Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 [6] May 2014: 55-58

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Digestion Mechanisms in the Stomach and the Intestine of Horse

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ABSTRACT

Horses' digestive system is considered as an interface between ruminants and non-ruminants. Therefore, the digestive system of horses enables them to digest enzymes very rapidly in the fore part of the stomach (mouth to ileum). Also, such a system provides them with sufficient grounds for a high rate of microbial fermentation in the end part of the stomach (CaecumTractum). Besides, gastrointestinal tract of horses digest and ultimately metabolize different nutritional materials such as carbohydrates, fat, and protein. For horses, the final hydrolysis by the existing enzymes is operated in the brush border of the small intestine, which leads to the release of free glucose. The most volume of carbohydrate fermentation in the intestine is fatty-vaporizable acids such as acetate, propionate butyrate. Generally, the digestion of protein is done by pancreatic proteases including trypsin, chymotrypsin, elastase and carboxy-peptidase. Furthermore, the existing bacteria in the end part of the gastrointestinal tract (especially within the Secom) are able to digest and absorb the proteins and produce microbial proteins. More than 10 to 30 percent of fat ration can be digested in the stomach. The fat ration which is not digested by saliva or gastric lipase is thereby digested by pancreatic lipase. Last but not least, the action of lipase takes place in the duodenum with regard to the help from emulsification produced by bile salts, bile fat, and the products resulting from the lipase digestion right before the intestine. This study aimed to investigate the digestion mechanisms in the stomach and the intestine of horse.

Key words: *Digestion system, nutritional materials, gastrointestinal tract, horse*

Received 10.02.2014 Revised 04.04.2014 Accepted 25.04. 2014

INTRODUCTION

Animals differ in terms of digestion physiology according to their consumption of food combinations. As a type of grazer, Ekos Kalabus horse is classified as an animal which possesses Bacteria intestine gland [1]. Non-ruminant animal digestive systems contain enzymatic digestion of carbohydrates, proteins, and fats in the stomach and the intestine, and also the fermentation of fiber in the region of the end part of the rectum. Likewise, digestive systems of humans, pigs, and dogs are considered instances of this type. Ruminants such as cattle and sheep possess more complex digestive systems that allow them to digest fibers and enzymes in the end part of their stomach. Nevertheless, horses enjoy a digestive system which is similar to ruminants' and non-ruminants' systems of digestion.

The digestive system of horses enables them to digest enzymes very rapidly in the fore part of the stomach (mouth to ileum). Also, such a system provides them with sufficient grounds for a high rate of microbial fermentation in the end part of the stomach (Ceacum Tractum). For animals which enjoy fermentation in the end part of their digestive systems, such as horses, digestion due to the digestive tract is done within it in the first place; then, microbial metabolism is done in the colon. The main position of microorganisms is located in the end part of the digestive tract of the horse. However, Al Jassim et al. [2] reported that there are also some bacteria in the stomach of a horse.

For animals such as horses which enjoy fermentation in the end part of the digestive tract digestion due to the digestive tract is done within it in the first place; then, microbial metabolism is done in the colon. Horses are classified as non-ruminant animals which feed on grass and their major nutritional materials are carbohydrates, proteins, and fats. To this end, the current study aims to investigate the digestion of such nutritional materials with reference to horses.

DIGESTION AND ABSORPTION OF CARBOHYDRATES

Considering the molecular structure of carbohydrates, these compounds can be utilized through hydrolysis or fermentation for horses. The molecular structure of carbohydrates x (4-1) operates through the carbohydrates that are digested by enzymatic digestion and those with molecular structure of x (1-4) operate by fermentative digestion. Hydrolysable carbohydrates for horses comprise of hexodes (e.g., glucose), saccharides, and some oligosaccharides, as well as non-resistant starch. On the other hand, fermentable carbohydrates include soluble fibers (gums, mucilage, and pectin). Some oligosaccharides, fructans, and galactans consist of resistant starch against enzymatic digestion, hemi-cellulose, cellulose, and lingo-cellulosic.

Enzymatic Digestion of Carbohydrates

The secreted enzymes for the digestion of carbohydrates in the intestine include alpha-amylase, alpha-glucose (sucrose, gluco-amylase, and maltase) as well as beta-galactosidase (lactase). The amount of alpha-amylase in the saliva of horses is low. As a result, before it reaches the stomach, no much digestion takes place. Stomach acid within the stomach causes the hydrolysis of carbohydrates and the process does not require enzymes. In the small intestine, carbohydrates begin with the enzyme alpha-amylase . Dyer et al. [3] reported that sucrose enzymes, lactase, and maltase in the small intestine of horses cause the absorption of mucous cells. They also found that sucrose enzyme activity in the duodenum and jejunum is higher than the ileum.

For non-ruminant animals, most of the starch digestion takes place in the small intestine. Pancreatic alpha-amylase is an enzyme endoglycosidase which breaks 1-4 glycoside alpha bonds in between the molecules of the amylase and amylo-pectin. When amylase and amylo-pectin are digested, maltose and iso-maltose are produced. Nevertheless, alpha-amylase does not have the characteristic to break 1-6 glycoside alpha bonds, resulting in the production of small oligosaccharides which possess about seven glucose units [4]. The final hydrolysis by the existing enzymes is operated in the brush border of the small intestine, which leads to the release of free glucose. These enzymes hydrolyze 1-4 alpha bonds and 1-6 glycoside alpha bonds [5].

Digestible Carbohydrate Fermentation

The main area of fermentation in horses is the end of the digestive tract. However, in every part of the gastrointestinal tract which has the well-grounded environment for the formation of microbial populations (pH greater than 5), bacteria exist [6]. Moore-Clover [7] reported a small amount of fermentation occurs in the small intestine of horses. The small amount of fermentation which may occur in the stomach and the small intestine causes the digestion of starch and fructans; nonetheless, it does not affect the digestion process of pectin and cellulose [8]. The most volume of carbohydrate fermentation in the intestine is fatty-vaporizable acids such as acetate, propionate butyrate. The other fatty acids that are produced within a little amount are lactate and valerate. Microbial fluorescent within the gastrointestinal tract is severely affected by the type of ration used.

Proteins

Proteins are made up of hundreds of amino acid molecules that are linked together by peptide bonds. Little amount of dietary protein in horses causes deficiency in growth [9,10] and reduced milk production [11]. Such a primary structure is folded and is shaped like buffer; ultimately, the second and third structures of proteins make the proteins. A number of proteins possess a set of several protein monomers. Since proteins are very large, they cannot be absorbed. In order to be absorbed through the epithelial cells lining in the small intestine, proteins' size should be reduced. The hydrolysis of peptide bonds and the breaking of polypeptide chains lead to a reduction in their size. The nucleic acids which belong to microbes and edible materials break due to the simultaneous activity of nuclease and phosphate-like pancreas' esters in the small intestine to their built-in nuclides [12].

Enzymatic Digestion of Proteins

The hydrolysis of proteins is carried out by a group of protease enzymes [13]. Protease is secreted in the form of inactive pre-enzymes which are called 'Zymogens'. If the synthesis of proteases was active, such a synthesis would result in the digestion of cells which have synthesized them. Pancreatic proteases comprise of trypsine, Chymotrypsin, elastase and carboxy-peptidase. The proteases influence on the middle or end of the protein molecules. There are some peptidases within the brush border of the intestinal epithelium. Luminal surface possesses the epithelial cells of the small intestine (including enterocytes) which are about 3000 to 6000 micro-villi [14] and they are called the brush border.

Microbial Digestion of Proteins

Each protein passing through enzymatic protein digestion from the small intestine is influenced by microbial fermentation. The existing Bacteria (especially within the Secom) are able to digest and absorb the proteins and produce microbial proteins. Nonetheless, unlike ruminants, horses are not able to absorb the proteins that the bacteria have produced unless they are trained for eating the feces.

Fat

Since fat enjoy a high digestive power, it is regarded as one of the richest sources of energy for horses. Also, the most prominent reasons for fat consumption within the gore ration include the reduction of heat-productive energy, the improvement of operation and the muscle metabolism in the athlete horses, as well as the reduction of the amount of nutritional materials and consumable water [15]. The fat of nutritional materials includes Triacylglycerols, phospholipids, and galacto-glycerides. Triacylglycerols (also called triglycerides) is a small macromolecule consisting of glycerol which establishes a fatty acid ester bond with each one of the three-carbon glycerol.

Fat Digestion

One of the most important sources of fat for the horse nutrition is the animal fat and vegetable oil. Vegetable oil is, to a high extent, unsaturated and its digestibility is 85-90. Besides, it provides a higher amount of energy for horses [16]. Fat digestion begins in the stomach of horses. Gastric lipase helps to digest fats and causes the adjusting of water to other fatty acids. More than 10 to 30 percent of fat ration can be digested in the stomach [17]. Its Digestive enzymes are secreted from the cells of the tongue, throat is, or stomach [18]. The fat ration which is not digested by saliva or gastric lipase is thereby digested by pancreatic lipase.

The action of lipase takes place in the duodenum with regard to the help from emulsification produced by bile salts, bile fat, and the products resulting from the lipase digestion right before the intestine [18]. Emulsify fat provides more space for the action of lipase. Bile salts cause the formation of stream and facilitate the digestion of fat. Such salts are regarded as the most prominent factor on the digestibility of fat within the ration and they are unsaturated. Bile salt is secreted from the liver; hence, it helps the activation of lipase, the creation of pancreas for the digestibility stream, as well as the absorption of fat. Most of the animals gall is stored in the gallbladder; however, horses do not possess gallbladder and the gall which is produced in their liver is directly secreted into the intestine [19].

Moreover, bile salts extract slippery fatty acids from the activity area of lipase. This leads to the separation of the enzyme molecules from the surface of lipid droplets are. Lipase protein is secreted from pancreas which connects the lipase molecule with the substrate fat; hence, it avoids the lipase and fat fragmentation. Furthermore, pancreas secretes other fatty digestive enzymes such as the pancreatic cholesterol of esterase which hydrolyzes the cholesterol [20].

CONCLUSIONS

The digestive system of horses is regarded as an interface between ruminants and non-ruminants. Digestion of carbohydrates is easily done. Also, the digestion of proteins and fats mainly takes place in the stomach and small intestine through the pertaining enzymes (i.e., amylase, protease, and lipase). However, due to the fact that horses graze, their cell walls with respect to carbohydrates that are resistant to the enzymes secreted by horse are carried out by enzymes secreted from the existing microorganisms in the cecum (fermentation digestion). The ultimate result of microbial digestion is the production of volatile fatty acids which provide some of the energy required for horses' maintenance, mobility, as well as pregnancy.

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