PRODAIRY
Education & Applied Research

The Manager

NOVEMBER 2022

Innovative applications of Cornell dairy research make real-world impact

This issue of *The Manager* is sponsored by:

Papillon
Feed Efficiently

The Manager

NOVEMBER 2022

FOCUS: CORNELL RESEARCH

INSIDE

Cover photo: Professor Joe McFadden advises graduate student Ananda Fontoura on milking cows. Photo credit: Justin James Muir

JULIE BERRY
Communications Manager
Cornell CALS PRO-DAIRY
jrb7@cornell.edu

DR. TOM OVERTON
Director
Cornell CALS PRO-DAIRY
tro2@cornell.edu

Photo credit: Amy Fox.

Jason Oliver joins Dairy Environmental Systems program at PRO-DAIRY

Jason Oliver, PhD, joins the PRO-DAIRY team as Senior Extension Associate of the Dairy Environmental Systems program.

Oliver is from the Finger Lakes region of New York and has hands-on knowledge of regional farming operations and practices. Recognizing the importance of farms to our rural communities, state, nation, and One Health (the unified health of humans, animals, plants and environment), he has dedicated his research and extension efforts to supporting the environmental stewardship of farming systems.
His research interests include the development of practical biotechnologies for the treatment of emissions, effluents and greenhouse gases from livestock facilities. He has conducted extensive on-farm, applied research and worked collaboratively with industry stakeholders to address emerging issues and regulatory considerations including water quality, odor, antimicrobial resistance, and climate change resiliency. Oliver is also a dedicated educator with diverse instructional experiences that include teaching at several land-grant institutions, extension work in the Midwest and New York, and four years developing and teaching an agricultural education program at a rural high school.

A paper co-authored by Oliver was recently recognized by the *Journal of Dairy Science* as being among the most highly cited and recently published (2019-present). The paper "Invited review: Fate of antibiotic residues, antibiotic-resistant bacteria, and antibiotic resistance genes in US dairy manure management systems" was authored by Oliver, Curt Gooch, Stephanie Lansing, Jenna Schueler, Jerod Hurst, Lauren Sassoubre, Emily Crossette, and Diana Aga, and appeared in the 2020 issue of the journal, 103:1051-1071.

Oliver has a BS in Environmental Biology from SUNY-ESF, MS in Ecology & Environmental Science from University of Maine, and PhD in Biosystems Science, Engineering & Management from the University of Minnesota.

What can milk constituents tell us about cow calcium status?

Jackson Seminara, Dave Barbano, and Jessica McArt

Photo credit: Jason Koski. Cornell teaching dairy barn.

Dairy cows respond to the challenges of the transition period in ways that are both dynamic and cow specific. This is especially true for the challenge of maintaining calcium balance immediately following calving. With the onset of lactation, cows begin secreting copious amounts of calcium in their milk, to the extent that their dietary intake cannot compensate for the loss of this essential mineral. Cows must coordinate a response to this challenge to maintain calcium balance, and those that fail to do so often develop milk fever, or clinical hypocalcemia. While this is certainly an important disease, prepartum diet management, and well-established treatment protocols minimize the impact that milk fever has on cows and herds. For cows that do not develop milk fever, individual dynamic responses to the early lactation calcium challenge are varied. These individual responses can be identified by measuring blood calcium at one and four days in milk (DIM), such that the dynamics of calcium at and between these timepoints can classify individual cows into one of four "calcium dynamic groups." Each group is associated with different health and production outcomes that, for the sake of this article, we consider: **worst**, at risk for negative health outcomes and producing the least milk; **bad**, at risk for negative health outcomes but producing decent to appreciable amounts of milk; **good**, consistently healthy and producing average amounts of milk; and **excellent**, consistently healthy and producing exceptional amounts of milk.

Because of these different outcomes, it is useful to classify cows into their respective calcium dynamic groups on farms. This way, dairy producers can identify cows that might be at a greater risk of disease or cows that might become high milk producers, and give each of these cow groups special treatment. Unfortunately, in the absence of an economical on-farm test for blood calcium, this remains a management impossibility. Without the ability to differentiate between these groups of cows, farmers must be content knowing that significant numbers of their cows are experiencing an invisible condition that predisposes them to disease and low milk production.

But what if it was possible to identify cows with different calcium dynamics without measuring blood calcium?

Milk analysis using Fourier-transform infrared spectroscopy, the technique used during routine DHI tests, has been used in the past to identify cows at risk of other negative health events, and for this reason we thought it might be possible to use these methods to discriminate between our calcium dynamic groups. So, we conducted a study to find out.

Our study was carried out on a freestall dairy in Cayuga County, NY, milking 4,500 cows thrice daily on a 100-cow rotary parlor. These cows were all fed a negative dietary cation anion difference diet prepartum. We sampled the blood of 343 multiparous Holsteins at one and four DIM to determine blood calcium concentration and milk from three to ten DIM for analysis of constituents. Using blood calcium concentrations, we classified cows into their calcium dynamic groups and then looked at their milk constituents.

We found that the bad and worst calcium groups did not differ from each other with respect to any of the measured constituents, on any of the sample days. The worst group had consistently lower protein percentage in their milk than the good cows, and lower lactose percentages at early timepoints. The excellent group had higher lactose than the worst group at the beginning of the sample period and higher products of protein degradation (milk urea nitrogen) toward 10 DIM. De novo fatty acids (sum of C4 thru C14), fatty acids found in milk, synthesized in the mammary gland, and thought to be an indicator of positive ruminal health, was higher in the milk of good cows than in the milk of any other group for the majority of the sample period. Preformed fatty acids (C18 and greater), another group of milk fatty acids originating in the diet or from mobilized body reserves and thought to be an indicator of energy deficit, was higher in the milk of excellent cows than the milk of good cows, which was surprising,

Continued on page 4

CORNELL RESEARCH

***What can milk constituents tell us about cow calcium status?**, cont'd from page 3*

but likely an indication of their immense need for energy due to high milk yield. The differences in milk ketone bodies were largely unremarkable. Over the sample period excellent cows produced more milk than the worst cows on all of the days, more milk than the good cows on half of the days, and more milk than the bad group on a quarter of the days. Overall, milk constituents of the good group were consistently different from those of the excellent, bad and worst groups. Even though the excellent group shared some constituent patterns in common with the bad and worst groups, milk production of the excellent group clearly differentiated this group from the worst group.

While these findings are certainly promising, we cannot generalize to every group of dairy cows. This study was conducted on a single dairy in upstate New York; thus, the findings may be the product of unique population, management scheme, or environment. Additionally, we cannot infer any causal relationships between calcium dynamics observed and the associated constituent levels.

Despite these limitations, this study does indicate that there may be relevant differences between the constituent profiles for cows of differing calcium dynamics. Therefore, this work adds evidence that Fourier-transform infrared spectroscopy can be used as a tool to capture nuances in calcium dynamics on commercial dairies and thus influence cow management and health. Though other studies must be performed to determine if this method can be widely applicable, our study indicates that these methods hold potential and further research is warranted.

Jackson Seminara (jas927@cornell.edu) is a DVM/PhD student with the Department of Population Medicine and Diagnostic Sciences, Cornell University. **Dave Barbano** (dmb37@cornell.edu) is a Professor with the Department of Food Science, Cornell University, College of Agriculture and Life Sciences. **Jessica McArt** (jmcart@cornell.edu) is an Associate Professor, Ambulatory and Production Medicine Clinic, Cornell University, College of Veterinary Medicine.

Should you delay oral calcium bolus supplementation for fresh cows?

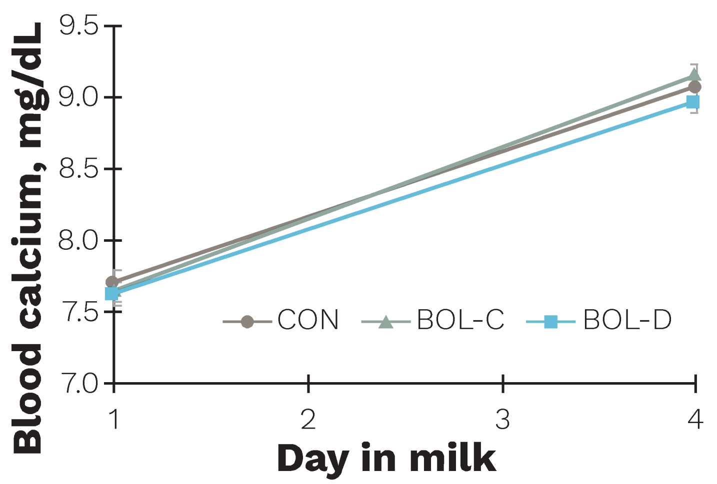
Claira Seely and Jessica McArt

Subclinical hypocalcemia (SCH) is an invisible threat to both the dairy cow and producer. As nearly 45 percent of multiparous cows experience SCH during the early lactation period, producers can implement dietary strategies such as feeding negative dietary cation anion difference (DCAD) rations in the late dry period or administering prophylactic calcium treatments to fresh cows to minimize the risk of SCH. Although negative DCAD rations have successfully reduced the incidence of clinical milk fever, many cows still experience SCH after calving. For this reason, it is commonplace to administer supplemental calcium at calving to help maintain blood calcium concentrations. Despite the widespread use of oral calcium boluses, their impacts on production and health are variable. Large-scale field studies show that when high-producing or lame cows are given calcium boluses after calving, they produce more milk and experience less disease than cows of similar status not given a bolus. However, low-producing cows and primiparous cows are negatively impacted by calcium bolus administration.

Adding to the complexity of managing SCH are the dynamics of blood calcium during the first several days of lactation. Generally, blood calcium drops during the first 24 hours after calving as the cow adjusts to the demands of milk production, and thus historically this has been deemed the optimal time to diagnose SCH.

FIGURE 1

Blood calcium concentrations from 919 multiparous Holstein cows randomly assigned to one of three treatments at calving: 1) no supplemental calcium at or around parturition (CON, n=308), 2) an oral calcium bolus containing 43 grams of calcium at calving and one days in milk (DIM) (BOL-C, n=312), or 3) an oral calcium bolus containing 43 grams of calcium at two and three DIM (BOL-D, n=299).



However, we have recently discovered that cows with low blood calcium at four days in milk (DIM) are more likely to experience additional diseases, produce less milk, and consume less feed than cows who only experience a drop in calcium at one DIM. With this in mind, we have asked ourselves if perhaps delaying oral calcium bolus administration to two and three DIM, as opposed to the commonly used zero and one DIM treatment strategy, would benefit cows with reduced blood at four DIM, and result in improved blood calcium, increased milk production, and less disease?

To answer this question, we collected data on 919 multiparous Holstein cows from four farms in northeastern and central NY from June through September 2021. At calving, cows were randomly assigned to one of three treatments:

1 no supplemental calcium at or around parturition (CON, n = 308)

2 an oral calcium bolus containing 43 grams of calcium at calving and one DIM (BOL-C, n = 312)

3 an oral calcium bolus containing 43 grams of calcium at two and three DIM (BOL-D, n = 299)

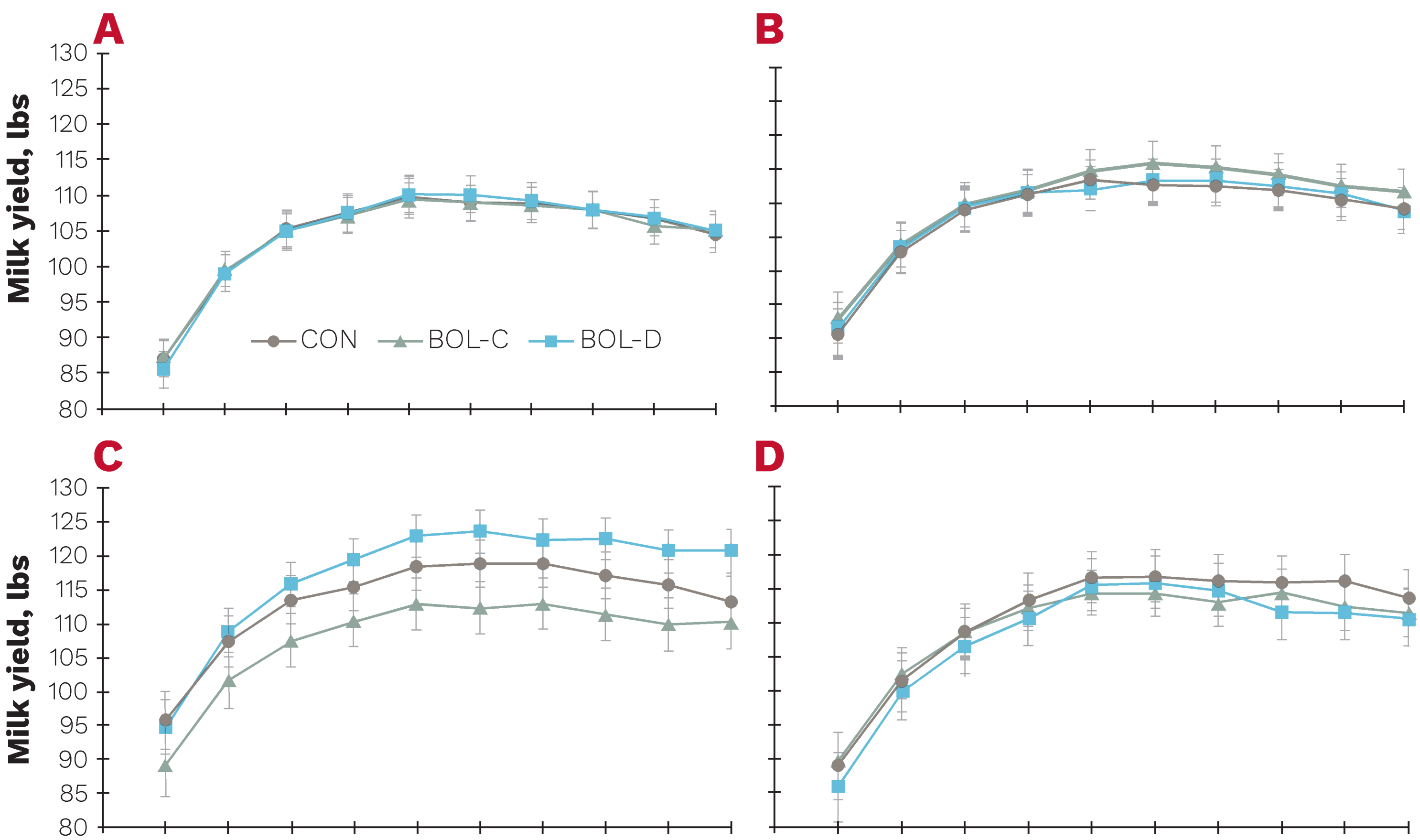
We measured blood Ca at one and four DIM. Milk production was recorded for the first 10 weeks of lactation and health and culling events were recorded for the first 30 DIM.

Blood calcium concentrations were similar between treatment groups (**Figure 1**), and both the CON and BOL-C cows had average blood calcium concentrations of 8.4 mg/dL. The BOL-D cows had an average Ca concentration of 8.3 mg/dL. Milk production was not impacted by bolus administration. The CON cows produced an average of 107.8 lbs/day while the BOL-C cows produced 106.5 lbs/day, and the BOL-D cows produced 108.7 lbs/day. Interestingly, when we looked at differences in milk production between different parity groups (parity two, three, and four or more), we found that cows entering their third lactation having received the delayed bolus treatment produced 4.4 lbs/day more milk than their counterparts in the CON or BOL-C groups (**Figure 2**). In addition, we saw no difference between treatment groups in the incidence of

Continued on page 6

FIGURE 2

Milk production from multiparous Holstein cows randomly assigned to one of three treatments at calving: 1) no supplemental calcium at or around parturition (CON, n =308), 2) an oral calcium bolus containing 43 grams of calcium at calving and one days in milk (DIM) (BOL-C, n = 312), or 3) an oral calcium bolus containing 43 grams of calcium at two and three DIM (BOL-D, n = 299). Panel A represents all cows, panel B represents parity two cows, panel C represents parity three cows, and panel D represents parity four or more cows.



Should you delay oral calcium bolus supplementation for fresh cows?, *cont'd from page 5*

metritis, displaced abomasum, or herd removals during the first 30 DIM.

Despite our thought that delaying oral calcium supplementation to two and three DIM, as opposed to traditional administration at zero and one DIM, would improve blood calcium and result in increased milk production, we found little evidence to support this. Delayed bolus administration did result in higher production in third-lactation cows, but unfortunately this improvement did not carry over to the fourth-and-greater-lactation cows. Older cows may be experiencing a calcium deficit so large due to their higher milk production, that no matter the timing of supplementation, oral calcium boluses might not provide enough additional calcium to improve blood calcium and production.

The results of our study support previous reports suggesting that oral calcium supplementation benefits a subgroup of cows. Taking this into consideration, administering calcium boluses to high-producing, lame, or older cows may be financially advantageous for producers as blanket treating every cow is costly and the financial gains from improved milk production are only realized in select groups.

Claira Seely (crs336@cornell.edu) is a PhD candidate with the Department of Population Medicine and Diagnostic Sciences, Cornell University, College of Veterinary Medicine. **Jessica McArt** (jmcart@cornell.edu) is an Associate Professor with Ambulatory and Production Medicine Clinic, Cornell University, College of Veterinary Medicine.

Feeding calcium and dietary cation-anion difference in the close-up period: How much is enough?

Geneva Graef and Thomas Overton

The transition period is a tumultuous period for a cow and those of us trying to manage them. During this time cows are particularly prone to mineral and metabolic imbalances that can leave them more susceptible to diseases as well as lower milk production and poorer reproductive performance. Of particular concern is the issue of calcium (Ca). At and around calving calcium is in high demand for fetal development, birth, and lactation, while leaving enough for a cow's normal physiologic needs. Fortunately we can prepare the cow to improve her chance of success through this transition period by managing the dietary cation-anion difference (DCAD) in the close-period to improve her calcium metabolism around and after the time of calving. This allows her to more efficiently use calcium stores rapidly when she needs it most. There are also some strategies to consider when managing dietary Ca. When it comes to either Ca or DCAD feeding, the question always returns to, if we choose one or both strategies, how much is enough?

This can be a difficult question to answer, but recent work at Cornell University's Ruminant Center sought to do exactly that. The objective of the study was to determine the effects of two levels of DCAD and two levels of dietary Ca on cow mineral status and production through the transition period. It was hypothesized that cows fed more DCAD and dietary Ca would have improved mineral status and milk production. The two levels of DCAD fed in the close-up period, 21 days prior to expected calving, were categorized as either "FULL" or "PARTIAL" and determined by urine pH. Cows fed "FULL" DCAD diets targeted a urine pH of 5.5 to 6.0 and those fed "PARTIAL" DCAD targeted a urine pH of 6.5 to 7.0. The two levels of Ca fed in that period were either 1.5 percent or 0.7 percent of DM.

Overall, four diets were tested:

1. 1.5 percent Ca FULL
2. 1.5 percent PARTIAL
3. 0.7 percent FULL
4. 0.7 percent PARTIAL

Sample collection began at enrollment (39 to 32 days before expected calving) through study exit (63 DIM) and included feed intake, and blood and urine samples for mineral analysis, colostrum, and milk yield.

CLOSE-UP RESULTS

Average urine pH for cows fed FULL and PARTIAL were well within their targets (FULL = 5.64 vs. PART = 6.71 ± 0.10). Dry matter intake (DMI) was lower in cows fed FULL DCAD diets than those fed PARTIAL (28.99 vs 29.32 ± 0.5 lbs/d). Drops in DMI during the close-up period, such as those observed in this study, is generally expected to be greater in cows fed acidified diets. This study included two Ca measurements in the blood, ionized and total (iCa and tCa, respectively). Ionized calcium is referred to as the available and "active" Ca, which is considered free for use by the cow. Alternatively, tCa refers to the total circulating Ca in the blood in both bound and free form. Given that they measure different components, while numerically different, some relative association between the two measures are often observed. Interestingly in this study, prepartum tCa was reduced in those cows fed FULL, though that finding was not replicated in the prepartum iCa measures. Urine Ca excretion rate was increased in cows fed FULL and cows fed 0.7 percent Ca in the close-up (there was no observed interaction of Ca X DCAD).

POSTPARTUM RESULTS

Cows fed 1.5 percent Ca prepartum tended to eat more in the postpartum period than cows fed 0.7 percent Ca (48.1 vs. 46.1 ± 0.8 lbs/d; P = 0.07), respectively. Conversely, previous studies have reported increased prepartum DMI to increased calcium diets. Dietary Ca significantly impacted blood iCa and tCa so that cows fed 1.5 percent Ca had decreased concentrations of both compared to cows fed 0.7 percent Ca during the first two DIM. These blood parameters are particularly interesting when evaluating the colostrum and milk results. Colostrum weight tended to be about 7.6 lbs greater in cows fed the 1.5 percent Ca FULL diet prepartum compared to the other treatment groups (**Figure 1**) without significant differences in quality (measured by IgG); however, this was an unexpected outcome and warrants more research. Additionally of note, recorded milk yields in weeks one through three and one through nine tended to be greater in cows fed 1.5 percent Ca FULL opposed to the other three diets (**Figure 2**).

MAIN TAKEAWAYS

While there were some decreases in both iCa and tCa postpartum in cows fed 1.5 percent Ca diets, milk yield tended to increase in cows fed 1.5 percent Ca FULL. Colostrum yield increased for cows fed 1.5 percent Ca FULL compared to other treatments.

Overall, it is recommended that a high-Ca diet fed in conjunction with a well-managed DCAD strategy that targets a urine pH range of 5.5-6.0 is optimal in transition cows.

FIGURE 1
Colostrum yield (lbs) and standard error of means reported by treatment

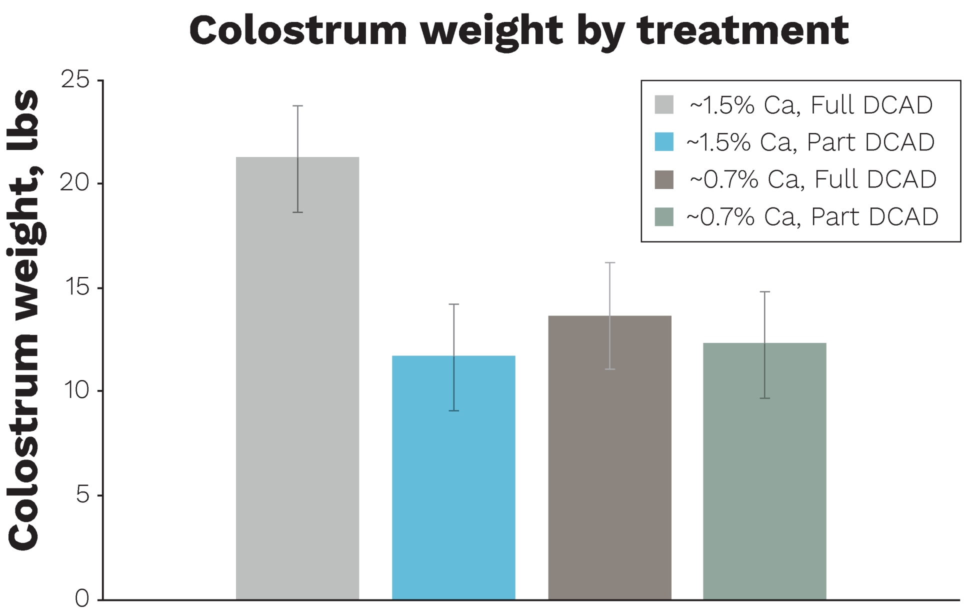
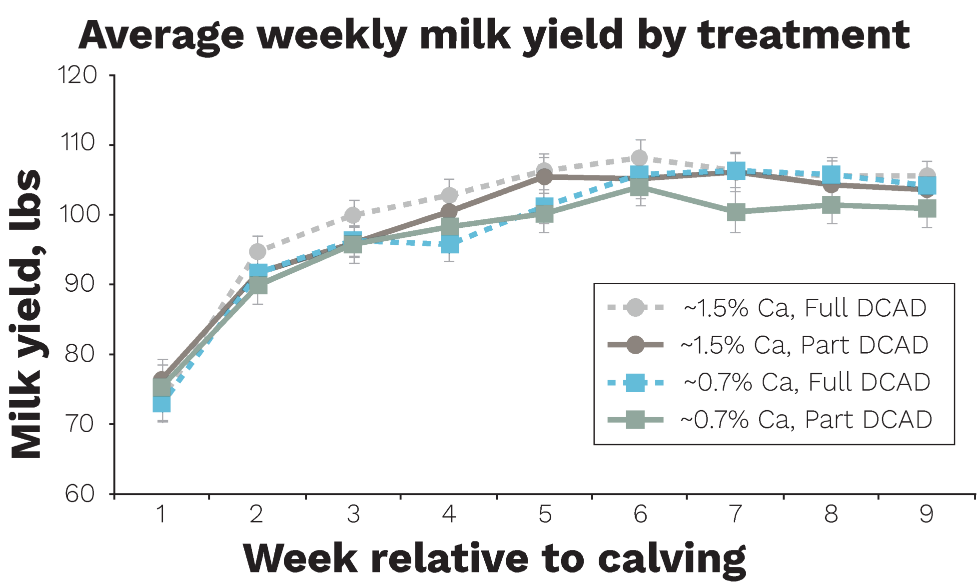


FIGURE 2
Milk yield (lbs) and standard error of means for weeks one through nine reported by treatment



Geneva Graef (gmg228@cornell.edu) is a PhD student in Dr. Overton's laboratory at Cornell University. **Thomas Overton** (tro2@cornell.edu) is a Professor and Animal Science Department Chair at Cornell University.

CORNELL RESEARCH

What is the impact of subclinical hypocalcemia diagnosed at four days in milk on reproductive outcomes?

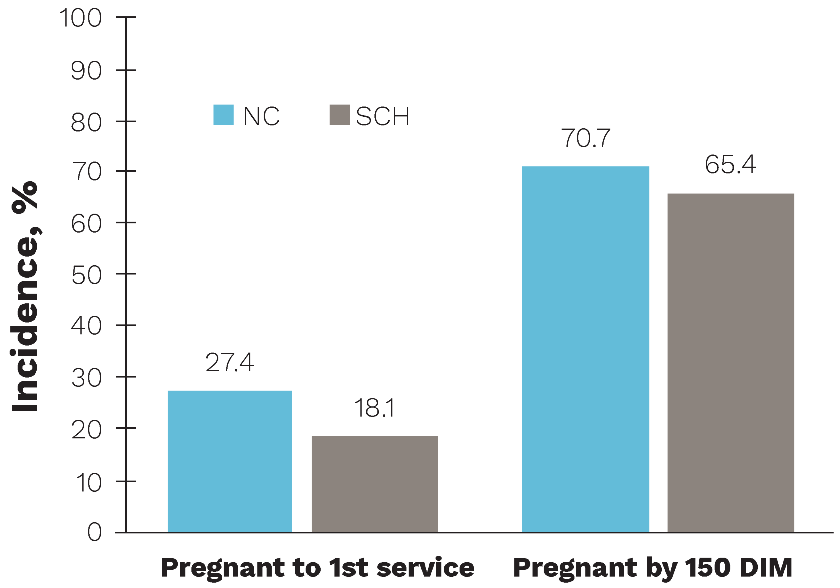
Claira Seely and Jessica McArt

While often undiagnosed due to the absence of clinical signs and the price tag associated with collecting blood samples required for diagnosis, subclinical hypocalcemia (SCH) affects nearly 45 percent of multiparous dairy cows. Traditionally, one day in milk (DIM) was thought to be the opportune time to diagnose SCH; however we have recently discovered that decreases in blood calcium occurring at four DIM are more closely associated with lower milk production, reduced feed intake, and an increased risk for additional disease development. Although we understand the negative effects of SCH, particularly episodes occurring at four DIM, on future health and milk production, its effect on reproductive success is largely unknown. Results from past reports are inconsistent, likely due to the range of days in which SCH was diagnosed, as well as the variation in calcium cutpoints used for diagnosis. As successful and efficient reproduction is critical for the success of dairy operations, we were interested in exploring the association of SCH occurring at four DIM with the odds of pregnancy to first service and the time from calving to pregnancy.

We collected data from four commercial dairy farms in northeastern (farms A and B) and central NY (farms C and D) from September 1 to November 1, 2020 and July 15 to September 25, 2021 (farms C and D) and June 2 to July 10, 2021 (farms A and B). A total of 697 multiparous Holstein cows were enrolled in our study (farm A, n = 65; farm B, n = 30; farm C, n = 87; farm D, n = 515). Each farm was visited daily, and blood samples were collected from all cows at four DIM and analyzed for total calcium. Cows were then classified as normocalcemic (n = 515) with blood calcium greater than 8.8 mg/dL at four DIM or as SCH (n = 182) with blood calcium 8.8 mg/dL or less at four DIM.

FIGURE 1

Percent of cows pregnant to first service and pregnant by 150 DIM from 697 multiparous Holstein cows classified as normocalcemic (n = 515) if blood calcium was greater than 8.8 mg/dL at four DIM or SCH (n = 182) if calcium was 8.8. mg/dL or less at four DIM.



For reproductive management, farms A and B utilized an Ovsynch protocol with a voluntary waiting period of 74 days and average time of first artificial insemination of 78 DIM. Farms C and D utilized activity monitors to detect heat, and cows not detected in heat subsequently underwent an Ovsynch protocol. The average voluntary waiting period for farms C and D were 55 and 47 days, respectively, and the average time of first artificial insemination was 67 and 62 DIM.

The average blood calcium concentration for all cows in our study at four DIM was 9.2 ± 0.7 mg/dL. Of the 697 cows enrolled in our study, 74 percent were classified as normocalcemic and had a mean calcium of 9.6 ± 0.4 mg/dL, and 26 percent were classified as SCH and had a mean calcium of 8.4 ± 0.4 mg/dL. 18 percent of SCH cows were diagnosed pregnant to first service while 27.4 percent of the normocalcemic cows were diagnosed pregnant to first service (**Figure 1**). Cows with SCH at four DIM had 25 percent reduced odds of being diagnosed as pregnant to first service compared to normocalcemic cows. We also found that SCH cows were 18 percent less likely to become pregnant by 150 DIM compared to normocalcemic cows (**Figure 1**). The median time to pregnancy for SCH cows was 119 ± 16 days, and 65.4 percent of SCH cows were diagnosed pregnant by 150 DIM. The median time to pregnancy for normocalcemic cows was 103 ± 11 d, and 70.7 percent of normocalcemic cows were diagnosed pregnant by 150 DIM (**Figure 2**).

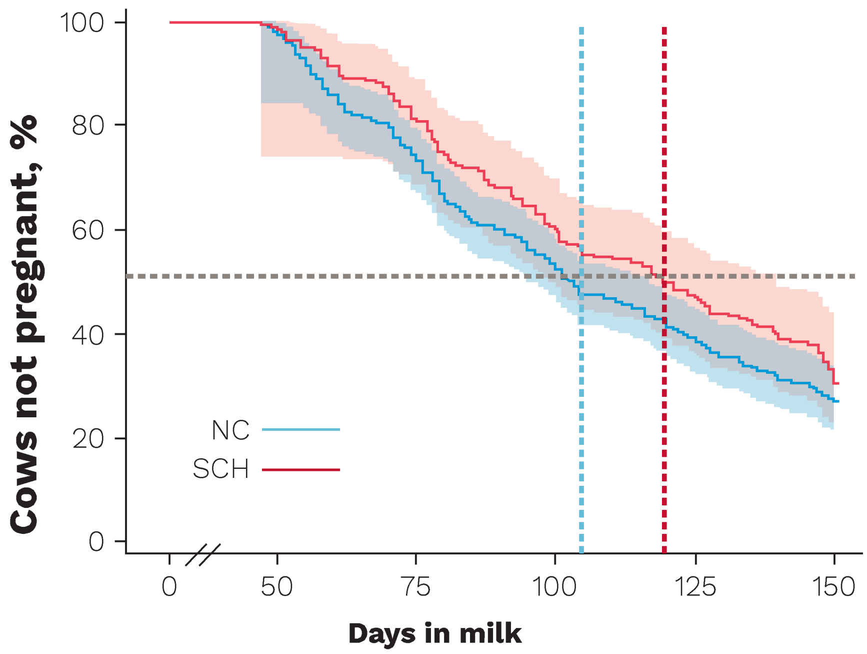
More than being the major mineral in milk, calcium is essential for many cellular actions, and of particular importance to the transition cow is the role of calcium in immune cell function. Subclinical hypocalcemia can compromise immune function, and cows with SCH are at increased risk for developing uterine diseases. As uterine diseases are associated with decreased reproductive success, this might help explain why we saw a reduction in reproductive outcomes in SCH cows.

As a cow begins lactation, her energetic and nutritional demands dramatically increase, and she is not able to consume enough feed to meet the increased demand. Cows with SCH at four DIM also consume less feed than normocalcemic cows and are likely experiencing greater energy deficit than normocalcemic cows. Reduced intake not only puts cows at increased risk for additional metabolic diseases but might also have long-lasting impact on ovarian follicles developing at this time, resulting in reduced capacity to become pregnant at a future date.

The results of our study suggest that SCH occurring at four DIM is associated with decreased reproductive success in multiparous cows. Previous reports have also shown that cows with SCH at four DIM produce less milk, consume less feed, and are at increased risk for additional disease development compared to cows that are normocalcemic at that time. Taken together, reductions in blood calcium occurring at four DIM might represent a metabolic disruption to the cow, effecting both her future productive and reproductive potential.

FIGURE 2

Percent of cows not pregnant by 150 DIM from 697 multiparous Holstein cows classified as normocalcemic (n = 515) if blood calcium was greater than 8.8 mg/dL at four DIM or SCH (n = 182) if calcium was 8.8. mg/dL or greater at four DIM. The median time to pregnancy for SCH cows was 119 ± 16 d (dashed red line) and 103 ± 11 d for the NC cows (dashed blue line). The black dashed line indicates when 50 percent of cows became pregnant, and the shaded regions represent 95 percent confidence intervals.



Claira Seely (crs336@cornell.edu) is a PhD candidate with the Department of Population Medicine and Diagnostic Sciences, Cornell University, College of Veterinary Medicine. **Jessica McArt** (jmcart@cornell.edu) is an Associate Professor with Ambulatory and Production Medicine Clinic, Cornell University, College of Veterinary Medicine.

Methionine and omega-3 fatty acid feeding for transition cows

Joseph McFadden and Tanya France

The transition period, characterized as the three weeks pre- through three weeks postpartum, is a critical life event for the dairy cow. Around calving, cows involuntarily reduce feed intake; however nutrient demands increase to support fetal growth and milk production. A systemic inflammatory response also occurs at calving which can increase the risk for developing metabolic diseases. For example, the development of fatty liver is a common condition for the transition cow. Milk loss from health incidences particularly in the first 21 days in milk are major contributing factors for economic loss in the dairy industry. Because of these challenges, nutritional strategies are implemented with the goals of improving health and

Continued on page 10

CORNELL RESEARCH

Methionine and omega-3 fatty acid feeding for transition cows, *cont'd from page 9*

milk production in the transition cow. Methionine (Met) and omega-3 fatty acid (n3 FA) feeding have received attention due to their health benefits.

Methionine is an essential amino acid and the first limiting amino acid for milk synthesis in cows. The industry utilizes rumen-protection (RP) technologies to enhance post-ruminal supply of Met to the cow. Enhanced Met status improves milk and milk protein synthesis, reduces oxidative stress, and enhances liver function in cows. Past recommendations for feeding Met have been to feed RP-Met at 0.08 percent of ration DM. However, considerable progress at Cornell University has been made to formulate diets based on individual amino acid requirements in lactating cattle on the basis of metabolizable energy supply.

Fatty acids (FA) are fed to dairy cows to increase energy density of the diet. Omega-3 fatty acids are fed to cattle as calcium salts to protect against ruminal degradation and increase post-ruminal delivery for intestinal absorption. Eicosapentaenoic acid (EPA; C20:5) and docosahexaenoic acid (DHA; C22:6) are two very long chain n3 FAs commonly found in fish oil. EPA and DHA can activate the anti-inflammatory response as they are precursors to resolvins and protectins, two important inflammation-resolving mediators. EPA and DHA can simultaneously reduce the inflammatory response by inhibiting proinflammatory cytokines. There are, however, no established feeding rates for n3 FAs in dairy cattle.

But... what is the connection between Met and n3 FAs? Met is considered a methyl donor and is a precursor to the universal methyl donor S-adenosylmethionine (commonly known as SAM) which donates methyl groups via the phosphatidylethanolamine-N-methyltransferase (PEMT) pathway to form phosphatidylcholine (PC). There is evidence in non-ruminants that the PEMT pathway prefers very long chain FA such as DHA. The production of PC is critical for the formation of very-low-density lipoproteins which aid in reducing fatty liver while partitioning fats to the mammary gland to incorporate into milk. We believe that this pathway is downregulated during the transition period due to insufficient dietary supply of Met and n3 FAs. Because little is known about the effects of co-supplementation of these nutrients, we conducted a study to investigate the effects of dietary Met and calcium salts enriched in n3 FAs on milk production and liver function in transition cows.

In a randomized study design at Cornell University, 79 multiparous Holstein cows were assigned to one of four dietary treatments:

1 Met unsupplemented (-Met) with calcium salts of palm oil not enriched in n3FA (-n3FA; 0 percent n3FA; EnerGII; Virtus Nutrition, USA)

2 Met supplemented (+Met; Smartamine M; Adisseo Inc., France) with -n3FA

3 -Met with calcium salts enriched in n3FA (+n3FA; 3.2 percent EPA and DHA; EnerG-3; Virtus Nutrition, USA)

4 +Met with +n3FA from week -three prior to expected calving through week four of lactation

Cows were fed corn silage-based TMR, both pre- and postpartum, which were formulated to provide Met at ≤ 0.96 or ≥ 1.13 g Met / Mcal metabolizable energy for -Met and +Met, respectively. Calcium salts were fed at 1.5 percent FA (percent of ration DM) for all treatments. Liver biopsies were performed at -1, +1, and +3 weeks relative to parturition. Blood samples were collected weekly. Cows were milked thrice daily and milk samples were collected twice a week.

We first discovered that postpartum

FIGURE 1

Least square means of energy-corrected milk yields of Holstein cows from weeks one through four of lactation

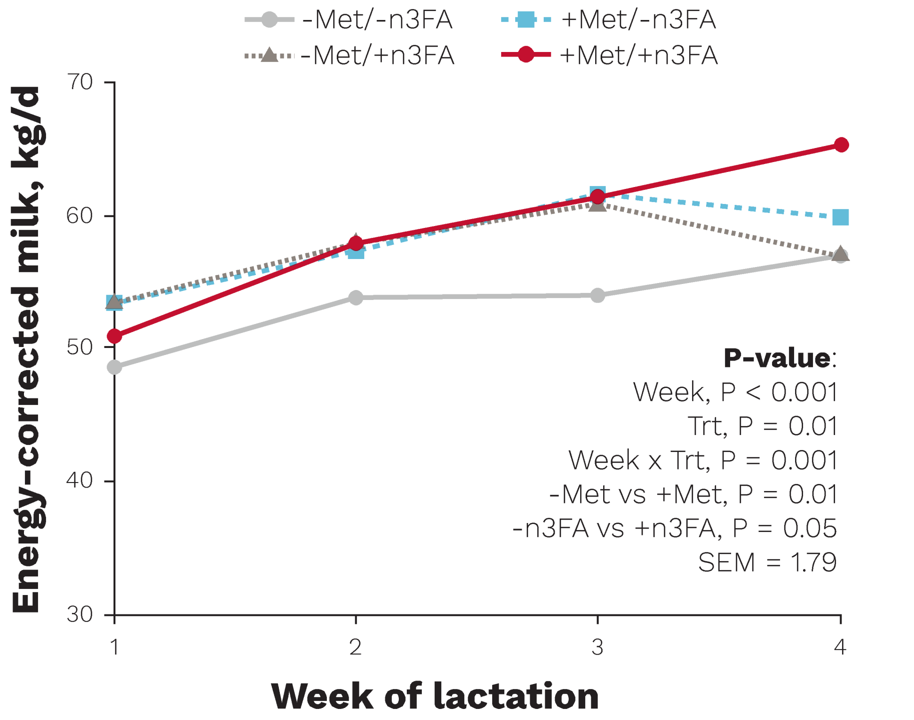
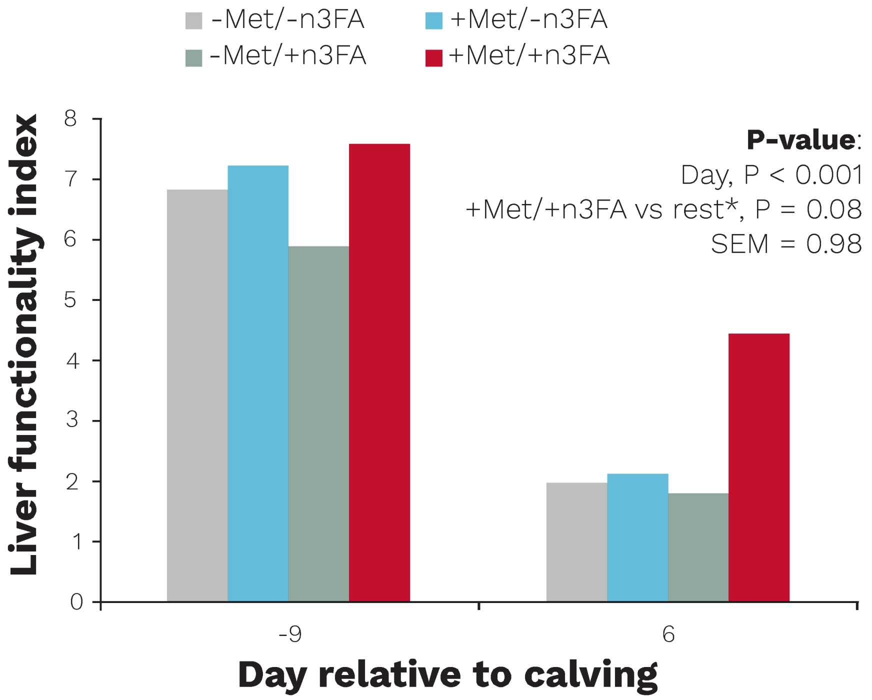


FIGURE 2

Liver functionality index values of Holstein cows at day -9 and +6 relative to calving
*Rest = +Met/-n3FA and -Met/+n3FA



dry matter intake increased in both +Met and +n3FA diets compared to -Met/-n3FA. And while milk yields were not different between treatments, we found that energy-corrected milk yields were greater in +Met and +n3FA diets compared to -Met and -n3FA (**Figure 1**). Interestingly, energy-corrected milk yields had an overall increase of 5.53 kg/d in the co-supplementation (+Met/+n3FA) diet compared to -Met/-n3FA.

To understand the effects of co-supplementation on liver function and to provide a potential explanation as to why we observed greater energy-corrected milk yield in +Met/+n3FA, we first calculated liver functionality index values. This calculation utilizes concentrations of serum bilirubin, albumin, and total cholesterol, all of which are considered negative acute-phase proteins (APP) found in the liver. Negative APP concentrations will change relative to the onset and recovery of an inflammation occurrence. A higher liver functionality index value is indicative of a greater-functioning liver and the cow's ability to recover from inflammation (in this case due to the calving process). We found that the postpartum liver functionality index values tended to be greater in cows fed +Met/+n3FA diet (**Figure 2**). We wanted to determine if methyl donor metabolism is altered in the liver to further our idea that the co-supplementation feeding strategy would improve liver function. To do this, we measured liver SAM and S-adenosylhomocysteine (SAH) concentrations. SAM is converted to SAH via the PEMT pathway, such that measuring these metabolites can be used to indirectly determine the activity of the PEMT pathway. While SAM was not affected by treatment, liver SAH increased with +Met or +n3 FA's, indicative that both Met and n3 FA upregulate the PEMT pathway in transition cows.

Our study shows that feeding transition cows a diet adequate in Met and with calcium salts enriched in n3 FAs can enhance lactation performance by increasing energy-corrected milk yield over the first four weeks of lactation and improve liver function by altering liver methyl donor metabolism.

Joseph W. McFadden, (jwm@cornell.edu) is an Associate Professor of Dairy Cattle Biology and **Tanya France** (tlf54@cornell.edu) is a PhD candidate at Cornell University, Department of Animal Science.

Leaky gut and the warning signs of heat-stressed dairy cattle

Ananda Fontoura and Joseph McFadden

Since pre-industrial times, global surface temperatures have risen considerably and most of the warming occurred in the past 40 years. Reflective of this global trend, temperatures in the United States northeast region have also increased, and projections indicate additional warming that can reach up to 40.6°F by 2100, and estimate an increase in the intensity and frequency of extreme heat weather events, and a decrease in the intensity and frequency of cold extremes for North America. If these predictions come to fruition, higher occurrence of periods of extremely high temperatures will most likely affect both animal and human health, and will increase the incidence of

Continued on page 12

CORNELL RESEARCH

Leaky gut and the warning signs of heat-stressed dairy cattle, *cont'd from page 11*

heat-related illnesses. Due to this, heat stress will likely become more prevalent in the future. And indeed, the effects of climate change on production systems have often been highlighted as one of the main challenges currently faced by crop and animal-based systems. This is important to United States dairy systems because of the inherently increased heat production of high-producing dairy cows, which makes them more sensitive to warmer climates and heat fluctuations. Therefore, a better understanding of the mechanisms by which heat stress compromises the production of dairy products is important because it will allow us to develop heat stress alleviation therapies.

Exposure to high ambient temperature leads dairy cows to be heat-stressed, a consequence that comes from their inability to dissipate thermal energy from their body into the environment. To survive these periods of increased heat load, they undergo behavioral and physiological adaptive changes that allow survival. These changes include, but are not limited to, increased respiration rate, sweating, reduced feed intake, diminished physical activity, reduced productive (e.g., growth and lactation) and reproductive performance (e.g., pregnancy rates, and in-utero deleterious effects to the progeny). Current research in non-ruminants (e.g., rodents, pigs, and humans) indicates that heat-stressed mammals experience modifications in gastrointestinal health and barrier. As means of improving body cooling, animals shunt blood supply from the visceral organs, including the intestines, towards the skin surface. This weakens the protective barrier of intestinal cells and allows for bacteria and its products such as endotoxins to enter the blood circulation. This increased gastrointestinal permeability is commonly called "leaky gut" and is highlighted as one of the factors that can trigger the immune system and cause systemic inflammation. Thus, it is important to confirm if heat stress evolves with leaky gut in lactating dairy cows because the immune system relies on glucose availability to fight infections, which in turn, can further jeopardize milk production during heat stress.

Current heat abatement practices focus on providing shade, fans, sprinklers, and misters to enhance cow comfort and improve heat stress resilience in dairy cattle. These practices are common but only partially reduce the effects of heat stress by improving the means of internal heat dissipation. They also demand water and increase fossil fuel utilization to operate, which in the grand scheme of sustainability practices might also be a problem in the future. Because of this, current dairy science research is focused on identification of nutritional strategies to alleviate the effects of heat stress. There is a plethora of nutritional strategies using commercially available feed additives and in a broader sense, these supplements are aimed at improving inflammation, oxidative stress, and intestinal health of heat-stressed dairy cattle.

Dietary supplementation of organic acids (OA; e.g., citric and sorbic acids) and pure botanicals (PB; e.g., thymol and vanillin) represents a promising strategy to support and reduce antibiotic usage in livestock production systems. These compounds have unique antimicrobial, anti-inflammatory, antioxidant, and immunomodulatory properties, which when combined, have potential to improve gastrointestinal health by controlling pathogenic bacteria growth and enhancing intestinal barrier. Studies in poultry and swine indicate that supplementation of OA/PB improves intestinal barrier and decreases inflammation, which resulted in improved bodyweight gain and feed efficiency in those species. Our research team also evaluated OA/PB supplementation in heat-stressed weaned dairy calves and observed that supplementing OA/PB increased starter intake of heat-stressed calves and improved average daily gain when compared to the unsupplemented heat-stressed group. Upon completion of the trial, OA/PB supplemented calves had heavier bodyweights and hot carcass weight relative to unsupplemented calves.

At Cornell University, our team recently completed a trial where we evaluated the effects of heat stress and dietary OA/PB supplementation on gut permeability and milk production. We wanted to test the hypothesis that exposure to extreme heat would cause leaky gut and consequently decrease milk production and that OA/PB supplementation (25 percent citric acid, 16.7 percent sorbic acid, 1.7 percent thymol, 1.0 percent vanillin, and 55.6 percent triglyceride; AviPlus R®, VetAgro, Inc.; 75 mg/kg of live weight) would alleviate these outcomes. 46 multiparous pregnant and lactating Holstein cows were enrolled in the study.

Cows were randomly assigned to one of four groups for 14 days:

1 Thermoneutral conditions (TN-Con, n = 12; temperature-humidity index [THI] 68)

2 HS conditions (HS-Con, n = 12; diurnal THI 74 to 82)

3 TN conditions pair-fed to match HS-Con (TN-PF, n = 12)

4 HS fed OA/PB (HS-OAPB, n = 10)

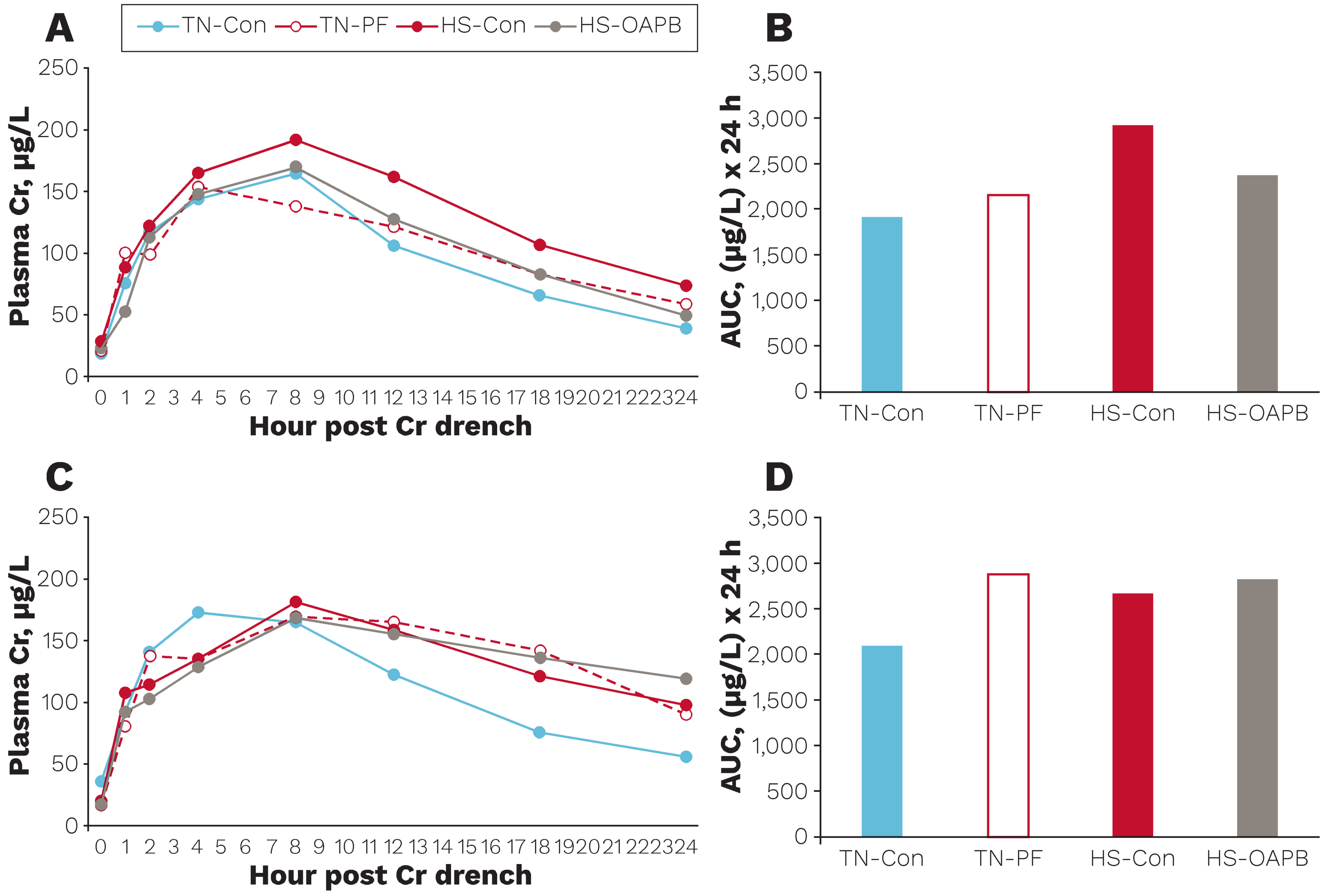
Cows were milked twice daily and fed a corn silage-based total mixed ration top-dressed without (triglyceride only) or with OA/PB. Acute and chronic changes in gastrointestinal permeability were evaluated using the paracellular permeability marker Chromium (Cr)-EDTA on days three and 13, respectively.

We observed that HS-Con cows had increased gut permeability starting after four hours post Cr drench and remained elevated until 24 hours (**Figure 1a**) on day three, relative to TN-Con cows. Importantly, this increased permeability seems to be independent of feed intake, as TN-PF cows had smaller Cr area-under-the-curve (AUC) when compared to HS-Con (**Figure 1b**). In addition, we also observed decreased permeability in cows that were supplemented with OA/PB, relative to HS-Con. On day 13, HS-Con cows had similar plasma Cr AUC relative to TN-PF and TN-Con (**Figure 1d**); however, TN-PF cows tended to have greater plasma Cr concentrations from 12 to 24 hours post bolus, relative to TN-Con (**Figure 1c**). In terms of productive performance, HS-Con had greater water intake, and lower yields of milk and milk lactose and protein, relative to TN-PF cows. HS-OAPB cows consumed more water and tended to consume more feed, relative to HS-Con. In addition, HS-OAPB also had greater energy-corrected milk yields relative to HS-Con cows, which could be explained by the greater milk protein yield of HS-OAPB cows. Overall, these results highlight important mechanisms that might account for milk production losses and health impairments caused by heat stress independent of reductions in feed intake. In addition, dietary OA/PB supplementation represents a means to partially restore milk production in dairy cattle experiencing heat stress, and thus can be incorporated into already existing feeding strategies to optimize production of heat-stressed cattle. ▮

Ananda Fontoura (abf63@cornell.edu) is a Postdoctoral Research Associate with the Department of Animal Science, Cornell University. **Joseph W. McFadden** (jwm43@cornell.edu) is an Associate Professor of Dairy Cattle Biology with the Department of Animal Science, Cornell University.

FIGURE 1

Effects of heat stress and dietary organic acid and pure botanical supplementation on gastrointestinal permeability measured by plasma Cr concentrations (A, C) and Cr AUC (B, D) after a Cr-EDTA drench challenge in pregnant multiparous and lactating Holstein cows. Figure A and B are relative to day three whereas Figure C and D are relative to day 13 of heat stress conditioning.



CORNELL RESEARCH

Implementing selective dry cow therapy on farms across New York state

Tracy Potter, Amber Forrestal, Michael Capel, and Daryl Nydam

Selective dry cow therapy (SDCT) is an effective way to use antimicrobials judiciously on dairy farms while decreasing treatment costs and maintaining herd health. In the Netherlands it has been enforced since 2014 and the national somatic cell count (SCC) has decreased. As of 2022 the European Union banned prophylactic use of antibiotics in animal source food production. Each year legislation with similar rules is proposed in New York state but has not yet passed. Many on-farm randomized trials in the USA, some conducted in NYS, show that when SDCT is implemented well, it does not detrimentally impact udder health. SDCT provides a way to save on treatment costs and ease product allocation when antibiotics are on backorder. However, adoption of the practice has been slow in the USA.

To improve the adoption of this practice in New York, we formed a team of veterinarians to help interested dairy producers and their herd veterinarians (with financial reimbursement for their time) to implement SDCT successfully. Not all farms are a good fit for SDCT. Herds that wish to employ this management practice should already have good udder health (e.g. bulk tank SCC less than 250,000 cells/mL), control of contagious mastitis pathogens (e.g. Strep ag and Staph aureus), and routine detection of clinical mastitis cases. An in-depth discussion between the herd veterinarian and farm stakeholders before adoption is necessary. This discussion should include current practices (e.g. appropriate use of teat sealants), data available to make the selection process (e.g. DHIA test data), best practices for dry-off and dry pen management (e.g. SOPs for excellent hygiene during the dry-off procedure), and how to monitor progress going forward.

Observing the dry-off procedure performed by all employees involved is a notable area to improve overall herd performance and is critical for SDCT success. A resource for objective evaluation of dry-off procedure was created by veterinarians at Quality Milk Production Services (QMPS) in NY and is a useful tool to monitor employee performance over time (www.dairyroutines.com). This website has materials on how to treat a cow at dry-off and administer teat sealants, among other valuable udder health tools.

Our team enrolled 24 farms over the course of one year with an average herd size of 1,000 cows. 17 of 24 farms have continued SDCT use. Among the farms that discontinued SDCT, three had a "toxic" mastitis case in the dry period, one had a Staph aureus "flare up," and three had "seasonal" milk quality challenges. A variety of SDCT methods were used to decide which high-risk cows were treated with intramammary antibiotics and a teat sealant, and which low-risk cows had only a teat sealant applied. Most herds used the algorithm that we built into DC305 to distinguish between high- and low-risk cows, with 18 of 24 also using DHIA testing. On average, herds decreased dry cow antibiotic use by 53 percent (**Figure 1**). The metrics we used to monitor herd infection dynamics before and after SDCT included average monthly somatic cell count (approximately 200,000), fresh cow mastitis incidence (approximately 2.8 percent), average herd prevalence of a high first test (approximately 18 percent), average herd prevalence of subclinical infection (**Figure 2**), average new infection risk, and cure risk. For all but a few herds, 95 percent confidence intervals overlapped for all outcomes before and after starting SDCT and differences were relatively small.

Given the positive outlook from SDCT research findings, we were encouraged to help other veterinarians and producers in our region adopt this method of selective antimicrobial use to save on dry-cow treatment costs and perhaps help avoid imposed legislation.

IN SUMMARY

This project showed that while SDCT is a practical way to employ judicious antimicrobial use on qualified dairy farms, it is not guaranteed to produce success on every farm. Many enrolled farms (17 of 24) continue to have success and are expecting to continue this new norm. Key factors to look for before enrolling are the current milk quality metrics and the data available to create a sound SDCT algorithm to decide between high-risk cows to administer intramammary antibiotics and a teat sealant, and low-risk cows which only get teat sealant administered. In addition, it is important to monitor its success, dry-off technique, and the dry cow environment. If this cohort is representative of other farms across the nation and world, an opportunity exists for many more farms to adopt this practice. ▮

This project was partially financially supported by the National Institute of Food and Agriculture U.S. Department of Agriculture, under grant award number 2018-68003-27467. This work

FIGURE 1

Reduction in antibiotic use at dry-off compared to blanket dry cow therapy

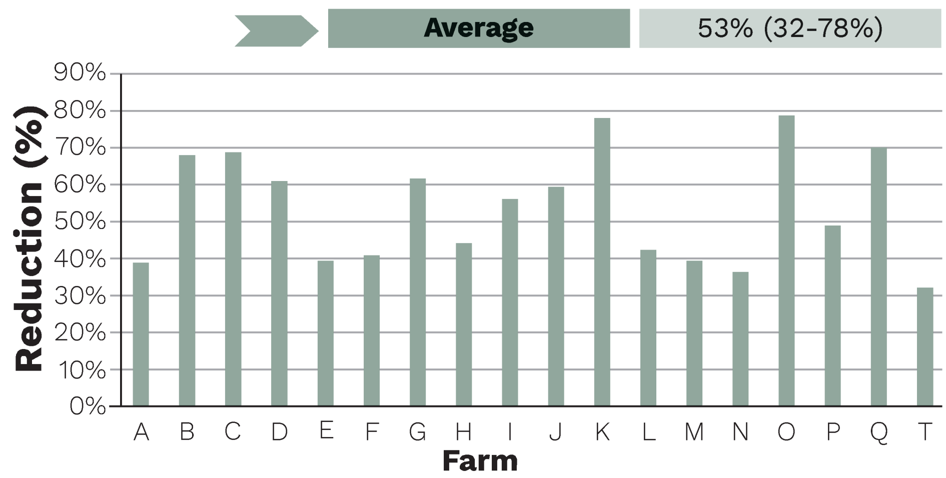
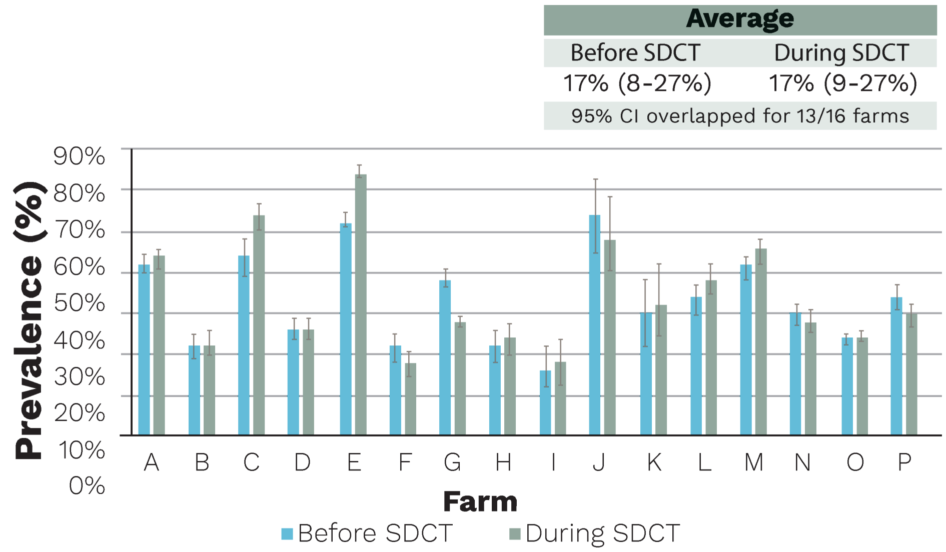


FIGURE 2

Average monthly prevalence of cows with a subclinical infection (somatic cell test greater or equal to 200,000)



was also financially supported by New York Farm Viability Institute, which provided the funds for veterinary reimbursement.

Tracy Potter (tlp64@cornell.edu) and **Amber Forrestal** (amf326@cornell.edu) are DVMs with Quality Milk Production Services, Cornell University, and Perry Veterinary Clinic. **Michael Capel** (capelmk@gmail.com) is a partner at the Perry Veterinary Clinic. **Daryl Nydam** (dvn2@cornell.edu) is a Professor of Dairy Health and Production, Department of Population Medicine and Diagnostic Sciences, College of Veterinary Medicine, Cornell University.


Meet Gemini Proteins.
The highly digestible amino acid supplements designed for herd performance.
GEMINI
PROTEINS
Gemini Proteins™ deliver the consistent, high-quality, rumen-undegraded protein and amino acids necessary to reduce nitrogen overfeeding and help your herd reach optimal performance. And with our unmatched quality standards and rigorous control procedures, you can be sure that your cows are receiving the balanced amino acid profile they need to stay healthy and productive—adding dollars to your bottom line.
Visit GeminiProfits.com for a profit analysis showing how much you can boost your bottom line with Gemini Proteins.