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Effect of zinc amino acid complex-to-zinc sulfate ratio on the performance of Holstein cows

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ABSTRACT

Multiparous (n = 70) and primiparous (n = 66) Holstein cows were balanced by 305-d previous mature-equivalent milk yield and parity and assigned to 1 of 3 dietary treatments to evaluate the ratio of zinc sulfate to zinc amino acid complex (CZ) in pre- and postpartum Holstein cows fed diets containing 75 mg of added zinc/kg. Treatments were (1) 75 mg of supplemental zinc/kg of dry matter (DM) provided entirely as zinc sulfate (0-CZ); (2) 0-CZ diet, except 33.3 mg of zinc sulfate/kg of DM in the prepartum and 15.5 mg of zinc sulfate/kg of DM in the postpartum diet were replaced by CZ from Availa-Zn (16-CZ; Zinpro Corp., Eden Prairie MN); and (3) 0-CZ diet, except 66.6 mg of zinc sulfate/kg of DM in the prepartum and 40.0 mg of zinc sulfate/kg of DM in the postpartum diet was replaced by Availa-Zn (40-CZ). Cows were housed at the Iowa State University Dairy Farm and were individually offered a total mixed ration containing dietary treatments beginning at 28 ± 15 d before expected calving date until 250 d in milk. Relative to 0-CZ, multiparous cows (but not primiparous) fed CZ (16-CZ or 40-CZ) had increased (20%) colostrum IgG concentrations. Prepartum DM intake (DMI) was decreased with CZ supplementation. Postpartum DMI was decreased in cows fed CZ, whereas milk yield (MY) was increased in the 40-CZ-fed cows relative to those fed both 0-CZ and 16-CZ. Feed efficiency increased linearly when measured as MY/DMI, 3.5% fat-corrected MY/DMI, and solids-corrected MY/DMI. Regardless of level, feeding CZ decreased services per conception. Feeding 16-CZ decreased milk fat concentration and feeding CZ linearly increased milk urea nitrogen concentration. In summary, supplementing zinc as a mixture of CZ and zinc sulfate, as opposed to supplementing only zinc sulfate, has beneficial effects on production parameters in dairy cows, with those benefits becoming more apparent as the ratio of CZ to zinc sulfate increases.
Key words: zinc, production efficiency, lactation, somatic cell

INTRODUCTION

Zinc is indispensable for normal animal growth and health (NRC, 2001). Zinc is essential to over 300 enzymes (Dibley, 2001), many of which affect the metabolism of carbohydrates, proteins, lipids, and nucleic acids (NRC, 2001). Interactions with other metal ions, particularly copper and iron, and the presence of dietary organic chelating agents are 2 major factors affecting the efficiency of dietary zinc absorption (NRC, 2001). Research has demonstrated that amino acid complexes of trace minerals improve mineral bioavailability (Wedekind et al., 1992; Paripatananont and Lovell, 1995) as well as mineral retention (Nockels et al., 1993). Spears (1989) concluded that zinc from zinc oxide and zinc methionine complex was absorbed to the same extent by lambs, but more zinc was retained from zinc methionine complex as a result of lower urinary excretion.

Improved dairy cattle nutrition and management has markedly increased milk yield (**MY**) during the past few decades. Enhanced milk synthesis results in a concomitant increase in nutrient demands. The recommended dietary zinc content for dairy cattle is between 18 and 73 mg/kg of DM, depending upon the cows' life cycle stage and DMI (NRC, 2001). The requirement for zinc can be substantial, especially at peak milk production (4 mg/kg of milk; NRC, 2001). The effects of dietary antagonists, environment, stress, mineral source, and level of supplementation are not accounted for within current NRC (2001) trace mineral recommendations.

Improved dairy cow performance has been observed in cattle fed supplemental zinc in excess of NRC (2001) recommendations. For example, Campbell and Miller (1998) observed reduced days to first estrus and a tendency for reduced days to first service in cows fed 74

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mg/kg of supplemental zinc [50:50 blend of zinc sulfate and zinc amino acid complex (**CZ**)] during the last 6 wk of gestation. Further, a 12-trial summary by Kellogg et al. (2004) indicated that feeding CZ (180 to 400 mg of zinc/d) increased ECM yield and decreased milk SCC relative to inorganic zinc. The zinc-methionine complex was fed in addition to inorganic zinc in all but 3 of the aforementioned trials. Excluding the 3 trials where total diet zinc content was not reported and assuming that 30 mg of total zinc/kg was derived from feedstuffs, supplemental zinc content averaged 48 mg/kg of DM. The reduction in milk SCC reported by Kellogg et al. (2004) was augmented when zinc was fed at ≥360 mg/head per day (7 of the 12 trials) from CZ. However, the responses observed were partially confounded by the level of supplemental zinc. In addition, the supplementation of zinc-methionine complex began during the dry period in only 3 of the 12 trials. Therefore, we hypothesized that increasing the ratio of CZ to zinc sulfate during both the dry and lactation period would improve the performance of Holstein cows fed the same amount of supplemental zinc.

MATERIALS AND METHODS

Animals and Sampling

Animal care and use was according to a protocol approved by the Iowa State University Institutional Animal Care and Use Committee (Ames). The experiment was conducted from November 2010 through March 2012 at the Iowa State University Dairy Research Farm. Multiparous (n = 100) and primiparous (n = 84) Holstein cows were balanced by 305-d previous mature-equivalent MY (if multiparous) and parity and assigned to 1 of 3 dietary treatments beginning 28 ± 15 d before expected calving date and through 250 ± 6 DIM. Cows were initially excluded from the data set or removed from the trial using the following events defined at the onset of the experiment: spent less than 14 d on prepartum diet (n = 8), diagnosed as carrying twins (n = 5), off treatment for ≥10 d (i.e., if they were sick; n = 19), had <4 functional mammary gland quarters (n = 3), or were not pregnant as originally reported, died ,or were injured (n = 13). If a cow was removed from the experiment after 100 DIM, her data was included in the final data set up to the elimination date.

Formulated diets, analyzed nutrient composition, and chemical composition of forages are shown in Tables 1, 2, and 3, respectively. With the exception of zinc source, all other dietary ingredients were the same within the prepartum and postpartum TMR across treatments. Diets were formulated assuming that feedstuffs did not contribute Zn, Mn, Cu, and Co and that only the treatment mixes supplied Zn, Mn, Cu, and Co. Diets were isonitrogenous, isoenergetic, and balanced using Spartan Dairy Ration Evaluator 2.0 software (Michigan State University, East Lansing), which uses NRC (2001) recommendations. Prepartum diets were formulated for a Holstein cow with the following characteristics: consuming 10.6 kg of DM/d, 29 mo of age, 590 kg of BW, 0.36 kg of growth/d, and 10 d before freshening. Lactation diets were formulated for a Holstein cow with the following characteristics: consuming 23.2 kg of DM/d, 42 mo of age, in second lactation, 590 kg of BW, 0.41 kg of growth/d, 120 DIM, and producing 40 kg of milk/d with 3.7% fat and 3.2% protein. Upon the conclusion of the experiment, the latest version of the Cornell Net Carbohydrate and Protein System (CNCPS v6.1; Cornell University, Ithaca, NY) was released, allowing for improvements in estimating dietary ME and MP supply. Therefore, diet ME and MP were estimated using Nutritional Dynamic System (industry-licensed platform of CNCPS v6.1; RUM&N Sas, Emilia, Italy) based upon actual DMI and dietary chemical composition.

Based upon the previous work of Campbell and Miller (1998) and Kellogg et al. (2004), prepartum and postpartum diets were formulated to supply 75 mg of supplemental zinc/kg of DM. This is greater than the zinc requirement calculated using NRC (2001) for prepartum (30 mg/kg) and postpartum (56 mg/kg of DM) using the animal inputs described above. All diets contained the same quantity of supplemental zinc and only the proportion of zinc source differed between treatments (zinc sulfate and CZ; Availa-Zn 100; Zinpro Corp., Eden Prairie, MN). The zinc in CZ was bound to an amino acid in a ratio of 1 atom of metal bound to a single, unspecified amino acid. Treatments were (1) 75 mg of supplemental zinc/kg of DM, provided entirely as zinc sulfate (**0-CZ**); (2) 0-CZ diet, except 33.3 mg of zinc sulfate/kg of DM in the prepartum and 15.5 mg of zinc sulfate/kg of DM in the postpartum diet was replaced by CZ from Availa-Zn (**16-CZ**); and (3) 0-CZ diet, except 66.6 mg of zinc sulfate/kg of DM in the prepartum and 40.0 mg of zinc sulfate/kg of DM in the postpartum diet was replaced by Availa-Zn (**40-CZ**). The source and level of all other trace minerals were similar across treatments. Our highest CZ treatment in the prepartum phase (66.6 mg of CZ/kg on a DM basis) was designed to double the CZ dose (400 mg/d) used by Campbell and Miller (1998), whereas the highest CZ dose postpartum (40 mg of CZ/kg on a DM basis) was formulated to double the largest CZ fed (400 mg/d) in the summary report by Kellogg et al. (2004). For simplicity, the treatment identifications noted in further sections (0-CZ, 16-CZ, and 40-CZ) are associated with the level of CZ fed in the postpartum phase only, as this