fibres and blood vessels. The connective tissue capsule extended septa from the internal surface into the gland parenchyma, dividing it into lobules. These septa comprised collagenous, elastic and reticular fibres and were rich in adipose tissue. The septa also contained blood vessels, ducts, nerve fibres and ganglion cells. This confirms the previous finding in camel (Qayyum *et al,* 1987; Sultan and Ali, 1998; Hafez and Zaghloul, 2017; Attai *et al,* 2022).

Similar morphological observations had been reported in other domestic animals and man (Trautmann and Fiebiger, 1957; Coupland, 1958; Hirmatsu *et al,* 1993; Motta *et al,* 1997; El-sakhawy *et al,* 2016; Prakash *et al,* 2018; Mahesh *et al,* 2020). However, the high infiltration of the adipose tissue was a characteristic feature of the camel pancreas of this study. This adipose tissue had also been observed in the connective tissue septa of the pancreas of the guinea pig (Benseley, 1911; Dolenšek *et al,* 2015).

The exocrine portion of the pancreas findings in this study showed that it consisted mainly of secretory units and excretory ducts. The secretory units were tubuloacinars, with the acinar type more prominent. These findings confirmed previous results obtained in the camel pancreas (Tadjalli and Meamary, 1998; Sultan and Ali, 1998; Hafez and Zaghloul, 2017; Attai *et al,* 2022). Similar findings

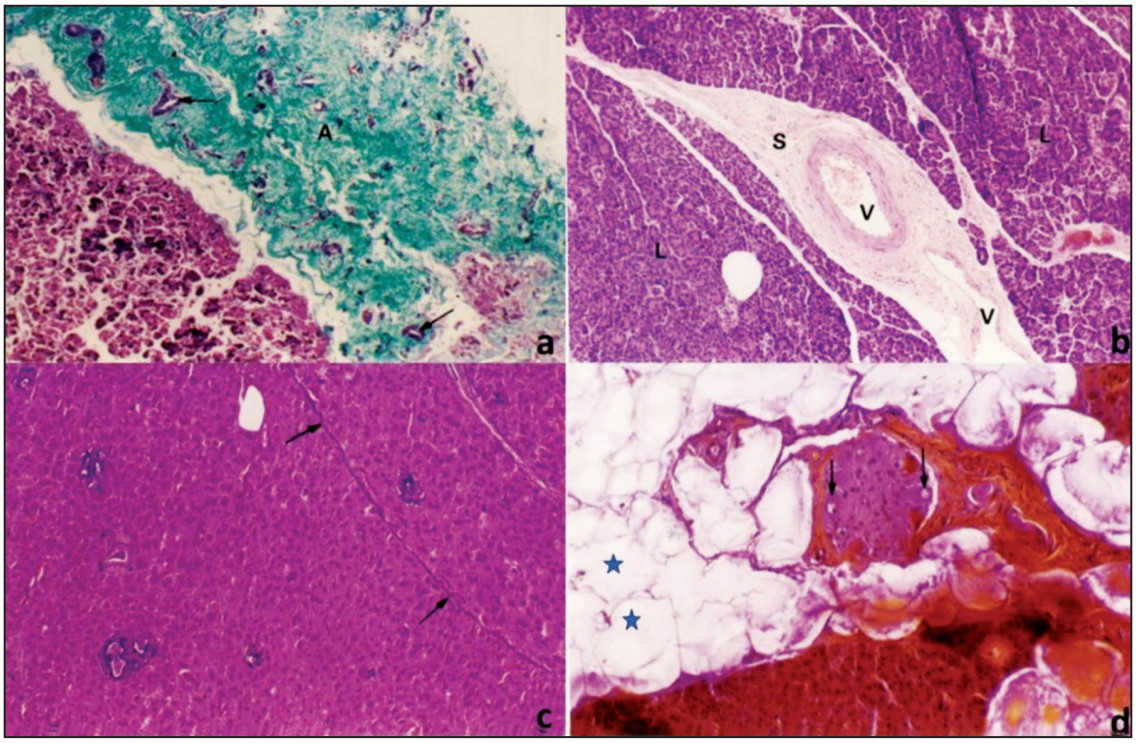

Fig 1. **(a)** A photomicrograph of camel pancreas showing a thick connective tissue capsule with collagenous fibres (A) and numerous blood vessels (arrows). Masson trichrome. X100. In **(b)**, there are lobules (L), separated by connective tissue septa (S) showing blood vessels (V). H and E. X100. While **(c)** verifying the elastic fibres in the connective tissue septa (arrows). Aldehyde fuchsin. X200. **(d)** showing ganglion cells in the connective tissue septa (arrows); adipose cells (stars). Modified aldehyde fuchsin method. X200.

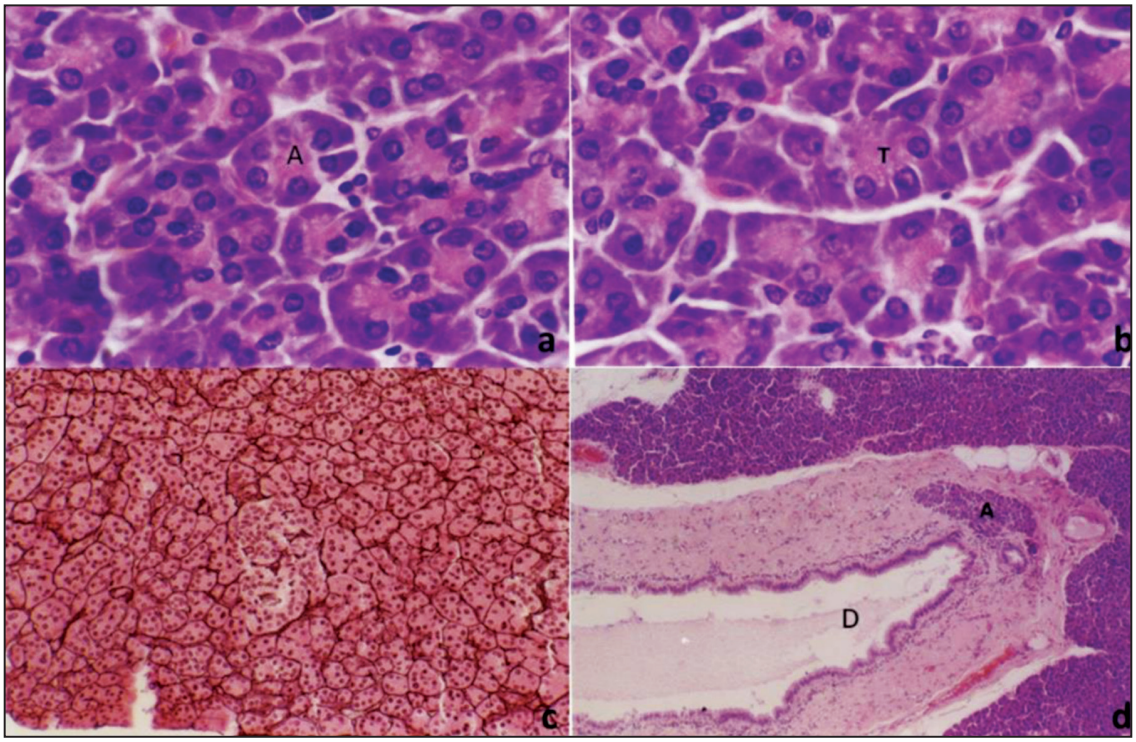

Fig 2. **(a)** Photomicrograph of the pancreas of the camel showing the abundant acinar-type secretory units (A). H and E.X1000. **(b)** A section of the pancreas of the camel showing tubular-type secretory units (T). H and E.X1000. **(c)** demonstrating the framework of the reticular connective tissue in the pancreas of the camel. Gordon and Sweet's method. X200. **(d)** showing some acinar cells in the connective tissue of a duct (A). H and E.X200.

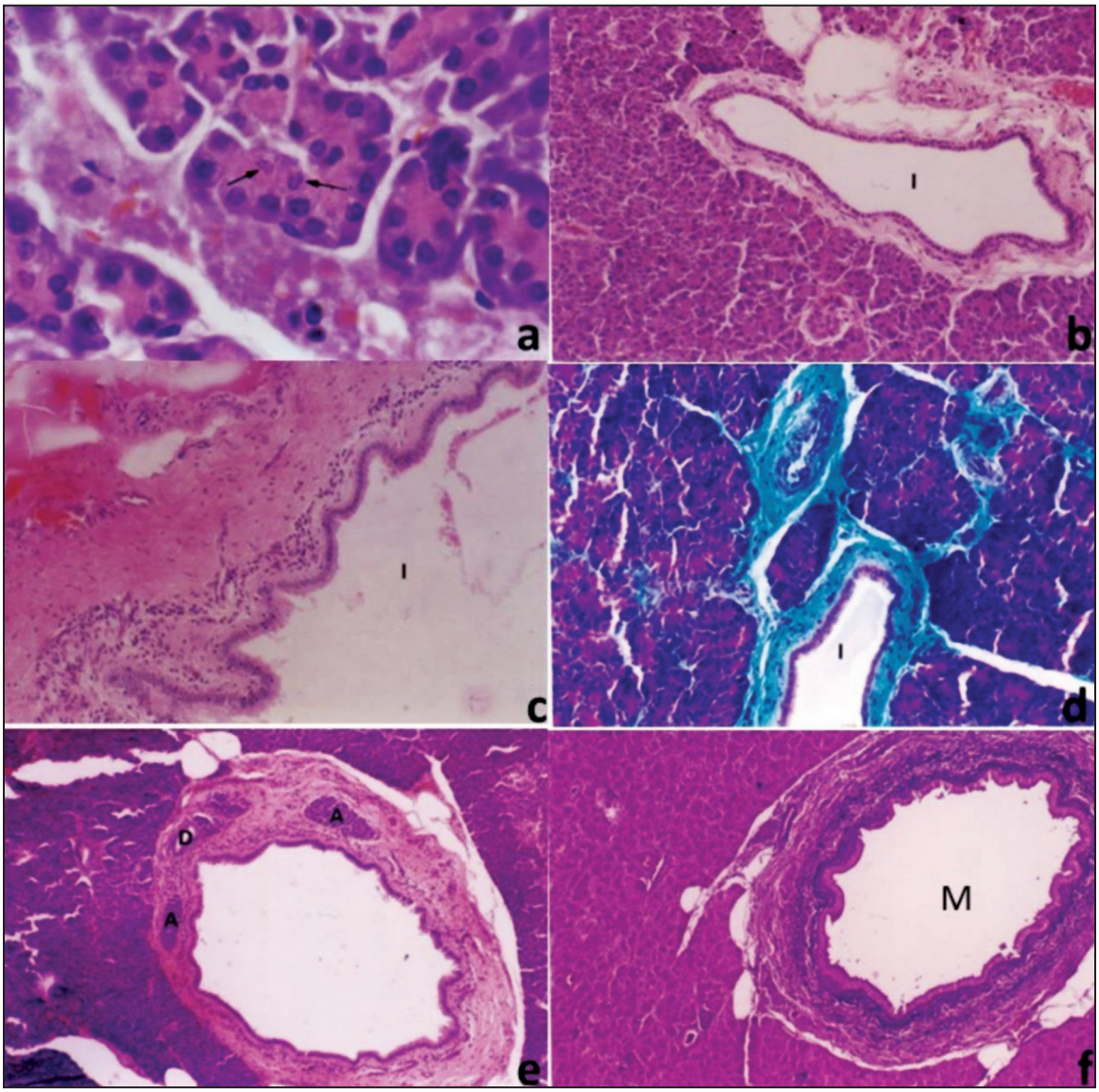

Fig 3. **(a)** A section of the pancreas of the camel showing centroacinar cells (arrows) in the acini. H and E. X1000. **(b)** showing an intralobular duct (I) lined with simple cuboidal epithelium. Bundles of collagenous fibres surround the epithelium. H and E. X200. **(c)** An interlobular duct (I) showing the low columnar epithelium and part of the thick connective tissue layer. H and E. X200. **(d)** A section through the parenchyma of the pancreas of the camel showing an interlobular duct (I) with thick collagenous fibres. Masson trichrome. X200. **(e)** The main pancreatic duct demonstrating the simple columnar epithelium, groups of acinar cells (A) and small duct (D) in the connective tissue layer. H and E. X100. **(f)** The main pancreatic duct (M) of the camel pancreas showing dense elastic fibres (black fibres). Aldehyde fuchsin. X100.

were reported in other animals and men (Ekholm *et al,* 1962; Laitio *et al,* 1974; Sisson, 1975; Dellman and Brown, 1981; Wheater *et al,* 1992; Mobini *et al,* 2008; Prakash *et al,* 2018; Mahesh *et al,* 2020). There were acinar cells in the connective tissue of the large ducts, a unique finding observed only in the present study.

The duct system of the camel pancreas started as centroacinar cells which were continuous, with the small ducts termed the intercalated ducts lined with a flattened to low cuboidal epithelium supported by a basal lamina. Similar findings were also observed in the camel (Tadjalli and Meamary, 1998) and other domestic animals (Gemmell and Heath, 1973; El-sakhawy *et al,* 2016; Mahesh *et al,* 2020). The intralobular duct was lined by simple cuboidal epithelial cells that rested on a basal lamina surrounded by bundles of collagenous fibres. This agreed with the findings in other animals and men (Kodama, 1983; Egerbacher and Böck, 1997; Tadjalli and Meamary, 1998). The interlobular duct was lined by a simple cuboidal to low columnar epithelium. A basal lamina and thick, dense connective tissue layer

supported the epithelial cells. Similar features had been reported by Kodama (1983), Wheater *et al* (1992) in other animals, Tadjalli and Meamary (1998) and Hafez and Zaghloul (2017) in camels.

The main pancreatic duct showed dense elastic fibres and small ducts within its thick connective tissue layer, which resembles the results in other animals and humans (McMinn and Kugler, 1961; Longnecker, 2014).

Conclusion

In conclusion, the histological structure of the exocrine portion of the camel pancreas was comparable to that of other domestic animals, with the tubuloacinar secretory units showing a greater degree of acinar type. The pancreas was covered by a connective tissue capsule and the septa were infiltrated with adipose tissue. In addition, some of the large interlobular and main pancreatic ducts contained acinar cells in their connective tissue walls.

Conflict of interest

None declared

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