

Nonruminant Nutrition Symposium: Rethinking Equine Nutrition

354 Defining amino acid requirements in horses: Application of the indicator amino acid oxidation technique. K. L. Urschel^{*1}, R. J. Geor², and P. A. Harris³, ¹*University of Kentucky, Lexington*, ²*Michigan State University, East Lansing*, ³*Waltham Centre for Pet Nutrition, Melton Mowbray, UK*.

Relatively little is known about the indispensable amino acid (AA) requirements of horses and how they are affected by physiological status. In the 2007 *Nutrient Requirements of Horses*, only lysine requirements are given and these requirements were not measured, but were extrapolated from the crude protein requirements. Because horses have a requirement for each indispensable AA rather than crude protein itself, it is important to know the individual AA requirements independent of crude protein. Most equine research has used either average daily gain or nitrogen retention to determine dietary AA adequacy; however, there are methodological drawbacks for each method. The indicator amino acid oxidation (IAAO) technique has been used extensively to determine AA requirements in pigs and humans and shows promise for use in horses. This method is based on the principle that indispensable AA are partitioned between protein synthesis and oxidation. The IAAO method measures the oxidation of an infused ¹³C-labeled AA (the 'indicator') in response to graded levels of intake of another AA ('test' AA). As test AA intake increases from deficient to adequate, more protein synthesis can occur and less indicator is oxidized, until the requirement is met and indicator oxidation remains low and constant. The IAAO method has 2 key advantages: 1) it is sensitive, reducing the number of subjects required and 2) it requires only a short adaptation period to each level of AA intake and therefore each subject can be studied at each level of test AA intake over a short period. Work has begun in developing the IAAO method for use in horses: isotope infusion and breath sampling methodologies have been established, an isotopic method to measure total CO₂ production has been validated, and the 'indicator' infusion rate has been verified to result in measureable amounts of ¹³CO₂ in the exhaled breath samples. Using the IAAO to determine indispensable AA requirements in horses will allow for improved equine diet formulation to more closely meet the AA requirements and minimize the amount of excess dietary protein.

Key Words: amino acid requirements, equine, indicator amino acid oxidation

355 Current knowledge on the relative role of the equine small and large intestine in amino acid absorption. N. L. Trottier^{*} and A. D. Woodward, *Michigan State University, East Lansing*.

The role of the small intestine as main site of amino acid absorption has been demonstrated using both in vivo and in vitro models of monogastric animals. There is limited information on the large intestine's contribution to the host N (nitrogen) homeostasis. Forage-fed equids rely on microbial fermentation of structural carbohydrates in the cecum and proximal large intestine; however, the accessibility of plant cell wall proteins to microbial proteases for amino acid availability and host absorption in the aborad gastrointestinal regions remain enigmatic. Knowledge of the small and large intestinal capacity for amino acid absorption would further our understanding of amino acid utilization in equids. Globally, the large intestine appears to significantly supply dietary N for absorption. Studies report larger contribution to total apparent N digestion from the large intestine compared with the small intestine. The relatively short time of passage through the small intestine parallels the lower digestive efficiency in that segment of the equine gastrointestinal

tract, with digestive compensation mediated by post-cecal absorption. Earlier work demonstrated that protein metabolized by the equine cecum yields amino acids, urea, and ammonia; however, the relative role of these N products to total N absorption during large intestinal passage are largely unknown. Genes known to transport cationic and neutral amino acids across epithelial cells of other animal species are expressed in the equine large intestinal epithelium. These transporters may facilitate the absorption of microbial and dietary-derived amino acids across the epithelium of the large intestine. In conclusion, some evidence points to the large intestine as a site for N and amino acid absorption. Unless equids have a requirement for N, such evidence may mitigate the contradiction between the high estimates of maintenance protein requirement and the purported absence of large intestinal indispensable amino acid absorption in the solely forage-fed equid

Key Words: horse, intestine, amino acid

356 Importance of volatile fatty acid metabolism for horses. J. K. Suagee^{*}, B. A. Corl, and R. J. Geor, *Virginia Polytechnic Institute and State University, Blacksburg*.

Horses evolved on sparse grasslands and have thus developed digestive mechanisms for extracting energy from energy-poor feeds. The upper portion of the equine digestive system is capable of digesting non-structural carbohydrates, such as starches and disaccharides to monosaccharides, while the cecum and large colon are sites for bacterial fermentation of structural carbohydrates. Thus, both diet-derived glucose and fermentation end products such as acetate, propionate, and butyrate are available to horses. The assumption that horses evolved on forages rich in structural carbohydrates, such as cellulose and hemicellulose, rather than non-structural carbohydrates, suggests an evolved capacity to meet energy requirements through volatile fatty acid metabolism. Horses primarily use acetate to synthesize fatty acids de novo in adipose tissue and lack the enzymatic pathway to convert glucose to acetate for fatty acid synthesis. The minimal capacity of the liver to synthesize lipids may indicate that the horse evolved to rely on hepatic gluconeogenesis. Estimates suggest that when fed a 100% forage diet, the horse can derive 50–60% of its glucose from propionate. Modern horse diets commonly consist of up to 50% grain-based supplemental feeds that are higher in non-structural carbohydrates. The effect of modern feeding practices on both hepatic gluconeogenesis and peripheral glucose metabolism is unknown. Future research should focus on determining how modern feeding practices alter volatile fatty acid production and metabolism. A further step would include investigating the effect of altered volatile fatty acid metabolism on the development of metabolic disorders that are associated with diets high in supplemental grain-based concentrates.

Key Words: acetate, propionate, horse

357 Glucose sensing and regulation of equine intestinal glucose transport. S. Shirazi-Beechey^{*}, D. Arora, J. Dyer, and K. Daly, *University of Liverpool, Liverpool, UK*.

Glucose is transported across the luminal membrane of enterocytes by the sodium/glucose cotransporter 1, SGLT1. This also activates water absorption in the intestine. Regulation of SGLT1 is essential for the provision of glucose to the body and thus is important for maintenance of glucose homeostasis. The major aim of this talk is to report on recent progress made toward identifying mechanisms involved in regulation of equine intestinal glucose transport in response to a change in diet.

Cloning and sequencing the cDNA encoding equine SGLT1 and the determination of SGLT1 amino acid sequence allowed us to determine SGLT1 expression in equine small intestine. In the horse, glucose is transported mainly across the brush membrane of enterocytes by SGLT1. In horses maintained on pasture forage the highest rate of glucose transport was in proximal > mid with little in distal part of the small intestine. However, in horses fed controlled diets containing different ratios of hay and grain, SGLT1 expression is enhanced, with time, in response to increased dietary hydrolysable carbohydrate, not only in the proximal, but also in the distal small intestine. We have shown that sweet taste receptor, T1r2+T1r3 and its coupled G protein, gustducin, are expressed in enteroendocrine cells of the intestine of several species including the horse. Dietary sugars and artificial sweeteners act in the intestine, on the sweet taste receptor to elicit upregulation of SGLT1.

Furthermore, knocking out either gustducin or T1r3 abolished the ability of mouse intestine to upregulate SGLT1 expression in response to increased dietary carbohydrate. Thus the equine intestinal sweet taste receptor has the potential to be used as a novel nutritional target to increase intestinal glucose and water absorption with the attendant promise of enhancing performance and overcoming the detrimental effects of post exercise dehydration.

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Key Words: SGLT1, equine, intestine