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Extruded soybean meal increased feed intake and milk production in dairy cows

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ABSTRACT

The objective of this study was to assess the effects of 2 extruded soybean meals (ESBM) processed at 2 extruder temperatures, 149°C (LTM) and 171°C (HTM), on performance, nutrient digestibility, milk fatty acid and plasma amino acid profiles, and rumen fermentation in lactating dairy cows. Nine multiparous Holstein cows were included in a replicated 3 × 3 Latin square design experiment with three 28-d periods. The control diet contained 13% solvent-extracted soybean meal (SSBM; 53.5% crude protein with 74.1% ruminal degradability and 1.8% fat), which was replaced with equivalent amount (dry matter basis) of LTM (46.8%, 59.8%, and 10.0%) or HTM (46.9%, 41.1%, and 10.9%, respectively) ESBM in the 2 experimental diets (LTM and HTM, respectively). The diets met or exceeded the nutrient requirements of the cows for net energy of lactation and metabolizable protein. The 2 ESBM diets increased dry matter intake and milk yield compared with SSBM. Feed efficiency and milk composition were not affected by treatment. Milk protein yield tended to be increased by ESBM compared with SSBM. Milk urea N and urinary urea N excretions were increased by the ESBM diets compared with SSBM. Concentration of fatty acids with chain length of up to C17 and total saturated fatty acids in milk fat were generally decreased and that of C18 and total mono- and polyunsaturated fatty acids was increased by the ESBM diets compared with SSBM. Blood plasma concentrations of His, Leu, and Val were increased by HTM compared with LTM and SSBM. Plasma concentration of Met was decreased, whereas that of carnosine was increased by the ESBM diets. Treatments had no effect on rumen fermentation, but the proportion of *Fibrobacter* spp. in whole ruminal contents was increased by HTM compared with SSBM and LTM. Overall, data from this crossover experiment suggest that substituting SSBM with ESBM in the diet has a positive effect on feed intake and milk yield in dairy cows.

Key words: extruded soybean meal, feed intake, milk fatty acid, dairy cow

INTRODUCTION

Microbial protein synthesized in the rumen and feed RUP are the main sources of AA for dairy cows (NRC, 2001), and their AA composition is becoming increasingly important when cows are fed diets supplying MP close to or below their requirements. We have demonstrated, for example, that AA such as His may become limiting in dairy cows fed MP below NRC (2001) requirements, partially due to the relatively lower concentration of His in microbial protein, compared with other EAA such as Met (Lee et al., 2012). Even if MP requirements are met, milk production and/or milk protein concentration may be increased by key EAA, through supplementation of the diet with synthetic rumen-protected AA, or digestible RUP from dietary origin (Broderick et al., 2009; Patton et al., 2014). This may be particularly true with alfalfa silage-based diets, which may be high in CP but still supply inadequate amounts of MP and EAA (Broderick et al., 1990; Dhiman et al., 1993). Several heat-treated soybean meal (**SBM**) products have been developed with the goal of providing a digestible RUP source in the diet. The production responses, however, have been variable (Broderick, 1986; Broderick et al., 1990; Socha, 1991; Flis and Wattiaux, 2005). Most of the commercial heat-treated SBM products have fat content of 1.2 to 2.2% (Amino Plus, AGP, Omaha, NE; Soy Pass, Ligno Tech USA, Overland Park, KS) up to 6.6% (SoyPLUS, West Central Cooperative, Ralston, IA; Soy Best, Grain States Soya Inc., West Point, NE). In a preliminary experiment, we analyzed extruded SBM (**ESBM**) and found a linear increase in its RUP content (determined in situ) with increasing the extruder temperature from 149°C to 160°C and 171°C (Isenberg et al., 2012). The ESBM contained around 10% fat, which may provide

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additional energy for high-producing dairy cows and may also favorably modify milk FA composition, assuming it does not negatively affect ruminal fermentation and fiber digestibility.

Therefore, the current experiment was conducted to test the effects of 2 ESBM on performance, nutrient digestibility, milk FA and plasma AA profiles, rumen fermentation variables, and bacterial and archaeal composition of ruminal contents in dairy cows. We hypothesized that, when substituting solvent-extracted SBM (**SSBM**) on an equal-weight basis, ESBM will increase plasma concentrations of key EAA, C18 unsaturated FA in milk, and milk yield or milk protein yield (or both) in dairy cows fed a corn silage-based diet.

MATERIALS AND METHODS

All procedures carried out in the experiment were approved by the Animal Care and Use Committee at The Pennsylvania State University.

Animals and Experimental Design

The experiment was a replicated 3 × 3 Latin square design balanced for residual effects and was conducted in the tie-stall barn of The Pennsylvania State University's Dairy Teaching and Research Center. Nine multiparous lactating Holstein cows averaging (±SD): 141 (±31.0) DIM, 41.5 (±4.68) kg/d of milk yield, and 650 (±54.7) kg of BW at the beginning of the study, were grouped into 3 squares based on DIM, milk yield, and parity. Six cows (2 squares) were fitted with 10-cm (internal diameter) soft plastic ruminal cannulas (Bar Diamond Inc., Parma, ID). Each experimental period lasted 28 d, with 18 to 21 d of adaptation to the diets, followed by 10 (DMI, BW, and milk yield and composition) or 7 (all other variables) d of data and sample collection. Cows were randomly assigned to 1 of 3 treatment diets (Table 1), which contained 13% of (DM basis) (1) SSBM (Cargill Inc., Roaring Spring, PA), (2) low-temperature (149°C) extruded SBM (**LTM**), or (3) high-temperature (171°C) extruded SBM (**HTM**). The extruded SBM were produced by Fabin Bros. Farms (Indiana, PA). Composition of the SBM used in the experiment is shown in Table 2. Diets were formulated to meet or exceed the NRC (2001) nutrient requirements for lactating Holstein cows yielding 41 kg of milk/d with 3.50% milk fat and 3.04% true protein at 25.5 kg/d of DMI and 638 kg of BW. The 2 ESBM diets were supplemented with 0.35% of urea (DM basis, replacing corn grain) to achieve a similar N concentration to the SSBM diet, and because of the lower RDP content of the 2 ESBM compared with SSBM (see Table 1). The 3 diets were mixed using a Kuhn Knight model 3142 Reel Auggie Mixer Wagon (Kuhn Knight Inc., Brodhead, WI) and were fed once daily (0630 h) as TMR to achieve about 5 to 10% refusals. All cows had free access to drinking water, were milked twice daily (0500 and 1700 h), and received rbST (Posilac, Elanco Co., Greenfield, IN; 500 mg, i.m.) at 14-d intervals (i.e., at the beginning and in the middle of each experimental period).

Sampling and Measurements

Individual feed intake (on as-fed basis) and milk yield of the cows were recorded daily throughout the experiment. Cow BW was also recorded daily for the entire experiment using AfiFarm 3.04E scale system (S.A.E. Afikim, Rehovot, Israel) while cows exited the milk parlor. Total mixed ration and refusals from each diet were sampled twice weekly, and samples were composited (on an equal weight basis) by week and diet. Samples of individual forages (i.e., corn silage, alfalfa haylage, and grass hay) and concentrate feeds were collected weekly. Forages were composited by experimental period, whereas one composite sample for the entire experiment was prepared for each concentrate feed ingredient. All samples were stored at −20°C, dried for DM determination at 65°C for 48 h in a forced-air oven, and ground with a Wiley Mill (1-mm screen; Thomas Scientific, Swedesboro, NJ) for further analyses. Dry matter intake was computed from the as-fed TMR intake using the DM content of the weekly composited TMR and refusals samples. Composite samples of individual feed ingredients were analyzed by wet chemistry methods for CP, degradable protein (SSBM and ESBM only; according to Krishnamoorthy et al., 1983), NDF, ADF, fat, ash, Ca, P, and estimated NFC and NEL by Cumberland Valley Analytical Services (Maugansville, MD; analytical methods are available from CVAS, 2015). The analyzed composition of the feed ingredients and their inclusion in the TMR was used to compute the CP, NDF, ADF, fat, Ca, and P concentration of the diets (Table 1). Concentration of RDP, RUP, NE_L, NFC and MP, protein fractions, and AA balances were estimated using NRC (2001) based on actual DMI, milk yield, milk composition, and BW of the cows during the experiment. Composite TMR samples were analyzed for starch according to Bach Knudsen (1997) and indigestible NDF (**iNDF**) as described by Lee et al. (2012). Samples of the 3 SBM (i.e., SSBM, LTM, and HTM) were also analyzed for AA (AOAC International, 2006, method no. 982.30 E) at the University of Missouri–Columbia's Agricultural Experiment Station Chemical Laboratory (Columbia, MO).