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Role of Exocrine Pancreas in Ruminant Digestion

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Abstract

Pancreas is a tubuloalveolar gland with exocrine and endocrine function. The pancreas of the ruminants consists of a distinguishable short body with left and right lobes. The exocrine part of the pancreas secretes the pancreatic juice which consists of the bicarbonates and enzymes essential for the digestion. The release of the pancreatic juice is triggered by the hormone cholecystokinin, which is produced when the food reaches small intestine. The alkaline secretion of the pancreas contains digestive enzymes and the enzyme precursors (proenzymes) that can digest protein, carbohydrates and lipids.

Introduction

The pancreas plays a crucial role in the process of digestion. It produces a juice filled with enzymes that are essential for breaking down carbohydrates, proteins, and fats, making them more easily absorbable by the body. This pancreatic juice is composed of water and bicarbonate ions, which are a clear, odorless, and tasteless liquid. This liquid dilutes other components and raises the pH level of stomach acids to an optimal range for enzyme activity. Within this digestive juice, you can find enzymes like amylase, lipase, proteases, nucleases, and elastase, all of which contribute to the efficient breakdown of fats, proteins, and carbohydrates to facilitate absorption.

The pancreas has a dual nature as a tubuloalveolar gland. It functions as an exocrine gland, primarily responsible for producing digestive enzymes (the larger part of its role), and also acts as an endocrine gland, producing hormones (a smaller part of its role). In ruminants, the pancreas is characterized by a distinct anatomy. It consists of a relatively short body with left and right lobes. The left lobe is situated in the retroperitoneal space and is in close proximity to the liver, diaphragm, and major blood vessels on its dorsal side. On its ventral side, it comes into contact with the intestines and the dorsal sac of the rumen. Meanwhile, the right lobe is larger in size and is positioned in the mesoduodenum, adjacent to the animal's flank. It runs along a portion of the descending duodenum.

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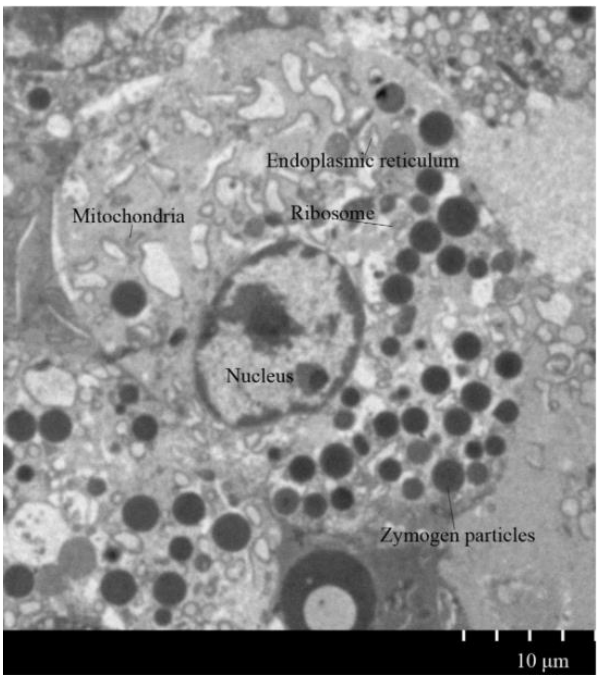
Functional Anatomy of exocrine pancreas of ruminants

The pancreas is segmented into distinct regions: head, neck, body, and tail. A delicate layer of connective tissue covers the outer surface of the pancreas. Within the exocrine part of the pancreas exists a complex structure known as the multi-branched lobular acinus, responsible for producing pancreatic enzymes, electrolytes, and other fluids. The pancreatic juice itself is composed of inorganic salts, zymogen particles, and water. This pancreatic juice flows through a duct into the duodenum, where it plays a crucial role in the digestion of starch, protein, and fat present in the chyme.

The acinus serves as the fundamental functional unit of the pancreas dedicated to its exocrine function. It consists of cone-shaped serous gland cells primarily synthesizing, storing, and secretion of various digestive enzymes. These acinar cells release zymogen granules into the acinar cavity through the process of exocytosis, and subsequently, these zymogen granules find their way into the duodenum via the pancreatic duct.



Ultrastructure of pancreatic acinar cells in dairy cows. Showing mitochondria, endoplasmic reticulum, and nucleus and zymogen particles.

Pancreatic Secretions

Only the exocrine part of pancreatic secretions is involved in the digestive process in the ruminants. It involves secretion of bicarbonate and digestive enzyme or precursors. The exocrine pancreas synthesizes and secretes several digestive enzymes (including amylase, lipase, and proteases) to digest feedstuff, supplying ruminants with nutrients (such as starch, fat, and protein).

Alkaline Secretion

The alkaline secretion of the pancreas consists of the bicarbonates and the chloride ions which is discharged in the duodenum through the ducts. The release of pancreatic juice (along with bile from the liver) is triggered by the hormone cholecystokinin, which is produced by the small intestine. This hormone is released as soon as food reaches the small intestine. The secretion of bicarbonate is required to neutralize the HCl concentration of the ruminal contents that enter the duodenum and also

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to neutralize acids produced from fermentation in the rumen. This is advantageous because it provides an optimal pH for the pancreatic enzymes and prevents damage to the thin, absorptive mucosa of the duodenum.

Enzymatic Secretion

The alkaline secretion of the pancreas contains digestive enzymes and the enzyme precursors (proenzymes) that can digest protein, carbohydrates and lipids.

Trypsinogen is a precursor to the digestive enzyme trypsin; it helps break down proteins and is activated by enterokinase present in the intestinal epithelium. Trypsin then becomes the activator for the other proenzymes. Digestion of the pancreas is prevented because the proteolytic enzymes are secreted as proenzymes. Spontaneous conversion of trypsinogen to trypsin is prevented in the pancreas by the presence of trypsin inhibitor.

Chymotrypsinogen a precursor to the digestive enzyme chymotrypsin, it works alongside trypsin to break down proteins and is activated by trypsin itself.

Procarboxypeptidase is a precursor to the digestive enzyme carboxypeptidase, it helps break down proteins and is also activated by trypsin.

Carbohydrates: The enzymes pancreatic amylase and maltase help break down carbohydrates into simpler sugars in the small intestine, which can then be absorbed by the body.

Lipids: The enzyme pancreatic lipase helps to digest triglycerides by breaking them down into fatty acids and glycerol in the small intestine.

The gastrointestinal hormones gastrin, CCK, and secretin work in conjunction with autonomic nerves to regulate the exocrine secretions of the pancreas. The release of enzymes and proenzymes is increased by parasympathetic stimulation, whereas the secretion of electrolytes and water is decreased.

Factors affecting exocrine function of the pancreas:

1. Age of the animal

The pancreatic exocrine function of ruminants is mostly influenced by the animal's age. The pancreas of animals gradually matures with age, producing more pancreatic juice overall and more digesting enzymes. In the small intestine of newborn calves, the activity of digestive enzymes containing amylase, protease, and lipase is low, but as age advances, the activity of these enzymes rises dramatically above that at birth.

2. Neurohumoral regulation

The central nervous system regulates pancreatic secretion through the vagus nerve. Blocking vagus nerve reduces the secretion of pancreatic juice and the activity of trypsin. Stimulation of cholinergic nerves can increase pancreatic exocrine secretion and increase secretion of endogenous secretin and cholecystokinin (CCK).

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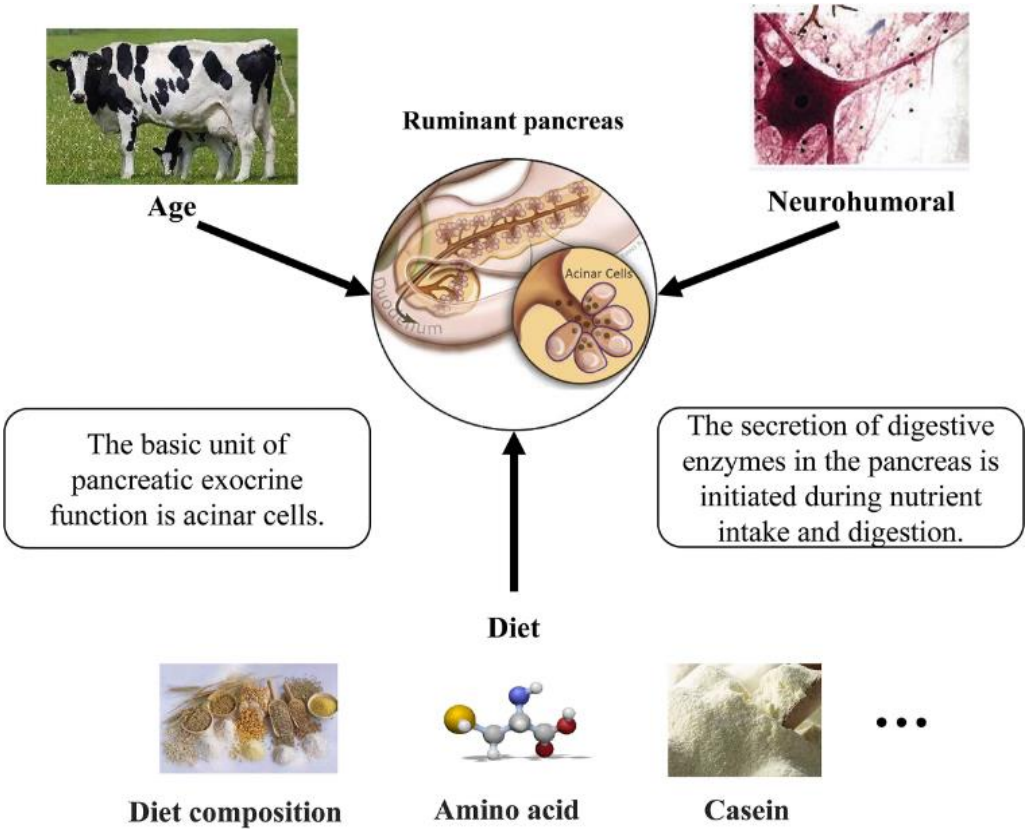
3. Animal Diet

When ruminants smell or see feeds, it stimulates the release of digestive enzymes by the pancreas. Different types of feed can affect the secretion of pancreatic enzymes. The proportion and type of dietary carbohydrates can affect the exocrine function of the pancreas, especially the secretion of amylase. There is a significant linear relationship between starch digestibility and chyme amylase, which indicates dietary rumen-protected starch affects pancreatic amylase secretion.

Functional amino acid such as leucine can be used as a nutrient signal to stimulate the secretion of α-amylase, trypsin, chymotrypsin, and lipase in a dose- and time-dependent manner. Phenylalanine increased amylase, trypsin synthesis, secretion, and mRNA expression in cow pancreas cultured in vitro.



Conclusion

Pancreatic secretions play very important role in digestive process of the ruminants. The alkaline secretion consists of bicarbonate ions that neutralize the HCl concentration of the ruminal contents. Cholecystokinin hormone secreted by the small intestine triggers the release of the pancreatic juice. The digestive enzymes and the proenzymes digest carbohydrates, proteins and lipids. Enterokinase enzyme present in the intestinal epithelium converts trypsinogen to trypsin which activates the other proenzymes. Trypsin, chymotrypsin and carboxypeptidase breakdown the proteins. Pancreatic amylase and lipase breakdown the carbohydrates and pancreatic lipase helps to digest triglycerides by breaking them down into fatty acids and glycerol. The activity of digestive enzymes containing amylase, protease, and lipase is low in newborn calves and increases with advancement of

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age. The secretion of pancreatic juice is regulated by CNS through vagus nerve, secretin and CCK hormones secreted by the duodenum.

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