Effects of Synbiotics on Rumen Fermentation

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Introduction

There is increasing scientific and public concern regarding the use of sub-therapeutic antimicrobials in cattle in North America. With the amendment of the veterinary feed directive regulation by the Food and Drug Administration, the use of sub-therapeutic antimicrobials (especially those used in human medicine) for production uses is being phased out in the US beef industry (FDA, 2015). As a result, there is a new sense of urgency in the development of economically competitive alternatives such as probiotics, prebiotics and vaccines that maintain animal health and do not compromise end-product quality. Synbiotics are simply the combination of pre- and probiotics and studies have shown that synbiotics exhibited synergistic effects such as increasing the proliferation of beneficial bacteria and boosting the perpetuation of newly introduced probiotics in the host (Montagne et al., 2003; Crittenden and Playne, 2009). Additionally, a combination of commercially available prebiotics and probiotics has been shown to eliminate morbidity and mortality losses associated with Shiga toxin-producing *Escherichia coli* infections in dairy calves (Baines et al., 2013). Results from these studies suggest that synbiotics have potential, but research is still lacking under feedlot conditions. Feedlot cattle are shipped and co-mingled with cattle from other sources which can lead to stress and lowered immune function. Additionally, feedlot cattle are fed high-grain finishing diets which can induce ruminal acidosis and other nutritional stress leading to multiple health disorders. Feeding synbiotics may help stabilize rumen pH and decrease acidosis, improve immune function, interfere with pathogen infections, and thus improve animal health. The project is expected to have a significant impact on cattle health and production efficiency, while helping address public concerns on the use of antimicrobials in livestock production.

Materials and methods

Study 1. In vitro screening of synbiotics

The effects of synbiotics on rumen fermentation were assessed by measuring in vitro gas production (GP), dry matter (DM) disappearance and volatile fatty acid (VFA) concentrations using the batch culture. A high grain diet (Table 1) was used as the substrate and seven different synbiotics (plus a positive and negative control) were evaluated in the present study.

Table 1. Ingredients and chemical composition of diet.

Ingredients	Composition (% DM)
Rolled corn	38.2
Modified DGS	29.3
Corn silage	31.3
Mineral supplement	0.92
Vitamin supplement	0.22

Chemical composition[1]	Composition (% DM)
Dry matter, %	52.2
Crude protein	14.7
Ether extract	3.14
eNDF	9.66
Neg, Mcal/lb	58.7
Calcium	0.41
Phosphorous	0.76
Potassium	0.91

[1]Values for the experimental diets were calculated from NRC (1996) feed library table based on the ingredient composition.

Study 2. Determine the effects of synbiotics on rumen health and fermentation

A study was conducted to determine potential health benefit and ruminal fermentation in steers fed high grain diets. Three synbiotics (hydrolyzed yeast +live yeast (LYHY), Celmanax + live yeast (CLY) and Synerall) were selected from study 1. Treatments (4) consisted of these three synbiotics and a control. Four rumen cannulated steers were randomly assigned to the following four dietary treatments: 1) Control (high grain finishing diet without synbiotics), 2) Control + CLY, 3) Control + LYHY, 4) Control + Synerall. The cannulated steers had ad libitum access to the dietary treatments. They were housed individually and fed once daily in a 4 × 4 Latin Square design with four periods of 21 days. In each period, the steers were adapted to the diet for 14 days and sampled for the last seven days. Ruminal fluid samples were collected from day 15 to 21 of the experiment to determine ruminal pH and VFA concentrations.

Results

In the initial in vitro screening study, there was no difference in asymptotic gas volume among the treatments (Table 2). Numerically, LYHY, Synerall and CLY had higher DM disappearance values (Figure 1). For the rumen fermentation study, the three synbiotics marginally increased ruminal pH versus the control treatment (Figure 2). For beef cattle in the feedlot, higher pH is desirable to minimize incidences of acidosis. Typically, ruminal pH of 5.6 is regarded as the reference point for chronic acidosis. Hydrolyzed yeast/live yeast treatment produced the least total VFA (TVFA) concentration (Figure 3). Considering that LYHY had the highest (numerically) DM digestibility, a lower TVFA concentration could be interpreted that LYHY partitioned more energy into microbial mass which will benefit the animals. After the ruminal fermentation study, LYHY treatment was selected based on lower acid load (VFA concentrations) compared with the other treatments. The selected synbiotics are currently being used in a feedlot finishing study.

Table 2. Effects of synbiotics on in vitro gas production kinetics.

Enzymes	M	c (h^{-1})	Lag time (h)
Positive control	155	4.85	-3.29
Negative control	154	6.56	-1.78
ALY	173	5.91	-2.11
LYHY	130	8.10	-0.62
CLY	167	5.49	-2.81
SyH	157	6.16	-1.77
SyF	146	7.34	-1.24
SynHC	136	7.12	-1.77
SynFC	133	6.99	-1.51
SEM	15.0	0.865	0.759
P value	0.453	0.281	0.405

M = asymptoptic gas volume (ml/g DM); c = rate of fermentation.

Figure 1: Effects of synbiotics on in vitro dry matter disappearance after 24 h of fermentation.

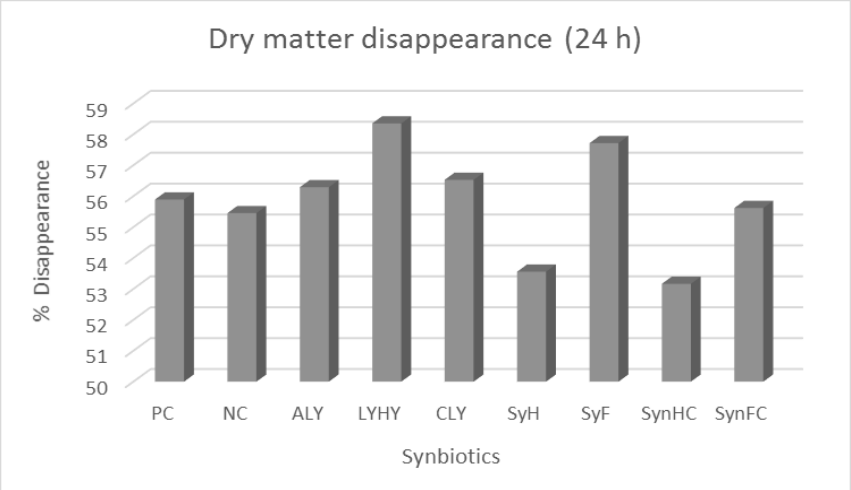


Figure 2: Effects of synbiotics on average pH values of ruminal fluid sampled on day 15 to 21.

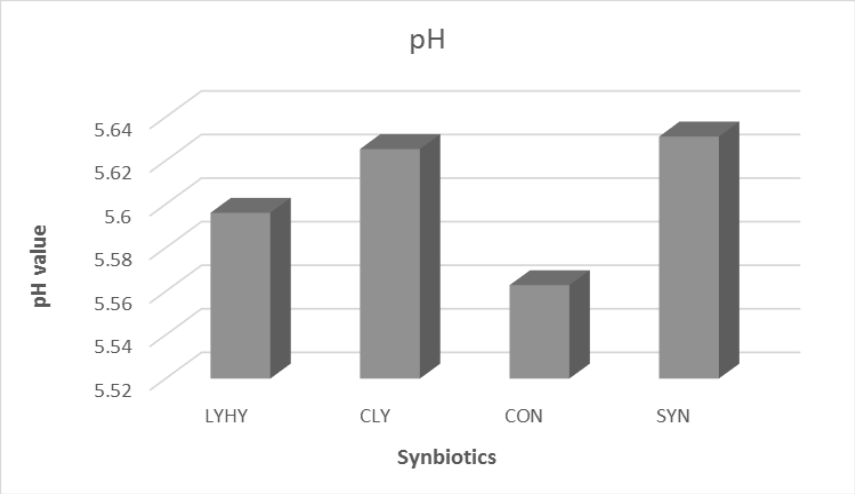
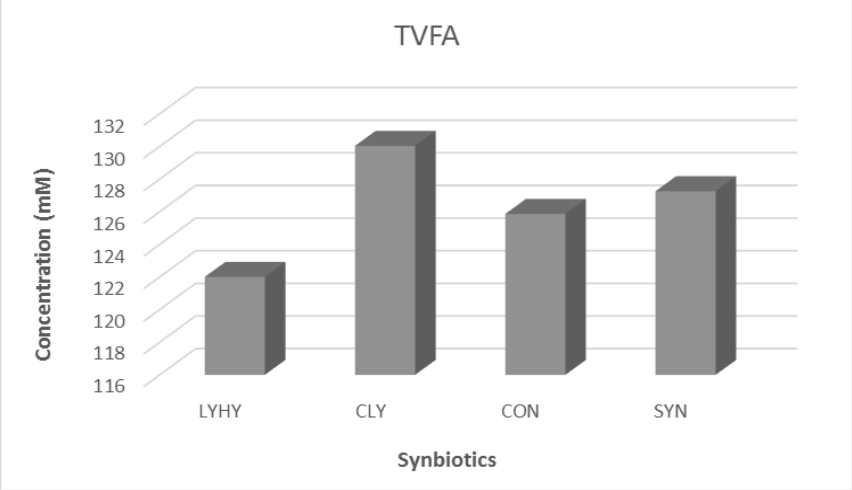


Figure 3: Effects of synbiotics total volatile fatty acid concentrations.



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