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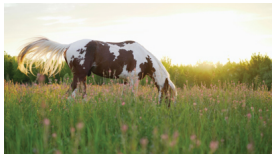
How does the horse digest feed and therefore make use of the nutrients contained within the feedstuffs it consumes? This question is of fundamental importance to equine nutritionists, and while it is not necessary for you to become bogged down in the intricacies of equine digestive physiology, a basic understanding of how the horse digests feed is necessary for the selection of appropriate diets and feeding practices.

At the outset, it is useful to remind ourselves that horses evolved as forage eaters, grazing for upwards of 16 to 17 hours each day and traveling considerable distances as they graze. The horse's digestive system is well suited to this feeding behavior – the stomach and small intestine are designed to cope with the almost continual entry of small amounts of food while the large intestine is geared toward the extraction of maximum nutritional value from the fibrous feeds. Now consider how the pressures of domestication have dictated changes in diet and feeding behavior: Continual access to pasture is but a dream for most horses, and many spend a considerable part of the day in a stall. As well, our own schedules dictate feeding programs – rather then continual grazing, horses are often fed large meals morning and night. The high-energy requirements of the performance horse have necessitated inclusion of more energy-dense ingredients such as cereal grains and fat in horse diets. All of these factors can contribute to digestive upsets, some of which can be avoided by returning the horse to a more "natural" feeding circumstance.



Twists and Turns

The basic components of the digestive tract are similar in all mammals – the mouth (including salivary glands), esophagus, stomach, small intestine, cecum and large colon. We can divide the horse's digestive system into two sections. The pre-cal section (esophagus, stomach and small intestine) function much as in man, dog and pig. On the other hand, the cecum and large

intestine work like the forestomachs of a ruminant (e.g. cow or sheep) – there is continual microbial fermentation of dietary fiber. For this reason, horses are classified as hindgut fermenters. In fact, normal function of the hindgut is heavily reliant on an adequate supply of dietary fiber. This is a key point – without adequate dietary fiber, the horse is predisposed to nutritional imbalances and colic problems.

The digestive process begins with the prehension of food, that is, food is grasped using a combination of the lips, tongue and teeth. When eating tightly packed hay, larger muscles of the head and neck are also used to grab and pull feed into the mouth. After prehension, the food is chewed (masticated) – this is an extremely important part of the digestive process – digestion is most efficient when hay and other fibrous feeds are ground into small pieces. Proper mastication of whole grains such as oats is also important to ensure optimal digestion in the small intestine. That is why it is so important that the teeth are in good working order. Poor teeth, a common problem in older horses, will result in decreased feed intake and weight loss, particularly in horses on an all-forage diet. Quidding, the dropping of partially chewed feed from the mouth, is a sure sign of dental woes. Choke (the lodging of a food bolus in the esophagus) and impaction colic can also occur when a horse has poor dentition.

The type of feed has a dramatic effect on the speed of ingestion. A horse will chew between 3500 and 4500 times per kg of dry hay consumed, taking about 40 minutes to eat each kg of hay. Therefore, if 12 kg of hay is provided each day, the horse will spend at least 8 hours feeding. When grains and other concentrate feeds are substituted for fiber in the diet, the total time spent feeding will be markedly reduced – 1 kg of oats can be consumed in 10 minutes or less, requiring only 850 chews. So, a diet of 7 kg hay and 5 kg oats will decrease feeding time by 2 to 3 hours. Such reductions in feeding time are thought to cause boredom and other behavioral problems (e.g. stable vices). This is another reason why fiber is such an important part of the horse's diet.

The horse produces saliva during chewing. Saliva moistens the ingesta thereby easing the passage of food from the mouth to the stomach. Saliva is rich in bicarbonate, which helps to buffer the acid secretions produced in the stomach. Here, the nature of the feed is also important – on a dry matter basis, twice as much saliva is produced when horses eat hay or grass compared to rains and other concentrates. Diets high in grain and low in forage will therefore decrease saliva flow and result in low gastric pH values, a risk factor for the development of gastric ulcers. Only a limited amount of digestion occurs in the stomach. The stomach's main job is to further liquefy the incoming food and "feed" the ingesta into the small intestine, where digestion really cranks into gear. However, gastric acid helps to breakdown some of the feed particles and the enzyme pepsin initiates protein digestion. In fact, the stomach produces gastric acid on a continuous basis – this works well when horses are grazing or nibbling on hay for much of the day because the incoming feed soaks up these gastric juices. However, if the horse is meal fed (morning and evening) the stomach will empty for long periods. In this situation, the acid can cause injury to the nonglandular portion of the stomach lining, gastric ulcers being the end result.

The actual extraction and absorption of nutrients contained within food begins in earnest ingesta enters the small intestine, a tube-like organ about 60 to 70 feet in length. Despite this

considerable length, the ingesta traverse the small intestine quickly. Some food enters the cecum within one hour and much of the ingesta will reach the fermentation vat by 3 hours after eating. This rapid transit reflects the coordinated activity of the nerves and muscles contained within the walls of the small intestine. Factors such as meal size, feed type and exercise will influence transit time. Big grain meals result in rapid gastric emptying and intestinal transit and a reduction in the digestion of the available starch. More on this later. Pelleted and ground feeds also tend to move faster through the small intestine than fibrous feeds such as hay and grass. Exercise also results in a moderate speeding of intestinal transit.

Sugar, Fat, and Protein

The small intestine is the primary site for the digestion and absorption of sugar and starch, protein and fat. The fat-soluble vitamins (A, D, E and K), calcium and some phosphorus are also absorbed from the small intestine. Let's first deal with sugar and starch. Molasses is perhaps the best-recognized source of dietary sugar for the horse – some "sweet feeds" are up to 10 percent molasses although the current trend is for lower amounts. However, pasture grasses are by far the most important source of sugar; a horse grazing full time could consume up to 2 kg of sugar (nutritionists use the term water-soluble carbohydrate or WSC). Sun-cured hay has a lower WSC content as there is loss following harvest.

Starch is the plant world's version of glycogen, the body's storage carbohydrate – a huge number of glucose molecules are linked by chemical bonds, forming a single structure. Starch is a major component of cereal grains – oats are about 50 percent starch while corn is between 65 and 70 percent starch. The simple sugars in molasses and grasses are easily digested; glucose is absorbed directly into the bloodstream while enzymes located on the small intestinal lining make other sugars available to the body. Starch is a slightly different story; the first step involves its breakdown to smaller sugars. Then, the enzymes on the intestinal lining act on smaller sugars until they are in an absorbable form.

Amylase, an enzyme released by the pancreas when ingesta enter the duodenum, is the catalyst for the first step. Unfortunately, compared to other mammals, amylase is in short supply in the horse. As a result, the horse has a limited capacity to digest starch – the upper limit probably varies between horses but as a general rule, a single grain or concentrate meal should contain no more than 5 lb. The starch story is further complicated by the fact that digestibility of starch varies between the grains. For example, the starch in whole corn is very poorly digestible. Fortunately, most manufactured feeds contain grains that have been processed to greatly improve starch digestibility in the small intestine. Even so, with grain feeding, (particularly large meals) there is always a risk that undigested starch will reach the large intestine. The digestion of protein and fat is more straightforward. Enzymes from the pancreas and those present on the intestinal lining digest proteins to their constituent amino acids, which are absorbed into the bloodstream.

Even though the "natural" equine diet is very low in fat, horses can digest fairly large quantities. Studies have shown that horses can tolerate a 10 percent fat diet (total diet), although there should be a gradual increase to this level to allow the digestive system to adjust.

The Boiler Room

The large intestine begins with the cecum, a structure that lies in the right flank area. This organ is 3 to 4 feet long and holds up to 15 gallons of fluid and ingesta. Adjoining the cecum is the large colon, the largest single structure in the digestive tract (about 40 percent of total capacity). Like the rumen of the cow, the cecum and large colon work like a fermentation vat. Literally billions of microorganisms (bacteria and protozoa) do the digestive work, producing enzymes that are able to breakdown the fibrous portion of the diet. This process is much more time-consuming compared to digestion in the small intestine and the ingesta dwell in the large intestine for upwards of 36-48 hours.

Dietary fiber is the portion of the ingesta not affected by the horse's own digestive enzymes. There are many (confusing) chemical and physical definitions of dietary fiber, but basically we are talking about the structural components of plant material. Some of this fiber can be digested by microbial enzymes, particularly cellulose and hemicellulose. On the other hand, lignin – another fiber form – is not digestible and will be passed in the feces. The type of dietary fiber greatly influences its nutritional value – for example, over-mature grass hay with relatively high in lignin, which depresses digestibility of the fiber. Other fiber sources such as young grass, beet pulp and soy hulls are highly digestible.

The products of the fermentation process are the volatile fatty acids (VFA's) acetate, butyrate and proprionate, heat, water and gas. The VFA's are absorbed into the bloodstream, providing an extremely important source of energy for the horse. Microbial enzymes also break down undigested proteins, which enter the large intestine, although the horse does not use this protein. Instead, the main end product of this process – ammonia – is used by the bacteria to produce proteins that are needed for their own growth and survival. On the other hand, vitamin K, another product of microbial activity, is absorbed into the horse's bloodstream. As a result, in most circumstances the horse does not require vitamin K in its diet.

Another very important function of the large intestine is the absorption of water. Each day, a huge quantity of water is secreted into the small intestine as part of the digestive process – about 30 gallons (100 liters) for a 500 kg (1100 lb) horse. As the ingesta moves down the various secretions of the large colon, much of this fluid is reabsorbed allowing the formation of semi-solid fecal material. The final step in the digestive process occurs in the small colon, where the waste material is formed into fecal balls that are evacuated through the rectum and anus.

In conclusion, remember that the horse's digestive system functions best when it is fed a predominantly forage diet on an almost continuous basis. Problems are much more likely when they are fed a relatively high concentrate, low forage diet, particularly when given two (or even one) large meals per day. Yes, the performance horse needs more energy than can be supplied by an all-forage diet, but try to spread the daily grain/concentrate allotment over more meals e.g. three rather than one of two. Finally, allow the horse to nibble on hay (or better, pasture) as much as possible.