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# Effect of protein level in prepartum diets on postpartum performance of dairy cows


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# EFFECT OF PROTEIN LEVEL IN PREPARTUM DIETS ON POSTPARTUM PERFORMANCE OF DAIRY COWS

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## Summary

Seventy-five Holstein cows were used in a randomized complete block design to determine the level of dietary protein required to support metabolic functions and maintain body reserves during the periparturient period and subsequent lactation. Cows fed the 14.7% protein diet prepartum had a more ideal body condition score during the entire prepartum and postpartum periods. During the first 90 days of lactation, few consistent differences occurred among prepartum diets for milk production, but the response to rbST was greatest for cows fed 11.7, 13.7 or 14.7% protein prepartum. Full 305-day lactation records showed the most milk, fat, and protein for cows consuming 13.7 or 14.7% protein prepartum. Results of our study indicate that using 13.7 to 14.7% crude protein with approximately 45% undegradable protein in the close-up diet for dairy cattle produces beneficial outcomes during the subsequent lactation.

(Key Words: Prepartum, Protein, Dairy Cows.)

## Introduction

The last 28 days prepartum and the first 28 days postpartum (periparturient period) may be the most critical times in a dairy cow's production cycle. The 28-day prepartum period is characterized by rapid growth of the fetus, metabolic transitions to support lactation, and ruminal adaptation to a dramatic change in diet ingredients to support lactation. Failure to meet the needs of the cow during this period results in health disorders after calving that negatively affect dry matter intake, peak milk yield, and total lactational yield. The protein needs of the cow during this time are not well defined, and the information available presents a conflicting view regarding the level of dietary protein and ratio of rumen degradable protein (RDP) to undegradable protein (RUP) necessary to support the rapidly developing fetus and maintain labile protein reserves sufficient to support metabolic systems immediately postpartum. Clearly, transition diets must meet the rumen microbial needs for energy and protein at a time when the cow's metabolic needs are increasing.

The objective of this study was to determine the level of dietary protein required to supply amino acids to support metabolic functions and maintain body protein reserves during the periparturient period.

## Procedures

Seventy-five multiparous Holstein cows were used. Diets were formulated to provide surplus energy (.72 Mcal/lb) and five levels of protein. Experimental diets were: 1) 9.7% crude protein (CP) or negative control (supplied less protein than required to support normal rumen microbial needs); 2) 11.7% CP supplied sufficient protein to meet rumen microbial needs; 3) 13.7% CP, protein above 11.7% was RUP; 4) 14.7% CP, protein above 11.7% was RUP; and 5) 16.2% CP, protein above 11.8% was RUP. Expeller soybean meal was substituted for solvent soybean meal to increase the RUP, while maintaining a similar amino acid profile. Cows were housed in a tie-stall barn to accommodate accurate measurements of individual dry matter intake. Treatments were initiated 28 days prior to projected calving

date and terminated at parturition. Cows were fed the same total mixed ration (TMR) after parturition, remained in the tie-stall barn until 90 days in milk, and then were moved to a freestall facility. Daily milk production and feed consumption were measured during the first 90 days postpartum, and milk samples (a.m./p.m. composite) were obtained weekly and analyzed for milk composition; milk protein, fat, lactose, solids-not-fat, MUN, and somatic cells were measured by the DHI Laboratory, Manhattan, KS. Body condition was scored at the beginning of the study and weekly thereafter. Body weight was measured on 2 consecutive days at the beginning of the study; weekly thereafter; and on days 1, 2, 27, 28, 59, 60, 89, and 90 postpartum. Urine ketones were measured daily beginning 10 days prepartum and ending on day 28 postpartum. Blood samples were obtained from the tail vein on days 28, 21, 10, 5, 3, and 1 prepartum and days 3, 7, 15, 20, 25, 60, and 90 postpartum. Urine samples were collected on the same days as blood samples. Health status and treatments were recorded daily while cows were in the tie-stall barn. Udder edema scores were recorded daily until parturition and then daily for 21 days postpartum. Calves were weighed within 6 hr after birth. Hay and corn silage samples were collected weekly and composited monthly for analysis. Grain mix and topdressing were sampled by batch and composited monthly for analysis. Corn silage dry matter was determined weekly, and the amount fed was adjusted to provide the appropriate dry matter.

## Results and Discussion

Compositions of the experimental diets are shown in Tables 1 and 2. Soyplus (mechanical extracted SBM) was substituted for solvent SBM to increase the RUP content of the diets, and corn grain was replaced by SBM as the percentage of CP in the diets increased. The problem these substitutions created was that the nonstructural carbohydrate (NSC) component of the diet decreased from 42% to 31% as dietary protein increased. However, the NSC contents of all diets should have been adequate to support rumen function. Dietary fat ranged from 3.1% to 3.9% and should not have had a major influence on performance.

Prepartum performance responses of cows to the experimental treatments are shown in Table 3. Cows fed 14.7% protein consumed the most dry matter (35.9 lb/day), whereas cows fed 16.2% protein consumed the least (32.1 lb/day). All cows gained weight and condition from day 28 prepartum until parturition. Energy balance was lowest for cows fed 16.2% protein, and they gained the least amount of weight. Differences were observed in udder edema scores and urine ketones across treatments. Edema scores and urine ketones were lowest for cows fed intermediate levels of protein, and cows fed the diets at either extreme had greater edema scores and urine ketones. No differences were observed in calving difficulty or calf birth weights across treatments. Three cows out of the 75 were treated for milk fever, one fed 11.7% protein and the other two fed 13.7% protein.

All cows were switched to the same TMR after calving. Dry matter intake varied across treatments (Table 4) during the first 90 days postpartum. Cows fed 11.7% protein prepartum had greater intakes during the first of 90 days of lactation. Average production and composition of milk also were affected by treatment during the first 90 days of lactation. Cows fed 11.7 or 14.7% protein prepartum produced more milk and along with those fed 13.7% protein prepartum had a tendency for higher milk protein percentages. Cows fed 14.7% protein prepartum had greater fat yield and lactose yield but a lower MUN value and somatic cell count.

Recombinant bovine somatotropin (rbST) was administered to cows during the ninth week of lactation, and the response was measured in each treatment. Cows fed intermediate levels of protein prepartum (11.7 to 14.7%) responded similarly to rbST with respect to milk yield, whereas cows fed 16.2% protein prepartum did not respond, and those fed 9.7% protein prepartum showed a slight response. Complete lactation milk production data revealed that cows fed 13.7 or 14.7% protein prepartum had the

highest 305-day milk production, cows fed 11.7% protein prepartum were intermediate, and those fed 9.7 or 16.2% protein prepartum produced the least. The cows fed 13.7 or 14.7% protein prepartum also tended to produce the most milk fat and protein.

NRC (1989) recommends that dry cow diets contain 11.8% CP. Results from our study support this recommendation based on the first 90 days of lactation. However, based on full lactation, cows fed 13.7 or 14.7% protein prepartum produced more milk, milk fat, and milk protein than those fed lower levels of protein (9.7 or 11.7%). Cows fed the greatest level of protein consumed less feed prepartum and had the lowest milk production. Although cows fed only 9.7% protein had feed intakes similar to those of cows fed more protein, they produced less milk than cows fed intermediate levels of protein. Much of the difference in whole lactation performance seemed to be in response to rbST. Intermediate levels of protein prepartum (13.7 or 14.7%) seemed to maximize the response to rbST, presumably by maximizing body reserves that were subsequently mobilized to support lactation.

**Table 1. Compositions of Experimental Diets**

| | Prepartum Diets (% protein) | | | | | |
|---|---|---|---|---|---|---|
| Ingredient | 9.7 | 11.7 | 13.7 | 14.7 | 16.2 | Postpartum |
| | ))))))))))))))))) % of DM ))))))))))))))))) | | | | | |
| Alfalfa hay | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 | 28.35 |
| Prairie hay | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | - |
| Corn silage | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 20.49 |
| Corn grain | 32.42 | 27.74 | 23.06 | 17.88 | 12.69 | 21.48 |
| Whole cottonseed | - | - | - | - | - | 9.56 |
| Soybean meal | - | 4.68 | 9.36 | 4.36 | - | 20.07 |
| Soyplus® | - | - | - | 9.36 | 19.73 | - |
| Limestone | .60 | .60 | .60 | .60 | .60 | 2.70 |
| Dicalcium phosphate | .74 | .74 | .74 | .74 | .74 | 1.80 |
| TM salt | .50 | .50 | .50 | .50 | .50 | .65 |
| Mg oxide | .50 | .50 | .50 | .50 | .50 | .45 |
| Vitamin ADE premix | .12 | .12 | .12 | .12 | .12 | .20 |
| Vitamin E premix | .08 | .08 | .08 | .08 | .08 | .035 |
| Se premix | .04 | .04 | .04 | .04 | .04 | .035 |

**Table 2. Nutrient Compositions of Experimental Diets**

| | Prepartum Diets (% protein) | | | | | |
|---|---|---|---|---|---|---|
| Item | 9.7 | 11.7 | 13.7 | 14.7 | 16.2 | Postpartum |
| Crude protein, % | 9.7 | 11.7 | 13.7 | 14.7 | 16.2 | 18.2 |
| ADF, % | 23.3 | 23.6 | 23.4 | 24.2 | 24.6 | 19.9 |
| NDF, % | 36.6 | 37.3 | 37.2 | 38.0 | 39.5 | 30.9 |
| $NE_L$, Mcal/lb | .71 | .72 | .70 | .70 | .70 | .78 |
| Calcium, % | .42 | .43 | .45 | .46 | .46 | .66 |
| Phosphorus, % | .34 | .38 | .40 | .41 | .41 | .53 |

**Table 3. Effects of Prepartum Protein Level on Prepartum Responses**

| | Prepartum Dietary Protein, % | | | | | |
|---|---|---|---|---|---|---|
| Item | 9.7 | 11.7 | 13.7 | 14.7 | 16.2 | SEM |
| Dry matter intake, lb/day | 34.50 | 35.10 | 34.30 | 35.90 | 32.10 | 1.3 |
| Body weight initial, lb | 1500 | 1485 | 1470 | 1472 | 1500 | 15 |
| Body weight final, lb | 1562 | 1559 | 1550 | 1558 | 1561 | 15 |
| BCS initial | 2.88 | 2.97 | 3.04 | 2.95 | 2.96 | 0.06 |
| BCS final | 3.13 | 3.10 | 3.19 | 3.34 | 3.05 | 0.06 |
| Energy balance, Mcal/day | 4.80 | 5.20 | 4.10 | 4.90 | 2.50 | 0.90 |
| Edema score[1] | 1.47 | 1.48 | 1.43 | 1.33 | 1.47 | 0.12 |
| Urine ketone, mg/dL[2] | 0.55 | 0.05 | 0.00 | 0.00 | 0.15 | 0.21 |
| Calving difficulty score | 1.33 | 1.53 | 1.00 | 1.07 | 1.07 | 0.13 |

[1]Cubic response (*P*<.05).
[2]Quadratic response (*P*<.01).

**Table 4. Effects of Prepartum Protein Level on Responses during the First 90 Days Postpartum**

| | Prepartum Dietary Protein, % | | | | | |
|---|---|---|---|---|---|---|
| Item | 9.7 | 11.7 | 13.7 | 14.7 | 16.2 | SEM |
| Dry matter intake, lb/day[1] | 53.80 | 57.20 | 54.30 | 55.00 | 53.90 | 2.0 |
| Milk yield, lb/day[1] | 86.10 | 87.00 | 83.00 | 87.10 | 85.90 | 4.2 |
| Milk protein, %[2] | 3.04 | 3.11 | 3.10 | 3.09 | 2.99 | .05 |
| Milk fat yield, lb/day[3] | 3.17 | 3.11 | 2.98 | 3.24 | 3.11 | .13 |
| Lactose yield, lb/day[4] | 4.30 | 4.26 | 4.04 | 4.34 | 4.21 | .20 |
| Milk urea nitrogen, mg/dL[5] | 17.04 | 15.72 | 16.04 | 15.35 | 15.21 | .43 |
| Somatic cell score, X 1000[6] | 419 | 279 | 359 | 134 | 399 | 120 |
| Response to rbST, lbs[6] | 1.4 | 3.1 | 4.7 | 5.3 | -.2 | 1.8 |

[1]Quartic response (P<.05). [2]Quadratic trend (P=.06). [3]Cubic response (P<.05).
[4]Quartic response (P<.01). [5]Quadratic response (P<.05). [6]Linear response (P<.05).

**Table 5. Full-Lactation Responses Based on 305-Day Lactation**

| | Prepartum Dietary Protein, % | | | | | |
|---|---|---|---|---|---|---|
| Item | 9.7 | 11.7 | 13.7 | 14.7 | 16.2 | SEM |
| ME milk yield, lb[1] | 22,517 | 23,099 | 23,944 | 24,280 | 21,730 | 941 |
| ME milkfat yield, lb[2] | 800 | 789 | 843 | 850 | 755 | 33 |
| ME milk protein, lb[3] | 687 | 711 | 733 | 750 | 659 | 30 |

[1]Quadratic response trend (P=.06).
[2]Cubic response trend (P=.07).
[3]Quadratic response (P<.05).