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Meta-analysis of lactation performance in dairy cows receiving supplemental dietary methionine sources or postruminal infusion of methionine

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ABSTRACT

The objectives of our study were to evaluate the productive response to methionine supplementation in lactating dairy cows and to define a relationship between metabolizable Met (MP Met) intake and production. A database of 64 papers meeting the selection criteria was developed evaluating postruminally infused DL-methionine (9 papers with 18 control diets and 35 treatment comparisons), 2-hydroxy-4-methylthio butanoic acid (HMTBa) provided as either a liquid or Ca salt form (17 papers with 34 control diets and 46 treatment comparisons), Mepron (Evonik Industries, Essen, Germany; 18 papers with 35 control diets and 42 treatment comparisons), and Smartamine (Adisseo Inc., Antony, France; 20 papers with 30 control diets and 39 treatment comparisons). Dietary ingredients and their accompanying nutritional compositions as described in the reports were entered into the Cornell-Penn-Miner software to model the diets and to predict nutrients that were not reported in the original publication. Data were analyzed using a weighted analysis of response to supplementation compared with the intraexperiment control, as well as through a regression analysis to changing dietary MP Met. Data included in the analysis were from experiments published between 1970 and 2011 with cows supplemented with between 3.5 and 67.9 g of Met or its equivalent from HMTBa. Cows supplemented with Smartamine consumed more, whereas cows supplemented with Mepron consumed less DM compared with controls. Milk yield did not significantly respond to Met supplementation, although it tended to increase for cows supplemented with HMTBa and Mepron. Milk protein yield was increased due to supplementation from all sources or from infusion, and protein concentration was greater for all supplements or infusion of DL-Met, except for cows supplemented with HMTBa. Irrespective of Met source, milk protein yield increased 2.23 g of protein/g of MP Met until reaching the breakpoint. Milk fat yield was increased for Mepron and HMTBa, whereas milk fat concentration was increased for infused DL-Met and for cows supplemented with HMTBa. Based on regression analysis, response of milk fat yield to Met supplementation was not different for infused DL-Met, Mepron, and Smartamine (1.87 g of fat/g of MP Met), whereas the response to HMTBa was significantly greater at 5.38 g of fat/g of MP Met.
Key words: methionine, lactation, 2-hydroxy-4-methylthio butanoic acid (HMTBa)

INTRODUCTION

Feeding the lactating dairy cow for optimum performance and efficiency has become increasingly more sophisticated as knowledge of the nutrient requirements of cows has increased (NRC, 2001). A component of this increased knowledge and sophistication has been in the area of AA nutrition. As environmental regulation, high feed costs, and periodic ingredient scarcity become increasingly important drivers of nutritional management decisions, a greater emphasis on AA nutrition will be required. Methionine is usually considered one of the first limiting AA for milk protein synthesis (Schwab et al., 1992; Rulquin et al., 1993; NRC, 2001). As with many AA, Met has several metabolic fates in addition to its role in protein synthesis, such as in trans-sulfuration and methylation reactions resulting in cysteine (Brosnan and Brosnan, 2006) and choline synthesis (Emmanuel and Kennelly, 1984).

To successfully provide metabolizable AA to the cow, synthetic sources of Met are often supplemented; these synthetic sources must be protected from rumen degradation. Two methods of protecting Met from ruminal degradation have been used successfully: chemically differentiated Met hydroxy analog in a form of 2-hydroxy-4-methylthio butanoic acid (**HMTBa**) and physically encapsulated DL-Met. Responses to increasing metabolizable Met have often, though not always, resulted in improvements in productive performance (Rulquin et al., 1993). This variability of response may be due to the variety of factors affecting Met require-

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ment, including the presence of other limiting AA (Varvikko et al., 1999) and stage of lactation (Schwab et al., 1992; Socha et al., 2008). An additional complication in assessing the effectiveness of supplemental MP Met is the response variable measured to determine the effect of supplementation (Patton, 2010). That is, changes in concentration of a milk component may or may not translate into comparable changes in yield of that component.

To arrive at the requirement for MP Met, the NRC (2001) combined results from experiments in which a variety of physically encapsulated DL-Met supplements or DL-Met infusion treatments were studied; other analyses have been conducted similarly (Rulquin et al., 1993; Vyas and Erdman, 2009). Whereas grouping responses across sources can result in broad conclusions about the effectiveness of MP Met supplementation, information about the effectiveness of the individual available sources is lost. Patton (2010) addressed this in a recent meta-analysis in which responses due to supplementation with Mepron (Evonik Industries, Essen, Germany) and Smartamine (Adisseo Inc., Antony, France) were differentiated in the analysis and different inferences were made for each of the supplements. Analysis of only experiments in which DL-Met is infused postruminally could yield important insight into the magnitude of the expected response from supplemental sources that would be fed. Also missing from previous analyses are experiments that evaluated the use of HMTBa as a source of supplemental MP Met. Whereas the rumen escape of HMTBa has been debated in the literature (Koenig et al., 2002; Noftsger et al., 2005; Zanton et al., 2012), the production effects of HMTBa have been extensively investigated. However, a comprehensive estimate of the effectiveness of supplementation is unavailable for lactating dairy cows. Therefore, in the current study, an analysis of the productive responses to supplemental Met feeding from commercially available sources was conducted with reference to the expectation observed through DL-Met infusion experiments. The objectives were to evaluate the productive response to Met supplementation in lactating dairy cows and to define a relationship between increasing MP Met intake and production.

MATERIALS AND METHODS

Literature Search, Selection Criteria, and Diet Evaluation

To accomplish the objectives of the current study, literature relating to the Met nutrition of lactating dairy cows was identified through searching the Nerac Inc. (Tolland, CT) database (1960–2009), a Google Scholar search (through December 2012), and references from published meta-analyses (Rulquin et al., 1993; NRC, 2001; Doepel et al., 2004; Vyas and Erdman, 2009; Patton, 2010; Robinson, 2010). Search scope was initially broad to enroll as many candidate papers as could be identified to be subjected to the selection criteria, which included (1) publication in a peer-reviewed journal; (2) the amount of HMTBa and physically encapsulated DL-Met fed or the amount of DL-Met infused; (3) milk production and at least 1 milk component of dairy cows were the primary outcome measurements of the studies; (4) an appropriate control diet was included (the same diet as fed to the supplemented cows without supplemental Met source); and (5) sufficient information to allow for diet modeling including DMI. The analysis was limited to the following sources of supplemental Met: postruminally infused DL-Met, HMTBa provided as either liquid or in Ca salt form (e.g., Alimet, MFP, or MHA from Novus International, St. Charles, MO), Mepron, and Smartamine. Excluded from the analysis were jugular-infused Met or HMTBa, the isopropyl ester of HMTBa (**HMBi**), and Ketonin due to the limited database available at the time of analysis.

Dietary ingredients and their accompanying nutritional compositions as described in the reports were entered into Cornell-Penn-Miner software (CPM Version 3.0.10; Cornell University, Ithaca, NY; University of Pennsylvania, Philadelphia, PA; Miner Institute, Chazy, NY) to model the diets. The use of CPM-Dairy allowed prediction of a broad spectrum of nutrients, such as metabolizable Lys and MP Met that may not have been reported in the original publication. When the chemical composition of forages or other ingredients were reported in the original publication, a similar ingredient was edited with the chemical composition of the reported ingredient. When the chemical composition was not reported in the publication, a similar ingredient was selected from the CPM-Dairy feedbank library as long as the final CPM-Dairy prediction for ration CP or NDF was within 10% of the reported value.

Actual milk production and composition were entered in the CPM-Dairy session. Milk protein was assumed to be CP unless it was obviously stated as true protein. Crude protein was assumed to contain 93% true protein (NRC, 2001). If unreported, milk component yield or concentration was calculated based on other reported information present in the original publication. If insufficient information existed in the original publication to calculate unreported data with confidence it was considered missing data for the analysis of that component. This situation only occurred for milk protein; if the milk protein data were missing, a milk CP of 3.0% was used for dietary modeling.