

FEEDING STARCH TO BROWSING RUMINANTS

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Introduction

This article summarizes the role of carbohydrates in ruminant nutrition, and the effect of starch in browsing herbivores.

Starch and ruminant nutrition

In the wild, browsing ruminants select diet items including leaves, fruits, forbs and foliage from trees and shrubs, as opposed to grazing ruminants which select grass and roughage. Additionally, browsing ruminants have a relatively larger lower gastrointestinal tract, and their rumen is predicted to have less selective retention and more passage of available carbohydrate and protein to the lower GI tract (Van Soest 1994). Regardless of their type of feeding strategy, browsing and grazing ruminants have both evolved to utilize carbohydrate fractions of plants as energy sources, via anaerobic fermentation by gut microorganisms in the rumen.

The carbohydrate fractions of plants are a very diverse category of compounds, but generally include non-cell wall components (simple sugars, starches and fructans), and cell wall components (pectins, hemicellulose, cellulose and lignin). Starch is the primary storage carbohydrate in plants and is a major component of many common feed ingredients (Van Soest 1994). Starch can be digested by mammalian and microbial enzymes, producing glucose (mammalian enzymes) or lactic acid (microbial enzymes) (Van Soest 1994).

Starch fermentation in the rumen reduces rumen pH, which can result in gastrointestinal disturbances and acidosis (Van Soest 1994). Even brief periods of acidosis can cause inflammations, ulceration and scarring, as well as liver scarring and long term reduction of rumen absorptive capacity (reviewed by Owens, Secrist et al. 1998). Hoof inflammation, bloat, energy balance issues, and bacterial overgrowth are other concerns related to over-feeding starch to ruminants (reviewed by Russell and Rychlik 2001).

Factors that can mitigate the effect of starch in the diet include dilution of the starch-rich diet with roughage, or modulating the intake of starch (Owens, Secrist et al. 1998). Additionally, dietary rumen buffers such as monensin, probiotics, bicarbonate and dietary protein level can modulate the incidence of rumen acidosis (Owens, Secrist et al. 1998).

Effects of starch on browsing ruminants

Domestic ruminants (generally grazing ruminants) are routinely fed substantial quantities of starch-rich cereal grains. In response to the potential health concerns related to feeding starch to browsing ruminants, commercially prepared, low starch diets have been introduced. Several research trials have determined that these diets are more suitable for browsing ruminants. For example, mule deer fawns fed a low starch diet (4%) had lower propionate and butyrate, and higher acetate: propionate ratios in their blood compared to animals fed higher starch levels (12-24%) (McCusker, Shipley et al. 2008). Since higher forage based diets are associated with higher acetate and lower propionate, and reductions in propionate are associated with reduced acidosis, these data support the hypothesis that low starch diets promote more optimal rumen



Fig1. Giraffe eating browse silage (©Declan O'Donovan)



Fig2. Bongo eating foliage (© Tom Bailey).

physiology than do high starch diets. Similar results were obtained using *in vitro* culture systems with mule deer rumen fluid to examine a variety of dietary components (Brooks, Koutsos et al. 2008). Finally, giraffe fed a low starch diet for 3 years have had correction of previously inverted blood calcium: phosphorus ratios, suggesting that rumen function and acid-base balance was improved (Koutsos, Armstrong et al. 2007).

Conclusions

It is clear that exotic ruminants have evolved to eat diets that are relatively low in starch. In captivity, for browsing and grazing ruminants, high starch diets can cause rumen dysfunction and systemic health concerns. Therefore, any time that starch is introduced into the diet of a captive ruminant, it should be done very slowly to allow for adaptations of the rumen environment, in order to prevent acute acidosis. Additionally, a diet low in starch is the best option for feeding captive browsing ruminants, and alleviates many of the concerns presented in this paper.

References

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