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# The effect of dietary crude protein and phosphorus on grass-fed dairy cow production, nutrient status, and milk heat stability

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## ABSTRACT

Dietary crude protein (CP) and phosphorus (P) have the potential to alter dairy cow production, nutrient status, and milk heat stability, specifically in early lactation. This study examined the effect of supplementary concentrates with different CP and P concentrations on blood N and P status and on milk yield, composition, and heat stability. The concentrates [4 kg of dry matter (DM) concentrate per cow daily] were fed to grazing dairy cows (13 kg DM grass) during early lactation. Forty-eight spring-calving dairy cows were allocated to 4 treatments: high CP, high P (HPrHP; 302 g/kg DM CP, 6.8 g/kg DM P), medium CP, high P (MPrHP; 202 g/kg DM CP, 4.7 g/kg DM P), low CP, high P (LPrHP; 101 g/kg DM CP, 5.1 g/kg DM P), and low CP, low P (LPrLP; 101 g/kg DM CP, 0.058 g/kg DM P), for 8 wk. Levels of N excretion were significantly higher in animals fed the HPrHP and MPrHP concentrates; P excretion was significantly lower in animals fed the LPrLP concentrate. Reducing the level of P in the diet (LPrLP concentrate) resulted in a significantly lower blood P concentration, whereas milk yield and composition (fat and protein) were not affected by either CP or P in the diet. The effect of the interaction between treatment and time on milk urea N was significant, reflecting the positive correlation between dietary CP and milk nonprotein N. Increasing supplementary CP and P (HPrHP) in the diet resulted in significantly lower milk heat stability at pH 6.8. The findings show that increasing dietary CP caused a decrease in milk heat stability, which reduced the suitability of milk for processing. The study also found that increasing dietary CP increased milk urea N and milk nonprotein N. Increasing dietary P increased fecal P excretion. These are important considerations for milk processors and producers for control of milk processing and environmental parameters.
**Key words:** supplementation, nitrogen, phosphorus, milk heat stability

## INTRODUCTION

Temperate northern European countries, including Ireland, have a major competitive advantage in their ability to produce between 12 and 16 t of grass DM/ha over a 300-d growing season (Dillon et al., 2008). Ireland's dairy industry is largely based on grass as the primary nutrition source because this is the cheapest source of feed for milk production (Finneran et al., 2010). Maximizing the percentage of grass in the dairy cow diet has been shown to reduce overall milk production costs, thereby maximizing farm profitability (Dillon et al., 2008). Milk supply in Ireland is highly seasonal because calving dates on most farms coincide with the beginning of the grass-growing season (Dillon et al., 1997).

A seasonal pattern of grass growth leads to potential feed deficits in spring and autumn. The use of supplements such as concentrates and forages has an important role in filling the feed deficit at these times (Burke et al., 2008). Supplementing grazed grass diets in early spring, when grass is in short supply, has been shown to have a positive effect on milk yield and composition (Bargo et al., 2003). With the abolishment of milk quotas in the European Union in 2015, the Irish dairy industry is expected to expand (Dillon et al., 2008). One strategy for increasing milk production is to increase dairy cow numbers, which will result in increased stocking densities. This will necessitate greater supplementation in the spring and autumn.

Several studies (Forster et al., 1983; Kung and Huber, 1983) have shown that increasing dietary CP concentration has a positive effect on milk yield, milk protein concentration, and milk solids yield. Continued increases in dietary CP concentration, however,

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give diminishing returns in terms of milk production (Stockdale, 1995). It has been shown that offering a grass silage-based diet with a dietary CP concentration of only 150 g of CP/kg of DM did not have negative effects on milk production (Castillo, 2001). Increased dietary CP increases the amount of protein degraded in the rumen. If RDP exceeds microbial needs, large amounts of ammonia are produced, absorbed into the blood, converted to urea in the liver, and ultimately excreted in the urine (Olmos Colmenero and Broderick, 2006). Although the majority of urea is excreted in the urine, some diffuses into the milk, where it is measured as MUN (Kauffman and St-Pierre, 2001), which can adversely affect milk heat stability, an indicator of milk processability. In spring, grass CP concentrations in Ireland tend to be greater than 20% DM (O'Neill et al., 2013). Choosing a supplementary concentrate with low CP concentration may be an effective strategy for dairy farmers to reduce MUN and the amount of N excreted in urine.

Phosphorus fertilizer use in Ireland was 36% lower in 2012 compared with 2002 (DAFM, 2013). This reduction in P fertilizer use is associated with an overall reduction in grass P concentration (Schulte and Lalor, 2007). With grass being the primary source of nutrition in Ireland for dairy cows, any reduction in grass P concentration may lead to an overall reduction in the dietary P intake to levels below the recommended 0.35% P/kg of DM (NRC, 2001). Animal P status is important because P has more known functions in the animal body than any other mineral element (NRC, 2001). A P-deficient diet (<0.35%) can negatively affect milk yield and milk composition (Wu and Satter, 2000). Approximately half of P in milk protein is complexed with CN (Satter, 2003). A reduction in dietary P may have negative consequences for CN and ultimately milk processability (Satter, 2003). Phosphorus, either excreted directly by livestock or applied to the land in the form of slurry or manure, can reach waterways and lead to nutrient enrichment (eutrophication) of both fresh and coastal waters (Smith et al., 2001). Improving P utilization by reducing P excretion while meeting dietary P recommendations is an important strategy to reduce the environmental footprint of dairy farms.

We hypothesized that an increase in dietary CP would increase MUN and have consequential negative effects on milk heat stability. Furthermore, we hypothesized that a reduction in dietary P would reduce milk CN concentration, reducing milk heat stability, and would reduce P excretion. The objective of the present study was to investigate the effects of offering supplementary concentrates differing in CP and P concentrations to grazing dairy cows in early lactation on milk yield, composition, and heat stability, and on N and P status.

## MATERIALS AND METHODS

### *Location*

The experiment was conducted at Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland (50°09′N, 8°16′W; 35 m above sea level). The area used was under permanent pasture with a predominantly perennial ryegrass (*Lolium perenne* L.) sward.

### *Experimental Design and Animals*

The experiment was a completely randomized block design and was conducted between February 29 and May 1, 2012. Forty-eight lactating dairy cows (36 multiparous and 12 primiparous) with an average calving date of January 31, 2012, were used in the study. During the first week postcalving, the cows were offered approximately 15 kg of grass DM/cow and 2 kg of concentrate DM/cow daily. Following this, and until the start of the experimental period, the cows were offered approximately 15 kg of grass DM/cow and 4 kg of concentrate DM/cow daily.

### *Treatments*

The cows were blocked based on milk yield, milk protein concentration, milk solids yield, BW, and BCS, and were randomly assigned to 1 of 4 treatments: high CP, high P (**HPrHP**), medium CP, high P (**MPrHP**), low CP, high P (**LPrHP**), and low CP, low P (**LPrLP**). Each treatment group was offered grazed grass and a different concentrate. The 4 treatment groups grazed independently in the same paddock separated by temporary strip wires. They were offered 13 kg of fresh grass DM/cow. Once daily, 4 kg of concentrate DM/cow was offered. The HPrHP, LPrHP, and LPrLP concentrates were offered after morning milking on an outdoor winter feeding pad. Cows were secured with a self-locking stall swing (O'Donovan's Engineering, Coachford, Co. Cork, Ireland) to ensure that each cow received the correct concentrate allocation individually. The MPrHP concentrate was offered during morning milking via the Dairymaster feed delivery system (Dairymaster, Causeway, Co. Kerry, Ireland). The MPrHP concentrate was offered in the milking parlor because of the lack of available space in the self-locking stall swing. The HPrHP concentrate was a 30% DM CP coarse feed containing 0.68% DM P. It was composed (% DM) of 20% soybean meal, 20% distillers grains, 20% rapeseed, 18% barley, 15% citrus pulp, 5% liquid molasses, and 2% mineral mix. The MPrHP concentrate was a 20% DM CP pellet containing 0.47% DM