CANADA · ALBERTA LIVESTOCK RESEARCH TRUST INC.

DAIRY RESEARCH RESULTS
from the Agriculture and Agri-Food Canada Research Centre, Lethbridge

Adding Enzymes to Dairy Diets

1. Background

Enzymes are routinely included in poultry diets to remove antinutritional factors from feeds, to increase feed digestibility and to supplement the enzymes secreted by the bird's own digestive system. Similar enzyme preparations have been promoted for swine diets, but economic responses are less predictable.

Until very recently, few attempts had been made to add enzymes to ruminant rations, for two reasons:

- the enzyme activity in the rumen is normally very high and, presumably, not easily increased by the addition of a relatively small amount of enzyme in the diet, and;
- since enzymes are proteins, it has been assumed that they would be readily degraded by rumen microbes.

Fibrolytic (fibre-digesting) enzymes have been tested as forage additives for dairy diets with variable, but encouraging, results. In a recent trial conducted at the University of Idaho, mid lactation cows were fed an alfalfa hay and silage-based total mixed ration (TMR), where the forage was sprayed with an enzyme preparation 24 hours before feeding. Daily production by the cows fed the enzyme treated forage increased by 1.3 kg of milk, 0.8 kg of fat and 0.6 kg of protein.

Our own work on feed enzymes has produced some remarkable improvement in beef cattle performance. In our early studies, high concentrations of crude commercial enzyme mixtures were used, at relatively high cost. More recently, we have developed a method that allows us to apply relatively low, and more cost-effective levels of feed enzymes. Using this technology, we have improved average daily gains of beef cattle fed legume hay by 30%. Based on March 1995 prices, the return to the cost of enzyme was 8.5:1. When enzymes were applied to barley in finishing diets, the return to enzyme cost was 3:1.

In 1996, we began a series of trials to test the efficacy of enzymes in diets for lactating cows. But before discussing the results of those trials, here is the background required to understand the applicability of this technology:

How enzymes work

Enzymes are proteins (see article **1P1**) that *catalyze* (facilitate) chemical reactions in biological systems. Enzymes are essential in the digestion of feeds into their chemical components (e.g., glucose, amino acids) which are in turn used by rumen microbes or directly by the cow. Most enzymes are highly specific, breaking distinct chemical bonds within their substrates and, therefore, the complete digestion of a complex feed such as alfalfa hay requires the activity of literally hundreds of unique enzymes.

The specificity of an enzyme for a particular substrate is usually represented by a 'lock-and-key' analogy as illustrated in figure 1. Often, the name of the enzyme suggests the substrate it digests: proteases digest protein, cellulases digest cellulose, lactase digests lactose. Starch digesting enzymes are called amylases because starch is made up of two types of chains: branched amylopectin and linear amylose. Xylanases are involved in the digestion of hemicellulose, which has a xylan backbone.

As figure 1 suggests, each enzyme has a unique three-dimensional structure which is critical to its ability to bind specific substrate. If the structure of the enzyme is altered either by unfavourable pH (e.g., exposure to acid), temperature (e.g., heat

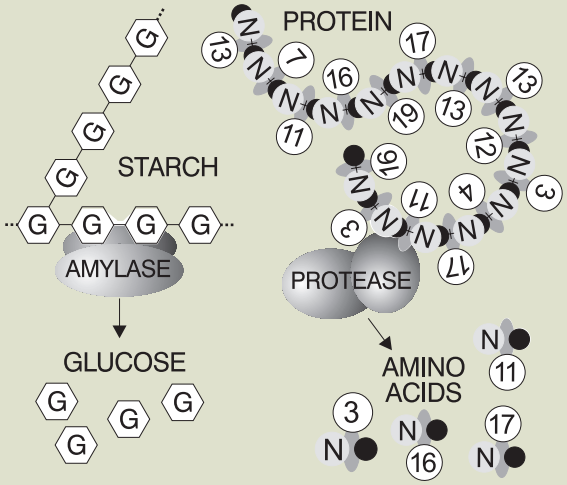

Figure 1 : Schematic illustration showing how an enzyme's active site 'fits' specific substrates.

during pelleting) or digestion (e.g., contact with proteases), enzyme activity will diminish and the enzyme will not be as effective at digesting feed. Stability of enzyme activity in adverse environmental conditions differs widely among enzymes.

Commercial enzyme products marketed as feed supplements are bacterial or fungal fermentation extracts. These preparations vary widely in the types and concentrations of specific enzymes they contain. As a result, their ability to digest particular feeds is also variable. Most are marketed on the basis of their ability to break down fibre, but many also digest other substrates, such as starch and protein. This variation in activity suggests the potential to select particular enzymes for application to specific feeds.

Industrial enzymes are expensive. In order to reduce the cost of enzyme technology, it is necessary to increase the effectiveness of feed enzymes. The approaches we have taken are:

- to select enzymes that have high activity and bind specifically to feeds, and;
- to modify enzymes to increase their resistance to rumen degradation.

A third approach is to use chemicals termed *enzyme enhancers* that promote the binding of enzymes to their substrates. These chemicals may increase the digestive activity of feed enzymes, or increase the digestive activity of the enzymes that are naturally produced by the microorganisms within the rumen.

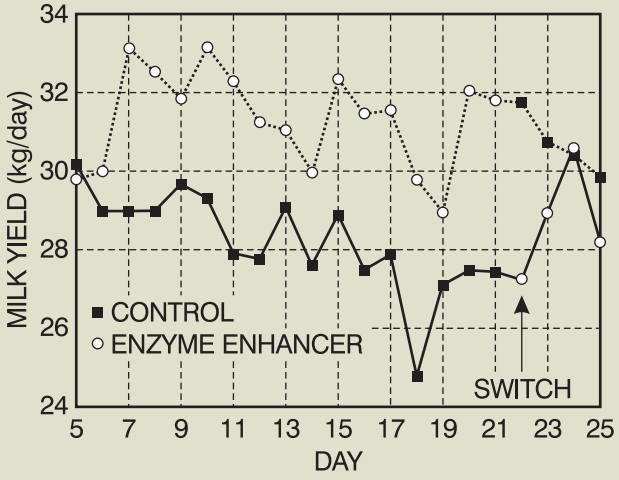

Figure 2 : Enzyme enhancer was incorporated into the concentrate fed to treated cows. On day 22, feeding of the enzyme-containing concentrate was switched from the treated to the control cows, producing an immediate response.

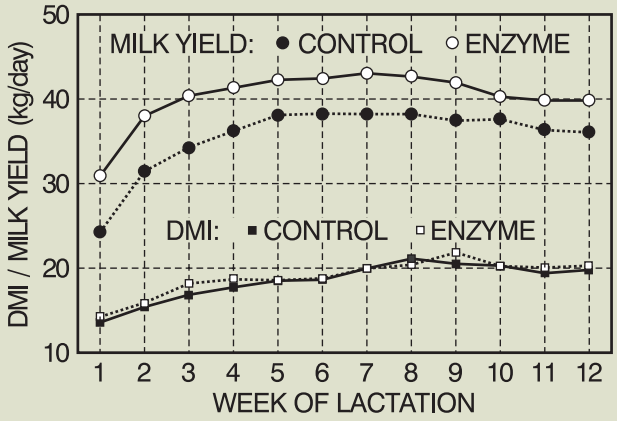

Figure 3 : Milk yield and dry matter intake (DMI) responses to a control diet compared with a diet in which enzyme was incorporated in the concentrate.

Work by Dr. Jim Shelford's group at the University of British Columbia has demonstrated that these enhancers can significantly increase the ability of rumen bacteria to digest fiber. In a short duration dairy feeding trial, use of an enhancer increased milk production from 2.5 to 3.5 kg per cow per day. Results are illustrated in figure 2.

Preliminary results with a selected enzyme preparation

Figure 3 shows preliminary results of our first dairy feeding trial where a selected enzyme preparation was included in the concentrate portion of a total mixed ration (TMR). The enzyme used was one which had produced our best results in high grain, beef feedlot trials. It was high in cellulase and xylanase activity; low in amylase. At its current price, the rate of enzyme addition we used cost about 46¢ per cow per day. Given the average increase in milk yield of 5.4 kg/day seen in our preliminary trial, return on investment would be in the range of 5-6:1.

We anticipate that, once this enzyme preparation is commercialized and assuming its use is widely adopted, its cost may decrease significantly. And, as further trials define the optimum conditions for its profitable application, we expect to see even more favourable profit margins. We will present the results of our ongoing work in subsequent articles.

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