Recent Advances in Horse Nutrition

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Introduction

The biggest advancement in feeding horses in the past 10 years hasn't been in the quantity of energy, protein, vitamins or minerals needed meet their requirements, but in the feeds used to provide these nutrients.

Like all animals, the horse has the largest requirement for energy (or calories) to sustain body functions. Performance horses, broodmares and growing horses often require more energy than an all-forage diet can provide. Traditionally, we have relied on cereal grains to boost the energy content of the diet. Although grains are widely available and relatively cheap, researchers and horse owners are becoming more aware of problems associated with feeding grain to horses. As a result, there is greater focus on finding feeds that are compatible with both the equine digestive system and the lifestyle of today's horses.

This paper will review the unique digestive anatomy of the horse and their capacity to digest the starch in grains. Common and recently discovered problems associated with grain feeding will be discussed, as well as the search for feed ingredients better suited for horses.

The Equine Digestive Tract

Horses evolved as continuous grazers, eating small amounts of forage throughout the day. This high fiber diet and continual eating behavior is reflected in the anatomy and functionality of the equine digestive tract. Horses have a small stomach for their body size (~3 gallons) best suited for small, frequent meals. From the stomach, feed passes relatively rapidly (~3 to 6 hours) through the small intestine where enzymatic digestion of protein, starch and sugar takes place. Together, the stomach and small intestine (or foregut) comprise only 35% of the equine digestive system. The largest component of the horse's digestive tract is the hindgut (cecum and colon), which makes up 65% of the total digestive tract. Feed spends the longest amount of time here (24 to 36 hours), thereby allowing microorganisms inhabiting the hindgut access to the fibrous components of the diet. Horses may obtain 60 to 100% of their energy from volatile fatty acids produced via microbial fermentation of fiber (Glinsky et al. 1976).

Due to its smaller size, the digestive capacity of the equine foregut can easily be overwhelmed by large single meals. Depending on the composition, undigested feed entering the hindgut may allow excessive and uncontrolled microbial fermentation, which can induce various digestive problems. Instead, the equine digestive tract is designed to allow large quantities of fiber-rich feeds to be continuously ingested and utilized. Therefore, sufficient quantities of fiber in the equine diet are a prerequisite for normal function of the hindgut and normal digestion.

Starch Digestion

The early horse's diet consisted solely of high fiber forage. Modern equine diets often include grain, containing 50 to 70% starch. When the horse was domesticated, more energy was needed in the diet to cover the cost of energy expended during work. Since grains contain 1.5 to 2 times the energy of forages, grains became the feed additive of choice. Today, it is not unusual for a racehorse to receive 60% or more of their total diet in the form of grain. Many lactating mares and growing horses also receive a significant portion of their diet as grain.

Although horses are equipped to digest the starch in grain, they have a lower level of amylase activity in the small intestine compared to other monogastric species (Kienzle et al. 1994). As a result, the extent to which starch is digested in the small intestine is dependent upon the particular grain fed, processing of the grain, level and rate of intake, time and frequency of forage feeding, and individual horse variation (Kienzle 1994). Briefly, a greater proportion of the starch in oats is digested in the small intestine compared to starch from corn or barley. Processing (rolling, crimping, grinding, etc) generally increases the digestion of starch in the small intestine by increasing the surface area for enzyme digestion. As the level of starch intake increases, digestion in the small intestine decreases due to increased rate of passage. Finally, feeding forage following a meal rich in starch will speed up the passage of digesta, thereby decreasing the digestion of starch in the small intestine.

Microbes living in the hindgut will quickly ferment any starch or sugar that is not digested by enzymes in the small intestine. Small quantities of starch may not upset the delicate balance of bacteria inhabiting the hindgut. However, large grain meals can easily overwhelm the digestive capacity of the small intestine, allowing excessive quantities of starch to reach the hindgut. As hindgut microorganisms rapidly ferment the starch, lactic acid begins to accumulate, creating an acidic environment within the bowel that results in the death of bacteria and digestive upset (Radicke et al. 1991).

The amount of starch that can be tolerated will vary with the type of grain and the type of processing; however, a few guidelines have been suggested. To minimize overflow to the hindgut, one researcher has suggested that the maximum amount of starch that should be fed at one meal is 3.5 to 4 g/kg body weight (Potter et al. 1992). However, Cuddeford (1999) has suggested that other research supports a much lower value of 2.0 g/kg body weight. That means if a grain contains 50% starch, the maximum amount of grain that could be fed without significant starch overflow to the hindgut is 4 g/kg body weight or about 2 kg of grain for a 500 kg horse. The energy requirements of many performance horses, broodmares, and growing horses are high enough to necessitate feeding large amounts of grain, and the limit to starch digestion can easily be exceeded, particularly if these horses are fed only once or twice a day.

Health Risks Associated with High Grain Diets

One of the consequences of high grain intakes in horses is the reduced amount of energy available from the grain when it bypasses digestion in the small intestine. Harmon and McLeod (2000) have suggested that the energetic value of starch that is fermented is only about 75% of the value of starch that is digested in the small intestine. Therefore, adding

grain to the diet to boost energy content may actually provide less energy as grain intake increases.

A more worrisome consequence of high grain intakes is the potential impact on gastrointestinal health and function. Large grain meals have the potential to alter gastrointestinal motility, stimulate large fluid shifts, and impact the gut microflora (Clarke 1990). Tinker et al (1997) reported an increased risk for colic when horses received more than 2.5 kg of grain per day, with a further increase in risk when grain intake exceeded 5 kg. High grain diets have also been implicated as a contributing factor in gastric ulceration (Andrews 2001). Volatile fatty acids produced via fermentation of carbohydrates have been shown to cause acid injury in the equine stomach. Grain feeding also reduces saliva production, forage intake and time spent feeding, thereby reducing buffering ability, making the sensitive stomach vulnerable to attack by the constant production of acid. Finally, laminitis, a disease condition associated with the hoof and its attachment to the bony structure of the equine foot, is linked to a number of risk factors with overeating of grain (starch) the best known cause. In fact, grain overload is commonly used as a method to induce laminitis in research animals.

In addition to the digestive disturbances above, grain-rich diets may also exacerbate several metabolic disease states by promoting insulin resistance (Kronfeld 2003). Insulin resistance in horses has been associated with obesity (Hoffman et al. 2003) and laminitis (Johnson et al. 2004), & may play a role in tying up (Valentine et al. 2001) and osteochondrosis (Ralston, 1996).

Minimizing Grain in the Diet

The risk of digestive upset from starch overload and rapid fermentation in the hindgut, as well as the adverse metabolic consequences aggravated by grain feeding to starch-sensitive horses, has stimulated interest in alternative energy sources to grain.

Supplementation of horse diets with fat, typically in the form of vegetable oils, has received a lot of research attention in the last 15 years and fat-added grain mixes have since become commonplace within the commercial feed market. On a pound for pound basis, vegetable oils have about 3 times the energy as oats and 2.5 times the energy of corn, but the calories are coming from fatty acids, not starch. Supplemental fat is well utilized by the horse, with true digestibility estimated at approaching 100% (Kronfeld et al. 2004). In addition, supplemental fat does not appear to negatively affect the digestion of other nutrients in the diet (Kronfeld et al. 2004); however, there is continuing interest in verifying the effect of high fat diets on calcium absorption in growing horses. High levels of fat (23% of the total diet) are well tolerated by horses (Kronfeld et al. 2004); however, most “high fat” feeds on the market are considerably lower. For example, a commercial grain mix containing 10% fat fed in a 50:50 hay:grain ratio would result in a total diet fat content of about 7%.

More recently, there has been interest in replacing a portion of the grain not only with fat, but also with highly digestible fiber sources, such as beet pulp and soybean hulls. Beet pulp has been shown to be well-utilized by the horse, with an energy content comparable to oats (Lindberg and Jacobsson, 1992). Similarly, Ott and Kivipelto (2002) found that

substituting 25% of the oats with soybean hulls in a grain mix produced similar growth responses in weanling horses fed an oat-based grain mix. Although high in fiber, both beet pulp and soybean hulls contain a high proportion of soluble fiber that is easily fermented in the horse's hindgut. The advantage to these easily fermented fibers is that they provide an energy content similar to grain, but they are low in starch and therefore pose a lower risk of digestive upset and metabolic disturbances.

Another recent trend is the formulation of feeds for overweight horses. Whether it's due to overfeeding, lack of adequate activity, or the horse's feast-famine cycle of evolution making them sensitive to regular feeding and modern grain mixes and hays, obesity is becoming more and more common in horses. As a result, there is interest in finding suitable high fiber, low calorie feed ingredients, yet still give the horse the nutrients it needs and the continuous chew time it desires. These qualities are particularly important for overweight horses that are sensitive to starch and sugar (eg, insulin insensitive). Although research in this area is in its infancy, avoiding grain and other high starch or sugar feeds, as well as ensuring a consistent source of fiber low in fructans, will likely result in the development of a complete feed that will serve as the horse's only food source.

Conclusion

Although grain has been a staple ingredient in many equine diets, there are inherent risks for digestive and metabolic disturbances when horses consume diets high in starch and sugar. As a result, there is a movement to base feed selection on digestive compatibility. Feeds containing oil, beet pulp and soybean hulls may prove effective low starch/sugar alternatives for horses requiring energy supplementation beyond that provided in forage. In addition, high fiber diets with consistent composition are imperative for horses with carbohydrate sensitivity.

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