Anatomy of the digestive system

PART 2:

THE SMALL INTESTINE

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Digestive and metabolic disorders are very common in the domestic horse and in the majority of the cases they can be traced back to the way we manage and feed our horses.

In this three part series we dissect the equine gastrointestinal (GI) tract to gain a better understanding of the digestive process and learn how we should keep our horses, and what feeding management we should follow to maintain optimal (digestive) health in our horses.

The GI tract of an adult horse (~500kg) is about 30 meters long and has a total volume of approximately 180 litres. The entire tract can be divided into two functional parts; the foregut and the hindgut (see fig 1). In the first part of the series on the anatomy of the digestive system (March issue) we discussed the first part of food digestion - from the mouth to the stomach of the horse. In this article we continue by having a closer look at the small intestine, and next month we will describe the large intestine.

The small intestine

The small intestine of an adult horse (500kg) is about 20-25m long, 7 to 10 cm in diameter and has a capacity of 50 to 70 litres. It has three parts: duodenum, jejunum and ileum (figure 1).

The duodenum is short, approximately 1 m, and can be separated into a cranial, descending and ascending portion. The jejunum covers the majority of the small intestine and the ileum is the shortest section (0.7 m) which opens into the caecum of the horse.

Although the small intestine has a relatively small diameter, the intestinal walls are covered with wrinkles or folds which contain millions of finger-like projections called villi, which are themselves studded with millions of smaller projections called microvilli (see figure 2). The presence of these villi on the inside of the small intestine means that the surface area is much larger than if the lining were just a flat surface. This increased surface area helps with the digestion of carbohydrates and proteins.

The passage of food through the small intestine is rapid; it reaches the caecum approximately 1 to 8 hours after ingestion. Much of the food moves through the small intestine at the rate of about 30cm/min. The passage rate is influenced by the type of feed consumed. Pelleted feeds are digested at a faster rate than hay. Also fresh grass moves more rapidly than hay.

Feeding horses after a fasting period can also increase the transit of food from the stomach to the caecum. It is important to realise that fasting periods happen more often than people think.

Many horse owners feed their horses two meals per day, one before they go to work and one at the end of the day. Most of the time these feeds, especially sweet feeds, are very appetizing and horses will adapt to the routine and stop grazing hours before their meal arrives. This means that when you then feed your horse the evening meal the passage rate is very rapid and food will not be effectively digested. As described in the previous part, to maintain proper digestive function it is important to feed fibre in order to slow down the gastric emptying as well as the passage rate through the intestines.

The digestion process

When food is mixed and broken down in smaller particles it leaves the stomach and enters the duodenum. The presence of food in the stomach and gastric hydrochloric acid (HCl) in the duodenum stimulates the release of the hormone secretin into the blood, which regulates the secretion of pancreatic juice in the duodenum. Bile from the liver is added for the digestion and absorption of fats and fat-soluble vitamins. Stimulation of bile from the liver is also caused by the presence of gastric HCl in the duodenum. Bile is a complex alkaline fluid containing water, electrolytes and a number of organic molecules including bile acids, cholesterol, phospholipids and bilirubin. Unlike humans, horses don’t possess a gall bladder, so bile flows continuously through the biliary tract into the duodenum.

The biliary duct and pancreatic duct both open into the duodenum at the major duodenal papilla (figure 3). The horse also possesses an accessory pancreatic duct that opens on the minor duodenal papilla opposite the major papilla (see fig 3).
The alkali (ionic salts) in pancreatic juice and bile help preserve an optimal reaction in the intestine for the proper functioning of digestive enzymes secreted in the tract.

Food undergoing digestion leaving the stomach will quickly rise to a pH of 7.0 or slightly above. Much of the protein and fat, and about 50 to 70% of the soluble carbohydrate or nitrogen free extract are digested in the small intestine. Protein, carbohydrates fats and most of vitamins and minerals are absorbed also from the small intestine.

The Starch and Fructan challenge for the small intestine

In part one we discussed the popularity of including cereals, cereal by-products, protein meals and oils in the diet of the performance horse. Most of these high energy feeds for working horses contain high proportions of cereal starch. These have many benefits but can also potentially cause a lot of health problems.

The percentage of carbohydrates digested in the small intestine is largely influenced by feed processing, the properties of the starch granules, other food structures such as plant cell wall, transit time through the small intestine, the quantity fed in the meal, and the availability and concentrations of digestive enzymes.

As stated earlier about 50-70% of the soluble carbohydrates are digested in the small intestine, resistant starch together with undigested starch, will pass into the large intestine of the horse where it may be fermented to short chain fatty acids and lactate.

The fermentation process in the hindgut will be described in more detail in part three of the series. But as we highlighted in Part 1 and other nutrition articles, an overload of non-structural carbohydrates (NSC) such as starch into the hindgut can cause digestive disorders.

One of the ways to increase starch digestibility and reduce fermentation in the hindgut is to process the feed by cooking, which is done by many commercial feed manufacturers. The processes used include expansion or extrusion of products and infrared micronisation of cereals. Processing can significantly affect starch digestibility, the best example is that of corn, but the extent of the effect of processing depends largely on the nature of the process, equipment used and conditions of process.

Although, the cooking process improves the digestibility of starch in the small intestine, the digestion will decline as starch intake increases. So even if you feed products that are processed by cooking they still can cause digestive dysfunction when you overfeed! It’s all about balance and moderation, feed little and often!

There is some research data that provides us with some guidelines on how much starch we can feed that is still considered ‘safe’. The studies suggest that the amount of starch per meal should not exceed 0.2-0.4% of the body weight. However, there are many variables that will affect this “safe” value such as the starch source, the interaction with other feed products, the transit time through the small intestine and the enzyme availability. There is also variability in each individual horses’ ability to digest starch, which can be linked to the way they chew their feed. For example, horses that have bad teeth and/or eat fast will have a reduced digestibility of starch in the small intestine compared to horses that eat slower and grind their food to small particle sizes.

Another situation which challenges the digestive system of the horse is grazing lush pastures with high levels of NSC (fructan). Fructan cannot be digested by digestive enzymes in the small intestine, and if it escapes the hydrolysis in the stomach it will end up in the hindgut ungraded. The excess intake of fructans can cause similar problems to feeding an overload of starch.

To achieve optimal hind gut health, fibre intake should be maximised and the intake of simple sugars and starch (NSC) should be minimised. Starch intake can be easily managed, but regulating the intake of fructan from grass remains a more complex problem that requires a holistic management of horse feeding and pastures. It is possible to create a proper plan to safeguard the well-being of the horse.

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Further reading
Lewis, L.D. 1996. Feeding and care of the horse. 2nd edition, Lippincott Williams & Wilkins, USA.

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