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Feeding and lying behavior of heat-stressed early lactation cows fed low fiber diets containing roughage and nonforage fiber sources

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ABSTRACT

In addition to reduced nutrient intake, an environmental thermal load may directly affect milk yield in heat-stressed dairy cows. Feeding and lying behaviors of early lactation cows fed low fiber diets containing neutral detergent fiber (NDF) from roughage and nonforage fiber sources (NFFS) were investigated under summer conditions in Thailand. Immediately after calving, 30 multiparous cows (87.5% Holstein × 12.5% Sahiwal) were randomly allocated to dietary treatments for 63 d in a completely randomized design. The dietary treatments contained 25% of dry matter (DM) as dietary NDF. The control diet consisted of 13.9% roughage NDF from rice straw (RS). Two additional treatments were created by replacing 3.9% of DM with NDF from either soy hulls (SH) or cassava (*Manihot esculenta* Grantz) residues (CR), so that the roughage NDF content was reduced to 10%. During the experimental period, the minimum and maximum temperature-humidity indices (THI) were 86.4 ± 2.5 and 91.5 ± 2.7 during the day and 74.2 ± 2.1 and 81.0 ± 2.5 during the night, respectively, indicating conditions appropriate for induction of extreme heat stress. The duration of feeding and lying bouts decreased linearly with increasing THI. The DM intake during the day was greater for cows fed diets containing SH and CR than for those fed the diet containing NDF from RS. The number of meals during the day and night was lower, whereas meal size and meal length during the day and night were greater for cows fed diets containing SH and CR. Cows fed diets containing SH and CR lay down less frequently and longer during the day. These results suggest that under the severe heat stress during the day, early lactation cows fed the diet containing NFFS increased DM intake by increasing meal length and meal size rather than by increasing meal frequency and they spent more time lying. Cows fed diets containing NDF from SH and CR produced more 4% fat-corrected milk, lost less body weight, and had lower rectal temperatures measured at the 1530 h milking. Therefore, reducing the filling effect may contribute to reducing heat load derived from the change in feeding and lying behavior. This should be considered as a factor for impairing productivity of heat-stressed early lactation cows.

Key words: early lactation cow, heat stress, feeding behavior, lying behavior

INTRODUCTION

Increased heat load elicits physiological and behavioral responses, including increased core body temperature, respiration, reduced feed intake, reduced physical activity, and decreased milk yield (Collier et al., 1982). Reduced nutrient intake is primarily responsible for the diminished milk synthesis (Collier et al., 1982); however, it accounts for only about 50% of the decrease in milk synthesis (Rhoads et al., 2009), and lactating cows exhibit behavioral changes in feeding and lying when exposed to increasing heat load (Legrand et al., 2011). In addition to its effect on nutrient intake, an environmental thermal load may directly affect milk yield in heat-stressed dairy cows.

Cows in early lactation spend more time eating and less time lying than cows in late lactation (Nielsen et al., 2000). Cows fed a high silage diet also spend more time eating and less time lying (Nielsen et al., 2000) and have a greater daily roughage intake by increasing meal size rather than by increasing meal frequency, regardless of whether concentrate is consumed (Morita et al., 1996). A reduction in the time that cows spend lying can have a negative effect on blood flow to the mammary gland (Rulquin and Caudal, 1992) and the gravid uterus (Nishida et al., 2004). In addition, less lying time is a risk factor for lameness in cows housed in freestall systems (Chapinal et al., 2009). However, time constraints on both lying and eating behavior at the same time may reduce milk production (Munksgaard et al., 2005). Cows suffering from heat stress eat more frequently, consume smaller meals, and spend less time lying than those not heat stressed (Shiao et al., 2011). Whether a change in feeding and lying behavior of heat-stressed cows is biologically significant to lactation performance is of interest.

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Under a high heat load, physical factors derived from a higher fiber diet have greater hypophagic effects (Kanjanapruthipong et al., 2010). A nutritional approach to minimize the negative effect of heat stress on DMI is the partial replacement of roughage NDF with more digestible NDF sources from by-product feeds known as nonforage fiber sources (**NFFS**; Halachmi et al., 2004). However, little is known about how the source and amount of fiber affect heat-stressed dairy cows. Information on variation in feeding and lying behavior and production is limited for severely heat-stressed early lactation cows fed low fiber diets containing NDF from roughage and NFFS. The objectives of the current study were to determine the effects of low fiber diets containing roughage and NFFS on feeding and lying behavior, DMI, and lactation performance of heat-stressed early lactation cows.

MATERIALS AND METHODS

Experimental Design and Management of Cows

The Animal Care and Use Committee at Kasetsart University approved the experimental procedures used in this study. A study was conducted during summer months, from March 26 to May 27, 2012, and was undertaken at the WataKan dairy farm (a commercial dairy farm at Kampaengsaen, Nakornpathom Province, Thailand; 13°55′N, 100°7′E).

Thirty crossbred cows (87.5% Holstein × 12.5% Sahiwal) in their second and third lactations were dried off 60 d before their expected calving date and assigned immediately to a nonlactating diet with energy content close to (±0.05 Mcal/kg of DM) the NE_L requirement defined by NRC (2001). Body weight with conceptus, BW change, DMI, days pregnant, and calf birth weight were used as model inputs. Mild heat stress has been estimated to increase the maintenance energy requirement by 7% (NRC, 2001). Estimated diet energy concentrations (NRC, 2001) were calculated by summing the NE_L (Mcal) from maintenance [$(0.08 + 0.08 \times 0.07)$ Mcal of NE_L/kg of BW × $BW^{0.75}$], required for pregnancy [$(0.00318 \times \text{days pregnant} - 0.0352) \times (\text{calf birth weight}/45)]/0.218$, and BW change (BW change × 5.34 Mcal of NE_L/kg of BW), and then dividing the sum by DMI. Cows were kept in an opened 3-sided barn in one large pen and fed as a group during the nonlactating period. A prepartum diet was fed only for the 3 wk before expected calving date. Cows consumed the prepartum diet for 18.9 ± 0.9 d. At parturition, BCS of the cows was 3.38 ± 0.06 (on a scale of 1 to 5). All animals calved once the experiment began and were moved to an opened 3-sided barn after calving and were housed individually in stalls throughout the experimental period of 63 d. The barn measured 12 × 36 × 3 m (width × length × height) with an east–west aspect. The barn contained 40 stalls configured in 2 rows of 20 stalls each; these 2 rows were separated by a feeding alley. Stalls measured 150 × 300 cm, were equipped with rubber floormats (2 cm thick), and had individual feed and water troughs. The prevailing winds during this time of the year are from the southwest toward the northeast at 2.7 ± 0.4 km/h (monthly reports from the meteorological station at Kampaengsaen, Nakornpathom Province). The 2 stalls on the eastern end and the 3 stalls at the western end of each row were not used. The experimental stalls were allocated to 10 groups of 3 adjacent stalls. The experimental cows were randomly assigned to individual dietary treatments. Each cow with a different dietary treatment was randomly assigned to 1 of a group of 3 stalls. Therefore, each cow with different dietary treatments was housed next to each other. The experimental cows were distributed equally throughout the barn. All stalls were cleaned before the 0430 and 1530 h milkings. Cows had no supplemental cooling from fans or misters.

Soy hulls (**SH**) were defined as a high NDF ingredient and cassava residues (**CR**) were defined as a low NDF ingredient. Both SH (Ipharraguerre and Clark, 2003) and CR (Kanjanapruthipong and Buatong, 2004) are characterized by low lignin concentrations, a rapid rate of fermentation, and high digestibility. Soy hulls and CR were used as NFFS. Rice straw (**RS**) was cut using a motorized chopper (Rice straw specific model, Department of Agricultural Engineering, Kasetsart University, Nakornpathom Province, Thailand) to a particle length of approximately 2.0 (±0.2) cm and used as a source of roughage. The dietary treatments contained 25% of DM as dietary NDF. The control diet consisted of 13.9% roughage NDF from RS and 11.1% concentrate NDF. The roughage NDF content for 3.9% of DM was replaced with NDF from either SH or CR, so that the roughage NDF content was decreased to 10% (Table 1). The dietary treatments were mixed daily and fed as a TMR. Approximately half of each day's TMR was fed in the morning (0630 h) and the other half in the afternoon (1830 h). Refused feed was weighed before the morning and afternoon feeding, and the amount of feed offered was adjusted daily to allow 10% refusal.

The ambient temperature and relative humidity (**RH**) were recorded continuously by a thermograph (8613, B. S. 3231, Classell, London, UK) placed in the middle of the barn approximately 1.5 m above the feeding alley floor. The maximum and minimum ambient temperature and RH were determined for each day. The temperature humidity index (**THI**) was calculated using the equation THI = $(1.8 \times td + 32) - (0.55 -$