Multistate Research Project NC2040

2023 Meeting Minutes and Annual Report

Project/Activity Number: NC-2040

Project/Activity Title: Metabolic relationships in supply of nutrients for lactating cows

Period Covered: October 1, 2022 to September 30, 2023

Date of this Report: November 14th, 2023

Annual Meeting Dates: September 25-26, 2023

Participants:

In person:

1.	Sebastian Arriola Apelo	University of Wisconsin, Madison
2.	Ranga Appuhamy	Iowa State University
3.	Barry Bradford (chair)	Michigan State University
4.	Billy Brown (incoming secretary)	Kansas State University
5.	Luciano Caixeta	University of Minnesota
6.	Chi Chen	University of Minnesota
7.	Shane Cronin (student)	University of Delaware
8.	Tanya Gressley	University of Delaware
9.	Chanhee Lee	Ohio State University
10.	Paola Piantoni	Cargill
11.	Agustin Rius	University of Tennessee
12.	Kathryn Ruh (student)	University of Wisconsin, Madison
13.	Amit Sharma (visiting scholar)	Iowa State University
14.	Guillermo Schroeder	Cargill
15.	Heather White	University of Wisconsin, Madison
16.	Zheng Zhou (secretary)	Michigan State University

Virtual:

17.	Veridiana Daley	Land O'Lakes
18.	Jeff Firkins	Ohio State University
19.	Kevin Harvatine	Pennsylvania State University
20.	Francesca Hopkins	University of California, Riverside
21.	Tim Hackmann	University of California, Davis
22.	Mark Hanigan	Virginia Tech University
23.	Matthias Hess	University of California, Davis
24.	Russ Hovey	University of California, Davis
25.	Heidi Rossow	University of California, Davis
26.	Pedram Rezamand	University of Idaho
27.	Steve Smith (administrative)	USDA NIFA

Minutes of Annual Meeting:

NIFA updates were provided by Steve Smith (handout shared). Guillermo Schroeder introduced Cargill R&D. We had a discussion related to the 2024 annual meeting. The meeting will likely be held at UC Davis Veterinary Medicine Teaching & Research Center located in Tulare, CA. The meeting will likely take place September 23-24, 2023 (alternative of September 30th – October 1st if any major conflicts with the first dates arise, such as Discover Conference). In addition to a tour of the UC Davis Veterinary Medicine Teaching & Research Center, it was suggested that we might visit facilities from a Contract Research Organization (DairyExperts) in Tulare. The suggestion was made that these be scheduled as optional and at the end of the meeting.

We had break-out sessions to plan collaborative efforts on 1) Metabolic & molecular interactions affecting synthesis of milk 2) Modeling/precision feeding systems 3) Shared database across institutions. During break-out sessions, each group discussed plans for publishing review papers together. Plans to meet with USDA program leaders to discuss grant submission to the right program and subsequent follow up by collaborative groups have also been discussed during these sessions. At the end of the meeting, we had a discussion to compare notes from the breakout sessions.

It was brought up that although introduction and methods have been minimized during the station reports this year, discussion time was still insufficient after presentation from each station. It was recommended that we group the presentations in the future with discussion time planned at the end to ensure sufficient discussion time (for example: 3 presentations on similar topics followed by 45 min discussion). The incoming chair will request a brief summary of attendees' current research program focus approximately 1 month before the meeting time to group presentations by research topic.

Agenda items for 2024 meeting:

- Allot time to continue break-out session to plan collaborative efforts
- Zheng (incoming chair) will send out questionnaire for research focus and group presentations

Accomplishments:

Activities

Objective 1: To quantify factors that impact supply and availability of nutrients utilized for efficient milk production while reducing environmental impact

Joint work between WI, MI, IA, Fl, and USDA-Beltsville has continued to support environmental and economical sustainability of dairy food production by improving feed efficiency of dairy cattle. This research determines the feed intake and feed efficiency of several hundred cows each year in order to improve genomic selection for feed efficiency. Additionally, the inter-disciplinary stations interrogated the impact of nutritional and managerial interventions to improve feed efficiency, and recently, methane emissions. The collaborators that are a part of NC2040 also have a USDA grant (PI: White; co-PIs: VandeHaar and Zhou) specifically determining the influence of post-absorptive nutrient use efficiency on the individual animal variance in feed efficiency.

To improve availability of nutrients utilized for efficient milk production, collaboration between DE station and Purina aimed to minimize hindgut acidosis and inflammatory responses in dairy cattle. In the past year, they determined the efficacy of 2 products fed to buffer hindgut pH, and their effects on phosphorylation of lymphocyte peptides as an indicator of cow immunometabolism. Collaborative work between Purina and WI station is also ongoing to develop an amino acid index to detect and correct amino acid imbalances in lactation diets.

Collaborative work is ongoing between VA and TN stations to assess the impact of a probiotic shown to mitigate heat stress effects on absorption of amino acids from the intestine.

Objective 2: To identify and quantify molecular, cellular, and organismal signals that regulate intake, partitioning and efficient utilization of nutrients

A collaborative effort lead by Dr. Heather White from WI station has been aimed at determining if milk withholding after lidocaine use is justified. Many projects within this objective utilize tissue biopsies and thus use lidocaine. Current FARAD recommendations of milk withholding after lidocaine use are based on very little data. Dr. Heather White's group has been quantifying the absence or presence of lidocaine in milk after a range of biopsy and surgical procedures in samples from NC2040 collaborators including Sebastian Arriola Apelo (UW) and Barry Bradford and Adam Lock (MSU) to ensure that a tool that enables these research questions to be answered, lidocaine use during tissue biopsies, remains feasible. Additionally, Chi Chen (U of MN) is analyzing some samples by LC-MS/MS to confirm ELISA results and quantify downstream metabolites.

On going collaboration between CA and WI stations has been aimed to illuminate how rumen bacteria carry out fermentation when missing a key enzyme of glycolysis. The stations are using ^{13}C-labeled glucose to reveal the biochemical pathway these bacteria use.

Objective 3: To use this knowledge of feed properties and metabolic and molecular quantitative relationships to challenge and refine nutrient requirement models leading to more accurate feeding systems for dairy cattle

Using data supplied by members of NC2040 (past and present); Dhiman, T.R. (WI station); Donkin, S.S. (IN station); Ferguson, J.D. and Varga, G.A. (PA station), Huyler, M.T. (WA station); Dr. Heidi Rossow from the CA station developed pen dry matter intake equations based on machine learning techniques that can be used to formulate a diet for a pen of cows that have a wide range of days in milk and non-normal intake distributions. The model is based on the changes in distribution of cows DIM from week to week in the pen. The DIM makeup of the pen is modeled after pen sizes and DIM makeups over seasons from the commercial dairy data.

Collaborative work between Purina and VA station is ongoing to predict daily dry matter intakes of lactating dairy cows using a combination of chewing activity and dietary nutrient content.

Outputs and Outcomes

Objective 1: To quantify factors that impact supply and availability of nutrients utilized for efficient milk production while reducing environmental impact

Joint work between WI, MI, IA, FL, and USDA-Beltsville has collected phenotypes for feed intake, feed efficiency, and methane production. The multi-disciplinary team already had one collaborative grant funded and another one pending to expand this research to include methane emissions and mitigation. MI and WI stations also have completed several studies interrogating tissue specific nutrient use as part of a joint USDA grant.

Collaborative work between Purina and DE station has demonstrated that Both T1 and T2 exhibited increased protein synthesis and cell differentiation, and possible increased T-cell activity. T3 reduced metabolic activity in comparison to abomasally infused with cornstarch (IS), with decreased production of cytokines from both the NF-kB and MAPK pathways. Both CON and T3 reduced immunometabolic activity compared with IS, while T1 and T2 increased protein synthesis and immune activity. High starch diets can cause acidotic conditions in the rumen and large intestine that drive systemic inflammation. This study indicated that a prototype product (T3) may reduce negative effects of high-starch diets.

Objective 2: To identify and quantify molecular, cellular, and organismal signals that regulate intake, partitioning and efficient utilization of nutrients

Collaborative work among WI, MI, and MN stations had demonstrated that lidocaine can be detected in blood immediately after administration of subcutaneous injected lidocaine but thus far, no lidocaine has been detected (less than background and less than the pre-surgery sample) in milk samples (n > 250) collected after a range of biopsies or displaced abomasum surgery. A new collaboration between H. White and C. Chen has been initiated and has already expanded to other topics of potential collaboration.

Objective 3: To use this knowledge of feed properties and metabolic and molecular quantitative relationships to challenge and refine nutrient requirement models leading to more accurate feeding systems for dairy cattle

In the past year, collaborative effort among various stations has developed pen dry matter intake that can be used to formulate a diet for a pen of cows that have a wide range of days in milk and non-normal intake distributions. This model can be used to simulate pen intake and milk production from commercial dairies that could be used to examine commercial dairy herd practices, manipulate N excretion from dietary sources and formulate diets to reduce methane production using computer models and could be a template for converting individual cow data such as nutrient requirements to pen nutrient requirements.

Collaboration among members from MI, WI, IL, MD, OH, CA, and VA stations resulted in development of the NASEM 2021 Dairy Requirement publication and model.

Impacts

Objective 1: We improved genetic selection and nutritional strategies to support feed efficiency in dairy cattle in order to improve the environmental and economical sustainability of dairy food production. We developed a model for more precise representation of pen dry matter intake translates into more precise feeding of nutrients for more efficient milk production, less nutrient waste for dairy cattle.

Objective 2: We provided data to support or refute recommendation of milk discard for drug use that results in discarding thousands of pounds of milk each year.

Objective 3: We developed models that allow diets to be formulated to reduce manure and methane excretion and emissions once the equations are incorporated into a mechanistic model of rumen function and milk production. We improved calf, heifer, and cow nutrient supply and requirement models allowing more precise feeding by industry professionals. Improvements in predictions of nutrient excretion allow environmental impacts to be considered when formulating diets. Correction of the bias in predictions of energy supply has allowed more appropriate assignment of economic value to ingredients. The addition of amino acid-based predictions of milk protein and requirements has allowed industry to better assess protein feeding to reduce cost and nitrogen excretion.

Publications/Deliverables

Abstracts:

1. Cavani, L., K. L. Parker Gaddis, R. L. Baldwin, J. E. P. Santos, J. E. Koltes, R. J. Tempelman, M. J. VandeHaar, H. M. White, F. Peñagaricano, and K. A. Weigel. Consistency of daily dry matter intake as an idicator of resilience: Heritability estimates and associations with feed efficiency in Holstein dairy cows. 2023. J. Dairy Sci. Abstract. Accepted. (UW, MSU)
2. Naughton, S., M. J. Vandehaar, H. M. White, and Z. Zhou. 2023. Differences in post-absorptive lipid metabolism may contribute to variation in feed efficiency in dairy cows. J. Dairy Sci. Abstract. Accepted. (UW, MSU)
3. Yilmaz Adkinson, A., M. Abouhawwash, K.L. Parker Gaddis, F. Peñagaricano, H.M. White, K.A. Weigel, R. Baldwin, J.E.P Santos, M.J. VandeHaar, J.E. Koltes, and R.J. Tempelman. 2023. Using Milk Spectral Data to Predict Dry Matter Intake Based on Different Cross-Validation Schemes. J. Dairy Sci. Abstract. Accepted. (UW, MSU)
4. Legarra, A., M. J. VandeHaar, R.J. Tempelman, J.E. Koltes, H.M. White, K.A. Weigel, R. Baldwin, P. Van Raden, F. Peñagaricano, J. Santos, and K. L. Parker Gaddis. 2023. pedigree and genomic adjustments for ssGBLUP applied to residual feed intake. J. Dairy Sci. Abstract. (UW, MSU)
5. Lucey PM, Rossow HA. 2023. Predicting dairy pen dry matter intake distribution shape with machine learning. California Animal Nutrition Conference, May. First place poster competition. (CA, WI, IN, PA)
6. Lucey PM, Rossow HA. 2023. Predicting dairy pen dry matter intake distribution shape with machine learning. ADSA 2023, Ottawa Canada. (CA, WI, IN, PA)
7. S. Cronin, F. Perry, C. M. K. Bradley, V. Daley, F. Gadeyne, M. Bustos, R. J. Arsenault, and T. F. Gressley. 2023. Effect of abomasal starch and hindgut buffers on lymphocyte kinome profile. ADSA 2023, Ottawa Canada. (DE, Purina)

Publications:

1. Cavani, L., K. Parker Gaddis, R. Baldwin, J. Santos, J. Koltes, R. Tempelman, M. VandeHaar, H. White, F. Penagaricano, and K. Weigel. 2023. Consistency of dry matter intake in Holstein cows: heritability estimates and associations with feed efficiency. J. Dairy Sci. Accepted. (UW, MSU)
2. Van Staaveren, N, H. De Oliveira, T. Chud, K. A. Weigel, H. White, and C. Baes. 2023. The Resilient Dairy Genome Project – a general overview of methods and objectives related to feed efficiency and methane emissions. J Dairy Sci. Accepted. (UW, MSU)
3. Houlahan, K., F. Schenkel, F. Miglior, J. Jamrozik, R. Stephansen, O. González-Recio, N. Charfeddine, D. Segelke, A. Butty, P. Stratz, M. VandeHaar, R. Tempelman, K. A. Weigel, H. White, F. Peñagaricano, J. Koltes, J. Santos, R. Baldwin, and C. Baes, Christine. 2022. Estimation of genetic parameters for feed efficiency traits using random regression models in dairy cattle. JDS. Accepted. (UW, MSU)
4. Lucey P, Rossow HA. 2023. Describing the distribution type of dry matter intake for dairy cow pens based on pen characteristics. Animal https://doi.org/10.1016/j.animal.2023.100888 (CA, WI, IN, PA)
5. Stephansen, R., P. Martin, C. Manzanilla-Pech, B. Gredler-Grandl, G. Sahana, P. Madsen, K.A. Weigel, R. Tempelman, F. Peñagaricano, K. Parker Gaddis, H. White, J. Santos, J. Koltes, F. Schenkel, D. Hailemariam, G. Plastow, E. Abdalla, M. VandeHaar, R. Veerkamp, C. Baes, and J. Lassen. 2023. Novel genetic parameters for genetic residual feed intake in dairy cattle using time series data from multiple parities and countries in North America and Europe. , J Dairy Sci. Accepted. (UW, MSU)
6. Martineau, R., D. Ouellet, D. Pellerin, J. Firkins, M. D. Hanigan, R. White, A. LaPierre, M. Van Amburgh, and H. Lapierre. 2023. Ability of three dairy feed programs to predict post-rumen outflows of nitrogenous compounds in dairy cows: A meta-analysis. J. Dairy Sci. (in press). https://doi.org/10.3168/jds.2022-23215. (OH, VA, NY)