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Plasma protein and supplemental isoleucine in milk replacers for dairy calves

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ABSTRACT

We measured the effects of milk replacers containing 0, 33, 66, or 100% of the total replaceable whey protein as bovine plasma protein (PP), without or with Ile supplementation, on the intake, growth, and health of 124 male Holstein calves for 35 d. Milk replacers were formulated to contain 18% crude protein and 20% fat, with contents of Lys and Met equalized. When fed to calves at 1.5% of body weight (dry matter basis) under thermoneutral conditions, diets were predicted to allow average daily gains of 0.55 kg/d based on metabolizable energy or 0.40 kg/d based on apparent digestible protein. Protein supply was more limiting than energy so that differences in protein use could be detected. Dry matter intakes decreased with increased PP, irrespective of Ile supplementation. Final body weights decreased linearly with increasing PP, regardless of Ile supplementation. Average daily gain tended to be affected in a quadratic manner as PP increased, either with or without Ile supplementation; average daily gain and gain-feed ratio were greatest for calves fed diets containing 33% PP and lowest for calves fed 100% PP. The analyzed Lys content in the milk replacers was variable compared with formulated values, and this may have affected growth results. However, the gain-Lys ratio was affected by an interaction of the linear effect of increasing PP with Ile supplementation: it decreased with increasing PP but was improved by supplementation with Ile for calves fed 100% PP. Body measurements decreased with increasing PP inclusion; only decreased heart girth was reversed with Ile supplementation. The lowest and highest inclusion of PP, regardless of Ile supplementation, decreased the occurrence of scours compared with the control diet (all whey protein). Calves fed the lowest and highest PP without Ile supplementation also had fewer total days of scours in the first 21 d. In addition, calves fed 100% PP without supplementation of Ile had fewer days of medication compared with the control diet. Even at the highest PP inclusion, average daily gain was minimally affected if Ile was supplemented. Growth rates, gain-feed ratio, and gain-Lys ratio were decreased at higher PP inclusion, but Ile overcame part of the reduction in gain-Lys ratio for 100% PP. Additional titration studies will have to be conducted to determine optimal PP inclusion rates, with a focus on supplementation of potentially limiting essential AA, as well as effects at higher growth rates.

Key words: calf, milk replacer, plasma protein, amino acids

INTRODUCTION

In the United States, over 85% of heifers are fed milk replacer (**MR**) for at least a portion of the preweaning period (USDA, 2012). In MR formulation, protein ingredients represent a major proportion of the cost. Whey proteins have become the standard for all-milk-protein MR, because they are highly digestible and contain a satisfactory AA profile when supplemented with Met (Davis and Drackley, 1998). However, depending on the market, milk-derived proteins can be expensive to include in calf MR. As a result, research has focused on finding alternative protein sources for MR that will promote calf performance similar to milk-derived proteins.

Spray-dried plasma proteins (**PP**) are good sources of EAA, with the exception of Lys, Met, and Ile, and are processed to maintain the functional characteristics of proteins, including albumin and IgG. Plasma proteins have been evaluated in calf MR and have been shown to provide similar (Quigley and Bernard, 1996; Quigley and Wolfe, 2003) or improved (Morrill et al., 1995; Quigley et al., 2002) performance compared with all-milk-protein MR. In previous studies, researchers have replaced up to 25% of total milk CP with PP, but MR with more than 25% of CP replaced by PP have not been evaluated. As a result, the upper limit of successful inclusion of PP in calf MR is unknown. In weanling pig diets, PP supplements are widely used;

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research has shown that inclusion at up to 6% of the total diet increases ADG and average daily feed intake in the first 2 wk after weaning, and improves the feed conversion ratio (van Dijk et al., 2001). Our objective in this experiment was to determine the effects of MR containing 0 to 100% of the total replaceable milk protein as bovine PP, without or with supplemental Ile, on calf growth and health.

MATERIALS AND METHODS

Calves, Arrival, and Housing

All procedures were conducted under protocols approved by the University of Illinois Institutional Animal Care and Use Committee. Four groups of 31 male Holstein calves, less than 1 wk old, were purchased from sale barns in Wisconsin or New York and transported to the University of Illinois Nutrition Field Laboratory research site. The first 2 groups arrived in July and September 2009, respectively; the third and fourth groups were purchased in March and June 2010, respectively. Upon arrival, calves were fed 4 L of electrolyte solution (Land O'Lakes Electrolyte System; Land O'Lakes Inc., Saint Paul, MN). Each calf was vaccinated with TSV-2 (Pfizer Inc., New York, NY), administered ceftiofur crystalline free acid (Excede, Pfizer Inc.) and selenium-vitamin E (MuSe, Intervet Schering-Plough Animal Health, Union, NJ), and had its naval dipped with povidone iodine (Durvet Inc., Blue Springs, MO). Blood was sampled via jugular venipuncture into a 10-mL evacuated serum separation tube (Becton Dickinson, Rutherford, NJ) to estimate serum protein concentration using a refractometer. Blood sampling time was ~1 h after administration of electrolytes and was similar for all calves. Remaining serum was divided into aliquots and stored in polypropylene tubes at −20°C until it was analyzed for total IgG concentration.

Calves were housed in south-facing individual hutches (Calf-tel; Hampel Corp., Germantown, WI) placed 1.5 m from one another. Hutches were placed on crushed limestone, which was covered by landscape cloth (DuPont) and a layer of straw. Straw bedding was checked daily, and additional straw was added as needed for each calf.

Feeding and Management of Calves

Calves were blocked on the day of arrival (d 0) by BW and serum protein concentration, and then randomly assigned within each block to 1 of 7 MR treatments (Table 1) that contained increasing amounts of PP (NutraPro B, APC Inc., Ankeny, IA) without or with supplemental Ile. Treatments were control, all-milk-protein MR (**0PP**); 33% PP addition (**33PP**); 33% PP addition plus Ile to equalize to diet 0PP (**33PP+**); 66% PP addition (**66PP**); 66% PP addition plus Ile to equalize to diet 0PP (**66PP+**); 100% PP addition (**100PP**); and 100% PP addition plus Ile to equalize to diet 0PP (**100PP+**). Milk replacers were manufactured by Milk Specialties Co. (Eden Prairie, MN).

The isonitrogenous diets were formulated to contain 18% CP, 20% fat, 1.75% Lys, and 0.51% Met. The formulation strategy was to increase PP incrementally until it replaced all whey proteins, with the exception of the whey proteins provided in the spray-dried, protein-encapsulated fat. The maximum amount of whey proteins replaced in the 100% PP formulas (100PP and 100PP+) was approximately 88%. Lactose was added to maintain its content in the 100% PP diets, because dried whey and whey protein concentrate were removed.

In formulation of the diets, AA balance was considered using the ideal protein concept, in which the EAA are expressed relative to Lys content as the reference AA. The target profile for growth used was an unpublished estimate from M. E. Van Amburgh (Cornell University, Ithaca, NY). This profile was determined from whole-body AA composition of 65- and 105-kg preruminant Holstein calves (Van Amburgh et al., 2015) and is generally consistent with the earlier profile estimate from Williams and Hewitt (1979). Lysine was provided in the control diet entirely from the whey proteins, whereas L-Lys HCl was added to diets containing PP to equalize Lys content to control values. Supplemental DL-Met was added to all diets to bring the formulated Met content to 0.51%. For diets with supplemental Ile, we aimed to equalize its content with that in the control (0PP) diet. Dietary contents of the remaining AA were determined by their content in whey protein and PP.

Calves were fed MR (reconstituted to 12.5% solids) twice daily at 0530 and 1630 h for 5 wk. During wk 1, calves were fed at a rate of 1.25% of BW (DM basis) and during wk 2 to 5, calves were fed at a rate of 1.5% of BW. The amount fed was updated weekly based on BW. Diets fed at this rate were predicted to provide allowable gains of 0.55 kg/d based on ME and 0.40 kg/d based on apparent digestible protein for a 50-kg calf under thermoneutral conditions (NRC, 2001). The average mean temperature for the first 2 groups of calves was 20°C, and for the second 2 groups of calves it was 15.5°C (www.wunderground.com), which is within the thermoneutral zone of young calves (NRC, 2001).

Intake of MR was recorded daily. Water was offered ad libitum, and intake was recorded daily. Starter was not offered during the study. Body weight, heart girth, and withers height were measured upon arrival and