The Use of Fermentation Extracts in Animal Feeds

T. A. Jenkins

Jenkins Biolabs, P.O. Box 8546, Riccarton, Christchurch, New Zealand

Abstract : *Fermentation extracts are shown to have a significant effect on ruminant livestock performance demonstrating that a probiotic effect can be achieved with a non-viable product. Single doses of 3 ml of the fermentation extract product Rumen-Zyme resulted in daily weight gains in lambs between 21 and 131 grams per day extra over control in three trials. In an experiment on dairy cows with daily dosing of 3 ml Rumen-Zyme, milk yields were shown to increase over a four-week period to a relative 2 litres per cow per day over control. The results on sheep and dairy cows are interpreted in light of current knowledge of probiotics.*

Introduction

Probiotics have been defined as "a live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance" (Fuller, 1989) and traditional thought was based on the microbes inoculating the host gut. Research on ruminant livestock, however, has shown that the most effective probiotic organisms for adult ruminants are often ones that cannot survive for more than a few hours in the rumen environment (Fuller, 1999). Two such organisms are the fungi *Saccharomyces cerevisiae and Aspergillus oryzae.* Moreover, one well-researched product, Amaferm (Biozyme Inc.), is based on fermentation extracts of *Aspergillus oryzae* and contains no live organisms. Fuller (1992) pointed to the inclusion of such non-viable products as probiotics.

Weidmeier *et al.* (1987) showed a possible advantage in using a combination of both probiotic organisms (*A. oryzae* extract and *S. cerevisiae* live cells) due to apparent differences in modes of action between the species. Jenkins Biolabs developed a fermentation extract probiotic product (Rumen-Zyme) from these two fungi and a range of other fungi and bacteria (including lactic acid bacteria). Experimental results of the effect of Rumen-Zyme on lamb live weight gains and cow milk yield in New Zealand pastoral systems are presented in this paper.

Materials and Methods

Sheep Trials

In the sheep experiments, lambs were randomly selected as treatment (Rumen-Zyme drenched @3 mL per head) or control and then run as one mob. The three representative trials (Table 1) included lambs initially in apparently healthy condition (West Melton and Waiwera) and lambs in initially poor condition at Oxford. At Oxford, most lambs had scours, low weight gains, high worm burden and around 50% tested positive for pneumonia. In the Oxford and West Melton trials, the heaviest and lightest lambs were not included in the trial to avoid outlier bias effects on the results.

In the West Melton trial, lambs were tagged with individual weights recorded before and four weeks after treatment to allow statistical comparison (one-tailed t-test).

Table 1. Design of Sheep Trials

Area	Date (Duration in no. of days)	No. Treated (No. Control)	Sheep Breed	Initial Lamb Condition
West Melton, Canterbury	Jan, 2000 (28)	50 (50)	Corriedale	Good
Oxford, North Canterbury	Feb, 2001 (13)	20 (20)	Romney X Poll Dorset	Poor
Waiwera, Southland	Feb, 2001 (19)	192 (181)	Romney	Good

Dairy Trial

The dairy trial was conducted near Edgecumbe, Bay of Plenty on a computerised herd. Twenty treated (Rumen-Zyme drenched @ 3 mL day^{-1}) and 19 control cows were monitored for individual daily milk production (litreage) and body weight.

The comparison began on 6 January 2001 and treatment continued for four weeks. In the week before commencement the cows selected for treatment were an average of 0.3 litres per cow down (not statistically significant given the variation in the cows, $p = 0.45$). Control cows in the month before commencing started off on average 4 kg heavier than treated cows (487 kg compared to 483 kg; not a statistically significant difference $p=0.40$). Statistical analysis was a one tailed t-test and regression analysis on the result trend.

Results and Discussion

Sheep Trials

In all three lamb trials, the Rumen-Zyme treated animals had higher average daily growth rates (Table 2). In the West Melton Trial, treated lambs began 870 grams lighter on average relative to control (not statistically significant $p=0.20$ due to the amount of variation present). At the end of 4 weeks the treated lambs were heavier on average than the control lambs with an extra weight gain of 0.96 kg (34.3 extra grams per day) on average. The difference in weight gain was statistically significant ($p<0.05$).

Farmers reported visible responses in all three trials with the most dramatic results (as seen in weight gains also) being in the Oxford trial. This fits with anecdotal observations and reports (Fuller, 1992) of greater responses to probiotic treatment being seen in animals in an initial poor condition or on poor quality feed.

Table 2. Lamb Weight Gain During the Trial Period

Mean Weight Gain (g per day) During trial period	West Melton	Oxford	Waiwera
Treatment	170	219	239
Control	136	88	218
Increase (Treatment over Control)	34	131	21

Anecdotal observations of treatment effect that require further research are dung firming (generally occurring within two days), “cleaner” fleeces and improved temperament.

Dairy Trial

In the dairy trial the treatment increased milk yield (Table 3). By the fourth week of treatment, the treated cows were producing 1.7 litres of milk extra over control ($p<0.05$). Over the test period, production was generally reducing per cow (due mostly to dry conditions) but the drop was on average higher with control cows at -4.7 litres per cow than with treated cows at -2.7 litres, representing a net 2.0 litre per cow per day advantage ($p<0.001$). Interestingly, the response in milk yield grew consistently over the four weeks (Figure 1; statistically significant: $r=0.95$).

There was an average 5.3 kg increase in weight in the treated cows over the four weeks compared to an average 1.7 kg increase in the control cows ($p=0.22$). Though not statistically significant, the result indicates that increased milk yield was not due to reallocation of resources from body weight (as Williams and Newbold, 1996 considered worthy of checking when assessing probiotics).

Table 3. Dairy trial - Milk Production (L cow^{-1} day^{-1})

Treatment	Litres cow^{-1} day^{-1}				
	Week 0 (before)	Week 1	Week 2	Week 3	Week 4
Rumen-Zyme	18.5	17.8	17.2	16.2	15.7
Control	18.8	17.9	16.7	15.1	14.0

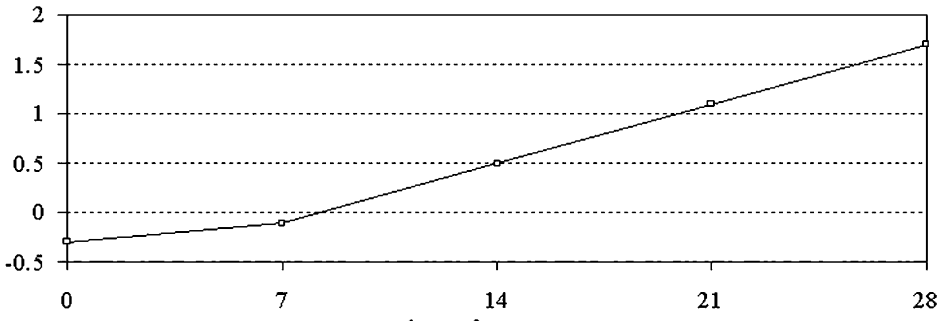

Figure 1. Difference in Milk Yield between Rumen-Zyme Treated and Control Cows

Mode of Action of Probiotics

With uncertainty about the way in which probiotics actually work, it is perhaps not surprising that there are some reported inconsistencies in results of probiotic use (Martin and Nisbet, 1992; Caton et al. 1993; Williams and Newbold, 1996; Fuller, 1999).

One mode of action for fermentation extracts may be the presence of significant levels of digestive enzymes. Rumen-Zyme does contain moderate levels of amylase (>4000 IU/L) and cellulase (>400 IU/L) that might affect digestion of starch and fibre digestion respectively. In a recent review, however, McAllister et. al. (2000) consider that whereas enzyme supplement technology is well established in the poultry industry, it is relatively new and has inconsistent results in ruminant livestock. It has been suggested (McAllister et al. 2000) that since most fibre digesting enzymes produced by rumen microorganisms generally have an optimum operating pH above 6.2, added fungal enzymes may boost digestion in low pH rumens e.g. in the presence of acidosis.

Other fermentation extract components that have been identified as potential probiotic agents are oligopeptides (short chains of amino acids that increase membrane permeability and uptake of nutrients), phospholipids (that may stimulate the host immune system, see Fuller, 1999), organic acids including malic acid (see Martin and Nisbet, 1992), antioxidants and microbial hormones (cytokinins, gibberelins etc that could stimulate microbial activity). These, as well as digestive enzymes and other possible mechanisms, require research.

Conclusions

While more research is in progress, the experimental results in this paper support the hypothesis that probiotic products do not need to be living organisms. Non-viable products offer significant advantages in stability, application, low dosage rate and ability to mix a range of fermentation extracts and other products. The results in these trials show statistically and economically significant benefits, but more research on the actual modes of action would aid optimization of the design and use of these products. The focus of future research by the author is the effect on rumen microflora of probiotic organisms and extracts. Due to similar questions on the mode of action of microbial inoculants and biostimulants in soil, parallel research is being carried out on soil microbiology.

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