Effect of Liquid Supplement pH and Acid Source on Supplement Intake of Mature Angus Cows

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The addition of hydrochloric or sulfuric rather than phosphoric acid to liquid feeds has shown benefits to producers of reducing liquid feed intake and individual animal variation in intake.

Summary

Effects of lowering pH of molasses-based liquid supplements using phosphoric acid, sulfuric acid, or hydrochloric acid on ad libitum liquid supplement intake of beef cows were evaluated in a 42-d trial. Seventy mature gestating Angus cows (ages 4 to 10 yr; 1,250 lb initial avg BW; 120 to 180 d gestation) were randomly assigned to one of fourteen 4-acre bahiagrass (Paspalum notatum) pastures with free-choice mineral mixture shade (artificial or natural), and ad libitum water. Seven treatments were created from a 16% CP liquid supplement. Treatments were control (no additions to liquid supplement), pH 3.2 by adding 2.1% sulfuric acid, pH 3.2 by adding 3.2% hydrochloric acid, pH 3.2 by adding 5.7% phosphoric acid, pH 2.3 by adding 4.2% sulfuric, pH 2.4 by adding 6.3% hydrochloric acid, and pH 2.3 by adding 11.3% phosphoric acid. Each treatment was randomly assigned to two groups (5 cows/group) for a 21-d period in a randomized block design. After the first 21-d period, treatments were reassigned (treatments were not assigned to same pasture/group in second period) and another 21-d consumption trial was conducted. Phosphoric acid added to achieve pH 3.2 lowered consumption 33% (7.88 lb) and the same acid added to achieve pH 2.3 lowered consumption 53% (5.61 lb) compared to control (11.84 lb). Sulfuric acid added to reach pH 3.2 reduced consumption 18% (9.66 lb) and sulfuric acid added to pH 2.3 reduced consumption 38% (7.39 lb). Hydrochloric acid added to create pH 3.5 tended to lower (P=0.13) consumption by 9% (10.76 lb) and hydrochloric acid added to reach pH 2.3 reduced consumption 30% (8.27 lb). Variation in individual animal intake for control showed a 33% coefficient of variation (CV) and the six supplements with lower pH had similar variations (17% to 39% CV).

Acidification of liquid supplements shows promise as a method of reducing liquid supplement consumption in beef cattle. In this experiment, lowering the pH of molasses-based liquid supplements reduced intake. The effectiveness of acid source varied, with phosphoric being most effective and hydrochloric being least effective when liquid supplements were adjusted to a similar pH. Another objective of this experiment was to evaluate the effect of acid source on intake variation among individual animals. All treatments except pH 3.2 using hydrochloric acid significantly reduced supplement consumption and all treatments except pH 3.2 using sulfuric acid reduced variation in consumption.

Introduction

Phosphoric acid has historically been the additive of choice to increase phosphorus concentration and reduce consumption of molasses-based liquid supplements. At common inclusion levels, over-consumption of supplement lends itself to over-consumption of phosphorus by grazing cattle. Particular feeding strategies utilized in current cow-calf based systems can increase the emissions of phosphorus. The costs, environmental worries, and difficulty of handling, which is associated with phosphoric acid, are specific concerns for the liquid feed industry. The challenge to livestock nutritionists is to determine the additives needed to achieve desired consumption levels without potential harm to the environment. We hypothesized that lowering pH of liquid supplements by including acids other than phosphoric acid will also reduce liquid supplement consumption. These acids may be associated with reduced costs and less potential for negative impact on the environment. This research investigated the effects of two inclusion levels of sulfuric, hydrochloric, and phosphoric acids on liquid supplement intake and variation in intake of gestating beef cows.

Procedure

This study was conducted at the University of Florida Santa Fe Beef Unit, located in northern Alachua County, Florida, for 42-d (October 5 to November 16, 2000).

Animals

Seventy mature gestating Angus cows (ages 4 to 10 yr; 1,250 lb initial avg BW; 120-180 d gestation) were randomly assigned to one of fourteen 4-acre bahiagrass (Paspalum notatum) pastures with free-choice mineral mixture shade (artificial or natural), and ad libitum water. Prior to the experiment, cows received routine health management, which included deworming with Ivermectin® (Merial Limited, Iselin, NJ) and vaccination for Clostridial and respiratory diseases, Vibrio bacterium Pasturella, Leptospirosis,and Vibriosis (CattleMaster® 4-L5, Smith Kline Beecham Animal Health, Exton, PA), permanent individual identification and pregnancy diagnosis. Cattle had previous experience with and were adapted to the liquid supplement feeding equipment. Seven liquid supplement treatments were randomly assigned to two pastures (5 cows/pasture) for a 21-d period in a randomized block design. Pastures were blocked according to percentage bahiagrass. After the first 21-d period, treatments were reassigned (treatments were not assigned to same pasture/group in second period) and another 21-d consumption trial was conducted. This resulted in four consumption measurement periods for each of the seven treatments. All procedures for this experiment were approved by the University of Florida Animal Care and Use Committee (#A551).
**Diets and Feeding Procedures**

All cows were offered a 16% CP commercial liquid feed as an ad libitum supplement to pasture in 634 lb capacity commercial liquid supplement feeders (RMI, Inc., Bartow, FL). Cows had access to only one lick wheel in the feeder, as opposed to two lick wheels, which is more common in production situations. The standard liquid supplement, pH 4.2; ~2.75% phosphoric acid (Table 1) was offered as a control and six additional treatments were included which lowered the pH of this liquid feed to pH 3.2 or pH 2.3 using concentrated forms of sulfuric acid (S), 93% sulfur, hydrochloric acid (C), 35% chlorine, or phosphoric acid (P), 24% phosphorus (“green” acid). The seven treatments were: Control, pH 3.2 by adding 2.1% S (S-3), pH 3.2 by adding 3.2% C (C-3), pH 3.2 by adding 5.7% P (P-3), pH 2.3 by adding 4.2% S (S-2), pH 2.4 by adding 6.3% C (C-2), and pH 2.3 by adding 11.3% P (P-2).

Liquid supplements were added to feeders on Monday of each week and on other days as necessary. Liquid supplement consumption was recorded at each offering by weighing the feeders before and after addition of supplement using a spring dial scale. Supplement consumption was calculated for each week during the 2-wk periods.

**Sampling/Data Collection**

Liquid supplement that was left in the feeder and liquid supplement after addition and blending was sampled weekly. Fecal grab samples were taken from the rectum on four occasions between days 10 and 21 of the period for all cows that received a dual marker system for that period. Forage samples were taken once each period for analysis of quality and availability. A forage harvester with bagging attachment and cutting width of 19 in was used to sample a 10 ft strip of each pasture at a cutting height of approximately 2 in. The entire cut was then weighed, subsampled, and sealed in a plastic bag after collection for further analysis.

**Statistical Analyses**

Treatment (TRT), pasture (PAS), and period (PER) data obtained from the randomized block design were analyzed as main effects using the GLM procedure of SAS®. Least squares means were separated when F-test was significant (P<0.05).

**Results**

Cattle had adequate quantities of standing forage throughout the trial. Average available forage ranged from 2,727 to 4,884 lb/acre (4,150 lb/acre avg). Forage had CP values ranging from 8.83% to 11.56% (avg 10.92%), IVOMD values 32.35% to 42.50% (avg 38.18%), NDF values 78.70% to 81.20% (avg 80.99%).

Daily average supplement intakes for the 42-d trial are summarized in Table 2. Daily consumption over all treatments averaged 8.78 lb. Decreases in liquid supplement intake were observed for each treatment except C-3. However, C-3 tended to decrease (P=0.13) consumption by 9% versus control. When pH was lowered to 2.3 using HCl, 30% (P<0.01) less consumption than control was recorded. Treatment P-3 reduced consumption by 33% (P<0.01) and likewise consumption of P-2 was lowered by 53% (P<0.01), both compared to control. Treatments S-3 and S-2, using sulfuric acid, lowered daily supplement intake (P<0.01) by 18% and 38%, respectively.

When liquid feeds were adjusted to a similar pH, hydrochloric acid proved to be least effective and phosphoric acid was most effective at lowering liquid supplement consumption. Additionally, these acids help to maintain molasses-based liquid supplements in a more free-flowing liquid state during cold weather. Though the acidification of liquid feeds using hydrochloric, phosphoric, or sulfuric acid shows promise as a method of limiting intake, the expense and handling equipment necessary keep these acids from being practical on most farms and ranches. Growing environmental concerns about phosphorus content of runoff also limit the use of phosphoric acid by most livestock producers and gives incentive for the possible inclusion of other acids in commercial liquid feeds.

Different acid sources produced different individual intake variations. Though hydrochloric acid was least effective at reducing consumption, at pH levels 2.4 and 3.3, CV was less (17% and 25%, respectively) than control (33%). One explanation for this is that the addition of hydrochloric acid caused the liquid feed to become thinner and take on a pleasant odor. Intake was most limited by adding phosphoric acid and at pH levels 2.3 and 3.2, CV was less (31% and 23%, respectively) than CV of control. Supplement at pH 2.3 using sulfuric acid had CV lower (29%) than control but pH 3.2 with the same acid produced CV higher (39%) than control. Previous research has shown that social dominance and social interactions play an important role in feeding behaviors and supplement consumption. This is most apparent in herds with mixed ages and sizes of animals. Also, the presence or absence of suckling calves seems to play a role in liquid supplement consumption and variation in intake. Other researchers found that 2-yr-old cows consumed less liquid supplement from lick tanks than 3-yr-old cows on November range. The animals used in this trial were very similar in age, size, and breed type. Cows in this study were all mature, pregnant, and non-lactating. Thus, the variation in supplement consumption is more likely due to palatability and individual animal preferences.

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Table 1. Composition of liquid supplement as-fed.\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Component</th>
<th>Period 1</th>
<th>Period 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter, %</td>
<td>72.64</td>
<td>72.93</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>16.33</td>
<td>16.34</td>
</tr>
<tr>
<td>Total Sugars as Inverts, %</td>
<td>40.28</td>
<td>39.96</td>
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<tr>
<td>Phosphorus, %</td>
<td>0.75</td>
<td>0.80</td>
</tr>
<tr>
<td>Potassium, %</td>
<td>4.59</td>
<td>4.91</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>0.74</td>
<td>0.78</td>
</tr>
<tr>
<td>Sulfur, %</td>
<td>0.89</td>
<td>0.96</td>
</tr>
<tr>
<td>Sodium, %</td>
<td>0.09</td>
<td>0.09</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Liquid feed samples collected weekly and composited by period.

\textsuperscript{b}Free-choice mineral mix in addition to liquid supplement contained Ca 17%, P 9%, as calcium carbonate, monocalcium phosphate and dicalcium phosphate, Salt 25%, Mg as magnesium oxide 0.25%, Cu as copper sulfate 0.15%, Co as cobalt sulfate, 0.01%, I as calcium iodate, 0.01%, Mn as manganese sulfate, 0.20%, Se as sodium selenite, 0.0040%, Zn as zinc sulfate 0.40%, and F not more than 0.09%.

Table 2. Effect of liquid supplement pH and acid source on free-choice consumption.

<table>
<thead>
<tr>
<th>Treatment = pH of liquid supplement and acid source</th>
<th>Control\textsuperscript{a}</th>
<th>S-3\textsuperscript{b}</th>
<th>C-3\textsuperscript{c}</th>
<th>P-3\textsuperscript{d}</th>
<th>S-2\textsuperscript{e}</th>
<th>C-2\textsuperscript{f}</th>
<th>P-2\textsuperscript{g}</th>
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<tr>
<td>pH</td>
<td>4.2</td>
<td>3.2</td>
<td>3.3</td>
<td>3.3</td>
<td>2.3</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Period</td>
<td>liquid supplement intake lb/hd/d</td>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9.86</td>
<td>8.41</td>
<td>8.39</td>
<td>5.97</td>
<td>6.59</td>
<td>6.66</td>
<td>4.87</td>
</tr>
<tr>
<td>Avg.</td>
<td>11.84\textsuperscript{h}</td>
<td>9.65\textsuperscript{j}</td>
<td>10.76\textsuperscript{h,i}</td>
<td>7.88\textsuperscript{k}</td>
<td>7.39\textsuperscript{k}</td>
<td>8.26\textsuperscript{l,k}</td>
<td>5.60\textsuperscript{l}</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Standard liquid supplement (pH 4.2; containing ~2.75% phosphoric acid).

\textsuperscript{b}Created by adding 2.1% sulfuric acid (93% acid) to control supplement.

\textsuperscript{c}Created by adding 3.2% hydrochloric acid (35% HCl) to control supplement.

\textsuperscript{d}Created by adding 5.7% phosphoric acid ("green" acid, 24% P) to control.

\textsuperscript{e}Created by adding 4.2% sulfuric acid (93% acid) to control supplement.

\textsuperscript{f}Created by adding 6.3% hydrochloric acid (35% HCl) to control supplement.

\textsuperscript{g}Created by adding 11.3% phosphoric acid ("green" acid, 24% P) to control.

\textsuperscript{h,i,k,l} Average intakes lacking a common superscript differ (P<0.05); SE=0.48.