

The Gastrointestinal Tract of the Horse

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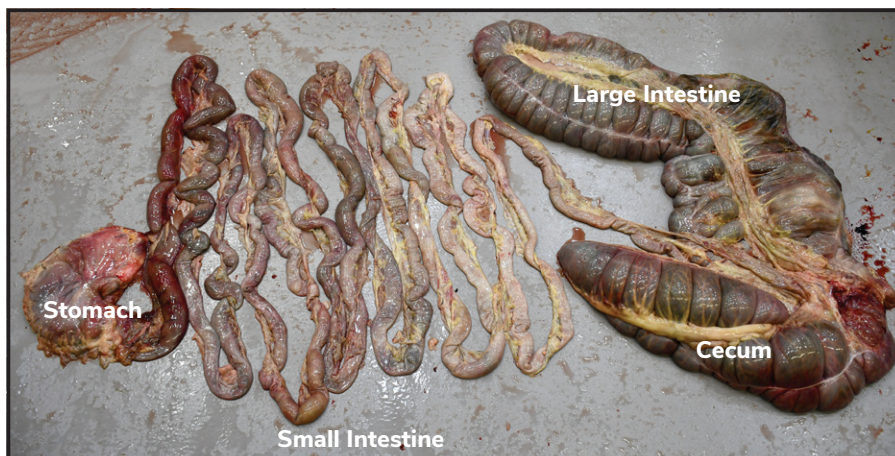
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Horse owners and managers need a basic understanding of how the equine gastrointestinal tract (GIT) functions to provide ideal nutrition and management for animals in their care. This fact sheet provides practical knowledge of the physiology and function of the equine GIT and its relation to best practices. Fundamental knowledge of the gastrointestinal tract and how it relates to performance and health is essential to making informed decisions about equine feeding.

The evolution of the horse provides a foundation for understanding the equine GIT and the diets horses consumed. Horses evolved on the plains and steppes of North America eating fibrous grasses before being domesticated in Western Eurasia. As prey animals, they adapted to a grazing, wandering lifestyle, eating small meals for at least 16 hours each day. Horses are non-ruminant, simple-stomached herbivores. They are hindgut fermenters, meaning the large intestine is the main site of fermentation of fibrous feedstuffs. This differs from ruminant animals like cattle, goats, deer, and sheep, which are foregut fermenters with a rumen and multicompartiment stomach. When the GIT of a horse is compared to other animals (Table 1), key differences emerge:

1. Horse stomachs are relatively small, which corresponds to continuous, small meals.
2. The horse hindgut is relatively large, allowing for optimal fermentation of fibrous feedstuffs that make up the majority of the equine diet.



Adapted from College of Veterinary Medicine, University of Tennessee.

Figure 1. Gastrointestinal tract of horse, showing from left to right the stomach, small intestine, cecum, and large intestine.

Table 1: Percentages of gastrointestinal volume for different species (Geor, Harris, and Coenen 2013).

	Pig	Ruminant	Equine
Stomach	29%	70%	9–10%
Small Intestine	33%	19%	30%
Cecum	6%	3%	16%
Large Intestine	32%	7%	45%

A further analysis of the horse's GIT shows why certain feeding management recommendations are made and highlights potential areas of concern.

The Equine Foregut

The equine foregut consists of the mouth, esophagus, stomach, and small intestine. The digestive processes in the foregut involve physical and chemical digestion with limited microbial action.

Mouth

Prehension (grasping) of feed by the horse is done primarily by the lips. Once feed is in the mouth, the horse masticates (chews) to break down the food. Horses chew in a grinding, circular motion to reduce feed size and increase the feed's surface area, which helps enzymes begin the digestive process. Teeth need to be checked periodically to ensure that the horse can chew properly, as sharp points can be created over time. If needed, the teeth can be floated (filing down certain areas of the teeth) by a licensed veterinarian or licensed veterinary technician under the supervision of a licensed veterinarian. Horses can produce 9 to 10 gallons (approximately 36 L) of saliva per day to lubricate food and help create boluses. A bolus is a round, easy-to-swallow mass of food. Saliva also has a buffering action in the stomach, helping modulate pH. Relatively little amylase is in equine saliva, so the chemical breakdown of carbohydrates is minimal until later in the digestive tract.

Pharynx and Esophagus

Once swallowed, the food passes through the pharynx—a short, funnel-shaped, muscular tube between the mouth and esophagus. Muscular action then forces food into the esophagus. Food or water cannot return to the mouth due to the trap-like action of the soft palate. If refluxed, food or water must pass out the nostrils. After passing through the pharynx, the food bolus enters the esophagus. This simple muscular tube is 4 to 5 feet long (approximately 1.4 m) in an adult horse and moves the food bolus to the stomach via regular, rhythmic muscular contractions, known as peristalsis (Figure 2). These contractions push in one direction, contributing to the horse's inability to regurgitate. While no breakdown of feedstuffs occurs here, mucous membranes lubricate food as it travels toward the stomach.

The esophagus can be the site of a condition known as choke. When a horse chokes, the esophagus is blocked. Swallowed feed can come out of the nostrils as a result. Although the horse can breathe, they cannot eat or drink with an esophageal obstruction. Therefore, this condition is an emergency, and a veterinarian should be contacted. Practices to decrease risk of choke include constant access to water, regular dental care, and discouraging bolting feed or hurried eating behavior, especially of pelleted feeds.

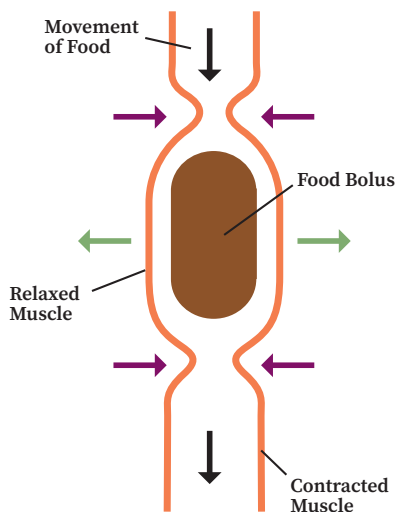


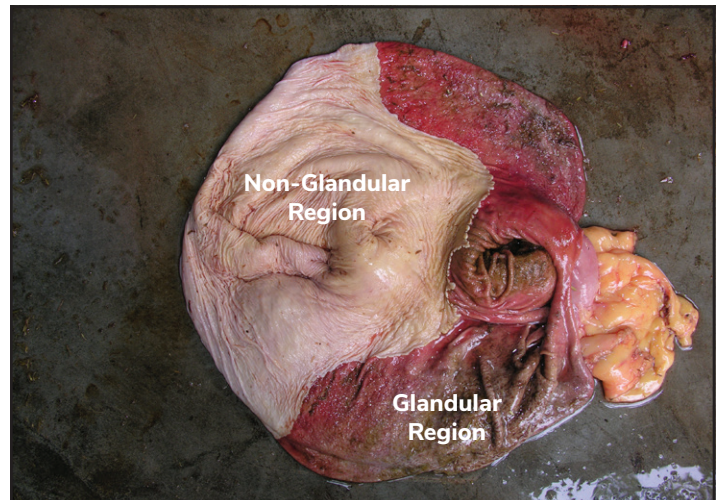
Figure 2. Illustration of peristalsis of food in the esophagus. (Illustration by Elizabeth Share, The Ohio State University.)

Feed exits the esophagus and enters the stomach through a muscular ring called the cardiac sphincter. This one-way valve controls the entry of the bolus from the esophagus and prevents food already ingested, or ingesta, and gas from entering the esophagus.

Stomach

Once the bolus enters the stomach, chemical digestion continues. The horse's stomach is relatively small compared to their total GIT, making up only 9% of the total tract volume and holding approximately 3 to 5 gallons (approximately 18 L). The stomach is split into glandular and non-glandular regions (Figure 3).

The glandular region contains cells that produce various secretions, including hydrochloric acid (HCl) and peptidases to break down protein. Minimal microbial digestion occurs in the gastric compartment of the horse's GIT. Note that under grazing conditions from which horses evolved, the stomach was never empty. In modern feeding situations, which often include two large feedings of concentrate and forage, the stomach can become empty. Even empty, the stomach continues to produce HCl. In the glandular region, cells also secrete mucus and bicarbonate to help protect against the low pH in that region of the stomach. In contrast, the non-glandular region does not have the same protection. In a typical modern horse diet that includes both concentrate and forage, low density or most recently swallowed food is located at the top of the stomach. This food maintains a higher pH due to continuous exposure to saliva. Higher density particles and liquid in the lower, glandular region of the stomach have a pH of 1–2 due to acid secretion (Table 2). Decreased roughage intake, due to feeding schedule or lack of availability, leads to a marked decrease in pH in the upper part of the stomach (pH 4.0 or less) that can increase the risk of forming gastric ulcers (Figure 4), particularly in the non-glandular region of the stomach.



Adapted from Dr. Carey Williams, Rutgers University

Figure 3. The glandular (dark pink) and non-glandular (pale pink) regions of a horse's stomach.



Adapted from Dr. Carey Williams, Rutgers University.

Figure 4. A normal stomach lining (top) compared to a stomach with ulcers present (middle and bottom).

Table 2: pH of digesta throughout the equine digestive tract (Geor, Harris, and Coenen 2013).

	Normal pH (lower numbers are more acidic)
Saliva	7.5
Stomach (diet and stomach area dependent)	Low density digesta, forages: 6–7 High density digesta, concentrates: 1–2
Small Intestine	Duodenum: 6.3 Jejunum: 7.1 Ileum: 7.3
Cecum (diet and mealtime dependent)	4.1–7.8
Large Intestine (colon; diet and mealtime dependent)	6.3–7.5

Small Intestine

There are three portions of the small intestine (Figure 5):

- duodenum
- jejunum
- ileum



Dr. Carey Williams, Rutgers University.

Figure 5. A segment of small intestine with the mesentery that attaches the intestine to the abdomen being displayed.

To exit the stomach, digesta/ingesta flows through the pyloric sphincter, into the first portion of the small intestine, the duodenum. The second part of the small intestine is the jejunum, and the third is the ileum, which is nearest to the ilium bone of the pelvis. Within the small intestine, enzymes secreted from the pancreas and small intestine continue to digest carbohydrates, proteins, and fats (Table 3). Horses do not have a gallbladder, so the liver continually secretes bile to assist in fat digestion. Amazingly, horses can digest and absorb relatively high levels of fat in their diets despite not having a gallbladder. Bicarbonate is also released into the duodenum to buffer pH, allow enzymes to function effectively, and protect intestinal linings.

The second and third sections of the small intestine (jejunum and ileum) contain a large number of villi and microvilli that increase the surface area of the intestines and absorption of digested nutrients. Bicarbonate is introduced again in the ileum, before the ileocecal junction. How much nutrient digestion and absorption occurs in the foregut is affected by feed processing, passage rate, feedstuff composition, and bioavailability.

Table 3. Approximate proportion of macronutrients digested and absorbed (Geor, Harris, and Coenen 2013).

	Digested	Absorbed
Soluble Carbohydrates ¹	90%	50–70%
Dietary Fat ²	100%	100%
Dietary Protein ³	50–70%	50–70%

¹ Non-fiber carbohydrates, i.e., primarily starch.

² Fed in limited quantities; there is an upper limit of effective fat inclusion in the diet.

³ Protein not bound to fiber.

Large grain meals can pass through the foregut without being optimally digested. The influx of nutrients into the hindgut can cause dysbiosis (disruption of the microbial population living there) leading to gas production, colic, and laminitis. Feeding horses small meals often and providing energy through forage can help avoid these issues. If a horse breaks into a feed room to consume a large amount of grain, contact your veterinarian.

The Equine Hindgut

Digestion and absorption of nonstructural (soluble) carbohydrates, protein, and fat in the foregut is possible, and for some nutrients, necessary. However, the majority of the equine diet is composed of structural carbohydrates that cannot be digested effectively in the foregut and are instead fermented in the hindgut (Figure 6). Fermentation involves the breakdown of energy-rich compounds—the structural carbohydrates found in forages—by microorganisms, including bacteria, fungi, and protozoa. These organisms make up the horse’s microbiome. Byproducts of fermentation include volatile fatty acids (VFA) that provide energy to the horse. VFA produced by microorganisms in the hindgut provide the majority of the horse’s energy requirement and are partly why horses are labeled “hindgut fermenters.”

The microbiome in the horse’s GIT includes bacteria and other microorganisms, such as protozoa. The proportions of different microbes affect the horse’s ability to process different feedstuffs. Different proportions can promote or limit the colonization of harmful microorganisms. Different microbial species use different substrates as fuel and, as a result, create different by-products, including VFA. The horse’s diet provides substrates for the ecosystem of microorganisms within the GIT.

The microbial population in the equine hindgut is very sensitive to diet composition and change. Microbes within the equine hindgut have different tolerances to changes in diet and pH. For example, microbes that digest starch (i.e., amylolytic) prefer a lower pH. Microbes that digest primarily forages (i.e., cellulolytic) prefer a slightly higher pH, and if the pH in the hindgut drops too low, they will die. This allows for an increase



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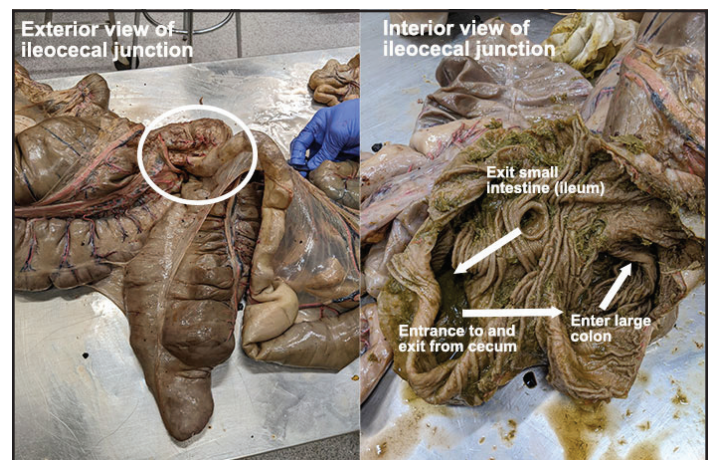
Figure 6. A horse’s hindgut.

in the amylolytic microbe population, resulting in a further reduction in the pH of the hindgut. Forage-based diets promote GIT health. If the diet is modified with even a simple switch of hay, it should be changed slowly over seven to 10 days. This gradual dietary change allows the microbiome to adjust without causing negative consequences to the horse.

Cecum

Once the digesta has passed through the small intestine, it enters the hindgut via the ileocecal valve/junction (Figure 7).

This three-way intersection allows digesta to enter the cecum (Figure 8) or large intestine from the ileum, or to leave the cecum and enter the large intestine. The cecum is a large, muscular mixing vat that has a capacity of roughly seven to 10 gallons, or 26 to 38 liters. The size and structure of the cecum slows the passage of digesta, providing microbes with up to seven hours to digest the fiber. The cecum moves digesta with strong muscular contractions. Due to the loose attachment of the cecum, these strong contractions can create a lot of movement, potentially twisting or displacing the cecum. A disturbed microbiome can



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Figure 7. An exterior view of the ileocecal junction (left). An interior view of the ileocecal junction (right).



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Figure 8. A horse's cecum.

create excess gas and potentially close the ileocecal valve. These issues can occur separately or together, contributing to colic risk. In the cecum, the microbiome is large and diverse. Both diet and pH affect the diversity and relative proportions of the different microbial species. While bicarbonate secreted into the small intestine helps maintain optimal pH, fermentation of the digestible fiber in forages results in the production of VFA, methane, carbon dioxide, and water. Protein breakdown by the microbiome occurs when fiber-bound or encapsulated protein escapes the foregut resulting in the production of ammonia, carbon chains, amino acids and other compounds that bacteria can utilize. B-vitamins are also synthesized in the cecum by microbes. In addition to B-vitamins, the horse absorbs VFA (energy source), ammonia, and water from cecal contents.

Large Colon, Small Colon, and Rectum

From the cecum, digesta enters the large colon via the ileocecal junction (Figure 7). This portion of the horse's GIT holds approximately 20 gallons (75 L). Ingesta normally passes through in two to three days, depending on diet. The large colon is made up of four sections:

1. right ventral
2. left ventral
3. right dorsal
4. left dorsal colon

The large colon doubles back on itself and becomes narrower—from 8 inches (20 cm) in diameter to 3–4 inches (9 cm) in diameter—between the ventral and dorsal sections. This location is known as the pelvic flexure (Figure 9). The narrowing of the colon slows the passage of digesta, allowing more time for microbial digestion. Unfortunately, the reduced passage rate also allows heavy particles, like sand, to settle out of the digesta, contributing to restricted blood flow if impaction colic and/or tissue necrosis occur. The pelvic flexure can be rectally palpated to help diagnose impaction colic cases.

Compared to the cecum, the microbiome of the large colon is even more varied. Microbial fermentation in the large colon continues to produce VFA, methane, ammonia, B-vitamins, and amino acids. Protein and amino acids that escaped from



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Figure 9. A segment of the colon, highlighting the pelvic flexure.

the foregut or were produced within the hindgut and cecum are largely utilized by bacteria and are not considered available for absorption by the horse. Within the colon, some minerals and electrolytes, such as sodium, chloride, and potassium, are absorbed along with water before ingesta moves into the small colon.

As ingesta moves from the large colon to the small colon, it enters the final portion of the horse's GIT. The primary function in the small colon is water absorption. Fecal balls form and move through the small colon toward the last 12 inches, which is referred to as the rectum, thus ending the journey through the equine gastrointestinal tract.

Other Key Points

Passage Rate

As stated previously, horses evolved on a diet primarily of forages, such as grass, that are high in structural, or fibrous, carbohydrates. Today, it's recommended that their diet be comprised of at least 50% forage, preferably more. Efficient digestion of this diet takes time. Passage rate, or the flow of feed through the horse's GIT over time, plays a key role in how efficiently the horse digests, absorbs, and uses feedstuffs.

Several factors affect GIT passage rate, including diet composition, meal size, and particle size, e.g., concentrates that are smaller and denser than forages or pre-processed forages. In general, large meals pass through the gastrointestinal tract faster



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Figure 10. A horse in a stall.

than small meals. Larger particle sizes, such as those found in long stemmed forages, move slower than smaller particles found in processed grains. Note that overloading any section of the GIT results in reduced digestive efficiency. Large concentrate meals are more likely to cause digestive upset, especially if they are not part of that horse's normal diet. Providing any grain or concentrate meals in small, frequent portions—as opposed to offering them in one or two larger meals—is recommended.

Gastrointestinal Tract (GIT) and Health

The horse's GIT lining is a first line of defense against harmful bacteria, pathogens, and toxins that pass through the horse. When that lining is compromised, a condition known as leaky gut syndrome, this allows harmful substances to pass through the gastrointestinal barrier and cause a number of problems, including systemic inflammation, which may contribute to laminitis, weight loss, and poor performance. Researchers suggest that diet along with stress can contribute to leaky gut syndrome. Strategies to reduce stress and inflammation in the GIT decrease the risk of a horse developing leaky gut syndrome. Prioritizing forage first and reducing starch and sugar in the diet are the main approaches to maintaining equine gastrointestinal health and keeping the intestinal barrier functioning at its best. Other considerations include housing horses together and providing enough turnout to reduce stress by promoting more physical activity.

Modern Feeding Practices

In a review of common feeding practices used for modern horses, stalling and meal feeding come to mind (Figure 10). Meal feeding can trigger digestive upset if the horse receives a large, non-structural carbohydrate-rich meal (e.g., one that is light on forage and heavy on grain). Overloading the foregut with a large grain meal may result in excess starch and soluble carbohydrates reaching the hindgut. Excess soluble carbohydrates reaching the hindgut can lower the pH due to the VFA produced by the amyolytic microbes. This decrease in the overall hindgut pH can result in negative consequences, including microbial death, endotoxin production, and an increased risk of colic or laminitis. These consequences can be avoided by exceeding the minimum forage recommendations (50% of diet) and staying below upper starch limits per meal (2 g/kg of body weight or 2 lbs/1000 lbs) in horse diets.

Table 4. Maximum intakes per meal of common feeds and cereal grains fed to horses to avoid overloading the foregut, which results in excess starch and soluble carbohydrates reaching the hindgut (Geor, Harris, and Coenen 2013).¹

Feed	% Starch	Maximum intakes per meal (target 2 g/kg BW)	
		Kg	Lb
Traditional sweet or pelleted feeds "high starch"	50–65	< 1.5–2	< 3.3–4.4
"Controlled starch" feeds	15–25	< 4–6.7	< 8.8–14.8
"Low starch" feeds	10–12	< 8.3–10	< 18.3–22
Corn	70	< 1.4	< 3.1

¹Based on 1100 lb. horse (500 kg). Other factors, besides starch, may affect this recommendation in individual horses. Other conditions may warrant further starch limitation, including gastric ulcers, recurring laminitis, and metabolic disorders.

Horses should have access to water at all times and the primary base of the diet should be forage. If the horse requires a concentrate or ration balancer feed because of poor forage quality or inadequate supply, or because the animal's activity requires additional nutrients to be provided through its diet, then use an appropriate product for the situation. Water availability is key for hydration, digestion, and reduction of choke potential. Feeding hay before concentrate will slow the passage rate of feed and reduce the potential risk for gastric ulceration.

In conclusion, understanding your horse's GIT function and structure increases your ability to reduce potential health risks and improve their digestive efficiency. Key points to remember include:

1. maintain a forage-based diet (at least 50%)
2. introduce diet changes, including changes of forage (hay or introduction to pasture), slowly (over seven to 10 days)
3. avoid feeding large, carbohydrate-rich meals (no more than 2 g starch/kg of body weight per meal—see Table 4)
4. consult a veterinarian immediately if you suspect GIT issues
5. break up the daily allotment of feed into as many small meals as practical
6. consult an equine nutritionist or your Extension educator for questions about your horse's diet

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