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# Milk Production of Dairy Cows Fed Differing Concentrations of Rumen-Degraded Protein[1]

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## ABSTRACT

Thirty-two multiparous and 16 primiparous Holstein cows in midlactation averaging 126 d in milk were used to determine the effects of rumen-degraded protein (RDP) concentration on lactation performance. Cows were assigned to diets in a repeated Latin square design with 3-wk experimental periods. Diets were formulated to provide 4 concentrations of dietary RDP [6.8, 8.2, 9.6, and 11.0% of dry matter (DM)] while rumen-undegraded protein remained constant (5.8% of DM). Diets contained 50% corn silage and 50% concentrate (DM basis). Ingredients within diets were equal across treatments except for ground corn, soybean meal, and ruminally protected soybean meal. Dry matter intake was not affected by treatment. Milk yield, fat yield, and protein yield all increased linearly when cows were fed diets with greater RDP. Milk fat and protein concentration each increased by 0.16 percentage units for cows fed 11% RDP compared with 6.8% RDP. Milk protein yield increased by 0.19 g/d for every 1 g/d increase in crude protein supplied mainly as RDP. As RDP increased, the efficiency of N use declined linearly. Milk urea N increased linearly when cows were fed increasing amounts of RDP, indicating increased losses of N via urine. Feeding deficient RDP diets to dairy cows can decrease nitrogen excretion, but it also decreases lactation performance. These data show an environmental benefit from underfeeding RDP to dairy cows according to National Research Council requirements, but at a financial cost to the dairy producer.
**Key words:** rumen-degraded protein, nitrogen efficiency, protein requirement, milk urea nitrogen

## INTRODUCTION

Over the past several decades, much of the research on determining protein requirements of high-producing dairy cows has focused on the amount and type of RUP in the diet. This research has established that during early lactation and before maximum DMI is reached, dairy cows need more protein than microbial synthesis in the rumen can provide to meet the requirements of high milk production (NRC, 2001). However, from the standpoint of AA profile and intestinal digestibility, microbial protein is often superior to most feed proteins (Clark et al., 1992). In their review of the literature, Clark et al. (1992) reported that microbial N supplied an average of 59% of nonammonia N absorbed from the small intestine. The goal of feeding high-producing dairy cows is to optimize ruminal fermentation so that microbial growth is maximized. Diets should be balanced to provide sufficient N and energy to optimize microbial growth.

One of the first steps in diet formulation for lactating dairy cows is to provide sufficient RDP to meet the requirements of rumen microorganisms. The total metabolizable protein requirement of the cow is met by supplementing RUP when microbial protein synthesis alone is insufficient to meet the metabolizable protein requirements. Because excess protein in the ration of dairy cows is excreted, excess dietary protein may contribute to N pollution of the environment. Improving diet formulation to meet but not exceed the RDP requirement of microbes will optimize microbial growth, reduce N excretion, and improve overall N use by the cow.

The NRC (1989) requirements for RDP suggested 10.4% RDP as the upper minimal dietary concentration required for microbial growth in high-producing cows. The most recent NRC publication (2001) ties RDP requirements to dietary energy intake where microbial N (g) is equivalent to 20.8 × total digestible nutrients (**TDN**). Assuming the maximal efficiency of RDP use for microbial N synthesis is 85%, the RDP requirement would be 24.5 g per g of TDN intake (NRC, 2001). Other research indicates that microbial synthesis may be improved when RDP is greater than 10.4% (Stokes et al.,

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1991a,b); however, no previous research has evaluated the effect of feeding ruminally degraded protein in decreasing gradient levels. Feeding recommendations for RDP have been based on in vitro and in situ studies and theoretical calculations, and recommendations need to be tested in animal feeding experiments. Furthermore, the risk of economic loss due to decreased milk production from underfeeding RDP needs to be balanced against the potential for environmental damage due to overfeeding RDP. It is therefore necessary to determine how much milk production is likely to be lost from underfeeding RDP.

In research trials, often the ratio of RDP to RUP is changed while the CP content remains constant. Results from these experiments are difficult to interpret because the increasing concentration of RDP is confounded with the decreasing concentration of RUP. The effects of RDP deficiency can be masked by RUP excess. For example, reduced microbial protein from lack of RDP may not influence production if RUP substitutes for the microbial protein lost and more RUP allows for greater recycling of N back to the rumen. The current study was designed to test the effects of reducing RDP on ruminal fermentation and milk production, and therefore we intended to change only RDP concentration.

The objectives of this experiment were to: 1) determine the effects of feeding RDP below predicted requirements on milk production, milk composition, DMI, feed efficiency, N use efficiency, and N excretion, 2) compare NRC (1989 and 2001) models with observed data from this experiment, and 3) quantify the cost in lost milk production from underfeeding RDP and compare that with the decreased feed cost. Results from this experiment will help determine optimal RDP concentrations of diets for lactating dairy cows to optimize milk production and milk components while reducing N excretion to the environment.

## MATERIALS AND METHODS

### *Cows, Treatments, and Management*

This study was conducted at the Central Maryland Research and Education Center under approval of the University of Maryland Animal Care and Use Committee. Thirty-two multiparous and 16 primiparous Holstein cows averaging 126 (SD ± 53) DIM were blocked by parity (8 squares multiparous and 4 squares primiparous) and randomly assigned to dietary sequences within twelve 4 × 4 Latin squares. Before the start of the experiment, half of these cows (16 multiparous and 8 primiparous) had been managed separately, and were given treatments of bST (Posilac; Monsanto, St. Louis, MO). These cows remained on bST throughout the experiment resulting in 6 bST-treated squares and 6 untreated squares. Latin squares were balanced for carryover effects to ensure that each treatment followed every other treatment one time within each square.

Each experimental period consisted of 21 d of which the first 14 d were for adaptation. Data from d 15 to 21 were used to compare treatment effects. Cows were housed in tie-stalls, milked twice daily at 0530 and 1730 h, and fed once daily at 0800 h. Cows treated with bST received injections on d 8 of period 1 of the study and continued to receive bST every 14 d. Therefore, cows received bST once during periods 1 and 3 (d 8), and twice during periods 2 and 4 (d 1 and 15). Because the design was a balanced 4 × 4 Latin square, an equal number of observations were made for each dietary treatment during periods in which bST was injected on d 8 vs. d 1 and 15. Two cows were removed from the study due to illness.

Diets were formulated to meet requirements for $NE_L$, RUP, minerals, and vitamins of a midlactation dairy cow (120 DIM) weighing 615 kg, producing 41 kg of milk with 3.5% fat (NRC, 1989). Diets contained 50% corn silage and 50% concentrate (DM basis). Ingredients of the diets were equal across treatments except for changes in ground corn, solvent-extracted soybean meal, and nonenzymatically browned soybean meal (Soy Pass; Lignotech USA, Rothschild, WI). Ration formulation and composition are shown in Table 1 and ingredient composition is shown in Table 2. Diets provided 4 concentrations of dietary RDP (% of DM) while RUP was formulated to remain constant at 5.8% of DM: 1) 6.8% RDP, 12.3% CP; 2) 8.2% RDP, 13.9% CP); 3) 9.6% RDP, 15.5% CP; and 4) 11.0% RDP, 17.1% CP.

Estimates of protein degradability of the feed ingredients were from NRC (1989 and 2001), except for both soybean meal ingredients, which were determined in situ using a nylon bag technique (Erdman et al., 1987). Bags containing approximately 5 g of sample were placed in duplicate in the rumen of a late-lactation Holstein cow fed the 9.6% RDP diet. Samples were removed from the rumen after 0, 3, 6, 12, 24, and 36 h. Bags were rinsed thoroughly, dried, and weighed. Crude protein disappearance data shown in Table 3 were fitted to a nonlinear model using the Marquardt iterative method as described previously by Erdman et al. (1987). Predicted CP degradation was calculated according to the NRC (2001) using feed analysis and estimated passage rates for the cows and rations in this study.

Each diet was evaluated for dietary N supply according to the NRC (1989 and 2001). The predicted protein requirement and supply for both models are presented in Table 4. The lowest RDP diet was estimated to provide 69 or 68% of required RDP, and the