

Supplementing Fructose-Based Block Supplements to Forage-Fed Cattle Increases Capacity for Lactic Acid Metabolism

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Introduction

Acidosis is one of the more important maladies afflicting cattle fed significant amounts of grain and has enormous economic impact for feedlots, dairies, and producers of seed stock. The highest incidence of acidosis occurs when animals are being transitioned from high-roughage diets to diets containing high levels of concentrates. When grain-based diets are consumed in excess, consumed too quickly, or fed without proper adaptation, digestive end products (organic acids) can accumulate within the rumen, resulting in acidosis. Lactic acid is one of the key organic compounds that accumulates under these conditions. Coupled with the animal's limited ability to metabolize lactate, accumulation of lactic acid in the rumen lowers ruminal pH and subsequently depresses feed intake. One means of preventing acidosis is to directly populate the rumen with lactate-utilizing bacteria. Alternatively, exposure to low levels of lactate (i.e., levels insufficient to harm the animal) may stimulate development of a population of lactate-utilizing bacteria. The objective of our study was to determine if supplementing low-moisture blocks made of high fructose corn syrup could increase ruminal lactate concentrations and subsequently stimulate growth of lactate-metabolizing bacteria. If successful, this could prove useful for adapting forage-fed cattle to grain-based diets.

Experimental Procedures

Blocks were manufactured by blending 24 lb of high fructose corn syrup (approximately 40% moisture) with 1 lb of vegetable oil. The mixture was placed into a steam-jacketed, scraped-surface kettle that was operated at atmospheric pressure and heated to a final temperature of approximately 250°F. The kettle then was subjected to vacuum for approximately 60 seconds, after which the dehydrated mixture was discharged into high-density polyethylene containers. Blocks were allowed to cool to room temperature and formed a solid, hardened mass. The blocks subsequently were broken into small fragments, weighed into 2-lb aliquots, and sealed in plastic bags until used.

Twelve ruminally cannulated heifers (1,179 lb) were fed a diet consisting of free-choice, long-stemmed prairie hay and loose salt. Heifers were weighed and assigned to individual feeding pens (5 × 12 ft) with slatted concrete floors. Each pen was equipped with a feeder and an automatic water fountain. Heifers were randomly allocated to one of two treatments (six heifers per treatment): control (no supplement) or block (2 lb per heifer daily of the fructose-based block supplement).

The study was conducted over a 3-day period. At approximately 7:00 a.m. each morning, a 2-lb aliquot of fructose block was administered via the ruminal cannula to heifers on the block treatment. On days 1 and 3 of the study, samples of ruminal digesta were removed from each animal via the ruminal cannula before feeding and at 30-minute intervals until 8 hours after feeding. Ruminal digesta samples were strained through

four layers of cheesecloth, pH was measured, and a sample was retained and frozen for analysis of lactic acid and volatile fatty acids. During the final collection of days 1 and 3, sterile anaerobic culture tubes containing 15 mL of a semi-defined lactate media were inoculated with 1 mL of strained ruminal fluid from each animal. The contents of each tube were homogenized using a vortex mixer, and absorbance (600 nm) was determined using a Spectronic-20 spectrophotometer. Culture tubes were placed into an incubator maintained at a temperature of 102°F for 24 hours. The tubes were removed from the incubator at hourly intervals throughout the 24-hour incubation period, and absorbance was measured. Changes in turbidity (associated with increased absorbance readings) were used as a measure of the proliferation of lactate-utilizing bacterial species.

Results and Discussion

Compared with cattle fed the control diet, supplementation with fructose-based blocks increased ruminal lactate concentrations by nearly 6-fold (Figure 1; $P < 0.05$). Peak differences occurred 1 to 3 hours after feeding the block and declined sharply thereafter. Peak concentrations of lactate were nearly doubled on day 3 compared with day 1 for supplemented heifers (data not shown), perhaps indicating that ruminal microorganisms adapt over a period of days by increasing the population of bacteria that synthesize lactate from fructose. Butyric acid, which is the primary end product associated with metabolism of lactate, was higher in supplemented cattle than in controls (Figure 2; $P < 0.05$). Increases in butyric acid levels within the rumen are likely the direct result of lactic acid metabolism by ruminal bacteria. This is supported by the fact that increases in butyrate concentration seem to lag behind the changes in lactate concentrations. Propionate concentrations tended to be higher during the intermediate sampling points for cattle administered the block (Figure 3; Treatment \times hour interaction, $P < 0.05$). Supplementing fructose-based blocks resulted in modest, transient reduction in ruminal pH (Figure 4; Treatment \times hour interaction, $P < 0.01$), essentially reflecting the increased fermentative activity in supplemented heifers. Ruminal pH of supplemented heifers was lower than controls between 1 and 3 hours after administration of the block ($P < 0.05$). At no point did pH decline to a level that would compromise fiber digestion.

Supplementing fructose blocks resulted in modest increases in turbidity of bacterial cultures (Figure 5) compared with cultures from control animals, revealing a greater capacity for supporting growth of lactic-acid-metabolizing bacteria. Additional days of supplementation may be warranted to further stimulate the proliferation of lactic-acid-utilizing bacteria.

Implications

Feeding fructose-based block supplements increased lactic acid production in the rumen for a short period of time, allowing for establishment of a population of lactic-acid-metabolizing bacteria in the rumen. This research provides a basis for future development of management strategies aimed at preconditioning calves to avoid acidosis when grains are introduced into the diet.

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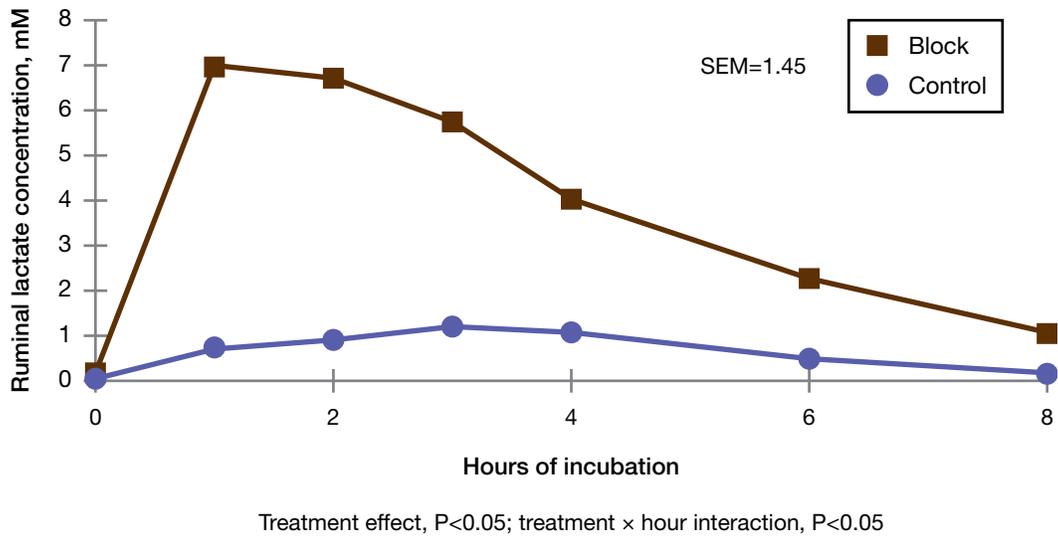


Figure 1. Ruminal lactate concentrations in heifers fed prairie hay with and without a fructose block supplement.

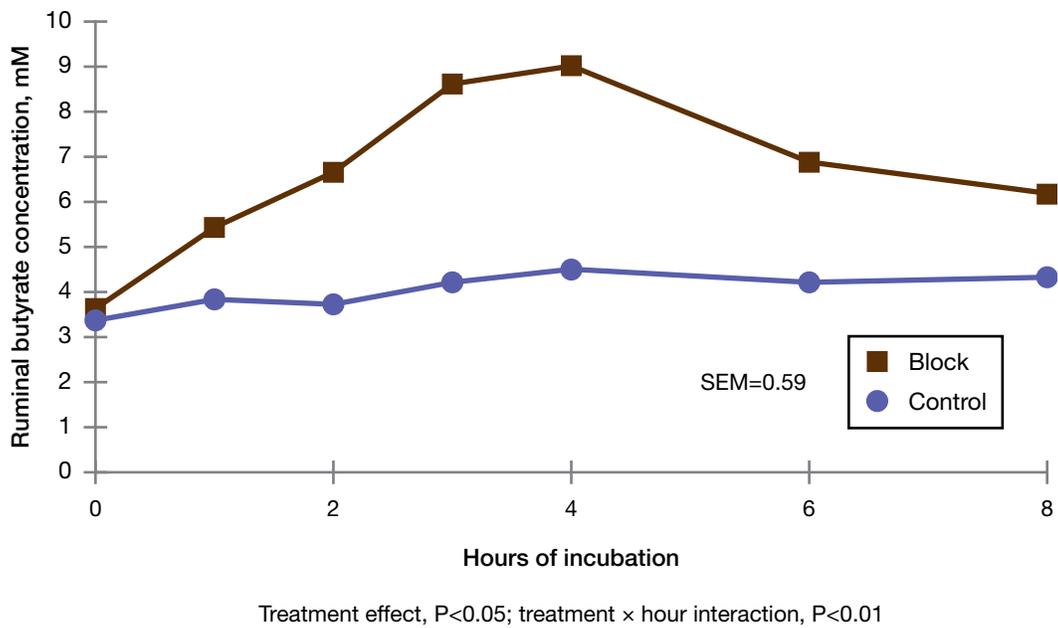


Figure 2. Ruminal butyrate concentrations in heifers fed prairie hay with and without a fructose block supplement.

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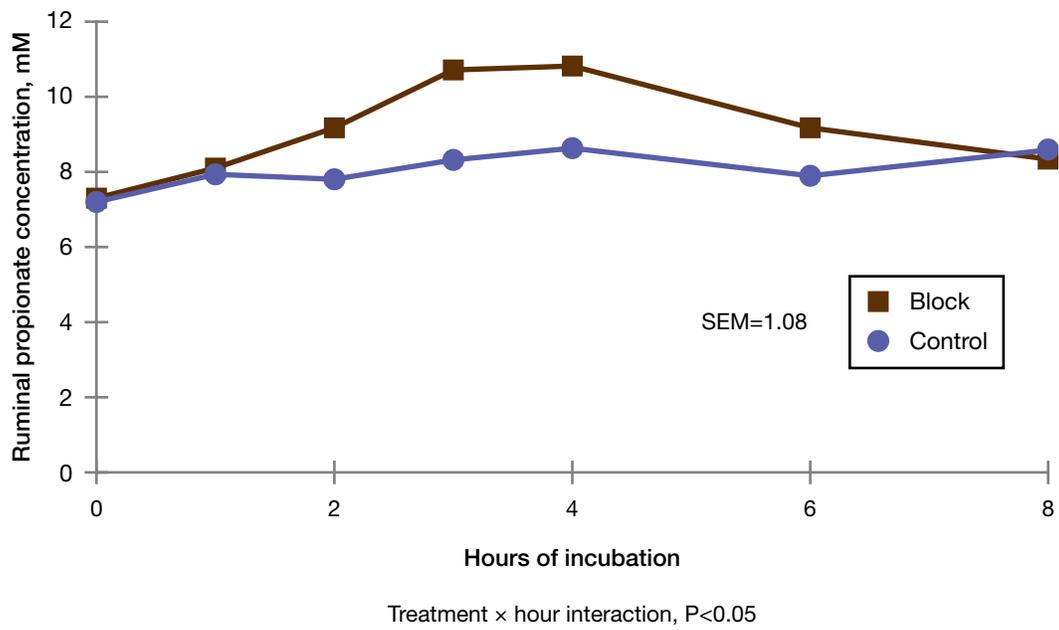


Figure 3. Ruminal propionate concentrations in heifers fed prairie hay with and without a fructose block supplement.

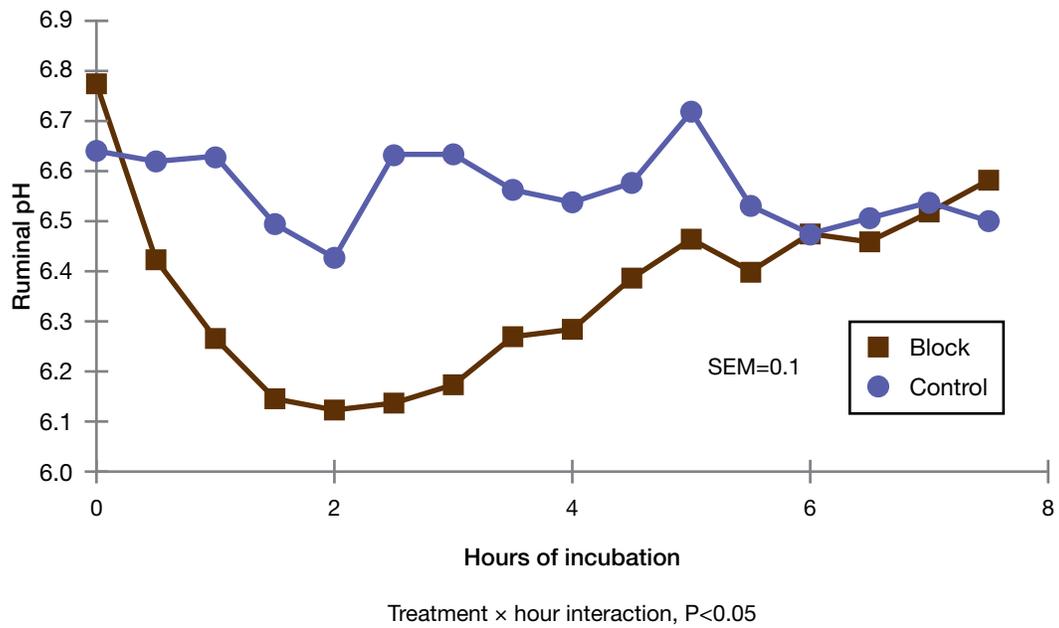


Figure 4. Ruminal pH in heifers fed prairie hay with and without a fructose block supplement.

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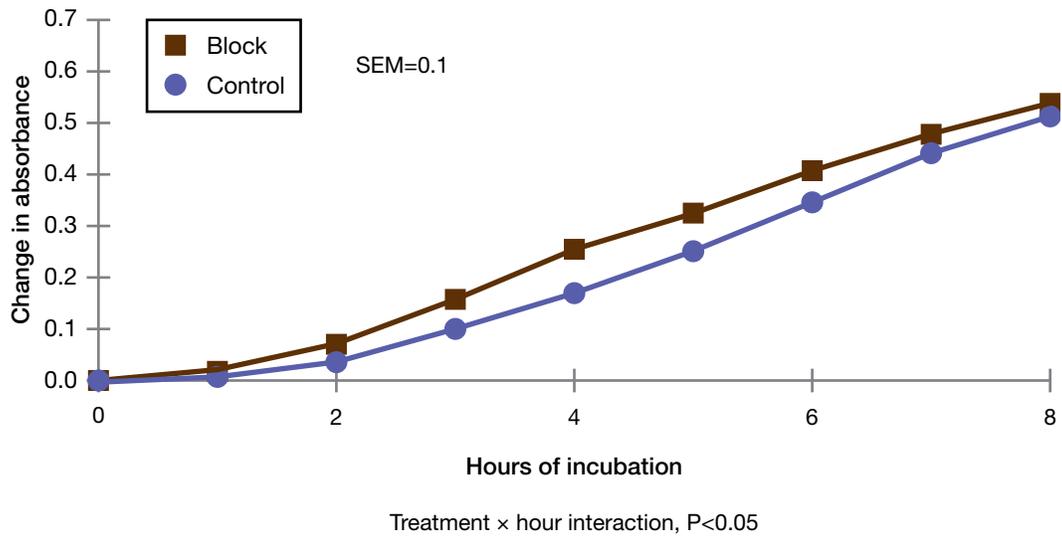


Figure 5. Change in turbidity (a measure of microbial growth) of ruminal cultures grown in lactic acid broth.