Effects of Feeding Exogenous Fibrolytic Enzymes to Dairy Cows

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Introduction

Dairy cattle and other ruminants are biologically designed to convert forages and other fibrous feeds into high quality products such as meat and milk. Forages are in general the least expensive source of energy for dairy cows. However, the efficiency of converting forages to milk is limited by the digestibility of forage cell walls. Under ideal feeding conditions cell wall digestibility in the total digestive tract is still generally less than 65%\(^42\). A recent study published by Danish researchers in the *Animal Feed Science and Technology* journal\(^{28}\) investigated the importance of corn silage fiber digestibility on dairy cows’ intake, milk
production, and body weight change. The dataset compiled for the study comprised 29 experiments with 96 diets, published in the literature since 1999. Average forage dietary concentration was 53.9% dry matter (DM) basis (ranged from 40.0 to 98.0%). Corn silage represented 77.6% (58.6–100%) of the total forage, for a total concentration in the diet DM of 42.0% (26.8–98.0%).

Daily milk yield and body weight gains increased respectively across studies 84 and 12 g/day for every one-percentage point increase in corn silage fiber (aNDFom) digestibility. Surprisingly, fiber digestibility did not significantly alter DM intake. Since corn silage was not the only ingredient in the diets, these effects would have been 1.29 greater if forage had consisted of only corn silage, and 2.38 greater if whole rations had been only \textit{corn silage}. In conclusion, digestible fiber is an important parameter to consider when feeding corn silage to dairy cows.

Mounting feed costs and consumer concerns about the use of growth promoters and antibiotics in livestock production, provide ample incentive to revisit and refine the use of enzyme additives in ruminant diets. These products can improve feed conversion efficiency and reduce the cost of milk production\textsuperscript{26}. Feed additives with enzymatic fibrolytic activity offer a potential to enhance forage digestion, feed efficiency\textsuperscript{17}, and income over feed costs (IOFC). Applying a blend of cellulase and xylanase enzyme products to forages (corn silage and alfalfa hay) prior to feeding 55:45 forage to concentrate diets, increased daily IOFC per cow from $0.32 to $0.88\textsuperscript{40}. When combining data from 20 studies and 41 treatments that added fibrolytic exogenous enzymes to dairy cow diets, Beauchemin \textit{et al.}\textsuperscript{8} reported overall increases of 1.0 ± 1.3 kg/d and 1.1 ± 1.5 kg/d in DMI and milk yield, respectively. From the standard deviations is clear that responses to adding fibrolytic enzymes to dairy cow diets have been variable\textsuperscript{26}. This variability is not surprising, given that most of the commercially available enzyme products evaluated as ruminant feed additives are developed for non-feed applications\textsuperscript{13}.

A meta-analysis on the effect of dietary application of exogenous fibrolytic enzymes on the performance of dairy cows was published recently in the \textit{Journal of Dairy Science}. University of Florida’s researchers\textsuperscript{4} included in the meta-analysis 15 peerreviewed studies with 17 experiments and 36 comparisons. The most commonly used exogenous fibrolytic enzymes was a cellulase-xylanase
complex (13 studies). Across all studies, feeding exogenous fibrolytic enzymes did not affect dry matter intake nor feed efficiency but tended to increase dry matter and fiber digestibility by relatively small amounts (1.36 and 2.30%, respectively). Enzyme application increased slightly milk yield (0.9 kg/day), 3.5% fat-corrected milk (FCM; 0.5 kg/day), and milk protein (0.03 kg/day). Surprisingly, increasing the rate of application of exogenous fibrolytic enzymes did not affect performance.

The use of feed enzyme additives in ruminant diets had slowed-down until recently given their relatively high cost, inconsistent response, and potential for improving animal performance with other emerging technologies. Higher costs of livestock production however, combined with the availability of newer enzyme preparations prompted a renewed interest in the potential of feed enzymes for ruminants. The total feed enzyme market quadrupled during the first decade of the 21st century. The split in their use by species has remained relatively similar, with sales highest for poultry, followed by swine, with the ruminant market still in its infancy. Feed enzymes for ruminants contain mainly cellulase and hemicellulase activities and are of fungal (mostly Trichoderma longibrachiatum, Aspergillus niger, A. oryzae) and bacterial (Bacillus spp.) origin.

Improvements in animal performance due to the use of feed enzymes have been attributed to increases in feed digestion. Fibrolytic enzyme application enhanced DM (4 – 12%) and fiber (7 – 40%) digestibility in lactating dairy cows. Three main factors complicate explaining the mechanisms by which fibrolytic enzymes increase digestion and utilization of feedstuffs in ruminants. First, feeds are structurally very complex, containing a variety of polysaccharides, protein, lipids, lignin, and phenolic acids, often in close association. Second, enzyme additives are usually blends of enzymes with many different actions, each of which differ in optimal conditions and specificities. Finally, ruminal fluid is by nature an extremely complex microbial ecosystem, containing multiple microbial species and their enzymes. Attempting to identify the individual mode of action of enzymes under such conditions would be nearly impossible.

The objective in this article is to review research trials that evaluated the effectiveness of fibrolytic enzymes feed additives on dairy cows’ intake, milk yield and milk composition, feed efficiency, and body reserves. Performance data were
obtained from 28 scientific articles published between 1999 and 2016, which studied the effects of dietary addition of fibrolytic enzyme products on the performance of lactating dairy cows (References: 2, 3, 9, 10, 11, 12, 14, 15, 17, 20, 21, 22, 24, 26, 29, 30, 31, 32, 33, 34, 37, 38, 39, 40, 41, 43, 46, 47, 49). It included 32 trials and 109 treatments conducted on research stations and commercial dairy farms.

All studies evaluated exogenous fibrolytic enzyme products with cellulase and xylanase activities, except those of Bernard et al.\textsuperscript{12} and Knowlton et al.\textsuperscript{29} which supplemented exclusively cellulases, and Mohamed et al.\textsuperscript{34} which contained exclusively xylanases. In addition to cellulase and xylanase activities, some enzyme complexes contained ferulic acid stearase\textsuperscript{3, 21}, amylase\textsuperscript{20, 24}, pectinase\textsuperscript{10}, or protease activities\textsuperscript{20, 24}.

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