Nutritional Management

MSU Research:

Optimal Dietary Phosphorus for Close-Up Cows

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Accurate and precise provision of phosphorus (P) in dairy rations is required both to meet cows' requirements and to achieve effective on-farm nutrient management and environmental sustainability.

Most recent research has addressed requirements and feeding of P to lactating cows because that is where the largest flow of P occurs in the dairy herd (Beede, 2003). Less attention has focused on the optimal ration P concentration for close-up (last 3 to 4 weeks before calving) Holstein cows with high genetic potential for milk production. Phosphorus nutrition of these particular cows is especially critical because they are less able than younger cows to mobilize P from bone around the time of calving.

For multiparous (second and greater lactation), late-pregnant (270 days of gestation) Holstein cows (average body weight (BW) 1500 to 1600 lb) the daily dietary P requirement is 30 to 33 grams/cow (NRC, 2001). Based on the NRC feed intake model these cows are predicted to consume about 30.1 pounds of ration dry matter/cow per day. Therefore, the recommended dietary P concentration in the close-up ration would be 0.24%, dry basis.

However, close-up rations in Michigan dairy farms typically contain higher P concentrations. This results from: **1)** over-supplementation of inorganic P in pre-fresh mineral mixes; or, **2)** the often high "background" P content of the base feed ingredients selected for the close-up ration (Beede, 2003). Both of these issues are addressed later in this article.

Also, in some cases, dietary P is supplemented in the close-up ration in excess of the NRC requirement because of recent herd problems with hypophosphatemia (clinical cases) around the time of calving and (or) concerns about low blood P discovered when assessing transition cow problems.

In fact, it is common to observe close-up ration formulations with 0.35 to 0.45% P, or more, dry basis. We hypothesize that these high P concentrations, higher than NRC recommendations, actually are bad for close-up and transition (3 weeks before through 3 weeks after calving) cows. We hypothesize that 0.24% P in the close-up ration is adequate and most efficacious for a normal transition into early lactation.

Therefore, we conducted an experiment to determine the optimal dietary P concentration and to characterize health and performance from 4 weeks before calving through 4 weeks after calving for multiparous Holstein cows with high milk yield potential.

Cows and Dietary Treatments

During a standardization period (60 to 28 days before expected calving) 45 multiparous Holstein cows all were fed the same far-off dry cow diet (0.31%P, dry basis). Beginning 28 days pre-calving, cows were assigned randomly to one of three totally mixed experimental rations that differed in P content. The three different P concentrations were: 0.21, 0.31 and 0.44%, dry basis. After calving, all cows were fed the same ration balanced for 120 pounds of milk/cow per day for 28 days.

Results before Calving

Table 1 shows average responses of cows during the last 28 days before calving. Feed dry matter intake (DMI; lb/cow per day or as a percentage of BW) was not affected by P content of the close-up ration. Average DMI of experimental cows was about 13% greater than that predicted by NRC (2001). As anticipated, P intake was different among the three experimental treatments because the dietary P% differed. Daily P intake averaged 34 grams/cow for cows fed the close-up diet with 0.21% P, very similar to the dietary requirement (NRC, 2001). Cows fed rations with 0.31 and 0.44%P consumed about 42 and 98% more P than those fed near requirement. Body weight and body condition score changes during the close-up period did not differ among treatment groups.

Responses around Calving

Blood serum P concentrations from samples taken during the close-up period (28 days) differed for cows fed rations with different P% (Table 1). However, blood serum P concentrations of cows fed 0.21% dietary P were still within the normal range (4 to 6 mg/dl) for dairy cattle. Serum P of cows fed 0.31 and 0.44% dietary P slightly exceeded the normal range. Cows fed 0.21% P had the lowest serum P concentrations through calving. However, by day 3 after calving their serum P concentrations rose above those of cows fed the close-up diets with 0.31 or 0.44% P **(**Figure 1). Serum P concentrations of cows fed 0.31 or 0.44% P were similar and within the normal range before and after calving or in the early days after calving.

On dairy farms, it is often surmised that if blood serum P concentrations are below the normal range around the time of calving that cows are deficient in dietary P. However, our results show that this is a false assumption. Note that cows in all three treatment groups had serum P concentrations below the "normal" range during the day of calving (day 0, Figure 1). None of these cows presented clinical hypophosphatemia

during the day of calving or in the early days after calving.

During assessment of transition cow problems, it is sometimes noted that blood serum P concentrations are below the normal range (4 to 6 mg/dl). Cows are presumed to be experiencing a dietary P deficiency. Often the action taken to correct the presumed problem is to increase P in the close-up diet. Based on our new research results this appears to be exactly the wrong action to take. Several cows in this experiment had P concentrations below 4 mg/dl the day of calving. However, all of these cows were able to naturally correct the low serum P concentrations within a day or two after calving, and no cows in the experiment presented clinical hypophosphatemia. Only one cow in the experiment (fed 0.31% P) presented clinical milk fever; she was treated and promptly recovered.

Table 1. Pre-calving responses of close-up cows (averages of data from 28 through 1 day before calving).

	Close-up ration P, %		
Response	0.21	0.31	0.44
Dry matter intake, lb/d	35.2	33.9	33.4
Dry matter intake, % of BW	2.07	2.08	2.01
P intake, g/d	34[a]	48[b]	67[c]
Body condition score change (1 to 5 scale)[d]	+0.12	+0.04	-0.01
Body weight change, lb	+34.1	+52.8	+56.8
Blood serum P, mg/dl	5.06[a]	6.41[b]	6.60[c]
Blood serum Ca, mg/dl	9.18	9.35	9.04
Blood serum Mg, mg/dl	1.88	1.88	1.93

[a,b,c] Averages within row differ (P < 0.01).
[d] Patton et al. (1988).

Serum Ca and Mg concentrations during the 28 days before calving were not affected by P% in the ration (Table 1). However, Figure 2 (page 22) illustrates a potentially important risk factor related to Ca homeostatis of transition cows. Cows fed the ration with 0.44% P had lower blood serum Ca concentrations the last few days before calving and especially the day of calving than cows fed 0.21 or 0.31% P. This suggests that these cows may be at greater risk of periparturient hypocalcemia if higher than needed P (0.44 vs. 0.21 to 0.24%, dry basis) is fed in the close-up ration.

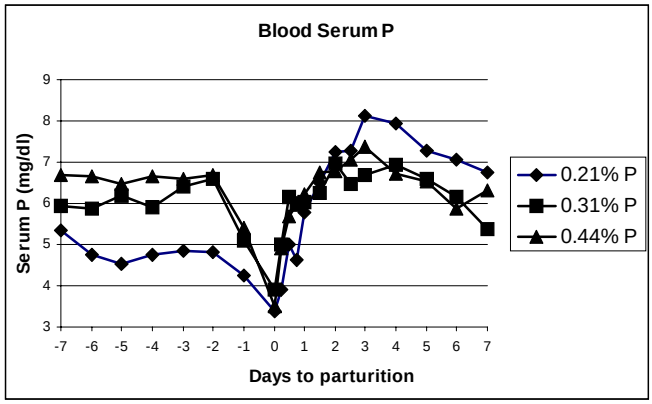

Figure 1. Blood serum P concentrations of multiparous Holstein cows from 7 days before through 7 days after calving.

After Calving

Table 2 (page 22) presents responses during the first 28 days after calving for cows fed their respective close-up rations differing in P concentrations. All cows were fed the same ration after calving. None of the measurements (DMI, body weight or body condition score change, or milk yield or composition) were affected by the P% of the close-up ration. The overall average energy-corrected milk yield of all cows in the experiment was about 116 lb/cow per day during the first 28 days of lactation.

Discussion

Results of this experiment do not support feeding P in greater concentrations or amounts than recommended by NRC (2001). In fact, these results demonstrate that providing about 30 grams/cow per day or 0.21 to 0.24%P, dry basis in the close-up ration was optimal in meeting the multiparous Holstein cow's dietary requirement. Results also provide evidence that feeding more than the requirement (e.g., 67 grams per day or 0.44%P) may be deleterious to Ca status during the periparturient period.

Over-supplementation or excess background P. Very few of the close-up rations fed to Michigan Holstein dairy cows require any P supplementation to achieve 0.24% P, dry basis. Commonly, the problem is that the P% of the close-up ration is too high (e.g., 0.35 to 0.5%). This may be due to over-supplementation via a pre-fresh mineral mix; this supplementation error can and should be corrected immediately. Excess ration P also may be due to the fact that the base feed ingredients used in the close-up ration contain P concentrations well in excess of that needed to provide the close-up cow's P requirement (see Table 2, page 4, January, 2003 issue of Michigan Dairy Review). The thought then might be, *"I've gotten the P% as low as I can with the ingredients I am using, there's nothing else I can do"*. However, selection of other special feedstuffs with lower P content for close-up cows may be effective to improve transition cow health and

performance. Results of the current experiment indicate that if the P% of the close-up ration is too high (e.g., 0.44%) then there is risk to cow health during the transition period.

Conclusions , Recommendations

Feeding dietary P to meet the NRC (2001) dietary requirement resulted in normal health and transition performance for multiparous Holstein cows with potential for high milk production. Based on the amount of feed DM consumed prepartum by cows in this experiment (average 34.2 lb/cow per day) or that predicted (30.1 lb/cow per day) by NRC (2001) for cows of similar body weight, P concentrations of the close-up ration in the range of 0.21 to 0.24% provided 30 to 35 grams of P per cow per day. Feeding higher concentrations (e.g., 0.44%P) may put cows at risk for periparturient hypocalcemia.

Several of the cows in the current experiment had serum P concentrations near the time of calving that were below the "normal" range. None of these multiparous cows exhibited any signs of clinical hypophosphatemia; and, lactational performance was normal during the first month after calving.

Close-up rations for multiparous Holstein cows consuming close to NRC-predicted amounts of feed during the last 3 to 4 weeks before calving should contain about 0.21 to 0.24% P and provide 30 to 35 grams of P per cow per day.

(More detailed information about the experiment is available from the authors upon request.)

Table 2. Post-calving responses of multiparous Holstein cows (averages of data from the first 28 days of lactation).

	Close-up ration P, %		
Response	0.21	0.31	0.44
Dry matter intake, lb/d	40.5	43.3	43.8
Dry matter intake, % of BW	2.88	3.05	3.00
Body condition score change (1 to 5 scale)[d]	-0.48	-0.47	-0.48
BW change, lb	-107.6	-125.8	-104.3
Blood serum P, mg/dl	6.33	6.09	6.13
Energy-corrected milk yield[b], lb/d	117.5	117.0	114.9
Milk true protein, %	3.06	3.11	2.99
Milk fat, %	5.44	5.32	5.04
Milk lactose, %	4.65	4.76	4.70
Milk solids-not-fat,%	8.61	8.77	8.63

[a] Patton et al. (1988).
[b] ECM yield, lb/day = 0.3246 x milk yield, lb/day + 12.86 x fat yield, lb/day + 7.04 x protein yield, lb/day; (Dairy Records Management Systems, 1999).

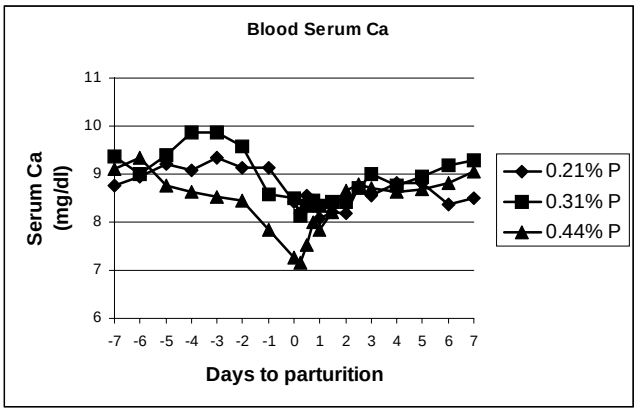

Figure 2. Blood serum Ca concentrations of multiparous Holstein cows from 7 days before through 7 days after calving.

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