J. Dairy Sci. 85:2000–2008

Impact of Feeding a Raw Soybean Hull-Condensed Corn Steep Liquor Pellet on Induced Subacute Ruminal Acidosis in Lactating Cows[1]

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ABSTRACT

We used four ruminally cannulated, multiparous Holstein cows (690 kg; 21 kg/d milk) in a 2-period crossover design to determine the impact of feeding a raw soybean hull-corn steep liquor pellet (SHSL) on induced subacute ruminal acidosis (SARA) in lactating cows. Cows were fed control [30% alfalfa hay, 15% corn silage, 34% corn, 9% whole cottonseed, 5% soybean meal (SBM)] or SHSL (20% of diet DM) diets as TMR. SHSL replaced 6.2% alfalfa hay, 3.7% corn silage, 6.6% corn, and 3.3% SBM. Periods were 15 d (10 d adaptation, 2 d for prechallenge measures, and 3 d of SARA challenge). Cows were fed once daily at a common DMI dictated by the cow consuming the least. Cows were fasted 12 h before the first SARA challenge. For each of the three SARA challenges, cows were offered 75% of their daily diet at 0600 h. The remaining 25% of diet DM was replaced by ground corn, which was mixed with the orts that remained 2 h after feeding and placed into the rumen. Ruminal pH declined linearly with time after feeding, and this decrease was greater during the SARA challenges. Ruminal lactate increased linearly with repeated SARA challenges. Concentrations of total ruminal VFA increased linearly after feeding, and increases were greater when cows were challenged. No differences were observed due to SHSL inclusion. The model induced SARA, but partial replacement of alfalfa, corn silage, corn, and SBM by SHSL did not influence responses to SARA challenges.
(**Key Words:** acidosis, soyhull, corn steep liquor)

Abbreviation key: CSL = condensed corn steep liquor, **NFC** = nonfiber carbohydrate using 100 – (% CP + % NDF + % ether extract + % ash), **SARA** = subacute ruminal acidosis, **SBM** = soybean meal, **SHSL** = raw soybean hull-condensed corn steep liquor pellet.

INTRODUCTION

Formulating energy-dense diets to meet the nutritional requirements of high producing dairy cows can promote subacute ruminal acidosis (**SARA**). Furthermore, the use of rapidly fermentable carbohydrates to meet energy demands often results in a decrease in milk fat (Sutton, 1989), which has been associated with suboptimal ruminal pH and acetate:propionate ratio (Sarwar et al., 1992). Conversely, high fill diets, which are formulated to provide adequate physically effective fiber to maximize buffering activity by stimulating rumination and salivation, often limit the animal's nutrient intake capabilities and result in decreased milk production (Varga et al., 1984). Diets high in NDF can be formulated using nonforage fiber sources such that starch content is lower than in diets containing primarily forage NDF. Potentially, this could alleviate the negative effects of starch on fiber digestion (Mertens and Loften, 1980). Yet, most nonforage fiber sources do not stimulate chewing activity (Clark and Armentano, 1997), potentially subjecting cows to SARA.

Raw soybean hulls are a nonforage fiber source readily available in the Midwest United States. They provide a highly digestible source of structural fiber with minimal lignin content (Garleb et al., 1988). However, compared with forages, soyhulls do not stimulate rumination and can lead to reduced ruminal pH (Weidner and Grant, 1994a). Dietary ingredients replaced by soyhulls largely influence the observed effects on ruminal acidity. When substituting soyhulls for mostly forage, reduced ruminal pH was reported (Sarwar et al., 1991; Cunningham et al., 1993), but when soyhulls replace a portion of the concentrate, only insignificant changes in ruminal pH occur (Sarwar et al., 1992; Cunningham et al., 1993).

Received December 11, 2001.
Accepted February 4, 2002.
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Condensed corn steep liquor (**CSL**), a byproduct of the wet corn milling industry, contains a mixture of carbohydrates, amino acids, peptides, organic compounds, heavy metals, inorganic ions, and *myo*-inositol phosphates (Hull et al., 1996). Johnson et al. (1962) reported significantly higher crude fiber, cellulose, and DM digestibilities when lambs fed a 50% roughage diet were supplemented with CSL. Corn steep liquor also has been used successfully as a protein supplement for beef cattle grazing dormant winter range (Wagner et al., 1983). Paradoxically, in vitro ruminal fermentation evaluations indicated CSL had a positive effect on starch digestion but a negative effect on cellulose digestion when compared to soybean meal (**SBM**; Filho, 1999).

Our laboratory has developed a pelleted feedstuff (**SHSL**) containing 75% raw soybean hulls and 25% CSL (DM basis). Previous research indicated SHSL is a palatable product that is high in fiber and protein and suitable for lactating dairy cattle diets (DeFrain et al., 2001). Substituting SHSL for a portion of forage and grain, the fiber (29% ADF, 37% NDF) of raw soybean hulls and CP of CSL (44.2%) may enhance nutrient delivery to the dairy cow without causing SARA.

Our experiments were designed to determine the ruminal fermentation pattern of cows fed SHSL and to evaluate the effect of SHSL when consumed by cows experimentally challenged with SARA.

MATERIALS AND METHODS

In Vitro Acid Buffering Capacity

The acid buffering capacity of alfalfa hay, corn grain, raw soybean hulls, and SHSL were evaluated in vitro. Acid buffering capacity was measured in triplicate using procedures from Jasaitis et al. (1987). Samples were ground using a Wiley mill (1-mm screen), dried for 24 h at 105°C; DM was assumed to be 100%. After air-equilibrating, 0.5 g was suspended in 50 ml of deionized water. Using a pH meter equipped with a combination electrode (Orion, Boston, MA), initial pH and further measurements were recorded after 3 min of equilibration, during which time contents were continuously stirred using a magnetic stir bar. Acid titrations were performed by adding 0.1 *N* HCl in variable increments (depending upon stage of titration) until sample pH was decreased to 4, at which time total volume of acid added was recorded. Acid buffering capacity was calculated as [(total volume of acid required × 0.1 *N* HCl)/(initial pH − 4)].

SARA Challenge

Four ruminally cannulated (10-cm i.d., Bar Diamond, Inc., Parma, ID), multiparous Holstein cows (690 kg; 21 kg of milk/d) were used to investigate the effect of SHSL on rumen fermentation and SARA during an experimental challenge. Cows were housed in tie-stall facilities at the Kansas State University Dairy Teaching and Research Center (Manhattan, KS). All cows were administered recombinant bovine somatotropin (Posilac, Monsanto, St. Louis, MO) at 14-d intervals throughout the trial. Periods were 15 d (10-d adaptation, 2 d for prechallenge measures, and 3 d of subacute ruminal acidosis challenge) and separated by 10 d to eliminate carryover effects. A graphic representation of the experimental protocol is illustrated in Figure 1.

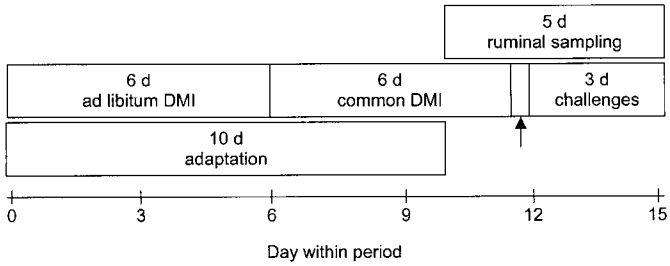

Figure 1. Feeding and sampling protocol used to induce subacute ruminal acidosis (SARA).

Dietary treatments (Table 1) were control and SHSL fed at 20% of diet DM. This level of SHSL inclusion was based on data from an acceptability trial using lactating dairy cows (DeFrain et al., 2001). Concentrations of NEL, crude protein, ADF, and NDF were formulated to be similar between diets by replacing portions of alfalfa hay, corn silage, ground corn, and solvent soybean meal with SHSL. Expeller soybean meal replaced solvent soybean meal in the SHSL diet to equalize diet RUP. Concentrations of menhaden fish meal and blood meal were similar between treatments.

A Data Ranger feed cart (American Calan, Northwood, NH) was used to mix diets daily at 0530 (all phases) and 1630 h (d 1 through 6). During the first 6 d of the 10-d adaptation phase, TMR and ort samples were collected daily and dried at 105°C to determine daily intake. During d 7 to 12, cows were fed once daily at a common DMI as a percent of BW dictated by the cow consuming the least during the first 6 d of adaptation. Cows were fasted 12 h before the first SARA challenge. For each SARA challenge (d 13, 14, and 15), cows were offered 75% of their daily diet at 0600 h. The remaining 25% of diet DM was replaced by ground corn (average particle size of 2500 μ) that was mixed with orts remaining 2 h after feeding (see Table 3 below) and placed into the rumen at that time.