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Effects of feeding rumen-degradable valine on milk production in late-lactating dairy cows

Kayla M. Hultquist and David P. Casper[1]
Department of Dairy Science, South Dakota State University, Brookings 57007

ABSTRACT

The study objective was to determine if feeding the rumen-degradable AA Val can increase milk production comparable to recombinant bovine somatotropin (bST). Eight multiparous late-lactating (255 ± 26.4 d in milk) Holstein dairy cows were blocked by milk yield (34.1 ± 8.25 kg/d) and randomly assigned to 1 of 4 treatments in a replicated 4 × 4 Latin square design with 21-d periods (7 d for dietary adaptation and 14 d for data collection). Treatments were control (CON), a single injection of recombinant bST (rbST), and Val fed at 40 (V40) and 80 g/d (V80). Cows were fed a total mixed ration with a distillers dried grains carrier at 113.4 g/d containing none or added AA. Dry matter intake (21.3, 22.0, 22.8, and 21.5 kg/d for CON, rbST, V40, and V80, respectively) was similar among treatments, except cows receiving V40 had greater dry matter intake than cows receiving V80. Milk yield (22.0, 26.1, 25.2, and 24.9 kg/d), 3.5% fat-corrected milk (22.1, 25.4, 24.4, and 24.3 kg/d), and energy-corrected milk (22.7, 26.1, 25.1, and 24.9 kg/d) were increased at similar amounts for cows receiving rbST, V40, and V80 compared with CON cows. Milk fat percentages (3.51, 3.36, 3.32, and 3.38%) were greatest for CON cows compared with cows receiving V40, whereas cows receiving other treatments were intermediate and similar. Milk protein percentages (3.20, 3.12, 3.15, and 3.13%) were greater for CON cows compared with cows receiving rbST and V40, whereas cows receiving V80 were intermediate and similar. Ruminal isobutyrate (1.19, 1.24, 1.44, and 1.74 mol/100 mol) concentrations were increased for cows receiving V40 and V80 compared with CON and rbST cows, with cows receiving V80 having greater concentrations than cows receiving V40. Plasma growth hormone concentrations (1.78, 1.99, 1.55, and 1.45 ng/mL) were greater for cows receiving rbST compared with cows receiving V40 and V80, whereas CON cows were intermediate and similar. Plasma insulin-like growth factor-1 concentrations (60.4, 106.1, 65.9, and 58.3 ng/mL) were greater for cows receiving rbST compared with cows receiving other treatments. This study suggests that feeding rumen degradable Val can increase milk yield comparable to recombinant bST.
Key words: amino acid, dairy cow, growth hormone, milk production

INTRODUCTION

With the world population expected to reach 9 billion people by 2050 (Capper et al., 2008), new approaches and technologies need to be discovered to feed the growing world population. If the world population does indeed reach 9 billion people, milk production will need to increase by more than 22 billion kg from 2006 production levels (Capper et al., 2008). Achieving this growth will require increased production with very efficient utilization of resources.

It has been difficult and frustrating to achieve consistent milk production responses when balancing rations for metabolizable AA on commercial dairy operations (D. P. Casper, personal communication). Feed formulation software packages that give different rations when balancing for AA due to different methods for calculating requirements is just one of many concerns. One issue with AA balancing is the lack of knowledge on how much AA gets metabolized by the rumen, how much escapes the rumen, and how much is absorbed across the intestinal wall (Kung and Rode, 1996). Some research studies (Zanton et al., 2014) have shown that increasing AA in the diet has led to increased milk production, an important aspect to dairy producers, but other studies (Zanton et al., 2014) have not demonstrated a response. In addition, nutrients and their metabolites can be metabolic regulators. So it may be possible that other mechanism(s) may exist for describing the observed responses of lactating dairy cows when fed rations balanced for AA. Thus, future research needs to identify these new mechanism(s) to create formulation systems that will give accurate and consistent results when

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[1]Corresponding author: david.casper@sdstate.edu

balancing rations for AA to achieve consistent, predictable, and optimal milk production. The hypothesis of the current study is that the nutrient concentration of the ration may be influencing the endocrine system of the lactating dairy cow.

The dairy industry has made strides in the last few decades to achieve higher milk production through the use of fewer resources. Recombinant bST, which has been shown to increase milk production by 10 to 15% (Etherton and Bauman, 1998) was approved by the US Food and Drug Administration in 1993 (Capper et al., 2008), and in 1994 recombinant bST became available for commercial use as Posilac (Elanco, Greenfield, IN; Etherton and Bauman, 1998). Although no human health risks have been found in the more than 90,000 research studies conducted on somatotropin (Etherton and Bauman, 1998), the public has not been favorable toward the use of hormones to increase milk production and recombinant bST has been banned in certain countries, including the European Union and Canada (Ozhikandathil et al., 2014), along with certain milk processors and food service companies within the United States, including McDonald's (Dairy Herd Management, 2015) and Starbucks (Organic Consumers Association, 2007).

Isoacids have also been used in the past to enhance milk production of lactating dairy cows via increasing ruminal fiber digestion (Papas et al., 1984; Peirce-Sandner et al., 1985), but commercialization failed due to an unpleasant odor (National Center for Biotechnology Information, 2015). Liu et al. (2009) demonstrated that feeding isobutyrate (an isoacid) resulted in an 11% increase in blood growth hormone (**GH**) concentrations. This observation presents an opportunity to use isobutyrate (Val metabolite) to stimulate the release of natural GH from the anterior pituitary.

One potential alternative to feeding isobutyrate is to feed the synthetic AA, Val, which does not emit any unpleasant odors. Our hypothesis was that Val will be metabolized by the rumen microbes to isobutyric acid through ruminal microbial oxidative deamination and decarboxylation (Rosener and Uhlenhopp, 1987), which will then be absorbed across the rumen wall into the blood stream. Increased blood concentrations of isobutyrate will stimulate additional GH release from the pituitary gland, which will then enhance milk production through the GH-IGF-1 axis. Thus, the objective of our study was to determine if the supplementation of synthetic Val could increase milk production that would be similar to the administration of recombinant bST, and therefore become a viable alternative for recombinant bST for dairy producers that are not allowed to use recombinant bST.

MATERIALS AND METHODS

Animals and Diets

This research project was conducted at the South Dakota State University (**SDSU**) Dairy Research and Training Facility (**DRTF**; Brookings, SD) from April 22 to July 27, 2014, and all procedures were approved by the SDSU Institutional Animal Care and Use Committee before the start of the study. Eight multiparous late-lactating (255 ± 26.4 DIM) Holstein dairy cows housed in a freestall barn were blocked by milk production (34.1 ± 8.25 kg/d) and randomly assigned to 1 of 4 treatments using a replicated 4 × 4 Latin square design having 21-d periods with 7 d for dietary adaptation and 14 d for data collection. Treatments were (1) control (no injection of recombinant bST or Val supplementation; **CON**), (2) a single injection of 14-d slow-release recombinant bST (Posilac, Elanco) given on d 1 of wk 2 of each period subcutaneously to either the right or left side of the tailhead (**rbST**), (3) Val (L-Val, Ajinomoto North America Inc., Fort Lee, NJ) fed at 40 g/d (**V40**), and (4) Val fed at 80 g/d (**V80**).

Cows were fed a TMR (Table 1) once a day consisting of 55% forage (60% corn silage and 40% alfalfa haylage from the 2013 crop season) and 45% grain on a DM basis with a distillers dried grains carrier included at the rate of 113.4 g/d that contained none or added Val at the designated amounts. The grain mix was similar among all 4 treatments and was mixed at the SDSU Feed Mill and delivered to the DRTF approximately every 2 wk. The ration was balanced using Agricultural Modeling and Training Systems (**AMTS**) software (Agricultural Modeling and Training Systems LLC, Groton, NY) for 38.5 kg/d of milk produced by cow weighing 703 kg that was assumed to be pregnant (NRC, 2001). The Val content in the TMR before the addition of Val was formulated to provide 121% of the daily requirement of metabolizable Val for the cow at 139.9 g/d. This was calculated using the set equations and values in the AMTS software (Agricultural Modeling and Training Systems). All other essential AA were balanced to meet or exceed the requirements of a lactating dairy cow at this stage of production (NRC, 2001). The TMR and distillers dried grains carrier were mixed for 5 min using a Super Data Ranger (American Calan Inc., Northwood, NH) before dispensing the TMR.

Twelve days before the beginning of the study were used for training cows to use the Calan Door System. This study did not use Rumensin (Elanco Animal Health, Indianapolis, IN), and recombinant bST shots were discontinued before the Calan Door System training period and given to the rbST treatment on d 1 of