What is dietary fiber, and why is it important in the equine diet?

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Note – Much of this summary is taken from longer manuscripts presented at the Mid-Atlantic and California Animal Nutrition Conferences in 2012. The topic highlights an area of research that has been the focus in my lab for the last 5 years.

Summary

Physically effective neutral detergent fiber (peNDF) is defined as the physical characteristics of fiber (primarily particle size) that influence chewing activity and the biphasic nature of ruminal contents (Mertens, 1997). This is a characteristic of feedstuffs that has received significant attention, particularly in the area of dairy cow nutrition. The 2007 NRC Nutrient Requirements for Horses states that "Similar concepts have not been developed in horses, but research on the effect of fiber amount and type on digestion and gastrointestinal health is needed" (NRC, 2007). In the last 10 years there have been a number of important studies that examine this question of the physical form of fiber and the impact that form may have throughout the horse's gastrointestinal tract as well as the overall health of the animal. Some excellent information can be found in these reviews (Van Weyenberg et al., 2006; Hill, 2007; Fritz et al., 2009; Santos et al., 2011). The objective of this overview and presentation is to help those participating to think about dietary fiber. What role might it play in the equine diet beyond an energy source? How might its use influence the risk of important equine health concerns such as gastric ulcers, gastrointestinal inflammation, and even laminitis? As an outcome, participants should have a greater appreciation of how and why dietary fiber particle size may be an important dietary consideration in horses.

Grazing Evolution

Horses, like cattle, are herbivores and depend on fiber as a significant portion of their diets. Both species are well suited to their nutritional environment due to a number of different physical and behavioral adaptations. Prior to their domestication, the diet of horses and cattle consisted mainly of grass and legume forages obtained by grazing. Neither cattle nor horses ingested diets containing the ratios of particle size seen in the diets of domesticated animals today. The increase in the amount of smaller particles and reduction of fiber in both cattle and horse diets lends a number of advantages; improved digestibility, increased energy and nutrient density, consistency of nutrients and energy, and ease of handling and transport to name a few. However, the argument can also be made that this dietary change does not fit well with the feeding strategy and anatomy (see below) that has evolved over millions of years of evolution. From a production (milk or athletic) standpoint the cow or horse kept domestically today needs more nutrients and energy than any wild animal could obtain, but the form that that diet takes needs to be considered with the anatomical and behavioral characteristics of the animal being fed. There is evidence that the risk of many health problems in both cattle and horses could be reduced through increased attention to the amount and form of fiber included in the diet (Forbes and Kyriazakis, 1995).

Gastrointestinal Anatomy and Fiber

The nutritionist would be foolish to ignore gastrointestinal anatomy when formulating the diet of any animal. However, at times it seems that equine nutritionists do not always give the horse's gastrointestinal tract the same attention that ruminant nutritionists give to their animals. The gastrointestinal tract is the physiologic system through which the nutrients and energy provided must be processed, so that animals can make use of what is provided in the diet. For both cattle and horses, fiber is often one of the larger dietary inputs, so throughout both tracts there are obvious adaptations to handle the range of molecules that fit under the term fiber.

Mouth

The fresh or preserved forages that horses ingest must first be chewed to reduce particle size. The technical term for this is comminution, simply defined as the reduction of particle size and volume through grinding or crushing. Chewing stimulates the majority of saliva production. Saliva plays a number of important roles in both species, including cleansing of dentition, bolus formation, lubrication, buffering, and enzymatic digestion. It is readably apparent that a horses jaw and dentition are a highly evolved chewing machine. What happens if we change the physical makeup of the feed in a way that reduces the need for chewing?

Stomach

The equine stomach has been studied extensively due to its accessibility and important health concerns such as gastric ulcers (Merritt, 2003). Briefly, the horse's stomach is divided into two major regions characterized by the tissue that lines the surface of those regions. The upper half of the stomach is lined by a stratified squamous epithelium, while the lower half of the stomach is lined with a glandular mucosa responsible for the secretion of hydrochloric acid, pepsin, and a protective mucous layer. It seems likely that the anatomical structure has evolved to match the common diet and environment of the horse. During my presentation, we will explore how different physical characteristics of the diet may impact the normal function of the equine stomach.

Small Intestine

The majority of fiber digestion does not occur in the equine small intestine. There is a relatively large influx of fluid into the small intestine through saliva, gastric and pancreatic juice, and bile (Alexander and Hickson, 1970). It is likely that this large volume of secretion is both helpful for the digestion and absorption that occurs in the small intestine, but also creating a substrate that will be delivered to the cecum and colon that is optimal for fermentation. We could find no work that demonstrates that the physical makeup of the diet has any impact on this pancreatic outflow, but this question may be worthy of investigation. Certainly, secretions in other regions of the gastrointestinal tract are influenced by the physical makeup of the diet so it is possible here.

Cecum and Colon

The hindgut of the horse may be an excellent example of form following function. In this sense we can explore the intricate and complex form of the cecum, and ventral and dorsal colon and explore how the different physical characteristics of feed may impact the function of these structures. One of the most interesting form/function relationships is the ability to separate the particulate and liquid components of digesta as well as particles of different size by different structures (Drogoul et al., 2000; Santos et al., 2011). This selective retention of larger particles has been suggested to occur at the cecocolic orifice and the pelvic flexure, while the retention of fluid may occur at the transition from the right dorsal colon to the transverse colon. We'll discuss how the physical characteristics of the diet may impact the normal function of the equine hindgut.

Equine Health

It is highly likely that the tolerance intervals of pH, temperature, water, passage rate, oxygen, and substrate availability in the gastrointestinal tract are important to maintaining gastrointestinal health in the horse. Abnormal decreases in pH can negatively impact any region of the equine tract. The two gastrointestinal regions most commonly affected by acidosis in the horse are the stomach and hindgut (Hintz, 2000; Merritt, 2003). In his review of the equine stomach, Dr. Merritt (2003) highlights some of the diet related factors that contribute to stomach ulceration in the horse. These include rapid fermentation of nonstructural carbohydrates, the associated rapid production of VFAs, and, under grain feeding conditions, the lack of a fibrous mat that facilitates a higher pH region where more fibrolytic bacteria reside and a buffering of the acid secreted by the glandular mucosa. In addition, he highlights research that indicated that the fibrous mat facilitates a progressive drop in pH from the dorsal of ventral regions of the equine stomach (Baker and Gerring, 1993). Carbohydrates that are not digested and absorbed in the small intestine will be fermented in the cecum and colon of the horse. Although obvious to many, this means both structural and nonstructural carbohydrates, the difference being the rate of fermentation and the associated pH. The nonstructural carbohydrates, in most cases starch, will be fermented rapidly and produce a lower pH environment. It is generally accepted that an acidic environment in the equine hindgut can result in numerous negative health consequences including colitis, colic, and laminitis (Clarke et al., 1990; Kronfeld and Harris, 2003). Through more thought out addition of dietary physically effective fiber, it is likely that the risk of these health disorders could be reduced, and welfare and performance improved.

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