Understanding Equine Digestion

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Nutrition
Fact Sheet 11

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When grazing, a horse feeds predominately on leaves, plant stems and buds, consuming the bulk of its feed as forage or grass. Starch from seeds does not naturally contribute a significant portion of the diet of a grazing horse. In contrast, stabled horses, especially those in upper level equestrian training, are obliged to consume low moisture (10% as fed), concentrate rations containing from 30- 60% by weight of starch-based grain mixes to meet their needs for energy in a volume that they are able to consume, with minimal bulk contributed by roughages of chaff, hay and access to grazing.

The horse is able to adapt to a wide variety of feeds because of its unique digestive tract structure, with a single stomach and small intestine layout, and a ruminant-like fibre fermenting, large volume hindgut for microbial digestion, utilising feeds of lower nutrient content.

As a horse owner, it is useful to have a good basic understanding of the feeding behaviour and digestive processes to ensure optimum digestive efficiency of horse being prepared for showing or competition.

The Digestive Layout and Digestive Physiology

It is an advantage to understand the unique digestive layout and function of the horse gut to provide a basis for formulating suitable diets, feeding times and avoiding digestive upset or the poor utilisation of a ration.

The Mouth

The oral cavity of the horse plays a crucial role in the collection and preparation of feed prior to it entering the other digestive compartments. The horse selects its feed based on the texture, smell, taste and length of the food, such as chaff, in the feed mix. Horses have a large muzzle and pliable lips that enable careful selection of individual feeds within a mix. The horse grinds or 'minces' its food with its teeth, with the lower jaw being 33% narrower than the upper jaw, creating a grinding action as the jaw 'sweeps' from side to side during chewing. The difference in width of the lower and upper jaw teeth necessitates a 'side to side' jaw sweep to chew food, resulting in the eventual development of hard, enamel sharp outer edges on the upper molars and inside edges on the lower molars. Sharp molar edges may lead to lacerations of the soft oral cheek me**mbranes and tongue, increasing discomfort and reducing the efficiency of chewing, and ultimately the food particle size passed on into the digestive tract.**

1. The Chewing Action

Horses grind or 'mince' food into small particles of less than 1.6-2.0mm in diameter by the repeated 'sweeping' action of the jaws, chewing each mouthful an average of 12 times, or 60-75 chews/minute over a range of feeds. However, lengths of roughage up to 12 mm are common in the stomach in a healthy horse with good teeth. It is thought that the longer roughage acts to increase the rate of passage through the small intestine, assist in holding water in the digestive system and open up the digestive mass in the hindgut to facilitate microbial digestion and maintain optimum consistency of the droppings.

Horses are unable to regurgitate or vomit and only have one pass of their teeth to prepare food into particles small enough for enzymatic and microbial digestion. Ruminants (cattle, sheep, goats) regurgitate the food mass 3-4 times to grind it into smaller particles and mix the food 'ball' or bolus with saliva and microbes to facilitate ruminal function. Horses need to grind the food mass thoroughly prior to swallowing, otherwise their digestive efficiency is impaired.

Horses which consume or 'bolt' their food too quickly, or do not chew and grind it adequately due to sharp-edged molars or other dental abnormalities, do not grind their food into small enough particles and have less efficient digestion, often losing condition. It is estimated that up to 15% of race horses in training do not prepare their food adequately because of sharp-edges or abnormal teeth., or they eat 'sweet' feeds too quickly without chewing and salivating efficiently to ensure optimum digestion needed for them to perform and race successfully. Up to 33% of aged horses die prematurely because of poor or abnormal teeth that reduces their ability to prepare feed for digestion.

A horse chews grains and hays at a different rate as follows,

Oats	800-1000 chews/kg
Hay	2000-2500 chews/kg
Sweet Feed	350-500 chews/kg – rapid consumption, reduced chewing andless buffering by saliva, possibly leading to an increased risk of gastric ulcers.
Feed pellets and mash	400-480 chews/kg

Horses with dental abnormalities often chew more and salivate profusely.

It is important to have a horse's teeth checked for sharp-edges at the start of each season and in 2-4 year olds which are losing teeth and 'caps' as they change from foal teeth to permanent teeth, the teeth should be checked and rasped every 6 months.

If a horse is 'bolting' its feed, I suggest that you cut a piece of heavy duty Weldmesh with 125mm x125mm boxes so that it fits snugly into the feeder and position it on top of the feed in the bin, forcing the horse to eat between the wires, reducing its ability to eat quickly or waste feed by pushing it out of the bin with its nose. There is also a significant difference in the efficiency of chewing of short-chopped (preferred fine-cut or double-cut 'racehorse chaff') and long-chopped ('rough cut') chaff mixed into the grain mix. Studies in Germany found that long chopped chaff with particles between 2-4 cm in length was more likely to be ground into smaller particles, along with the grain, with slower intake and more complete chewing, facilitating increased saliva secretion during chewing, as compared to fine-cut chaff.

2. Salivation

Horses secrete copious volumes of saliva – up to 12-14 litres/day when chewing dry feed mixes and up to 20 litres when consuming dry hay as the major roughage. Saliva has no amylase enzymatic content, but it has a high potassium and buffering bicarbonate content in its viscous, mucoid consistency which helps to provide a buffering, protective coating against gastric acid 'burn' around the 'gullet' inlet and upper non-glandular stomach region. Horses that eat quickly, especially sweet feeds that do not stimulate salivation, may not salivate adequately to prepare the food for entry into the stomach, and are more likely to develop gastric ulcers in training. In fact, feeding a small amount of 50mL of acid as apple cider vinegar mixed into 100mL of water in the meal after exercise will stimulate salivation and provide additional buffering and protection to the stomach wall.

The Stomach

The stomach is a 'J' shaped expandable bag, with relatively small capacity, ranging from about 5-7 litres, in a Thoroughbred sized horse. It facilitates only minimal fibre and protein digestive function, with little protein degradation by gastric acid. The stomach has different rates of passage of the food mass, relative to the fibre content. Highly fibrous feeds, such a poor quality hay or chaff, are passed more quickly through the stomach as compared to denser grains and protein meals, which accumulate within the lower glandular section of the stomach. New research has highlighted some starch and sugar fermentation activity in the more alkaline area within the upper curvature of the stomach before the food mass passes into the small intestine.. In this area, the passage rate is slower and the acidity approaches alkalinity (pH 7.0) to sustain microbial fermentation of starch and non-structural carbohydrates in the feed. The lower stomach compartment is lined with glandular membrane which secretes gastric acid, from 10-15 litres per day, with release on a near continuous flow, with or without food entering the stomach. In a stabled horse, the gastric pH can reach as low as pH 1.0 in the lower stomach area during fasting between feeds, which is thought to be a factor in the development of gastric ulcers when horses are exercised on an empty stomach. The upper area of the stomach wall has a non-glandular squamous cell 'skin-like' lining which has little natural acid resistance and relies on the neutral, near alkaline pH of roughage and saliva mix in the meal. Well chewed hay and chaff particles become suspended in the upper stomach section and the alkalinity of the large volumes of saliva entering with the food helps to protect it from acid attack and erosion.

1. *Microbial Activity*

New research suggests that microbial action in the alkaline area on the lesser curvature contributes up to 30% digestion of the non-structural carbohydrates or starches prior to the digestive mass entering the small intestine. In a grazing horse, the stomach is maintained at near full capacity, but in a stabled horse with twice a day feeds, the stomach almost empties between 12 hourly feeds, leading to a lower overall pH and almost cessation of microbial digestion between feeds due to the near continuous secretion of gastric acid from the glandular region. Studies have found that feed containing longer fibres of up to 12 mm or more in length extended the emptying time to facilitate microbial digestion. The lining of this area has been shown to be able to absorb and transport significant amounts of volatile fatty acids produced by gastric microbial activity, which can be converted to energy and muscle glycogen stores in working horses.

2. *Equine Gastric Ulcer Syndrome*

Gastric ulcers (EGUS) are known to result from acid attack of the non-glandular epithelium lining of the upper stomach wall and around the sensitive 'gullet 'inlet, particularly when a horse is exercised or traveled on an empty stomach prior to feeding. A quarter of a biscuit of dampened lucerne hay or 500grams (4 litres) of lucerne chaff given 30 minutes before exercise has been found in 2 studies to reduce the risk of EGUS by 50% in horses in training. Lucerne contains natural calcium and magnesium buffers, mucilage and soap-like compounds to help protect the upper gastric lining and stimulates chewing and saliva secretion more effectively than grass or cereal hays or chaffs.

The Small Intestine

The small intestine is between 21-25 metres in length (cattle have a 40metre long SI) with a volume of 40-50 litres. The transit speed of the food mass is around 30cms/minute, with faster passage time for fibrous foods, such as hay, chaff and laxative, green grass. The pH of the small intestine ranges from 7-8.5 being highest in the last section of the small intestine where it secretes large quantities of bicarbonate to maintain active pre-caecal microbial fermentation. The alkalinity of the small intestine helps promote and maintain active enzyme digestion and transport of sugars, amino acids, fats and other nutrients through the wall.

1. *Starch and Fat Digestion*

Ideally 50-70% of the starch and non-structural carbohydrates are digested by pancreatic amylase, brush border disaccharides and limited microbial digestive activity. Studies indicate that there is little amylase activity in a non-grain fed horse, although increased activity of amylase, proteinases and lipases can be conditioned by feeding concentrate starch, protein and fat containing feeds. Fat digestion by lipases can increase over a 2-4 week by a step-wise introduction of vegetable oil as an energy source in the diet of working horses. Overflow of excess starch and non-structural carbohydrates into the hindgut can be a problem when horses are "grained up' with high starch grains, such oats and corn, too quickly in training. Overload of undigested sugars into the hindgut can lead to an increase in lactic acid producing microbial activity, with a lowering of hindgut pH and low grade laminitis, seen as 'rings' on the hooves and foot soreness and a'scratchy' gait in horses on high grain feeds. In a survey in the USA in the early 1990's, it was found that 46% of racehorses in training on 5kg or more of grain had signs of low grade laminitis and reduced performance caused by foot soreness. In another study, it was found that feeding more than twice the volume of chaff relative to grain in a working horse's ration, reduced the efficiency of digestion of starch to energy in the small intestine, presumably due a 'smothering' effect of the excess chaff or fibre passing with the grain through the small intestine. More undigested starch was passed into the hindgut which in turn, increased the risk of low grade laminitis. Horses which consumed their food too quickly also had a higher risk of passing undigested grain into the hindgut and subsequent upset and laminitis.

2. *Protein Digestion*

Protein digestion to amino acids by enzymes is highest in the in the alkaline environment of the lower small intestine, with some microbial attack in the upper and central sections of the small bowel.

Microbial and excess dietary proteins are not significantly absorbed from the large intestine to meet amino acid needs. Horses therefore require a dietary source of good quality protein (balanced and adequate in essential amino acids) to meet their daily protein needs from small intestinal degradation of food proteins to amino acids. In contrast, cattle can utilise ruminal microbial protein as a source of protein when fed poor quality roughages.

3. Mineral Digestion

Calcium is the primary mineral absorbed (90%) from the small intestine, with its absorption facilitated by acid salts, phosphorus and Vitamin D. Other minerals, such as magnesium, sodium, potassium and chloride are well absorbed from the small intestine, and 50% or more of uptake of major trace-minerals occurs from the small intestine, with 90% of the phosphorus uptake from the hindgut. Excess calcium in the feed mix, especially supplementary mineral calcium as limestone or dolomite, can reduce the uptake of magnesium, manganese, zinc and iron from the feed mix. Contary to popular belief, dolomite is poorly absorbed from the small intestine of horses and contributes very little calcium and magnesium to correct low or inadequate levels of these important bone minerals in the feed. Dicalcium phosphate or DCP (23% calcium and 18% phosphorus with a 75% uptake) is the most efficiently absorbed commonly available calcium source for horses.

Large Intestine

The large intestine is equivalent to the rumen(paunch) of a ruminant, as it facilitates microbial fermentation of cellulose to volatile fatty acids and limited amounts of methane. The methane produced is metabolized by other microbes and horses do not pass methane in their droppings, reducing this major contribution to one of the most dangerous green-house gasses which is belched out by ruminating cattle, sheep, goats (as well as camels and alpacas) as ruminants.

Excess protein entering the large intestine is fermented to heat, with up to 6 times more 'heat waste' than excess starches and fibre fermentation.

The 'blind sac', or caecum, in the right flank area (1.2 metres long and 25-30 litres in volume), commences the microbial fermentation of fibre to volatile fatty acids and residues of proteins and starches overloaded from the small intestine.

The remaining large colon (3-3.7 metres in length or 50-60 litres) in volume accounts for 34% (about one third) of the total digestive tract volume. The food mass moves through at 2-3cm/minute, being mixed by a sophisticated system of retrograde flow and intestinal motility to facilitate microbial attack. The large colon is the primary site of microbial fermentative gas production, which can rapidly increase when a horse is provided with highly fermentable carbohydrate feeds and excess sugars. The primary secretion and uptake of water is from the large colon.

The small colon (3-3.2 metres) and rectum (0.3 metres) dry out the faecal mass as an important part of final water reclamation in maintaining hydration in the exercising horse.

Around 50% of the dry matter content of the droppings of a horse consists of viable, fermenting microbial cells passed out in the waste because they are not used as a source of protein and other nutrients by the horse. Damp horse droppings continue to ferment after being passed for up to 10 days.