Animal Feed Science and Technology 153 (2009) 11–27

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Effects of monensin on volatile fatty acid metabolism in periparturient dairy cows using compartmental analysis

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ARTICLE INFO

Article history:
Received 22 July 2008
Received in revised form 1 May 2009
Accepted 18 May 2009
Available online 13 June 2009

Keywords:
Monensin
Transition cows
VFA metabolism
Kinetics
Compartmental analysis

ABSTRACT

Eight multiparous periparturient Holstein cows fitted with ruminal cannulas were used in a split plot design to evaluate effects of monensin on ruminal volatile fatty acid (VFA) metabolism. Diets were supplemented with 300 mg/day of monensin, or no monensin, both prepartum and postpartum. Isotopic tracers, Na-1-^{13}C-acetate (Ac), Na-1-^{13}C-propionate (Pr), or Na-1-^{13}C-butyrate (Bu) were used as markers to describe VFA kinetics in the rumen. The Windows version of SAAM software (WinSAAM) was used to develop a steady state VFA model. A 9-compartment model was adequate to comprehensively describe ruminal VFA metabolism. The main VFA compartments consisted of Ac, Pr and Bu. The model estimated lower Bu and Ac interconversions with monensin, postpartum (Bu to Ac; 0.14 *versus* 0.12; P=0.04, and Ac to Bu; 0.32 *versus* 0.25; P=0.11) compared to when measured prepartum. Results demonstrate that dilution studies employing stable isotopes of VFA can be used to provide information on VFA metabolism of the periparturient dairy cow. A time frame of 320 min of labeled VFA infusion employing a single injection allows accurate quantification of VFA metabolism in the rumen. Compartmental kinetic analysis of major

Abbreviations: Ac, acetate; AclBu, acetate incorporation into butyrate; ADF, acid detergent fiber; BCS, body condition score; Bu, butyrate; BulAc, butyrate incorporation into acetate; BW, body weight; DM, dry matter; CP, crude protein; FSD, fractional standard deviation; GC–MSD, gas chromatography–mass selective detection; aNDF, amylase neutral detergent fiber; NEFA, non-esterified fatty acids; Pr, propionate; F, Tracer/(Tracer + Tracee) or TTR; RS, reproductive stage; TMR, total mixed ration; VFA, volatile fatty acids.

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0377-8401/$ – see front matter
doi:10.1016/j.anifeedsci.2009.05.007

VFA in the rumen indicate that monensin reduced about 0.125 the portion of the Ac that contributes to Bu by reducing movements of Bu originated carbons to the Ac pool. Monensin may affect certain biochemical pathways of interconversion of Bu and Ac in the rumen. Propionate kinetic data suggests that Pr behaves as a single pool in the rumen. Monensin did not affect Pr production in the rumen suggesting that monensin improves the metabolic status of the transition cow in a way other than increasing Pr production in the rumen.

1. Introduction

Transition dairy cows (i.e., 21 days prior to 21 days after parturition) have increased energy demands to meet requirements for the fetus and milk production (Bell, 1995). These demands may be satisfied by mobilizing body stores. Levels of blood non-esterified fatty acids (NEFA) concentrations may increase causing metabolic disorders such as ketosis and fatty liver (Duffield et al., 1998). Increasing glucose supply to the cow may decrease the need to mobilize fats preventing associated metabolic disorders (Drackley et al., 2003). Energy supply to the early lactation cow may be increased by supplementing diets with ionophores such as monensin (McGuffey et al., 2001; Arieli et al., 2001). Monensin alters volatile fatty acid (VFA) production in the rumen towards more propionate (Pr) production at the expense of acetate (Ac), which results in increased glucose availability to the animal through gluconeogenesis (Armentano and Young, 1983). As VFA contribute to energy requirements of a dairy cow by a factor of 0.80 (Bergman and Wolff, 1971), net Pr removal from the liver can increase by 0.69 in transition dairy cows (Reynolds et al., 2003). Therefore, it becomes important to investigate and elaborate the ways that monensin may affect VFA metabolism during the transition period.

Research on VFA metabolism has involved dilution studies with use of radioisotopes, mainly ^{14}C, and ^{3}H (Leng and Brett, 1966; Van Maanen et al., 1978) or ^{13}C stable isotopes (Martin et al., 2001). These studies were conducted with sheep, steers or lactating cows. Arieli et al. (2001) is the only study that investigated glucose metabolism of transition cows that were fed monensin prepartum, and they ignored the effect of monensin on VFA metabolism. Currently, information is lacking on effects of monensin fed through the transition period on VFA metabolism.

Our hypothesis was that monensin would alter VFA metabolism and the effects would be dependent upon the reproductive stage of the cow. The main objective of this study was to investigate and quantify the effect of monensin fed continuously through the transition period (i.e., from four weeks prepartum to eight weeks postpartum) on prepartum and postpartum VFA metabolism of the cow.

2. Materials and methods

2.1. Experimental design and treatment allocation

Eight rumen-cannulated multiparous periparturient Holstein cows were used in a split plot design to measure effects of monensin on metabolism of ruminal VFA (i.e., Ac, Pr and Bu) during the transition period (i.e., prepartum *versus* postpartum). Main emphasis was given to determining kinetic parameters and production rates of VFA during the periparturient period in dairy cows. Volatile fatty acid parameters such as individual and total VFA concentrations were also examined. Cows were randomly assigned to treatments 30 days prior to expected parturition with randomization restricted to balancing for previous lactation mature equivalent 305-day milk production and body condition score (BCS). Cows were also blocked according to expected calving date. The two treatments ($n = 4$ per treatment) were no monensin supplementation or 300 mg monensin top dressed/cow/d. Cow in the design was the whole plot, treatment was a whole plot factor, and reproductive stage (i.e., RS; prepartum or postpartum) was used as the subplot factor.