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Short communication: Characterizing metabolic and oxidant status of pastured dairy cows postpartum in an automatic milking system

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ABSTRACT

The periparturient period represents a stressful time for dairy cows as they transition from late gestation to early lactation. Undesirable fluctuations in metabolites and impaired immune defense mechanisms near parturition can severely affect cow health and have residual effects on performance and longevity. Metabolic and oxidative stress profiles of multiparous and primiparous dairy cows in traditional parlor and feeding systems are well characterized, but status of these profiles in alternative management systems, such as grazing cows managed with an automatic milking system (AMS), are poorly characterized. Therefore, the objective of this case study was to characterize the metabolic and oxidant status of pastured cows milked with an AMS. It was hypothesized that primiparous and multiparous cows milked with an AMS would experience changes in oxidative and metabolic status after parturition; however, these changes would not impair cow health or production. Blood was collected from 14 multiparous and 8 primiparous Friesian-cross dairy cows at 1, 7, 14, and 21 d relative to calving for concentrations of insulin, glucose, nonesterified fatty acids (NEFA), β-hydroxybutyrate, reduced glutathione, oxidized glutathione, and antioxidant potential. Milk production and milking frequency data were collected postpartum. Milk production differed on d 7 and 14 between primiparous and multiparous cows and frequency was not affected by parity. Primiparous cows had higher levels of glucose than multiparous cows. No differences in insulin, NEFA, or β-hydroxybutyrate concentrations were noted between multiparous and primiparous cows postpartum, though days relative to calving significantly affected insulin and NEFA. Primiparous cows also had higher antioxidant potential than multiparous cows during the postpartum period. Results from this study show that, although responses were within expected ranges, periparturient multiparous cows responded differently than periparturient primiparous cows with respect to metabolic and oxidative measures during the postpartum period at this pastured-AMS dairy, suggesting different management strategies may need to be considered with primiparous and multiparous cows.
Key words: automatic milking system, metabolic status, pasture, periparturient

Short Communication

The periparturient period, defined as 3 wk before and 3 wk following parturition, is a physiologically stressful time for dairy cattle. The physical, dietary, environmental, and social changes observed during this period are well characterized in traditional confinement operations that milk in parlors. Limited research has examined the effect of voluntary milking in an automatic milking system (**AMS**) on metabolic and immunological parameters of grazing periparturient dairy cows.

Primarily due to the stress of the periparturient period, a cow's immune system is impaired most in the week immediately before and the week immediately after parturition (Goff and Horst, 1997). The incidence of metritis, mastitis, retained fetal membranes, and mammary edema are all common issues postpartum, a time when a cow is known to naturally experience oxidative and metabolic stress (Sordillo and Aitken, 2009). Oxidative stress is a condition that occurs when excessive reactive oxygen species (**ROS**) are produced and antioxidant defenses are unable to neutralize the ROS. When a cow is expending a great deal more energy than is consumed, as is common in the early phase of lactation, a severe negative energy balance (**NEB**) can predispose her to different metabolic diseases (Mulligan and Doherty, 2008) and impair immune function (Goff and Horst, 1997).

Oxidative status is related to energy status in periparturient dairy cows (Bernabucci et al., 2005). Negative energy balance around calving plays a role in

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immunosuppression by acting on different leukocytes (neutrophils, lymphocytes) and proteins (e.g., immunoglobulins, complement) crucial for defense against infection and illness (Kehrli et al., 1989, 1990; Scalia et al., 2006). The immune system will not function efficiently when there are deficiencies in nutrition (e.g., energy, protein), as occurs with NEB during the periparturient period (Goff and Horst, 1997). Strong evidence exists that metabolic changes associated with calving and lactogenesis affect immune function regardless of milking or feeding strategy (Goff, 2006).

The objective of our case study was to characterize the metabolic and oxidative status of multiparous and primiparous pastured periparturient cows milked with an AMS. We hypothesized that grazing primiparous and multiparous cows milked with an AMS would experience changes in oxidative and metabolic status after parturition. Changes in any parameters of interest would not impair cow health or production; however, a difference between the primiparous and multiparous cattle would occur, with primiparous cows exhibiting greater changes. The combination of a pasture-based diet and the flexibility of an AMS would be less demanding on the cows during the periparturient period.

All procedures were approved by the Michigan State University Institutional Animal Care and Use Committee before the start of the experiment. Fourteen multiparous (**MC**) and 8 primiparous (**PC**) Friesian-cross dairy cows were enrolled based on expecting calving date. The study was conducted from April 12 to July 26, 2012, at a commercial dairy farm in central Michigan with 111 cows in the milking herd at the time of the study. The diet of the cows was pasture-based, containing a mixture of red clover (*Trifolium pretense*), white clover (*Trifolium repens*), and orchard grass (*Dactylis glomerata*). The temperature during the experimental period ranged from 8.3 to 34.4°C, with a mean of 22.7 ± 1.2°C. A total of 84.6 mm of precipitation was reported during the study period. Multiparous cows were enrolled 21 d before expected parturition date and PC within 1 d after parturition. Primiparous cows were not enrolled before calving due to the breeding program at the farm. Natural service was used for all PC, thus an accurate record of breeding was not available to predict a calving date with the same accuracy of MC bred with AI. All cows were monitored for health disorders during the experimental period and no animals were diagnosed with a health incident.

Dry cows and heifers were housed on pasture as one group and were rotated between pastures as necessary to meet the grazing needs of the cows throughout the spring and summer. Water was available ad libitum. Indoor access was limited, but a pack-bedded barn was available for calving if necessary. Cows were allowed to calve on pasture without human interference.

The milking herd was managed as a single group under the same breeding, feeding, grazing, and AMS milking protocols. The cows were housed in a loose housing system with 24 h/d access to outdoor pasture. The lactating herd was grazed rotationally on 101.2 ha of pasture subdivided into 26 paddocks. Water was available indoors only, ad libitum, from 2 automatic water troughs at opposite ends of the barn. Two Lely A3 Astronaut AMS (Lely, Maassluis, the Netherlands) were available for milking 24 h/d except for a total of 40 min/AMS per day when the units closed for cleaning and any repairs or servicing that was necessary. All cows had equal access to both AMS units; no management, traffic, or barn design restrictions were placed on the animals for AMS use. All cows wore a transponder around their neck for individual identification by the AMS and routing to pasture via a sort gate.

Sampling days for MC were −21, −14, −7, 1, 7, 14, and 21 d relative to calving (**DRTC**). Primiparous cows were only sampled 1, 7, 14, and 21 d after calving. Blood was collected from the coccygeal tail vein via venipuncture with Vacutainer needles and collection tubes (Becton Dickinson, Franklin Lakes, NJ). Twenty-gauge single-use needles were used to collect blood in EDTA(K2) tubes (for analysis of insulin, glucose, NEFA, and BHBA) and heparin tubes [for the analysis of antioxidant potential (**AOP**), reduced glutathione (**GSH**), and oxidized glutathione (**GSSG**)]. All blood samples were collected, stored, and processed according to manufacturer instructions for each individual assay. Careful consideration was given to the type of tube used to collect blood, preparation of blood or plasma for storage, temperature of storage, and duration of storage before performing the assay to ensure accuracy of results.

Insulin and glucose plasma samples were sent for analysis to the Diagnostic Center for Population and Animal Health at Michigan State University. Insulin was assessed via a radioimmunoassay (Human Insulin RIA Kit; Millipore Corporation, Billerica, MA). Glucose was quantified by the hexokinase G-6-PDH method using an Olympus AU640e analyzer (Olympus, Center Valley, PA). The reagent necessary for the assay was obtained from Beckman Coulter Inc. (Brea, CA). Assays for NEFA and BHBA concentrations were performed on plasma samples using commercial enzymatic colorimetric kits (NEFA: NEFA HR kit, Wako Chemicals USA, Richmond, VA; BHBA: procedure no. 2440, Stanbio Laboratory, Boerne, TX).

The GSH-to-GSSG ratio of each cow on all sampling days was evaluated using Bioxytech GSH/GSSG-412