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High-quality forage can replace concentrate when cows enter the deposition phase without negative consequences for milk production

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ABSTRACT

Mobilization and deposition in cows are different strategies of metabolism; hence, the aim was to study the possibility of reducing the crude protein (CP) supply during deposition to limit the use of protein supplements and minimize the environmental impact. A total of 61 Jersey and 107 Holstein cows were assigned to 4 mixed rations in a 2 × 2 factorial design with 2 concentrate to forage ratios (CFR) and 2 CP levels: high CFR (40:60) and recommended CP [16% of dry matter (DM); HCFR-RP], high CFR (40:60) and low CP (14% of DM; HCFR-LP), low CFR (30:70) and recommended CP (16% of DM; LCFR-RP), and low CFR (30:70) and low CP (14% of DM; LCFR-LP), where RP met the Danish recommendations. Cows were fed concentrate in an automatic milking unit. After calving, cows were fed HCFR-RP until entering deposition, defined as 11 kg (Jersey) or 15 kg (Holstein) of weight gain from the lowest weight after calving. Subsequently, cows either remained on HCFR-RP or changed to one of the other mixed rations. Comparing strategies during wk 9 to 30 of lactation showed higher dry matter intake (DMI) of mixed ration on HCFR compared with LCFR and on RP compared with LP. The DMI of the concentrate was higher on LCFR than on HCFR and higher on LP than on RP, resulting in overall higher DMI on HCFR and RP than on LCFR and LP. Crude protein intakes were higher on RP than on LP and starch intakes were higher on HCFR than on LCFR. Intakes of neutral detergent fiber tended to be higher on LCFR than on HCFR. Intakes of net energy for lactation were affected by CFR and CP level, with a higher intake on HCFR and RP than on LCFR and LP. No interactions were found between CFR and CP level for any feed intake variables. Yields of milk and energy-corrected milk were higher on RP than on LP, with no difference in yield persistency after the ration change. Milk composition did not differ among strategies but the protein to fat ratio was higher on HCFR than on LCFR and tended to be lower on RP than on LP. Differences in fatty acid composition were small, and de novo synthesis was high (>60%). Energy efficiency was higher on LCFR than on HCFR and no interaction with breed or parity was found. The N efficiency was higher on LP than RP, but with an interaction with breed due to lower N efficiency in Jersey than Holstein cows on HCFR-RP but higher N efficiency in Jersey than Holstein on LCFR-LP. In dairy production, concentrate in the mixed ration can be substituted with high-quality forage during deposition without negative effects on milk yield and composition when a sufficient CP level is ensured.
Key words: forage ratio, protein level, dairy cow, environment

INTRODUCTION

Research in dairy cattle nutrition has recently focused mainly on developing tools for controlling individual feed allocation to dairy cows, for example, to support their individual requirements for energy and nutrients according to stage of lactation. However, rising prices of feedstuffs, particularly ingredients for concentrate mixtures, have strengthened interest in substituting energy-rich cereal grains with high-quality forage and optimizing the use of protein-rich supplements. Furthermore, optimizing the protein supply for dairy cattle can reduce the environmental impact by reducing the loss of N to the environment (Oldham, 1984), which has become a major focal point in dairy production (Børsting et al., 2003).

The utilization of energy and protein in ruminants is intimately linked. Even though dietary protein is utilized both for amino acids and for microbial protein synthesis in the rumen (Oldham, 1984; Broderick, 2003), the efficiency of protein utilization is dependent on the energy supply. This is because rations high in energy support microbial protein synthesis in the rumen, thereby increasing the supply of microbial protein for utilization by the ruminant (Oldham, 1984; Broderick, 2003). Oversupplying energy is uneconomical and could cause problems for ruminants through a

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compromised rumen environment with decreased pH and fiber degradability from excessive starch intake, ultimately resulting in reduced production (Broderick, 2003). Oversupplying protein induces a physiological strain on the animal, which has to handle an excess of N in the body (Fenderson and Bergen, 1976), and it increases the environmental impact of dairy production through increased N excretion from the animal (Broderick, 2003).

Energy and protein demands in dairy cows change significantly with stage of lactation. In early lactation, the typical mobilization of body reserves shows that energy and nutrients are allocated to milk production. During the subsequent deposition period, energy and nutrients are increasingly allocated to other life functions, such as reproduction and weight gain (Bossen et al., 2009). Hence, the mobilization and deposition periods represent 2 distinctly different strategies of allocating energy and nutrients within the body (Knegsel et al., 2007; Bjerre-Harpøth et al., 2012).

Recent experiments have shown that it is possible to reduce the energy supply of individual dairy cows when they change from mobilization to deposition without detrimental effects on milk yield and animal health (Bossen and Weisbjerg, 2009; Bossen at al., 2009). However, the possibility of also reducing the protein supply has not been established under modern production conditions. Hence, the aim of the present study was to establish whether decreasing the concentrate to forage ratio (**CFR**) of the mixed ration (**MR**) from 40:60 to 30:70 could be accompanied by a decrease in CP supply from approximately 16 to 14% of DM for lactating dairy cows in deposition, without negatively affecting milk production.

MATERIALS AND METHODS

Animals and Experimental Design

All animal experiments complied with the Danish Ministry of Justice Law No. 726 (September 9th, 1993) concerning experiments with animals and care of experimental animals. A total of 61 Danish Jersey and 107 Danish Holstein cows, were, within breed, allocated to different treatment strategies according to parity (primiparous and multiparous) and expected calving date. Cows were allocated to 4 different feeding strategies in a 2 × 2 factorial design with 2 CFR and 2 CP levels in the MR. The 4 different treatment rations were as follows: high CFR (40:60) and recommended CP level (16% of DM; **HCFR-RP**), high CFR (40:60) and low CP level (14% of DM; **HCFR-LP**), low CFR (30:70) and recommended CP level (16% of DM; **LCFR-RP**), and low CFR (30:70) and low CP level (14% of DM; **LCFR-LP**). Starting weights for the cows were 598.9 ± 54.1 kg (Holstein primiparous), 664.4 ± 69.1 kg (Holstein multiparous), 429.8 ± 33.8 kg (Jersey primiparous), and 470.1 ± 41.6 kg (Jersey multiparous). All cows were fed the HCFR-RP ration commencing on d 1 after calving and until the individual cows had gained 11 kg (Jersey) or 15 kg (Holstein), respectively, from the lowest recorded weight after calving (pre-change). The desired weight gains were chosen based on previous studies showing that these weight gains were consistent with cows having entered deposition (Bossen and Weisbjerg, 2009; Bossen et al., 2009). Subsequently, the cows either remained on the HCFR-RP ration or changed to 1 of the other 3 rations until wk 30 of lactation (post-change). No cows were allowed to change rations earlier than wk 8 after calving regardless of their weight gain within that period of time. A total of 40 cows changed ration in wk 8 of lactation (i.e., as soon as it was allowed).

Housing and Management

The experiment was carried out at the Danish Cattle Research Centre (Tjele, Denmark) between January 2010 and May 2011. Cows were kept in a loose-housing system with slatted floors and stalls with mattresses. A free cow traffic system was applied, where cows were not restricted in access to mangers, stalls, or the automatic milking system (**AMS**) from DeLaval AB (Tumba, Sweden) at any point in time. Within the dairy unit, cows were organized in 3 groups (AMS groups), 1 with Jersey cows and 2 with Holstein cows, giving rise to approximately twice as many Holstein as Jersey in the study. Each group had access to an automatic milking unit (**AMU**) equipped with a device for automatic measurement of milk yield and milk sampling for chemical analysis. Additionally the AMU was equipped with a device for feeding a commercial concentrate mixture (**CCM**) and weighing of CCM refusals at the end of each cow visit. Below each AMU, a platform scale from Danvaegt (Hinnerup, Denmark) was installed for automatic weighing of cows at every milking. Body condition score was assessed every second week as described by Ferguson et al. (1994). The RIC system (Insentec, Marknesse, the Netherlands) was used for automatic recording of MR intake in mangers mounted on scales and with automatic cow registration by electronic ear tag. Dry matter contents of roughages were determined weekly and rations adjusted accordingly. When cows changed rations, they changed to a different set of mangers but remained in the same AMS group. Cows that remained on the HCFR-RP ration changed to a different set of mangers to even out any effect of changing the mangers from which cows ate.