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Effects of crude protein level in concentrate supplements on animal performance and nitrogen utilization of lactating dairy cows fed fresh-cut perennial grass

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ABSTRACT

Nitrogen pollution of air and ground water from grazing cattle is of increasing concern. Although several studies have investigated mitigation strategies for nitrogen output from dairy cows fed conserved forages and concentrates, similar research on fresh-cut grass in addition to production parameters is limited. The current study, using 3 dietary treatments and incorporating 2 genotypes, was designed to evaluate the effects of concentrate crude protein (CP) levels on animal production and nitrogen utilization efficiency (NUE) in lactating dairy cows. Twelve multiparous cows (6 Holstein and 6 Holstein × Swedish Red) were used in a changeover study with three 25-d periods and 3 diet treatments. Low, medium and high CP concentrate [14.1, 16.1, and 18.1%, respectively, dry matter (DM) basis] diets were fed at 32.8% DM intake combined with good-quality zero-grazed perennial ryegrass (18.2% CP, DM basis). Each period consisted of an adaption phase (18 d) housed as a single group, a 1-d adaptation phase in individual stalls, and a 6-d measurement phase with feed intake and feces, urine, and milk output recorded. We observed no significant interaction between cow genotype and concentrate CP level on any animal performance or NUE parameter. Total DM intake, milk yield and composition, and NUE were not affected by dietary treatment. However, increasing concentrate CP level increased (1) N intake by 42 g/d and excretion in urine and manure by 38 and 40 g/d, respectively, and (2) the ratio of urine N over manure N. Feeding high CP rather than low CP concentrate increased milk urea N (MUN) content by 3.6 mg/dL and total MUN output by 1.08 g/d. Crossbred cows had lower grass DM intake, total DM intake, total N intake, and energy-corrected milk yield. However, cow genotype had no significant effect on NUE or MUN parameters. Equations have been developed to predict urine N excretion using MUN output as a sole predictor or in combination with dietary CP level. The present study indicated that when grazing cows are fed good-quality pasture, feeding concentrates with a protein content as low as 14.1% may not negatively affect productivity. In addition, reducing concentrate CP concentration may be successful in reducing the urinary N excretion of lactating dairy cattle on pasture-based systems, but further research is needed to investigate the long-term effects of supplementary concentrate CP content on milk production.
Key words: dairy cow, concentrate protein content, fresh grass, milk production, nitrogen utilization

INTRODUCTION

Greenhouse gas emissions from livestock production systems, specifically ruminants, are a major source of environmental concern. With normal bovine feeding practices, a large percentage of dietary protein is inefficiently used, leading to increased manure N output and resulting environmental, health (Butler, 1998), and economic implications. Excess N excretion from ruminants can be converted to many forms, such as ammonia, a major air pollutant; N_2O, a greenhouse gas; and nitrate, a water pollutant. The considerable variation in levels of N excretion in urine across a range of dietary treatments highlights the potential for alleviation (Castillo et al., 2000). Grasslands are the most economical feedstuff for dairy farmers in Northern and Western Europe (Peyraud and Delagarde, 2013). However, because controlling forage nutrient composition can prove difficult,

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a feasible mitigation option for improving nitrogen utilization efficiency (**NUE**) may be to reduce the CP content in concentrate feeds. This may be possible in pasture-based systems as opposed to indoor systems on silage-based diets because pasture often possesses a CP content in excess of or close to 20% on a DM basis (Kavanagh et al., 2003), a value considerably greater than that typically found in conserved forage. Hence, it is vital that N partitioning be assessed in all commonly used farming practices to reduce pollution and maintain herd health in a cost-effective manner across dairy production systems. Previous studies have shown improved NUE, in particular reduced urinary N excretion, as a result of reduced concentrate CP levels (Castillo et al., 2000; Marini and Van Amburgh, 2005; Burke et al., 2008). However, whether improved NUE and N partitioning, in addition to production responses, can be achieved using low CP concentrates in a fresh-cut grass-based diet has not yet been determined.

Evidence also points to a genetic effect on N metabolism (Pareek et al., 2007; Beecher et al., 2014), although to a lesser extent than dietary CP content (Huhtanen et al., 2015). It is well documented that MUN is used to monitor feed management practice, specifically excess dietary CP, and has been suggested as an indicator for urinary N excretion (Jonker et al., 1998; Kauffman and St-Pierre, 2001). Previous literature has found the relationship between urinary N and MUN concentration may be subject to genetic influence (Kauffman and St-Pierre, 2001), with significant differences found between Holstein and Jersey cows. Some of this variation may be explained by milk yield and BW (Huhtanen et al., 2015) or as a result of genetic variation in urea transporters in the kidney and across the rumen epithelium, with different alleles resulting in increased or reduced activity (Aguilar et al., 2012). Conversely, some trials found no evidence of a genetic effect on N utilization (Zou et al., 2016) or MUN concentration (Carlsson et al., 1995). Swedish Red is a high-producing breed in common use in Northern Europe that has been crossed with Holsteins to improve fertility, udder health, and longevity (Heins and Hansen, 2012), resulting in greater projected lifetime profit and profit per cow-day than the Holstein breed (Heins et al., 2012). Because Holstein and Swedish Red represent important bovine breeds for milk yield and solids output, a comparison between Holstein and Holstein × Swedish Red crossbreds would be suitable for examining the genetic and physiological effects on variation of N partitioning in dairy cattle.

The objective of the present study was (1) to investigate the effects of animal genetics and varying concentrate CP content on milk production levels in combination with NUE and N partitioning parameters and (2) to develop linear and multiple relationships to estimate MUN and urinary N outputs for lactating dairy cows on similar diets to those offered in the present study using readily available data at the farm level.

MATERIALS AND METHODS

All animal procedures in the present study were conducted under experimental license from the Department of Health, Social Services and Public Safety of Northern Ireland in accordance with the Animal (Scientific Procedures) Act (Home Office, 1986).

Experimental Design

The current study was conducted during the 2014 grazing season at Agri-Food and Biosciences Institute (Hillsborough, Northern Ireland, UK), using 6 pure Holstein and 6 crossbred (50:50 Holstein × Swedish Red) cows fed fresh-cut grass and 3 differing concentrate feeds in a 3-period (25 d/period) changeover design study. Cows from each genotype were blocked into 3 groups of 2 cows based on milk yield, BW, and lactation stage, and were then randomly allocated to one of the 3 dietary treatments. The mean milk yield, BW, and DIM at the start of the trial were 26 ± 4.9 kg/d, 550 ± 39.9 kg, and 119 ± 20.5 d, respectively. The diet treatments were a low CP concentrate (**LCP**, 14.1%), a medium CP concentrate (**MCP**, 16.1%) and a high CP concentrate (**HCP**, 18.1%) on a DM basis offered at 35% DMI, in combination with fresh-cut perennial ryegrass offered at 65% DMI. Each experimental period consisted of (1) an initial 18-d feed adaption phase, where cows were housed as a single group with individual feed intake recorded; (2) a 1-d adaption phase in individual stalls; and (3) a 6-d digestibility unit phase, with daily recording of feed intake and total collection of feces, urine, and milk outputs.

The LCP and HCP concentrates were formulated separately; both contained the same feed ingredients and similar chemical composition (with the exception of CP content). The MCP concentrate was then produced by mixing the LCP and HCP concentrates in a 1:1 (wt/wt) ratio. The ingredients and chemical composition of LCP and HCP concentrates are presented in Tables 1 and 2, respectively. Half of the daily concentrate rations were offered at morning milking (0700 h) and half at afternoon milking (1500 h), and fresh-cut grass, harvested with a Haldrup 1500 (Plot Combine, Haldrup, Ilshofen, Germany) from a single sward, was offered at 1000 h each morning ad libitum. Herbage received a primary cut in April 2014 and was subsequently harvested at regrowth intervals according to month (increasing from 22 to 30 d from June to Sep-