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Effects of rumen undegradable protein supplementation on productive performance and indicators of protein and energy metabolism in Holstein fresh cows

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ABSTRACT

The objective of this study was to determine the effects of feeding increased dietary crude protein (CP) on productive performance and indicators of protein and energy metabolism during 21 d postpartum. Thirty multiparous Holstein dairy cows were balanced by previous lactation milk yield, body condition score (BCS) at calving, and parity and randomly allocated to 1 of 3 dietary treatments from calving until 21 d postpartum. Dietary treatments were 16.0% CP with 5.0% rumen undegradable protein (RUP) based on dry matter (DM) (16CP), 18.7% CP with 7.0% RUP based on DM (19CP), and 21.4% CP with 9.0% RUP based on DM (21CP). Diets were similar in net energy for lactation (approximately 1.7 Mcal/kg of DM) and CP levels were increased with corn gluten meal and fish meal. Dry matter intake (DMI) was increased by increasing dietary CP levels from 16.0 to 19.0% of DM, but dietary CP beyond 19.0% had no effect on DMI. Milk yields were 4.7 and 6.5 kg/d greater in cows fed the 19CP and 21CP diets versus those fed the 16CP diet, whereas 4% fat-corrected milk was greater for cows fed the 21CP than the 16CP diet (36.0 vs. 31.4 kg/d). Milk protein content and yield, lactose yield, and milk urea nitrogen were elevated by increased dietary CP. Milk lactose content and fat yield were not different among dietary treatments, but milk fat content tended to decline with increasing content of CP in diets. High CP levels increased milk N secretion but decreased milk N efficiency. Apparent digestibility of DM, CP, and neutral detergent fiber was greater on the 19CP and 21CP diets compared with the 16CP diet. Cows fed the 19CP and 21CP diets lost less body condition relative to those fed the 16CP diet over 21 d postpartum. Feeding higher CP levels increased the concentrations of serum albumin, albumin to globulin ratio, and urea nitrogen and decreased aspartate aminotransferase, nonesterified fatty acids, and β-hydroxybutyrate, but had no effect on globulin, glucose, cholesterol, or triacylglycerol. These findings indicated that elevating dietary CP up to 19.0% of DM using RUP supplements improved DMI, productive performance and the indicators of protein and energy metabolism from calving to 21 d postpartum.
Key words: dietary protein, performance, dry matter intake, fresh cow

INTRODUCTION

Following calving, cows experience negative nutrient balances, especially energy and protein, because nutrient intake is less than required to support lactation. Feeding high-grain diets is one approach used to reduce negative energy balance (**NEB**). However, because of greater propionate production, high grain diets might decrease DMI and increase the risk of metabolic disorders (Allen and Piantoni, 2013). Likewise, abomasal glucose infusion for reducing NEB failed to show benefits on DMI and milk yield immediately after calving (Ørskov et al., 1977; Larsen and Kristensen, 2009; Carra et al., 2013). Compared with NEB, negative MP balance has received less research attention (Grummer, 1995; Bell et al., 2000). Cows with protein deficiency will mobilize skeletal muscles and other protein sources. The mobilized protein reserves ranged from 8 to 21 kg during the first 5 to 6 wk postpartum (Komaragiri et al., 1998; Chibisa et al., 2008). During this time, protein mobilization is essential to supply AA and glucose for the mammary gland, but excessive mobilization results in increased incidence of metabolic disorders, immune dysfunction, and poor reproductive and lactation performance (Ji and Dann, 2013). Some previous reports (Cunningham et al., 1996; Broderick, 2003; Socha et al., 2005) indicated that increasing CP above 16.7% in dairy cows rations had no effect on milk production or milk components, but other studies (Broderick et al., 2002; Flis and Wattiaux, 2005) reported positive milk

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production responses when dietary CP levels increased with RUP supplements. In addition, Law et al. (2009) reported that increasing dietary CP levels from calving day to d 150 increased DMI and milk production and reduced BHB concentrations but had no effect on nonesterified fatty acids (**NEFA**) concentrations.

Most of these studies have been conducted on early- (>21d) or mid-lactation dairy cows (Wright et al., 1998; Broderick et al., 2008; Lee et al., 2015) and only a few studies (Brown and Allen, 2013; Larsen et al., 2014) have focused on increased protein supply in fresh cows. Larsen et al. (2014) investigated the effects of abomasal casein infusion on the performance of transition cows from calving until d 29 of lactation. They found that additional MP supply after calving can considerably increase milk production and improve plasma protein concentrations and immune status in dairy cows. Larsen et al. (2014) found that MP supply played a more important role than energy supply in postpartum cows.

In a recent meta-analysis of the effect of casein infusion on DMI responses on cows fed for ad libitum intake, Martineau et al. (2016) recognized that there was an interaction between MP balance values and casein infusion. They indicated that casein infusion increased DMI in cows with negative MP balance but had a negative effect on DMI when cows were in positive MP balance. This may be due to increased oxidation of AA in excess of requirements, increasing hepatic oxidation of acetyl-CoA and contributing to satiety (Martineau et al., 2016). Therefore, it was hypothesized that additional MP supply using RUP supplements in fresh cows can increase DMI for several weeks following parturition when cows are in negative protein balance. The objective of our study was to evaluate the effects of increased dietary CP levels on DMI, milk production, blood metabolites, nutrient digestibility, and nitrogen utilization in fresh cows.

MATERIALS AND METHODS

Cows and Experimental Design

The experiment was conducted on a commercial dairy herd in Iran from September to November 2010. Thirty multiparous Holstein dairy cows (mean parity ± SD; 3.3 ± 0.5) were used in a completely randomized design with 3 dietary treatments from calving until 21 d of lactation. Cows were assigned in a balanced manner to treatments based on previous milk yield, BCS at calving, and parity. During the close-up period, 21 ± 3 d before calving, cows were housed in a freestall barn and fed the same close-up diet (NE_L = 1.6 Mcal/kg, CP = 13.0%, DM basis) for ad libitum intake twice daily at 0800 and 1700 h. As cows showed primary signs of calving, cows were moved to maternity pens, and calf weight and first-milking colostrum yield were recorded immediately postpartum by calving personnel. After calving, cows were assigned to their experimental diets and moved to individual stalls where they were housed until 21 d after calving, with free access to water. Before treatment application, cows suffering retained placenta, milk fever, mastitis, pneumonia, laminitis, dystocia, and rectal temperature (≥39.4°C) were not entered in the experiment.

Chemical composition of individual feed ingredients are listed in Table 1. The diet fed to close-up cows and experimental diets (Table 2) were formulated according to the NRC (2001) model. The concentrate to forage ratio (DM basis) was 55:45 for all dietary treatments. Dietary CP was increased from 16.0 to 21.0% by replacing cereal grain (barley and corn) with fish meal (**FM**) and corn gluten meal (**CGM**). Resulting dietary treatments were 16.0% CP with 5.0% RUP (**16CP**), 18.7% CP with 7.0% RUP (**19CP**), and 21.4% CP with 9.0% RUP (**21CP**). Protein supplies and AA balances were estimated by actual individual cow DMI, BW, BCS, milk yield, and milk composition using NRC (2001) and CNCPS v. 6.5 (Cornell University, Ithaca, NY), respectively.

Sampling and Data Collection

Dietary treatments were fed as TMR 3 times daily at 0800, 1600, and 2200 h for 10% orts, and orts were collected and recorded daily. Samples of TMR and orts were taken twice a week, dried at 60°C for 48 h, and then composited by week and treatment. Individual feed ingredients were also sampled weekly and frozen at −20°C for chemical composition analysis. Feed samples were ground through a 1-mm screen and analyzed in 3 replications for DM (AOAC, 1990; method 930.15), CP using the Kjeldahl method (AOAC, 1990; method 984.13), ether extract using Soxhlet extraction method with diethyl ether (AOAC, 1990; method 920.39), ash (ignition at 600°C for 2 h; AOAC, 1990, method 942.05), ADF using cetyl trimethyl ammonium bromide (CTAB) and 1 *N* H_2SO_4 (AOAC, 1990; method 973.18), and NDF using sodium sulfite and heat-stable α-amylase (Van Soest et al., 1991).

The cows were milked 3 times daily at 0700, 1500, and 2100 h, and milk yields were recorded at each milking. Milk samples were taken weekly from 3 consecutive milkings and composited in proportion to milk yield. Milk samples were analyzed for fat, protein, lactose, and urea by mid-infrared spectroscopic procedure using a Milkoscan (CombiFoss 78110; Foss Analytical A/S, Hillerød, Denmark). Feed efficiency was calculated by dividing 4% FCM by DMI.