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Effects of Two Different Feeding Strategies During Dry-Off on Metabolism in High-Yielding Dairy Cows

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ABSTRACT

The objectives of this study were to investigate different feeding strategies of high-yielding dairy cows during dry-off. With a 12- to 13-mo calving interval and increasing milk yield, metabolic and health problems during the dry-off period will increase. Twenty-two dairy primiparous and multiparous cows were randomly assigned to 2 feeding treatments. One group was fed straw ad libitum (straw), and the other group was fed silage (4 kg/d of dry matter) daily and straw ad libitum (silage). At the dry-off point (d 0), the cows had an average milk yield of 17.1 ± 0.8 kg/d. All cows were milked in the morning on d 3 and 5 during the dry-off period. Rumen fluid was analyzed for volatile fatty acids (VFA), pH, NH_3-N, and protozoa were counted from samples collected at d –3, 4, and 17. Total VFA concentration decreased at dry-off in both treatments and the drop was most pronounced among cows fed straw. Rumen pH increased significantly in both groups, and cows fed straw had significantly higher pH during dry-off. Ammonia N in rumen decreased significantly at dry-off and there was a tendency to lowered NH_3-N in cows fed straw at dry-off. The plasma concentration of nonesterified fatty acids was markedly elevated during the dry-off period among cows in the straw treatment group, but was less pronounced among the cows fed silage with straw. The glucose level in plasma was not significantly affected during the dry-off period, and the insulin concentration was markedly reduced in both treatment groups. Plasma leptin concentration was lower in the lactating state than in the dry period. Both the β-hydroxybutyrate and urea concentrations in plasma were significantly reduced during dry-off. Our results indicate that dry-off markedly affected the metabolism in the blood and in the rumen of the cows, and that the cows offered only straw during the dry-off were most affected.
(**Key words:** dry-off, metabolism, starvation, metabolic stress)

Abbreviation key: Ac = acetate, **Bu** = butyrate, **EB** = energy balance, **FIL** = feedback inhibitor of lactation, **HFI** = cows selected for high milk fat percentage index, **LFI** = cows selected for low milk fat percentage index, **ME** = metabolizable energy, **Pr** = propionate, **SL** = selection line.

INTRODUCTION

The dry-off period is probably, with the exception of the weeks around parturition, the most physiologically demanding period for the high-yielding dairy cow. High-yielding cows managed conventionally with a 12- to 13-mo calving interval are dried off when still producing significant quantities of milk. Yields of 25 to 30 kg/d of milk at dry-off are not uncommon (Dingwell et al., 2001). At dry-off it is of vital importance that milk synthesis is rapidly inhibited to prevent milk leakage, which may negatively affect udder health (Dingwell et al., 2003). Dry-off induces reabsorption of milk and regression of mammary secretory epithelial cells (Stefano et al., 2002). In milk, a protein, feedback inhibitor of lactation (**FIL**), increases in late lactation and at dry-off. The FIL has a restraining effect on milk production, primarily by blocking constitutive secretion by the alveolar epithelial cells (Wilde et al., 1998). Concentration-dependence of autocrine inhibition in vivo suggests a mechanism in which the milk concentration of FIL increases as milk accumulates and is decreased by milk removal. The FIL has had a positive effect on apoptosis (programmed cell death) in mammary epithelial cells at the end of lactation and during involution (Stefano et al., 2002).

Reducing the nutrient supply also facilitates dry-off. This is a common practice among farmers; and feed advisors recommend a drastic reduction in nutrient supply during dry-off. Cows in early lactation that were deprived of food for 48 h responded with a marked

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reduction in milk production (Agenäs et al., 2003; Chelikani et al., 2004). Overnight starvation in rats reduces glucose uptake by the mammary glands by about 90% (Threadgold and Kuhn, 1984; Page and Kuhn, 1986). Metabolic stress in early lactation related to negative nutrient balance and its correlation to health disorders is well documented (Pryce et al., 1998). However, there is a lack of information about metabolic stress during the dry-off period, but concerns have been raised that major changes in the nutrient supply at dry-off might lead to metabolic disorders, especially among high-yielding cows (Skidmore et al., 1997).

The objective of the following study was to determine the effects of 2 dry-off protocols with different nutrient supplies on rumen and intermediary metabolism, and on rate of milk production reduction.

Table 1. Dry matter content, chemical composition, and calculated values for metabolizable energy (ME), crude fat, CP, NDF, ADF, and lignin.

	Silage	Straw	Concentrate
DM, %	34.1	90.9	89.94
ME, MJ/kg of DM	10.9	7.0	14.02
AAT,[1] g/kg of DM	71.3	47.1	119.35
PBV,[2] g/kg of DM	20.0	–54.6	22.67
CP, g/kg of DM	140.9	41.0	213.7
Crude fat, g/kg of DM	. . .	. . .	69.3
NDF, g/kg of DM	491.1	773.9	. . .
ADF, g/kg of DM	302.2	512.8	. . .
Lignin, g/kg of DM	50.9	105.3	. . .
Ash, % of DM	84.2	89.4	. . .
pH	4.0	. . .	. . .
NH_3-N, % of N	5.3	. . .	. . .

[1]AAT = Amino acids absorbed in the small intestine (Spörndly, 2003).

[2]PBV = Protein balance in the rumen (Spörndly, 2003).

MATERIALS AND METHODS

Animals, Management, and Experimental Design

Twenty-two primiparous and multiparous cows of the Swedish Red and White breed were included in this experiment. The study was carried out at the Swedish University of Agricultural Sciences in Uppsala, Sweden. The cows included in the study were bred with sires that were indexed for high (**HFI**) and low (**LFI**) milk fat percentage, but the selection lines (**SL**) had the same amount of energy produced in milk. The cows were selected based on their milk yield and udder health 1 wk before start of dry-off. The criteria were a yield of at least 15 kg/d of milk and milk SCC below 100,000 cells/mL. The experiment was conducted during 6 mo in the fall of 2002. The cows were allocated into 6 groups according to expected time to parturition. In each group the cows were randomly assigned to 2 different dry-off diets.

The cows were held in individual tie stalls with straw and sawdust bedding throughout the experiment. Before dry-off the cows were fed according to their requirements based on the Swedish feeding recommendations (Spörndly, 2003). Individual feeding of silage and concentrate was performed at 0600, 0900, 1300, and 1700 h each day. The chemical composition and DM content of the feeds used are shown in Table 1. Water was available in automatic water bowls and the cows had free access to salt licks. The actual dry-off procedure lasted for 5 d and is referred to as dry-off (d 1 to 5). The first day of dry-off (d 1) occurred approximately 8 wk before parturition. The experiment started 1 wk before d 1 and lasted 3 wk after d 1, i.e., a total of 4 wk. The cows were randomly assigned to 2 different dry-off treatments. They were fed 2 different diets during these 5 d. During the dry-off one treatment group (straw, n = 11) was fed straw ad libitum and the other treatment group (silage, n = 11) was fed 4 kg/d of DM silage and straw ad libitum. Due to an abortion, 1 cow was excluded from the experiment in the silage group. All cows were fed minerals according to their requirements. From d 6 to 12, all cows were adapted to a dry period feed ration consisting of 6 kg/d of DM silage and 1 kg/d of DM concentrate.

The cows were milked twice a day the week before dry-off, at 0500 and 1600 h. Milk yield was registered daily during the week before dry-off (d –5 to 0) and samples for milk composition analysis were obtained on 4 occasions (p.m. milking on d –6 and –3; and a.m. milking on d –5 and –2). During the dry-off period, cows were milked at 2 occasions, in the mornings of d 3 and 5. Samples for milk composition analysis were also collected during these 2 milkings. The Uppsala Local Ethics Committee approved the experimental design.

Samplings and Analyses

Feed. Silage and concentrate feed samples were collected once weekly. Weekly samples were pooled before analysis. Straw feed samples were collected every day whenever straw was included in the diet. The individual feed components were dried at 60°C in a forced-air oven for 24 h and ground in a hammer mill (1-mm screen). The DM content was obtained by drying the ground feed at 105°C overnight. The dried feed components were ashed at 550°C for 5 h to determine the organic matter in the feed. Silage and straw samples were analyzed for NDF, ADF, and lignin according to Goering and Van Soest (1970). Feeds were analyzed for CP by a fully automated Kjeldahl procedure (Technicon, Solna, Sweden). Metabolizable energy (**ME**) in the feeds was