J. Dairy Sci. 99:1–9
http://dx.doi.org/10.3168/jds.2015-10707


# *Short communication:* Markers of oxidant status and inflammation relative to the development of claw lesions associated with lameness in early lactation cows

**A. Abuelo,* J. C. Gandy,† L. Neuder,† J. Brester,† and L. M. Sordillo†[1]**
*Graham Center for Agricultural Innovation, Charles Sturt University and NSW Department of Primary Industries, Wagga Wagga NSW 2678, Australia
†Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing 48824

## ABSTRACT

Lameness is a major health disorder of dairy cattle and evidence suggests that it may be associated with oxidative stress (OS) during the transition period. Some debate exists, however, as to whether OS precedes the development of lameness or if OS occurs as a consequence of lameness. The purpose of this study was to test whether cows showing claw lesions during early lactation had a greater pro-oxidant and inflammatory status throughout the dry period or at the start of the lactation. Blood samples were taken from 30 cows from the same herd at dry off, movement to the close-up pen, and between 3 and 7 d in milk. Sera were analyzed for concentrations of haptoglobin, serum amyloid A, reactive oxygen and nitrogen species, and antioxidant potential. Blood samples also were subjected to total and differential white blood cell counts. Animals were monitored through 120 d in milk and grouped ex post into the following health categories: (1) exclusively hoof lesions; (2) other production diseases; or (3) nondiseased. Changes in oxidant status and inflammatory markers were significantly different with respect to metabolic and physiologic adaptations to calving and lactation. No differences in oxidant status, acute phase protein concentrations, or leukocyte populations were observed between the hoof lesions and the nondiseased categories. Thus, any associations between OS and lameness likely occurs closer to the onset of clinical signs or as a consequence of inflammatory responses due to localized tissue injury.

**Key words:** dairy cow, inflammation, lameness, oxidative stress, transition period

## Short Communication

Lameness is a major health disorder of dairy cattle that not only causes substantial production-related losses, but also has animal welfare implications due to severe pain (Cha et al., 2010). Lameness is a multifactorial disease that can result from a variety of causative factors, including diet, housing conditions, concurrent diseases, and genetic influences. Evidence is growing, however, suggesting that lameness also might be triggered during the transition period (Proudfoot et al., 2010; Lim et al., 2015).

Dairy cattle undergo substantial metabolic and physiological adaptations as they shift from late pregnancy to early lactation (Bell, 1995). When the production of pro-oxidants exceeds the antioxidant capacity of exposed tissues during times of enhanced metabolism, this often leads to the progressive development of oxidative stress (**OS**) in transition cows (Bernabucci et al., 2005; Castillo et al., 2005). The role of OS as an underlying cause of disturbances in the inflammatory responses and increased susceptibility to transition cow disorders is well supported by the current literature (Lykkesfeldt and Svendsen, 2007; Sordillo and Aitken, 2009).

Previous studies reported that dairy cows with claw lesions (Al-Qudah and Ismail, 2012) or abnormal gait (Zhao et al., 2015) show a higher systemic pro-oxidant status than their healthy counterparts at the time of the diagnosis. Biomarkers of OS also were elevated in sheep with hoof lesions (Talukder et al., 2015); however, these studies have proven an association between OS and lameness, but causality remains unexplored. Information is also lacking whether changes in oxidant status are a risk factor associated with the development of lameness in early-lactation cows. Changes in redox status are known to activate several inflammatory pathways (Sordillo and Aitken, 2009; Shi et al., 2015). Thus, enhanced pro-oxidant status of transition cows could potentially increase proinflammatory mediators in the corium, leading to lameness. We hypothesized that cows developing claw horn disruption during early

Received December 2, 2015.
Accepted March 12, 2016.
[1]Corresponding author: sordillo@msu.edu

**Table 1**. Ingredients and chemical composition of the diets supplied to the animals at the different stages of the present study

| | Dry off | | Close up | | |
|---|---|---|---|---|---|
| Item | Heifers | Cows | Heifers | Cows | Fresh |
| Total DM offered, kg | 10.2 | 11.9 | 11.3 | 13.0 | 17.9 |
| Nutrient analysis | | | | | |
| DM, % | 45.7 | 42.37 | 51.9 | 48.15 | 50.4 |
| CP, % of DM | 14.6 | 14.3 | 16.0 | 14.9 | 17.7 |
| MP, g | 1,005.8 | 1,026.3 | 1,185.8 | 1,371.4 | 2,354.3 |
| NDF, % of DM | 44.2 | 51.3 | 46.2 | 43.9 | 18.34 |
| Starch, % of DM | 6.9 | 6.8 | 16.6 | 13.5 | 27.7 |
| Ca, % of DM | 0.69 | 0.75 | 0.95 | 1.59 | 0.78 |
| P, % of DM | 0.34 | 0.28 | 0.35 | 0.41 | 0.39 |
| Mg, % of DM | 0.44 | 0.39 | 0.41 | 0.50 | 0.31 |
| K, % of DM | 2.12 | 1.95 | 1.24 | 0.96 | 1.34 |
| Na, % of DM | 0.33 | 0.14 | 0.05 | 0.11 | 0.39 |
| Cl, % of DM | 0.28 | 0.28 | 0.20 | 0.47 | 0.53 |
| S, % of DM | 0.14 | — | 0.24 | 0.45 | 0.24 |
| DCAD, mEq/kg | 15.02 | 13.65 | 5.33 | 6.16 | 15.8 |
| Zn, mg/kg | 37.7 | — | 82.2 | 106.2 | 75.7 |
| Cu, mg/kg | 7.85 | — | 18.7 | 24.1 | 17.2 |
| Mn, mg/kg | 26.26 | 0.39 | 61.3 | 79.1 | 56.4 |
| Se, mg/kg | 0.71 | 0.61 | 0.57 | 0.70 | 0.32 |
| Co, mg/kg | 0.43 | — | 1.05 | 1.35 | 0.9 |
| I, mg/kg | 0.43 | — | 1.05 | 1.35 | 0.9 |
| Vitamin A, kIU/kg | 15.56 | 9.22 | 15.56 | 17.22 | 9.52 |
| Vitamin D, kIU/kg | 2.20 | 1.79 | 2.73 | 4.41 | 1.68 |
| Vitamin E, kIU/kg | 192.0 | 162.3 | 167.1 | 158.7 | 39.68 |
| ME, Mcal/kg | 2.47 | 2.20 | 2.49 | 2.84 | 3.06 |
| $NE_L$, Mcal/kg of DM | 1.43 | 1.28 | 1.52 | 1.59 | 1.81 |
| Monensin, mg/d | — | — | 273.1 | 336.0 | 379.9 |

lactation had higher pro-oxidant status during the dry period and early lactation compared with healthy cows. Therefore, the aim of our study was to compare the expression of markers indicative of oxidant status and inflammation from the time of dry off to early lactation between cows that developed hoof lesions with those that remained healthy throughout the first several months of lactation.

The protocols used in our study were approved by the Michigan State University Institutional Animal Care and Use Committee and cows were enrolled with owner consent. This prospective study was conducted on a large commercial dairy farm associated with the Michigan State University Training Center for Dairy Professionals (Elsie, MI) from October 2014 to April 2015. This farm has an average of 3,300 lactating cows with a rolling herd average milk production of 12,250 kg/cow. Cows were housed in freestall barns, with cubicles bedded with sand, and grouped according to lactation number, DIM, and milk yield. Cows were milked 3 times daily in a double 40-stall or double 30-stall herringbone milking parlor. Feed alleys and walkways to and from the milking parlor had grooved concrete flooring. Alleys were cleaned with scrapers 3 times daily when cows were away for milking. Footbaths consisted of a 1% copper sulfate solution applied for 3 consecutive milkings, once a week for lactating, dry cows, and heifers, and twice a week in the cow and heifer close-up pens. All cows were fed a TMR (Table 1) delivered twice daily. Lactating cows were dried off approximately 60 d before the expected calving date. For this study, 30 pregnant Holstein cows (10 heifers, 10 cows entering their second lactation, and 10 cows entering their third or greater lactation) were randomly selected according to proximity in their expected calving date. Cows were followed from dry off until 120 d after calving.

On the farm, cow hooves were trimmed routinely at 120 to 150 DIM, at dry off (**DO**), and when showing signs of abnormal gait by the same trained foot-trimmer that also classified the lesions according to the modified ABC system of hoof lesion scoring (Burgi and Cook, 2006). Data on lesion location or severity also were recorded (data not shown). All claws of the animals enrolled in the study were examined by the foot trimmer at DO and 120 DIM. Only cows without claw lesions at enrolment (DO) were included in the study. Two members of the farm personnel, trained on mobility scoring, systematically monitored the cows weekly during the trial after TMR delivery and while the cows came out of the milking parlor. Lame cows were reported to the herd manager, who assessed the cow and presented it to the foot trimmer within a fortnight if the mobility