**NC 2042 Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

NC 2042 Meeting Minutes

October 12-14, 2017

**Attendees: (in order by last name)**

* Matthew Akins (University of Wisconsin-Marshville)
* Jill Anderson (South Dakota State University; **Committee -Secretary**)
* Andre Brito (University of New Hampshire)
* Phil Cardoso (University of Illinois)
* Mireille Chahine (University of Idaho)
* Hugh Chester-Jones (University of Minnesota)
* Marcia Endres (University of Minnesota)
* Peter Erickson (University of New Hampshire)
* Gonzalo Ferreira (Virginia Tech; **Committee -Chair**)
* Arlyn (Jud) Heinrichs (Penn State University)
* Bradley Heins (University of Minnesota, **Host**)
* Kenneth Kalscheur (USDA Dairy Forage Research Center)
* Gustavo Lascano (Clemson University)
* Robert Peters (University of Maryland)

(Kayla Aragona, Peter Erickson’s Ph.D. Student from University of New Hampshire was also in attendance)

1. Meeting called to order by Gonzalo Ferreira at 9:09 am on October 12, 2017

2. Introductions: Brad Heins gave an overview of University of Minnesota West Central Research and Outreach Center and their function and purpose.

3. Gonzalo Ferreira and Brad Heins went through the overall agenda for the few days: (Business meeting and Station Reports on Oct 12th, work on proposal re-write Oct 13th, and local farm tours Oct 14th).

4. Business Meeting Notes:

* It was motioned to approve previous meeting minutes by Marcia Endres, Jud Heinrichs seconded, and motion approved unanimously by committee.
* It was decided that Chair for 2018 will be Jill Anderson, as it is our normal procedure for the secretary to move into the chair position. After discussion the new secretary for 2018 will be Gustavo Lascano of Clemson University. No other member was nominated to run in opposition for secretary. It was moved by Phil Cardoso to accept these individuals for their new respective roles, seconded Pete Erickson, and unanimously approved by the committee.
* After some discussion it was decided that fall 2018 annual meeting will be hosted by Gonzalo Ferreira at Virginia Tech in October 2018. Acceptance of this location was moved by Phil Cardoso, seconded by Mirielle Chahine, and carried by the committee.
	+ Meeting may be held in Roanoke, VA which is closer to the airport
	+ Tentative Dates – would be Oct 11th & 12th – Need to check University schedules and other meeting schedules.
	+ Some discussion was on location for 2019. It was suggested that South Dakota State University or University of Wisconsin could be the next hosts.
* Had lengthy discussion on increasing our members and status of some members (especially those note in attendance).
	+ Some key membership updates:
		- Jeffrey Bewley from University of Kentucky has decided to withdraw from the group.
		- Robert Peters has changing responsibilities at University of Maryland and this will be his last meeting.
		- David Beede from MI State is retiring and will no longer attend.
		- Stephanie Ward has switched Universities, but plans to still plans to be a member.
	+ Ideas for increasing our membership:
		- Need a clearer process/procedure on how to join. Seems to vary by institution.
		- Need to document our collaborations better in reports and show benefits
		- Discussed how much should we change objectives to attract other researchers? Already pretty broad vs balance with maintaining a focus.
* Suggestions on a group Symposium at the American Dairy Science Association annual meeting were discuss. Phil Cardoso and Victor Cabrera suggested a symposium on water, but it was rejected. This year Phil will submit a suggestion to ADSA for a symposium on Production and Environment – will have to wait and see if it is approved.
* Had discussion and made a plan for working on the re-write. The objectives for the 2018 proposal are due on October 15th.
* Had discussion that in the five year report – need documentation of collaborations.
	+ Mirielle Chahine and Gonzalo Ferreira have done a couple Webinars and share about them with the group. They discussed doing a series on Webinars and posting on-line with like 20 min power points. Scheduling times with different group members. Need to look into if there is a way to post these on our website or if we need to generate a new website?
	+ Other Collaboration –Mirielle and Gonzola also had workshops on financials – in Idaho and Gonzola did a similar workshop in Nebraska.
	+ General discussion on encourage collaboration for planning grants. SARE grants? USDA grants?
* NC-2042 concludes in 2018
	+ We need to re-write the project this year
		- Request guidelines to Benfield
		- Change objectives?
		- The new chair (JA) will ask all members to prepare a 5-year report from each of the Experiment Stations. Not that we will have to have reports and station report earlier next year to have time to compile all the information into a comprehensive report.
	+ Discussed breakout sessions for tomorrow’s work on re-write proposal
		- Leaders to re-write each objective
		- What have we accomplished?
		- Symposium as a deliverable?
		- Write review articles for PAS or JDS
* Went through station reports of those members present. Took breaks for lunch and phone call form Dr. Benfield.
* Dr. Dave Benfield had a conference call with the group at 2:00 p.m.
	+ Gave an update on federal funding and UDSA climate.
	+ Gave some general advice and directions on the project rewrite:
		- Objective due October 15th into NMISS.
		- November 15 – all participants for Appendix E forms. Go through NMISS and AES.
		- Complete proposal due by December 1.
		- Dec 15th he reviews.
		- Reviews March and April.
		- June we have a chance for revision. July Revisions due.
	+ Next year will be 5 year report – needs to be a compilation. We will need to get a writing committee together. Divide up by objectives.
	+ Dave Benfield agreed to still serve as our group advisor moving forward.
* Dr. Steven Smith was unable to talk with us today.
* At the end of the day a motion was made by Hugh Chester-Jones to thank Brad Heins for arranging and hosting this meeting. It was seconded by Robert Peters. Motion was carried by the group.
* Business meeting and station reports sessions concluded at 5:25 p.m. Then the group went on tour of Univ. of MN. WROC research dairy unit and had dinner.

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 **Annual Station Reports**

**October 1, 2016 – September 30, 2017**

**Contributing Agricultural Experiment Stations and Order of Reports**

1. Clemson University – Gustavo Lascano
2. Cornell University - Thomas R. Overton
3. University of Idaho - Mireille Chahine
4. University of Illinois - : Felipe (Phil) Cardoso
5. University of Maryland – Robert Peters
6. University of Minnesota – Hugh Chester-Jones
7. University of Minnesota- Marcia Endres
8. University of Minnesota – Bradley Heins
9. University of Missouri – Harley Naumann,
10. University of New Hamphsire- Peter Erickson and Andre Brito
11. Pennsylvania State University – Arlyn Heinrichs
12. South Dakota State University – Jill Anderson
13. Virginia Polytechnic Institute and State University - Gonzalo Ferreira
14. USDA-ARS Dairy Forage Research Center, Madison, WI – Kenneth Kalscheur
15. University of Wisconsin – Matthew Akins
16. University of Wisconsin – Victor Cabrera

**Clemson University**

**NC2042: 2016-2017 Annual Report**

1. **Project Name:** Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.
2. **Cooperating Agency:** Clemson University Experiment Station, Clemson SC

**Personnel:** Gustavo Lascano (Project Leader), Department of Animal and Veterinary Sciences

**Specific objectives:**

1. Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.
2. Improve dairy cow management decisions through nutrient utilization, well-being and profitability.
3. Analyze whole farm system components and integrate information into decision-support tools to improve efficiency, enhance profitability, and environmental sustainability.
4. **Work progress and principal accomplishments**
5. **Effect of replacing corn with beet pulp in a high concentrate diet fed to weaned Holstein calves on diet digestibility and growth**.

T. S. Dennis, F. X. Suarez-Mena, T. M. Hill, J. D. Quigley, R. L. Schlotterbeck, and G. J. Lascano

 In this study, 48 male Holstein calves (59 ± 2 d of age, 77 ± 2.2 kg initial BW) were fed 95% concentrate, 5% chopped grass hay diets in groups with 4 calves/pen for 56 d. Pens were randomly assigned to 1 of 3 dietary treatments containing 0, 15, or 30% BP on an as-fed basis. Body weights, hip widths, and body condition scores were assessed at 56 (start of trial), 84, and 112 d of age. Dry matter intakes and refusals were recorded daily by pen. Digestion coefficients (**dC**) of the diets and microbial protein flows were estimated when calves were approximately 84 d of age. Fecal samples were collected daily from pen floors over a 7 d period and urine samples were collected from 2 calves/pen over a 2 d period and analyzed for purine derivatives. Calf ADG and hip width change decreased linearly (from 1.09 to 1.04 kg/d and 5.4 to 4.8 cm over 56, respectively) with increasing BP. Dry matter, OM (from 79.7 to 75.6%), CP (75.7 to 70.1%), and starch (97.1 to 93.1%) dC decreased with increasing inclusion rates of BP. Conversely, NDF (from 47.1 to 52.7%) and ADF (44.1 to 53.0%) dC increased with increasing BP. Estimates of urine output and microbial protein flow using purine derivatives did not differ among treatments. Under the conditions of this study, BP reduced growth largely through reducing diet digestibility in dairy calves from 56 to 112 d of age.

*Under objective 2.*

1. **Effects of combinations of prilled fatty acids with or without potassium carbonate on fermentation and biohydrogenation intermediates in continuous culture fermenters**

L.E. Koch, B.M. Koch, S.M. Hussein, V.M. Trutwin, T.C. Jenkins, C. Soderholm, J. Linn, J. Albrecht, and G.J. Lascano.

The addition of buffers such as K2CO3 have been investigated in how they alter ruminal fermentation and reduce accumulation of milk fat inhibitors (MFI). Thus, we hypothesized that prilled saturated free fatty acids (FFA; C16:0 and C18:0) combined with K2CO3 would provide a slower, more prolonged release of K2CO3 than feeding it alone in reducing production of MFI. Four treatments were randomly assigned to 8 continuous culture fermenters for 2 periods of 10 d. Treatments included 4 combinations of FFA (FA-A) and K2CO3 coated with prilled fatty acids (1:1; FA-B) representing 1.25:0 (**1**), 0.83:0.83 (**2**), 0.42:1.66 (**3**), and 0:2.5% DM (**4**) of FA-A to FA-B ratios. All treatments provided 1.25% DM of FA with K2CO3 increasing gradually from 0 to 1.25% DM. Data were analyzed using the MIXED procedure of SAS as a randomized complete block design with blocks of period and fermenters; where linear, quadratic and preplanned polynomial contrasts where evaluated. Addition of K2CO3 altered pH and biohydrogenation (Table 1). There was a quadratic increase in total VFA (*P*<0.01) but butyrate was reduced linearly (*P*<0.05), while valerate and isoacids increased quadratically with increasing K2CO3. Adding K2CO3 tended to increase the outflow of C18:1 (*P*=0.09), C18:2 (*P*=0.06) and reduce C18:3 (*P*=0.06) linearly. Biohydrogenation intermediates, *trans*-10 and *trans*-12 18:1, were quadratically reduced with K2CO3. These results indicate that combinations of prilled fatty acids and K carbonate increase pH and reduce production of biohydrogenation intermediates linked to milk fat depression exhibiting a quadratic response.

 **Table 1.** Biohydrogenation and pH profile

|  |  |  |  |
| --- | --- | --- | --- |
|  |   |   | Contrasts, *P-*value |
|   | TRT  |   |
| Item | **1** | **2** | **3** | **4** | SE | L | Q |
| pH | 6.06 | 6.26 | 6.32 | 6.22 | 0.06 | 0.07 | 0.03 |
| pH, h to 6.0 | 2.00 | 2.75 | 3.75 | 2.25 | 0.29 | 0.21 | <0.01 |
| pH, h < 6.0 | 7.00 | 4.50 | 3.00 | 5.50 | 0.68 | 0.08 | <0.01 |
|  min pH | 5.57 | 5.63 | 5.69 | 5.59 | 0.10 | 0.69 | 0.19 |
|  max pH  | 6.83 | 6.84 | 6.95 | 6.85 | 0.17 | 0.65 | 0.49 |
|  Biohydrogenation |  |  |  |  |  |  |  |
|  18:2 | 58.00 | 55.47 | 43.91 | 52.45 | 7.77 | 0.06 | 0.09 |
|  18:3 | 68.77 | 66.14 | 56.65 | 64.20 | 6.30 | 0.05 | 0.06 |

1. **Starch degradability in combination with sugar alter fermentation in continuous culture**

L.E. Koch, B.M. Koch, R.N. Klopp, S.M. Hussein, V.R. Trutwin, and G. J. Lascano

Evaluating starch degradability (ShD) in combination with starch level can be used as a better predictor for a diet to have a high milk fat depression potential. Adding sugar to a ration is common, but little is known about its effects in conjunction with a high or low ShD diet. The objective of this study was to determine the effects of adding lactose (L) or sucrose (S) to high or low ShD diets on fatty acid (FA) outflow and fermentation in continuous culture. Treatments included 2 ShD levels, high (HDS) and low (LDS), 4 levels of sugar, no sugar (N), lactose (L), sucrose (S), and a combination of L and S (C). Diets were formulated to contain 30% starch, 70 or 90% 7h ShD, and 5 (N), 7 (L), 7 (S) or 9% sugar (C). Fermenters were randomly assigned in a 2x4 factorial design and ran for 4, 10 d periods. Data were analyzed using the MIXED procedure of SAS with repeated measures in a model including ShD and sugar as fixed and fermenter and period as random. Preplanned contrasts were utilized to compare N vs all, S vs L, and, S and L vs C. Dry matter, OM, and ADF apparent digestibility (AD) were unaffected by ShD or sugar, but NDF AD differed with S and L vs C (*P*=0.02). Outflow of the saturated FA C12, C20, C22, and C24 were all reduced by HDS (*P*<0.01). Outflow of *trans*-11 18:1 tended to be greater with LDS, and *trans*-12 18:1 was greater with HDS (*P*=0.08 and *P*<0.01). Other FA outflows are listed in Table 1. Methane output decreased with sugar addition (*P*=0.03) and S vs L differed (*P*<0.01). Ammonia was greater with sugar addition (*P*<0.01) and all contrasts were significant. These results suggest that ShD with sugar can alter production of FA isomers, digestibility, and ammonia.

**Table 1.** Outflow of major fatty acids and isomers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **SUGAR ADDITION** |  | **CONTRASTS, *P*-VALUE** |
| **Item, mg/d** |  | **N** | **L** | **S** | **C** | **SEM** | **N vs ALL** | **S vs L** | **S,L vs C** |
| 18:1 | LDS | 361.2 | 378.6 | 343.5 | 319.6 | 29.54 | 0.12 | 0.13 | 0.39 |
|  | HDS | 351.9 | 368.4 | 369.9 | 358.9 |  |  |  |  |
| 18:2 | LDS | 573.3 | 655.8 | 576.5 | 536.2 | 52.82 | 0.25 | 0.84 | 0.10 |
|  | HDS | 653.8 | 736.8 | 720.8 | 686.6 |  |  |  |  |
| 18:3 | LDS | 89.3 | 96.2 | 84.9 | 79.3 | 6.51 | 0.37 | 0.87 | <0.01 |
|  | HDS | 69.7 | 96.6 | 92.2 | 89.3 |  |  |  |  |
| 18:1 *t-*12 | LDS | 9.2 | 8.1 | 9.3 | 8.2 | 1.42 | 0.54 | 0.74 | 0.90 |
|  | HDS | 11.2 | 12.1 | 10.4 | 10.7 |  |  |  |  |
| 18:2 *c-*9, *t-*11 | LDS | 7.6 | 2.0 | 1.4 | 1.4 | 1.80 | 0.31 | 0.15 | 0.07 |
|  | HDS | 2.7 | 1.6 | 1.0 | 1.0 |  |  |  |  |
| 18:2 *t-*10, *c-*12 | LDS | 14.7 | 13.7 | 11.5 | 8.2 | 2.06 | 0.09 | 0.13 | 0.57 |
|  | HDS | 12.4 | 15.5 | 12.4 | 13.0 |  |  |  |  |

1. **Effects of replacing corn with different levels of starch degradability with beet pulp as a source of soluble fiber on fermentation in continuous culture**

L.E. Koch, B.M. Koch, R.N. Klopp, S.M. Hussein, V.R. Trutwin, G. J. Lascano

Evaluating starch degradability (ShD) in combination with starch concentration can be used as a better predictor for a diet to induce milk fat depression (MFD). Starch with high rates of degradability may lead to decreased ruminal pH and changes in rumen biohydrogenation (BH) and accumulation of certain fatty acid isomers known as milk fat inhibitors (MFI). Substituting starch from corn with beet pulp (BP) as a source of soluble fiber (SF) can yield different fermentation patterns, yet still provide similar energy to the animal without compromising performance or exacerbating production of MFI. We hypothesized that replacing starch with a source high in SF, such as BP, will improve fermentation and flow of BH intermediates when added to a diet with high MFD potential. Treatments included two levels of ShD, high (HDS) and low (LDS), and 4 combinations of BP replacing corn, low (LSF; 0% beet pulp), medium low (MLSF; 13% BP), medium high (MHSF; 26% BP), and high (HSF; 39% BP). Diets were formulated to replace a portion of the starch with SF from BP and contained a basal level of soybean oil. Fermenters were randomly assigned to treatments in a 2x4 factorial design and ran for 4, 10 d periods. Data were analyzed using the MIXED procedure of SAS with repeated measures in a model including the fixed effects of treatment and period as fixed and fermenter as random effects. Digestibility coefficients (dC) for DM, NDF, and ADF were unaffected by ShD, but BP decreased OM dC quadratically (*P*=0.05; 67.0, 59.4, 54.7, 57.1% OM dC). The mean pH did not differ with ShD but a linear decrease in pH was observed with BP addition (*P*<0.01). Ammonia N (NH3N) concentration was greater in LDS treatment and there was a quadratic increase as BP was added. Acetate was not altered by ShD but was increased linearly with BP addition (*P*=0.01). Protozoa were not detectable during this study. The results of this study suggest that ShD did not affect dC or rumen pH but increased NH3N concentrations; increasing dietary concentrations of BP depressed pH, and increased NH3N concentrations, negatively affecting OM dC.

**5) Changes in rumen bacteria communities in continuous cultures fed high and low levels of unsaturated fatty acids with increasing rates of starch degradability.**

Richards,V., T.C. Jenkins, L.E.Koch, and G. Lascano

Dietary changes can alter the rumen environment and provoke shifts in microbial communities leading to incomplete biohydrogenation (BH).The objective of this study was to compare bacterial diversity in diets previously shown to cause shifts in BH intermediates. Diets containing low (LF) or high (HF) concentrations of unsaturated fatty acids (0 or 3.3% soybean oil added) were modified using corn sources with low (L), medium (M) or high (H) starch degradability (SKd; 48.4 L, 66.2 M, or 84.0% h−1 in 7 h in vitro test) and arranged in a 2 × 3 factorial design. Diets were fed for 4 10 d periods.Bacterial community composition from overflow samples was determined using Illumina MiSeq16S rRNA gene V4 variable region amplicon sequencing. Significant differences in β diversity among sample groupings were determined using a Python script within QIIME to perform a PERMANOVA. For individual relative abundance (rA) of interest, the MIXED procedure of SAS was used. Significance for main effect of fat and

linear and quadratic contrasts for SKd were set at *P* ≤ 0·10. Results showed 519 species belonging to 248 genera across treatments. Beta diversity was different between LF and HF (*P* = 0.10); and significantly increased with SKd (*P* = 0.02) with a pronounced separation between L and H SKd (*P* < 0.01). Among the 60 species of most frequently detected taxa, 29 showed a progressive decrease (n = 20) or increase (n = 9) in frequency moving from L to H SKd respectively. The rA of fibrolytic bacteria *Prevotella ruminicola* was increased while *Ruminococcus flavefaciens* was reduced (*P* ≤ 0.01) as fat was added. There was a linear decrease in rA of *Butyvibrio fibrisolvens* and *Butyvibrio hungatei* (BH enabler; *P* ≤ 0.10) as SKd increased. Whereas *Streptococcus bovis* and *Prevotella bryantii* (amylolytic) showed a linear increase as Skd increased (*P* ≤ 0.05). Taxa responsible for lipolysis (*Anaerovibrio lipolyticus*) or utilizing lactic acid (*Megasphaera* *elsdenii*) were not different. These results suggest that fat level affect bacteria diversity and that increasing the SKd with constant starch level causes significant changes in microbial communities.

1. **Usefulness of findings:**

**Experiment 1**

* Soluble fiber sources are often included in dairy calf diets to replace starch from cereal grains. Inclusion of increasing amounts (0, 15, and 30%) of beet pulp in high concentrate diets fed to dairy calves from 56 to 112 d of age reduced body weight gain and structural growth largely through reducing diet digestibility.

**Experiment 2**

* Total VFA and valerate increased quadratically with increasing K2CO3, indicating a possible buffering mechanism of the K2CO3 aiding in greater VFA production.
* Adding K2CO3 tended to decrease biohydrogenation of C18:2 and C18:3.
* Treatment 3 spent the least amount of time below pH 6, suggesting a continual buffering effect with combinations of supplements A and B.
* These results indicate that combinations of prilled fatty acids with K2CO3 can alter rumen fermentation of fatty acids and pH.
* Further research is warranted to investigate the release rate of addition of K2CO3 to prilled fatty acids, the subsequent effects on the microbial population, and the efficacy of these products when added to different diets in vivo.

**Experiment 3**

* Addition of sugar to continuous cultures altered fermentation profiles, pH, and protozoal populations
* These responses could be due to the level of sugar
* This study showed that replacing dry, unprocessed corn and processed corn having high rates of starch degradability in continuous cultures with different sources of sugar affect CLA isomer concentration in the rumen.

**Experiment 4**

* Addition of beet pulp to continuous cultures modified culture pH, LCFA outflow, and production of isomers
* These results suggest that in some scenarios beet pulp can reduced accumulation of isomers responsible for Milk fat depression

**Experiment 5**

* High levels of unsaturated fatty acids reduced OUT counts and bacterial richness in continuous cultures
* Starch degradability modified bacteria communities further by extensively affecting taxa distribution.
* Unsaturated fatty acids affect bacteria communities and increasing SKd modifies beta diversity and bacteria species with known rumen functions
1. **Publications**

**Peer-reviewed**

1. Type: Journal Articles Status: Published Year Published: 2017. Dennis, T.S., F.X. Suarez-Mena, T.M. Hill, J.D. Quigley, R.L. Schlotterbeck, and G.J. [Lascano.](http://www.journalofdairyscience.org/article/S0022-0302%2816%2930401-5/fulltext/) Effect of replacing corn with beet pulp in a high concentrate diet fed to weaned Holstein calves on diet digestibility and growth. J Dairy Sci. *In press.*
2. Type: Journal Articles Status: Published Year Published: 2017. Heinrichs, A.J., GF., Zanton., G.J. Lascano and C. Jones. Invited Review: 100 years of dairy heifer research. J Dairy Sci. *In press.*
3. **M.S. Thesis:**
* Effects on ruminal microbiome, health and fermentation profile of post-weaning strategies in Dairy Calves. R. Klopp. *In progress*

 **G. Ph.D. Dissertations:**

\* Effects of carbohydrate degradability on rumen fermentation and milk fat depression induction in dairy cows. L. Koch. *In progress.*

\* Developing new methodologies to assess microbial protein synthesis and flow in the rumen. S. Hussein, *In progress.*

1. **Leverage**

Clemson university current work has leveraged and interest from governmental, industrial and commercial partnership to maintain the level of support needed to keep the project viable.

**Annual Project Report**

**North Central Cooperative Research Project NC-2042**

**Year ending September 30, 2017**

**A. Project:** Management Systems to Improve Economic and Environmental Sustainability of Dairy Enterprises

**B. Cooperating Agency:**  Cornell University Agricultural Experiment Station, Ithaca, NY 14853

 **Personnel:** Thomas R. Overton, Department of Animal Science

 Daryl V. Nydam, Department of Population Medicine and Diagnostic Sciences

 Jessica A. McArt, Department of Population Medicine and Diagnostic Sciences

 Allison B. Lawton, Department of Animal Science

 **Project Objectives:**

Main objective: To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

1. To analyze management and nutrition strategies for replacement heifers as they pertain to production and profitability (heifers)
2. To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows)
3. To evaluate system components and integration of information into decision-support tools and whole-farm analyses to improve efficiency, control variation, and enhance profitability and environmental sustainability (whole farm)

**C. Work progress and principal accomplishments:**

***Objective 2: To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows).***

1. **Northeast dairy herd characteristics: transition cow management strategies, performance, culling, and health.**

A cross-sectional field study was conducted to describe transition cow management strategies and herd performance characteristics in high-producing dairies. A convenience sample of commercial Holstein herds (n=72) in New York and Vermont were enrolled between November 2012 and August 2015. Data reported represent annual data at herd enrollment. Herd size range was 345-2900 milk cows (mean±SD; 935±486) with a Dairy Herd Improvement herd milk average of 12283±1051 kg (n=50) and herd average milk yield/cow of 37.8±3.8 kg/d (n=69). Within the 40% of herds using recombinant bovine somatotropin (rbST) an average of 78% of eligible cows received rbST. Primiparous and multiparous animals had similar average days dry (56.5±5.6) and herd reported voluntary waiting period (58.3±9.4). All farms moved cows as parturition approached; 28% of herds moved animals to a maternity pen 0 to 3 d before calving; the other 72% used a calving pen, defined as animals moving to a pen when showing signs of calving. Eighteen percent of herds used separate calving locations for nulliparous and parous animals. Farms used a 1-group (9.7%) or 2-group (90.3%) dry cow system and 1-group (6.9%) or 2-group (93.1%) early lactation system for parous animals. Far-off and prefresh pens were either freestall (92.7%, 82.5%, respectively) or bedded packs (7.3%, 17.5%, respectively). Pens housing prefresh animals had animals moving in 1×/wk (71.6%) whereas 23.2% had animals moving in multiple times per week. From dry off until calving, number of pen moves for parous animals was either 2× (19.4%), 3× (69.4%), or 4× (11.1%) (n=72 herds). From 60 d prior to due date until calving, nulliparous animals were moved 1× (4.2%), 2× (50.7%), 3× (40.3%), or 4× (4.2%) (n=72 herds). Herd mean cull and death rate for animals ≤ 60 d in milk (DIM) was 5.9±4.5% for primiparous animals and 8.4±4.3% for multiparous animals (n=71). Herd mean (SD) cull and death rate for animals overall was 20.6% (7.8%) for primiparous animals and 35.7% (7.2%) for multiparous animals (n=71). Incidence of herd identified post-partum health events (n=71) were as follows; stillborn heifers: 5.9±1.8%, twinning: 4.1±1.4% (n=72), RP: 6.5±3.8%, metritis ≤ 30 DIM: 6.4±8.5%, DA ≤ 60 DIM: 2.0±1.6%, and ketosis ≤ 30 DIM: 6.6±8.9%. These results demonstrate the variability in current practices and health related outcomes in large, progressive dairies in the Northeast.

1. **The effects of varying undigested neutral detergent fiber and physically effective neutral detergent fiber content of fresh cow rations on dry matter intake, rumination, and milk yield in multiparous Holstein cows.**

The objective of this study was to evaluate the effects of varying levels of undigested NDF (uNDF240; NDF remaining after 240 h of in vitro fermentation) and physically effective NDF (peNDF) content of fresh cow rations on DMI, rumination, and milk yield. Previously unpublished data from our lab indicated that cows fed higher uNDF240 (approximately 10.7% DM) had higher DMI and improved health status compared with cows fed lower uNDF240 (approximately 8.3% DM) in the postpartum period. Multiparous Holstein cows (n = 56) were fed a common prepartum ration beginning 28 d before expected parturition and randomly assigned at calving to one of two postpartum diets differing in content of uNDF240 and peNDF. Treatment diets, high fiber (HF; n = 27) and low fiber (LF; n = 29), were formulated for equivalent MP and starch, with higher fiber levels achieved through the addition of straw in the HF diet. At 29 d in milk (DIM), HF cows were switched to the LF diet and all cows were fed the LF diet through 42 DIM. Repeated measures data were analyzed with the MIXED procedure of SAS with model effects of treatment, time, and treatment × time. A treatment × time interaction (P < 0.01) was observed for DMI when expressed as a percent of BW, such that DMI for cows fed HF was lower in wk 3 (3.05% ± 0.07 vs. 3.35% ± 0.07; P < 0.01) and 4 (3.13% ± 0.06 vs. 3.50% ± 0.06; P < 0.01) postpartum. Despite this difference in intake, total daily rumination was not different between treatments (overall mean 543.4 ± 3.5 min/d; P > 0.10) at any time point. A treatment × time interaction for average weekly milk yield was observed (P < 0.01), such that cows fed HF had lower milk production in wk 4 (46.4 ± 1.1 vs. 50.1 ± 1.0 kg/d; P < 0.01). However, differences in energy-corrected milk were not different (overall mean 47.8 ± 1.4 kg/d; P > 0.10). Increasing uNDF240 and peNDF content of fresh cow rations may limit intake starting in wk 2 postpartum; however, differences in milk yield were not observed until wk 4 postpartum and limiting effects were alleviated after switching to the LF diet. We speculate that the LF diet may have contributed adequate uNDF240 in this scenario, resulting in optimal DMI, whereas the additional uNDF240 in the HF diet may have had limiting effects.

1. **The effects of varying undigested NDF and physically effective NDF content of fresh cow rations on metabolism in multiparous Holstein cows.**

The objective of this study was to determine the effect of varying undigested NDF at 240 h (uNDF240) and physically effective NDF (peNDF) content of fresh cow rations on metabolism. Multiparous Holstein cows (n = 56) were fed a common prepartum ration beginning 28 d before expected parturition and assigned randomly at calving to 1 of 2 postpartum diets differing in content of uNDF240 and peNDF. High fiber (HF; 35.3% NDF, 12.1% uNDF240, 25.0% peNDF; n = 27) and low fiber (LF; 32.8% NDF, 9.5% uNDF240, 21.4% peNDF; n = 29) treatment diets were formulated for equivalent metabolizable protein (110 g/kg DM) and starch (24.8% DM), with higher fiber levels achieved through the addition of straw. At 29 DIM, cows fed HF were switched to the LF diet and all cows were fed the LF diet through 42 DIM. Blood samples were collected 2×/wk prepartum, daily from d 0 through 7 DIM, 3×/wk through 21 DIM and 2×/wk to 42 DIM. Liver biopsies were obtained from a subset of 40 cows on d 7 ± 1.1 (mean ± SD) and 14 ± 1.0 postpartum and incubated in an in vitro system to determine liver capacity to convert [1-14C] propionate and [1-14C] palmitic acid to end products. Data were analyzed by repeated measures ANOVA with the random effect of cow within treatment and fixed effects of treatment, time, and treatment × time. A treatment × time effect was observed for plasma NEFA and was higher for cows fed HF particularly from 21 to 31 DIM (P = 0.01), plasma β-hydroxybutyrate was higher for cows fed HF from 12 to 31 DIM (P < 0.01), and plasma glucose was lower for cows fed HF from 9 to 27 DIM (P < 0.01) compared with cows fed LF. Cows fed LF tended to have greater liver oxidation of palmitate to CO2 (12.23 nmol/(g·h) vs. 10.94 nmol/(g·h); P = 0.15) and lower conversion to esterified products (226.9 nmol/(g·h) vs. 248.2 nmol/(g·h); P = 0.10) than cows fed HF. Conversion of palmitate to acid soluble products was not different between treatments and no effects on in vitro liver propionate metabolism were observed. Changes in plasma metabolites and liver fatty acid metabolism were consistent with lower dry matter

intake of cows fed the HF diet.

1. **Effects of prepartum dietary cation-anion difference on aspects of peripartum mineral and energy metabolism and performance of multiparous Holstein cows.**

The objectives of this study were to determine the effect of decreasing dietary cation-anion difference [DCAD = (Na+ + K+) – (Cl- +S2-)] of the prepartum diet on aspects of mineral metabolism, energy metabolism and performance of peripartum dairy cows. Multiparous Holstein cows (n = 89) were enrolled between 38 and 31 d prior to expected parturition and randomized to treatments in a completely randomized design (restricted to balance for previous 305-d mature equivalent milk production, parity and body condition score) at 24 d prior to expected parturition. Treatments were as follows: CON = low K ration, no anion supplementation (n = 30, DCAD = +18.3 mEq/100 g DM); MED = partial anion supplementation to a low K ration (n = 30, DCAD = +5.9 mEq/100 g DM) and LOW = anion supplementation to a low K ration to reach a targeted average urine pH between 5.5 and 6.0 (n = 29, DCAD = -7.4 mEq/100 g DM). Cows were fed a common postpartum diet and data collected through 63 d in milk. Urine pH (CON = 8.22, MED = 7.89, and LOW = 5.96) was affected quadratically by decreasing prepartum DCAD. A linear relationship between urine pH and urine Ca:creatinine ratio was observed (r = -0.81; P <0.0001). Plasma Ca concentrations in the postpartum period (d 0 to 14; CON = 2.16, MED = 2.19, and LOW = 2.27 mmol/L) were increased linearly with decreasing prepartum DCAD. A treatment by parity (second vs. third and greater) interaction for postpartum plasma Ca concentration suggested that older cows had the greatest response to the low DCAD diet and older cows fed LOW had decreased prevalence of hypocalcemia after calving. A quadratic effect of decreasing DCAD on prepartum DMI was observed (CON = 13.6, MED = 14.0, and LOW = 13.2 kg/d). Milk production in the first 3 wk postpartum was increased linearly with decreasing DCAD (CON = 40.8, MED = 42.4, and LOW = 43.9 kg/d) and DMI in this period also tended to linearly increase (CON = 20.2, MED = 20.9, and LOW = 21.3 kg/d). Overall, effects on intake and milk yield analyzed over wk 1 to 9 postpartum were not significant. This study demonstrates that feeding lower DCAD diets prepartum improves plasma Ca status in the immediate postpartum period and results in increased DMI and milk production in the 3 wk after parturition. Compared to no anion supplementation or lower levels of anion supplementation, greater improvements were observed with the lower DCAD feeding strategy in which an average urine pH of 5.5 to 6.0 was targeted.

1. **The effect of source of supplemental dietary Ca and Mg in the peripartum period, and level of dietary Mg postpartum, on mineral status, performance and energy metabolites in multiparous Holstein cows.**

The objective of this study was to determine the effects of feeding different supplemental sources of Ca and Mg in the peripartum period, and different dietary levels of Mg postpartum, on plasma mineral status, performance, and aspects of energy metabolism in transition dairy cows. Multiparous Holstein cows (n = 41) were utilized in a completely randomized design with a 2 × 2 factorial arrangement of treatments starting at 28 d prior to expected parturition. At 21 d prior to expected parturition, cows were assigned randomly to source treatments. Main effects were source assignments (CS = common sources of supplemental Ca and Mg or MA = a blend of common and commercial mineral sources with supplemental minerals primarily from a commercial Ca-Mg dolomite source; MIN-AD, Papillon Agricultural Company, Inc., Easton, MD) beginning at 21 d prior to due date; cows were further randomized within source treatments to one of two levels of Mg supplementation (LM = formulated postpartum diet Mg at 0.30% of DM or HM = formulated postpartum diet Mg at 0.45% of DM) beginning within 1 d after parturition. Final treatment groups included the following; common source, low Mg (CS-LM, n = 11), common source, high Mg (CS-HM, n = 11), MIN-AD, low Mg (MA-LM, n = 10) and MIN-AD, high Mg (MA-HM, n = 9). Treatment diets were fed and data collected through 42 d in milk. Postpartum plasma Mg concentrations tended to be higher for cows fed HM and cows fed CS, but there were no effects on peripartum plasma Ca concentrations. Peripartum plasma P concentrations were higher for cows fed MA. Dry matter intake (DMI) in the prepartum period was higher for cows fed MA (CS = 15.9 vs. MA = 16.8 kg/d) and postpartum DMI was higher in some groups depending on week. Plasma non-esterified fatty acid concentrations were lower for cows fed MA during both the prepartum and postpartum periods. A source by level interaction was observed for postpartum plasma β-hydroxybutyrate (BHB) concentrations such that cows fed CS-LM had numerically higher BHB and cows fed MA-LM had numerically lower BHB (geometric means; CS-LM = 7.9, CS-HM = 6.9, MA-LM = 6.3 and MA-HM = 7.3 mg/dL) than cows fed the other two treatments. Higher milk fat yield, milk fat content and fat- and energy-corrected yield during wk 1 for cows fed MA resulted in source by week interactions for these outcomes. This study demonstrated that varying supplemental Ca and Mg sources and feeding rates had minimal impact on plasma Ca status despite differences in plasma Mg and P concentrations. Effects on DMI and plasma energy metabolites suggest opportunity for strategic use of mineral sources in the transition period to promote metabolic health.

1. **The association of blood calcium concentration shortly after parturition with metritis and milk production in Holstein dairy cows.**

Our objectives were to evaluate the association of immediate postpartum blood Ca concentration with metritis and Dairy Herd Improvement Association (DHIA) first test milk production. A total of 314 primiparous (PP) and 1,111 multiparous (MP) cows from 6 herds in New York State were enrolled in a cohort study, and had a blood sample collected within 12 h of parturition. Diagnosis of metritis (defined as a watery, fetid, and reddish-brownish uterine discharge up to 14 d in milk) was performed by farm personnel. The effect of blood Ca concentration on metritis and first test milk yield for PP and MP were analyzed with Poisson regression and linear mixed models, respectively. Herd was included as a random effect in all models. Postpartum Ca concentration was not associated with metritis (10 and 8.5% prevalence in PP and MP, respectively) diagnosis in PP [P = 0.76; while controlling for the effect of retained placenta (RP)] or MP cows [P = 0.21; controlling for RP and parity (2nd versus 3rd or higher)]. Primiparous and MP animals with lower postpartum Ca concentrations produced more milk at first DHIA test than animals with higher Ca concentrations. After dichotomization of the Ca variable using previously reported subclinical hypocalcemia cut-points of 8.0 and 8.4 mg/dL, PP cows with Ca concentrations ≤ 8.0 (8%) and 8.4 (17.5%) mg/dL (controlling for metritis and d in milk at DHIA test) produced 4.0 kg (P = 0.006) and 2.4 kg (P = 0.01) more milk, respectively, than PP animals with Ca concentrations > 8.0 and 8.4 mg/dL at first DHIA test. Multiparous cows with Ca concentrations ≤ 8.0 (51%) and 8.4 (68%) mg/dL (controlling for metritis, displaced abomasum, parity, and d in milk at DHIA test) produced 1.8 kg (P = 0.002) and 1.5 kg more milk (P = 0.01), respectively, than MP animals with Ca > 8.0 and 8.4 mg/dL at first DHIA test. In our study, immediate postpartum Ca concentration had no association with metritis diagnosis, and cows with lower blood Ca concentration produced more milk in early lactation compared with cows with higher blood Ca concentrations.

1. **Effect of a single dose of an oral calcium bolus after parturition on plasma calcium concentration, milk production, and culling in Holstein dairy cows.**

Our objectives were to determine (1) the effect of a single dose of an oral Ca bolus after parturition on blood Ca concentration, and (2) the effect of this supplemental Ca approach on milk production and culling. For our first objective, cows from 1 commercial dairy were enrolled within 19 h after parturition (mean ± SD = 8.3 ± 5.3 h) and randomized within parity group (1st, 2nd, and 3rd or greater) to control [CON (n = 25); no

placebo] or bolus treatment [BOL (n = 25); 3 oral Ca boluses administered at once supplying 54 to 64 g of Ca (Quadrical, Biovet, Barneveld, WI)]. Blood samples were collected before group assignment and at 1, 2, 4, 8, 12, and 24 h thereafter. Plasma Ca concentration was analyzed by mixed effects repeated measures ANOVA. Cow within treatment was treated as a random effect and h postpartum, parity group, and Ca concentration at enrollment as covariates along with relevant treatment interactions. For our second objective, cows from 6 commercial dairy farms in New York State were enrolled as described for objective 1 (CON n = 1,973; BOL n = 1,976). First Dairy Herd Improvement Association test-day milk yield and culling data were collected from herd management software. We conducted a preliminary analysis using a multivariable ANOVA to analyze first test milk yield (treatment, parity group and herd as covariates) and a chi-squared test to examine the association between treatment and culling within 30 d in milk. Bolus administration did not affect mean plasma Ca concentration in the 24 h after bolus administration (CON = 2.00 ± 0.03 vs. BOL = 1.96 ± 0.03 mmol/L, P = 0.36). No preliminary associations between treatment and first test milk yield (CON = 38.1 ± 0.2 vs. BOL = 38.1 ± 0.2 kg/d, P = 0.88) or culling within 30 d in milk [CON = 4.1% (80/1,973) vs. BOL = 4.9% (96/1,976), P = 0.22] were observed. Administration of a single dose of an oral Ca bolus after parturition did not increase blood Ca concentration, and preliminary results indicate no association between treatment and early lactation milk production or culling.

1. **Gene expression of some hepatic gluconeogenic and fatty acid metabolism in early lactation dairy cows as affected by dietary starch and monensin supplementation.**

The objective of this study was to evaluate the impact of dietary starc level and monensin on the gene expression of some key enzymes relate to hepatic gluconeogenesis and fatty acid metabolism during early lactation Prior to parturition primiparous (primi; n = 16) and multiparous (multi; n = 33) Holstein cows were fed a common controlled energy close up diet with a daily topdress containing either 0 mg/d (Con) or 400 mg/d monensin (Mon). From d 1 to 21 postpartum, cows were fed high starch (HS; 26.2% starch, 34.3% NDF, 22.7% ADF, 15.5% CP) or low starch (LS; 21.5% starch, 36.9% NDF, 25.2% ADF, 15.4% CP) diet with a daily topdress containing either Con or 450 mg/d Mon, continuing with prepartum topdress assignment. Liver biopsies were obtained from cows on d 7 postpartum for mRNA gene expression analysis. There was a tendency for a Mon × parity interaction for CPT1A (P = 0.13) such that primi cows fed Con had increased CPT1A expression compared with primi cows fed Mon, whereas multi cows fed Mon had increased CPT1A expression compared with multi cows fed Con. There was a tendency for a starch × Mon interaction on HMGCS2 expression (P = 0.12) such that cows fed LS and Mon tended to have decreased HMGCS2 expression relative to cows fed LS and Con. There were tendencies for Mon × parity interactions for PC (P = 0.13) and PCK1 (P = 0.09) such that multi cows fed Mon tended to have increased expression for both PC and PCK1. Correlation analysis was performed for all gene expression variables. Overall, relationships were similar in directionality and magnitude between cows fed HS and LS and Con and Mon. However, for cows fed Con there was a positive relationship between HMGCS2 and PC (r = 0.44; P = 0.02) and HMGCS2 and PCK1 (r = 0.78; P < 0.01), whereas cows fed Mon there was no relationship (r = 0.08; P = 0.72 and r = 0.34; P = 0.10, respectively). Overall, cows fed diets of different starch content in early lactation and monensin throughout the transition period had some alterations in hepatic expression of genes related to glucose and fatty acid metabolism.

1. **A 100-year review: Metabolic health indicators and management in dairy cattle (Journal of Dairy Science Centennial Review Paper to be published in December 2017)**

Our aim in this Journal of Dairy Science Centennial Review is to describe the evolution of focus over the past 100 yr on metabolic indicators from discovery and description to evaluation at the individual cow and subsequently herd levels. Furthermore, we will discuss current and future technologies that will be employed in the dairy industry to utilize these indicators widely going forward. Knowledge of chemical changes in various fluids (e.g., blood, urine, and milk) accompanying numerous metabolic disease states in the dairy cow has existed since nearly the beginning of Journal of Dairy Science 100 yr ago. However, it is only during the last 25 yr that these metabolic indicators have been developed into useful tools for cow- and herd-level monitoring for disease and management. From the 1920s through the 1940s, our understanding of the changes in blood chemistry accompanying milk fever and ketosis increased as well as our understanding of the underlying biology. In the 1950s and 1960s, workers studying ketosis and energy metabolism began to evaluate changes in lipid metabolism reflected by concentrations of circulating nonesterified fatty acids; furthermore, initial development occurred for on-farm tests of milk ketones. During the 1970s, blood metabolic profiling was applied to dairy farms but found to be of varied and limited usefulness. The turning point occurred when large, observational studies of periparturient cow disease were pioneered in the U.S., Canada, and Europe in the 1980s, which further solidified our understanding of risk factors and epidemiological interrelationships among disease, production, and reproduction. In the early 1990s, scientists first incorporated indicators of metabolic health into large observational studies and determined important epidemiological relationships between these indicators and outcomes of interest. This field of study blossomed during the 2000s as several research groups conducted multiple investigations into metabolic indicators related to energy metabolism and began to develop cow-level thresholds and herd-level alarms for use in monitoring and management. This work was accompanied by additional studies to validate point of care instruments that could be used to implement these strategies at the cow and herd levels. Work in the 2000s continued to identify and evaluate other physiological indicators of inflammation and oxidative stress; however, these have yet to be incorporated into large-scale observational studies. Finally, use of technology (e.g., activity monitoring, cow-monitoring collars and tags, milk-based analysis using Fourier Transform Infrared spectroscopy) continues to receive significant attention going forward in order to allow eventually for real-time and automatic monitoring of metabolic indicators and improved health and herd management on dairy farms.

**D. Usefulness of findings:**

Results from the large, cross-sectional commercial farm-base study describe the current state of transition period management strategies and major transition period health events on dairy farms in New York and Vermont. Further analysis will be conducted on this dataset focused on nutritional strategies employed by the herds along with nonnutritional factors related to facilities and management and their relationships with health and productive outcomes.

Studies conducted and focused on undigested NDF (uNDF240) levels in the diet fed during the immediate postpartum period suggest that these levels can modulate postpartum DMI and plasma metabolites such as NEFA and BHBA. Based upon this and previous work, 12% uNDF240 limits DMI and increases NEFA and BHBA and about 9% uNDF240 in the diet may optimize DMI and energy metabolism.

Our work further supports the implementation of strategies to decrease dietary cation-anion difference (DCAD) in the prepartum period as a management strategy to improve postpartum blood calcium status and performance. In our study, targeting urine pH of cows fed DCAD diets to between 5.5 and 6.0 resulted in the greatest improvements in blood calcium and performance. Use of a commercial Ca-Mg dolomite source compared to common sources (calcium carbonate, magnesium oxide) did not affect blood calcium status in periparturient cows, but increased prepartum DMI and improved energy status prepartum.

We demonstrated that administration of a single dose of oral calcium after parturition did not result in overall effects on health or production in early lactation; further analysis suggested that selected subgroups of cows did benefit from oral calcium. Furthermore, cows with lower blood calcium in the first 12 h postcalving produced more milk and did not have greater incidence of metritis, suggesting that postpartum sampling for subclinical hypocalcemia should focus on time periods greater than the first 12 hours postpartum.

**E. Publications:**

 *Journal*

Leno, B. M., S. E. LaCount, C. M. Ryan, D. Briggs, M. Crombie, and T. R. Overton. 2017. The effect of source of supplemental dietary calcium and magnesium in the peripartum period, and level of dietary magnesium postpartum, on mineral status, performance, and energy metabolites in multiparous Holstein cows. J. Dairy Sci. 100:7183-7197.

Leno, B. M., C. M. Ryan, T. Stokol, D. Kirk, K. Zanzalari, J. D. Chapman, and T. R. Overton. 2017. Effects of prepartum dietary cation-anion difference on aspects of peripartum mineral and energy metabolism and performance of multiparous Holstein cows. J. Dairy Sci. 100:4604-4622.

Neves, R. C., B. M. Leno, T. Stokol, T. R. Overton, and J.A.A. McArt. 2017. Risk factors associated with postpartum subclinical hypocalcemia in dairy cows. J. Dairy Sci. 100:3796-3804.

Overton, T. R., J.A.A. McArt, and D. V. Nydam. 2017. A 100-Year Review: Metabolic health indicators and management of dairy cattle. J. Dairy Sci. 100:(in press).

*Abstracts*

LaCount, S. E., B. M. Leno, C. M. Ryan, and T. R. Overton. 2017. The effects of varying undigested NDF and physically effective NDF content of fresh cow rations on metabolism in multiparous Holstein cows. J. Dairy Sci. 100(Suppl. 2):115-116.

Lawton, A. B., J. R. Lawrence, M. E. Smith, W. S. Burhans, M. E. Van Amburgh, and T. R. Overton. 2017. The use of the Cornell Net Carbohydrate and Protein System in corn silage hybrid testing programs. J. Dairy Sci. 100(Suppl. 1):268-269.

Leno, B. M., R. C. Neves, M. D. Curler, M. J. Thomas, T. R. Overton, and J.A.A. McArt. 2017. Effect of a single dose of an oral calcium bolus after parturition on plasma calcium concentration, milk production, and culling in Holstein dairy cows. J. Dairy Sci. 100(Suppl. 2):39.

McCarthy, M. M., G. D. Mechor, and T. R. Overton. 2017. Gene expression of some hepatic gluconeogenic and fatty acid metabolism in early lactation dairy cows as affected by dietary starch and monensin supplementation. J. Dairy Sci. 100(Suppl. 2):307-308.

Neves, R. C., B. M. Leno, M. D. Curler, M. J. Thomas, T. R. Overton, and J.A.A. McArt. 2017. The association of blood calcium concentration shortly after parturition with metritis and milk production in Holstein dairy cows. J. Dairy Sci. 100(Suppl. 2):87.

 *Conference proceedings and book chapters*

Lawton, A. B., W. S. Burhans, D. Nydam, and T. R. Overton. 2016. Transition cow management and outcomes in Northeast herds. Proceedings, Cornell Nutrition Conference for Feed Manufacturers, Syracuse, NY.

Leno, B. M., S. E. Williams, C. M. Ryan, D. Briggs, M. Crombie, and T. R. Overton. 2016. Effect of peripartum source of magnesium and calcium, and postpartum feeding rate of magnesium, on intake, performance and mineral and energy status of multiparous Holstein cows. Proceedings, Cornell Nutrition Conference for Feed Manufacturers, Syracuse, NY.

Nydam, D. V., T. R. Overton, M. M. McCarthy, J.A.A. McArt, and B. M. Leno. 2016. Management of transition cows to optimize health and production. Large Dairy Herd Management. American Dairy Science Association, Savoy, IL.

**F. Impact statement:**

Transition cow nutrition and management continues to present opportunities for improvement on dairy farms. Compared to previous work in our group, current results suggest progress but more progress is to be made. Decreasing dietary DCAD prepartum improves blood calcium status and performance across populations whereas only subpopulations benefit from oral calcium administration. Greater development and application of metabolic health indicators will continue to improve monitoring and management of transition cow health and performance at the farm level.

**G. Leverage:**

Work conducted under this project leveraged approximately $310,000 of funding from private industry and an additional $250,000 of competitive funds available in New York to support agricultural research.

**Cooperative Regional Project NC2042**

**2016-2017 Annual Report**

**Project Name:** Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises

**Cooperating Agency:** University of Idaho Agricultural Experiment Station

**Personnel:** Mireille Chahine, Extension Dairy Specialist

**Collaborators:** Hernan Tejeda, Richard Norell, Mario de Haro-Marti, Joe Dalton, Pedram Rezamand, Mark McGuire, Amin Ahmadzadeh, University of Idaho; Gonzalo Ferreira, Virginia Tech; Alex Bach, IRTA Barcelona; Jason Ahola, Noa Roman-Muniz, Colorado State University.

**Project Objectives:**

1. Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.
2. Improve dairy cow management decisions through nutrient utilization, well-being and profitability.
3. Analyze whole farm system components and integrate information into decision-support tools to improve efficiency, enhance profitability, and environmental sustainability

**Accomplishments**

**Under objective 2:**

**Effects of spray-dried plasma product supplementation on transition and lactation on milk production and reproduction in dairy cows.** A. Bach, J. Polo, J. M. Campbell, M. E. de Haro Martí, M. Chahine

Spray-dried plasma (SDP) proteins are recognized as safe, high-quality feed ingredients for livestock due to their immune modulatory components, including immunoglobulins, bioactive peptides and growth factors. The objective of this study was to investigate the effects of feeding a SDP product during the first 200 d of lactation on production and reproduction parameters in dairy cows. Nine hundred 98 Holstein cows 260 d pregnant were enrolled in a randomized design. Before calving, cows were fed a late gestation ration containing blood meal (BM; 0.8% of DM; Control, n = 503) or SDP (250 g/d; n = 495) replacing BM on N basis. After calving, Control cows were fed a lactation ration containing 0.7% BM (DM basis). Cows on SDP prepartum were fed a lactation ration that contained 400 g/d of SDP, which replaced BM. First service consisted of a timed AI protocol applied to all cows that were >44–50 DIM. Following AI, cows were examined daily for return to estrus or for confirmation of pregnancy by rectal palpation at 35–41 and 70–76 d after AI. At 72–78 DIM, cows not pregnant were enrolled into an intrauterine progesterone program. Milk production and composition were monitored on a monthly basis at one milking. All data were analyzed using a mixed-effects model with repeated measures. Reproductive data were analyzed using mixed-effects logistic regression with treatment as a fixed effect and pen as a random effect. Cows fed SDP had greater milk yield (*P* = 0.01; 35.7 vs 36.8 ± 0.94 kg) and milk fat (*P* < 0.05; 3.45 vs 3.54 ± 0.08%), but there were no differences in milk protein or in milk SCC between Control and SDP cows. Milk yield improvement in SDP cows was evident during the second month of lactation and onwards. No differences in pregnancy rate, overall conception rate, days at which pregnancy occurred or body condition score were observed between treatments. In conclusion, substitution of BM by SDP in dairy cows increased milk yield and milk fat content without affecting reproductive parameters.

**Does a 500-ohm shunt resistor accurately characterize the electrical resistance of adult dairy cattle?** R. Norell., J. Spencer, A. Ahmadzadeh, M. E. de Haro Marti, M. Chahine

By Idaho statute, a 500-ohm shunt resistor must be used when investigating stray voltage on dairies and represents a “worst case” body resistance (BODYR) value for adult dairy cows (USDA stray voltage handbook 696, 1992). BODYR data from the 80s were typically collected from cows in tie stall barns and may not represent modern open lot and free-stall dairies. Our study objectives were to compare: (a) BODYR of 6 cow pathways, (b) effect of wet versus dry haircoats, and (c) 3 electrical connections to the mouth area. BODYR data were collected from 42 cows on a commercial open lot dairy in Idaho. Pathways were: front to rear hooves (FR), neck to all hooves (NALL), rump to all hooves (RALL), mouth to all hooves (MALL), mouth to front hooves (MF), and mouth to rear hooves (MR). NALL and RALL were tested with wet and dry haircoats and data were analyzed as a 2 × 2 factorial model in SAS. MALL, MF, and MR were evaluated with 3 mouth area connections (nose tongs (NT), metal bit (MT), and metal basket (MB)) and data were analyzed as a 3 × 3 factorial model in SAS. BODYR varied significantly between pathways and ranking median BODYR (ohms) from lowest to highest value yields: MALL (255), RALL-wet (314), MF (360), MR (361), FR (469), NALL-wet (544), RALL-dry (9,185) and NALL-dry (820,000). BODYR was significantly lower for rump versus neck location, for wet versus dry haircoats, and exhibited a significant location by haircoat status interaction due to significantly lower BODYR with dry rump versus dry neck. Cows were measured immediately after milking and the rump or udder may have received water spray or contacted wet pipework during milking. BODYR with the mouth connections and pathways were significantly lower for MALL than MF or MR; for NT versus MT and MB; and exhibited a significant interaction between mouth connections and hoof pathways. The percentage of measurements below 500 ohms varies by pathway: MALL (98%), MF (98%), MR (96%), RALL-wet (82%), FR (69%), NALL-wet (34%), RALL-dry (5%) and NALL-dry (0%). A 500-ohm shunt resister overestimates BODYR and underestimates electrical current flow at a given voltage for MALL, MF, MR, RALL-wet, and FR pathway. Contact method and haircoat condition influence measured BODYR of cows.

**The effect of adding zeolites to dairy manure compost on ammonia emissions and nitrogen speciation.** M. E. de Haro Marti, M. Chahine, H. Neibling, L. Chen

Composting of manures and other agricultural wastes is an acceptable and wide spread used waste management technique. As a waste management practice, composting reduces the volume of composted wastes between 35 and 50%, which allows the materials to be significantly more affordable to transport than raw wastes. Most manures, including dairy manure, don’t have the proper carbon to nitrogen ratio (C:N) for composting without the loss of nitrogen as ammonia during the composting process. A zeolite is a crystalline, hydrated aluminosilicate of alkali and alkaline earth cations having an infinite, open 3 dimensional structure. Zeolites are able to further lose or gain water reversibly and to exchange cations with and without crystal structure. The objective of this study was to demonstrate the effects of adding zeolites to the dairy manure compost mix on ammonia emissions and the quality of the final compost product. The study was conducted on a commercial dairy in Southern Idaho. Manure stockpiled during the winter and piled after the corral cleaning was mixed with fresh pushed up manure from daily operations, and with straw from bedding and old straw bales, in similar proportions for each windrow. Windrows were mixed and mechanically turned using a tractor bucket. Three replications of control and treatment were made. The control consisted of the manure and straw mix as described. The treatment consisted of the same mix as the control plus the addition of 8% of zeolites by weight during the initial mix. Windrows were actively composted for 120 d or more with 5 turns per windrow including the initial mix preparation. Data were analyzed using ANOVA. Cumulative ammonia emissions were reduced by 11% in the zeolite treated compost vs. control (2.76 mg NH3-N/m3 versus 3.09 mg NH3-N/m3; *P* < 0.05) during the first 3 turns which occurred in the first 45 to 55 d of composting. Nitrates concentration in the amended compost (702 mg/kg) was 3 times greater than in the control (223 mg/kg; *P* = 0.05). The project demonstrated the feasibility of using the addition of zeolites into the composting process as a Best Management Practice to reduce ammonia emissions and to change the nitrogen speciation during the composting process.

**Effect of betaine on total tract digestibility, rumen fermentation and rumen microbiome of dairy cows** M. Chahine, P. Rezamand, M. McGuire

The objectives of this study are to determine the effect of supplemental betaine on total tract digestibility, ruminal fermentation, and ruminal microbiome in mid-lactation dairy cows. Study is currently being conducted at the University of Idaho Dairy Center located in Moscow, Idaho. Twenty cows are used in a 3 x 3 latin square design with 3 periods and 3 treatments of rumen-unprotected betaine (betaine 97% purity; Amalgamated Sugar Co., Nampa, ID). Dietary treatments consist of: 1) Control, 2) 100 g/d betaine 3) 200 g/d betaine top-dressed on the regular University of Idaho Dairy TMR ration. Study will be completed in 2018.

**Under objective 3:**

**Risk assessment and management for dairy farmers in the western region (in progress)** Tejeda, H.; M. Chahine, G. Ferreira

This project is the result of a collaboration between 2 members of the NC 2042 (Dr. Gonzalo Ferreira, Virginia Tech and the University of Idaho). It addresses risk management education topics covering production, marketing risk, financial risk and human risk. These topics are addressed through educational workshops that include subject presentations, on-hands work with spreadsheets, delivery of fact-sheets, and discussions among peers and presenter(s). The workshops are for small and medium sized dairies (herd size of up to 1000 cows), as well as for young dairy producers, and will be delivered in three different locations in the State of Idaho. The locations are in Eastern Idaho, Southcentral Idaho (Magic Valley) and in Southwest Idaho (Treasure Valley). A two day workshop will be held in each location, and a total of 60 dairy farmers are expected to attend and understand, develop, analyze and discuss: (1) business strategic plans, (2) financial records, (3) investment analysis, (4) balance sheets, (5) farming systems, and (6) risk management decision-making tools.

**Publications:**

***Peer-reviewed Journal Articles***

Adams, A., J. Ahola, I. Roman-Muniz and M. Chahine. 2016. Effect of on-farm dairy Beef Quality Assurance (BQA) training on dairy worker knowledge of BQA and welfare related practices. Journal of Extension 54-5: Article 5RIB8.

Adams, A., J. Ahola, M. Chahine, A. Ohlheiser, and I. Roman-Muniz. 2016. Case Study: Effect of on-farm dairy Beef Quality Assurance training on welfare-related traits in lactating dairy cows. The Professional Animal Scientist 32 (3): 368-374.

***Peer-reviewed Extension publications***

Norell, R. J., B. G. Glaze., M. Chahine, and. N. L. Olsen. 2017. Methods for Measuring Dry Matter Content of Potatoes On-Farm. University of Idaho. CIS Bulletin 1219.

Menegatti Zoca, S., B. Glaze, D. A. Moore, J. C. Dalton, and M. Chahine. 2016. Genética y Genómica: Una Introducción. eXtension factsheet. [http://articles.extension.org/pages/73455/gentica-y-genmica:-una-introduccin](http://articles.extension.org/pages/73455/gentica-y-genmica%3A-una-introduccin)

***Abstracts***

Bach, A., J. Polo, J. M. Campbell, M. E. de Haro Martí, and M. Chahine. 2017. ffects of spray-dried plasma product supplementation on transition and lactation on milk production and reproduction in dairy cows. J. Dairy Sci. 100 (Suppl. 2):314-315.

R. Norell., J. Spencer, A. Ahmadzadeh, M. E. de Haro Marti, and M. Chahine. 2017. Does a 500-ohm shunt resistor accurately characterize the electrical resistance of adult dairy cattle?J. Dairy Sci. 100 (Suppl. 2):297-298.

M. E. de Haro Marti, M. Chahine, H. Neibling, and L. Chen. 2017. The effect of adding zeolites to dairy manure compost on ammonia emissions and nitrogen speciation.J. Dairy Sci. 100 (Suppl. 2):84.

***Proceedings***

M. E. de Haro-Marti, Chahine, M. Neibling, H. and L. Chen. 2017. Composting of dairy manure with the addition of zeolites to reduce ammonia emissions. Waste to Worth conference. Cary, NC. March 21, 2017.

**Leverage:**

Measuring electrical resistance of dairy cattle. 2017. R. Norell, M. Chahine and A. Ahmadzadeh. Idaho Dairymen’s Association, $17,786.

Risk assessment and management for dairy farmers in the Western Region. H. Tejeda, M. Chahine and G. Ferreira. USDA Western Extension Risk Management Education, 2017. $39,572.

Effect of feeding betaine on total tract digestibility, rumen degradation, and microbiome of dairy cows. M. Chahine, P. Rezamand and M. A. McGuire. The Amalgamated Sugar Company $79,453.

**NC2042: 2016-2017 Annual Report**

**University of Illinois at Urbana-Champaign**

**Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Personnel:** Felipe (Phil) Cardoso (Project Leader), Russell Pate (PhD student), Kelly Ryan (MS student), M. Ines Rivelli (PhD student), Taylor Damery (MS student), Stephanie Stella (MS student), and Maegan Weatherly (PhD student).

**Collaborators:** James K. Drackley, Romana A. Nowak, Matthew B. Wheeler, J. Loor, and D. W. Shike, University of Illinois; D. H. Keisler, University of Missouri; Leo Timms, Iowa State University; and J. R. Roche, Dairy NZ, New Zealand.

**Main objective:** To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

**Specific objectives:**

1. Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.
2. Improve dairy cow management decisions through nutrient utilization, well-being and profitability.
3. Analyze whole farm system components and integrate information into decision-support tools to improve efficiency, enhance profitability, and environmental sustainability.

**Work progress and principal accomplishments:**

*Under objective 2.*

**Rivelli, M.I., S.Y. Morrison, K.J. Haerr, S. Rodriguez-Zas, and F.C. Cardoso. (2017). Nutrition, reproduction, and young stock performance in dairy farms throughout Illinois: a Dairy Focus Team approach. The Professional Animal Scientist. 33:409-419.**

The world dairy industry has been changing over the last decades, and Illinois dairy farms are not an exception to these transformations. The objective of this study was to develop research and educational data that could help farmers to identify improvements and opportunities. To evaluate potential nutritional, reproductive, and young stock management opportunities, a total of 20 farms in Illinois were visited from May through June 2014.The farms were divided between the northern (NOR) and southern (SOU) regions of Illinois. During the visit to each farm, a questionnaire, DHI records along with the individual farm data set, samples of corn silage and TMR, and weather (ambient temperature, relative humidity, and wind speed) measurements were collected by a trained team of university and industry scientists. Average herd size was 413 ± 192 and 451 ± 949 lactating and dry cows for NOR and SOU, respectively. Average daily milk yield per cow was 37.9 ± 6.7 kg and 33.8 ± 5.7 kg for NOR and SOU, respectively (*P* = 0.21). Mean density of corn silage was greater for SOU than NOR (221.2 ± 8.2 vs. 168.5 ± 12.2 kg/m3, *P* = 0.003). Dry matter content of the TMR offered to both lactating and dry cows was greater for NOR than SOU (48.7 ± 1.7 vs. 44.1 ± 1.0%, *P* = 0.006). Yearly pregnancy rate (19.8 ± 2.2 vs. 12.6 ± 1.6; *P* = 0.006) was greater for cows and heifers in NOR than SOU. Results suggested that geographical aspects such as weather differences (NOR vs. SOU) are important factors related to performance of dairy farms. Educational and extension programs tailored to the aforementioned differences might be more effective.

*Under objective 3.*

**Development of the Dairy Focus Somatic Cell Count Calculator to analyze mastitis costs. R. T. Pate, K. T. Ryan, and F. C. Cardoso. Abstrac at ADSA 2017; Pittsburg – PA.**

In 2014, the National Animal Health Monitoring System reported that roughly 24.1% of all cows in the top 17 dairy producing states suffered from clinical or subclinical mastitis. Many milk processors award producers with bonus incentives for reaching higher milk quality. Most dairymen are aware of their bulk tank somatic cell count (SCC), however, what they lack is a way of determining how much monetary loss is incurred by not receiving a milk quality bonus. The Dairy Focus SCC Calculator (DFSCCC) which is an EXCEL™ based program allows producers to analyze their test day milk numbers and take appropriate action regarding SCC. The main goal of the DFSCCC is to assist dairy producers in making management decisions on an individual herd level, which will improve overall health and decrease economic losses due to mastitis. The DFSCCC allows producers to identify cows in the herd that are contributing the highest percentage to the bulk tank SCC. Also, the calculator identifies cows that have chronic or new cases of mastitis by sorting cows by highest current and previous test day SCC. The program also includes an ‘Economic Gains’ table which allows the user to view the differences between bulk tank values with and without high SCC cows. These values are influenced by the bulk tank milk amount, bulk tank SCC, current milk price, and milk quality bonuses per CWT if a SCC parameter is achieved once certain cows are removed. One case showed that if a producer removed one high SCC contributing cow from the bulk tank, that their pounds of milk shipped per month would be decreased by 1,905 kg, while the monetary value of the milk shipped increased by $10,370 per month. It is important to note that the high SCC milk that is no longer used in the bulk tank could be used for alternate purposes, such as calf feeding. The DFSCCC is very easy to operate and is free to download under the ‘Tools’ page at www.dairyfocus.illinois.edu. There are currently versions available for Dairy Comp 305™ and PCDart™, as well as a version for dairyman who prefer to enter data manually.

**Producer interactions (extension activities)**

1. Florida Ruminant Nutrition Symposium. Title: “Pre-and postpartum nutritional management to optimize energy balance and fertility in dairy cows”. Approximately 100 participants. February 7, 2017, Gainesville, FL.
2. Western Dairy Management Conference. Title: “Managing Health and Reproduction Identifying the Costs and the Importance of Required Nutrients”. Approximately 1,600 participants. February 28, 2017, Reno, NV.
3. VI Jornada Kemin sobre nutricion de vacuno the lechero. Title: “Alimentación en base a aminoácidos para mejorar el rendimiento reproductive (Feeding amino acids for improved reproductive performance)” Approximately 100 participants. June 5, 2017, Lugo, Spain.
4. Kemin Europe Annual Seminar: Connecting Dots of Amino Acid Nutrition – Nutrition to Maximize the Farm Efficiency. Title: “Feeding amino acids for improved reproductive performance” Approximately 150 participants. June 7, 2017, Lisbon, Portugal.
5. EW Nutrition and Dos Pinos Cooperative Dairy Training and Workshop: Title: “Pre- and postpartum nutritional management to optimize health and fertility in dairy cows” Approximately 30 participants. July 26 and 27, 2017, San Jose, Costa Rica.
6. Form-A-Feed Professional Dairy Conference. Titles: “Impact of Feeding Amino Acids on Reproduction” and “Corn Silage: Fungal Disease, The Silent Killer” Approximately 250 participants. January 19-20, 2017, Morton, MN.
7. Cargill producer meeting series. Title: “The 10 steps for a successful transition period”. Approximately 60 participants. February 1, 2017, St. Henry, OH.
8. Group of nutritionists from Mexico during the Western Dairy Management Conference. Title: “Impacto de los aminoácidos en la reproducción (The impact of amino acids on reproduction)”. Approximately 12 participants. February 28, 2017, Reno, NV.
9. Annual Wisconsin Association of Professional Agricultural Consultants Meeting. Title: “Foliar fungicide application on corn can enhance dairy cow performance”. Approximately 60 participants. March 3, 2017, Wisconsin Dells, WI.
10. CRI Distributor University – Large Dairy Herd Management. Title: “Transition Cow Nutrition and Heifer Nutrition and How These Impact Reproduction and Production.” Approximately 20 participants from North, Central, and South America. May 19, 2017, Verona, WI.
11. 4-State Dairy Nutrition and Management Conference. Title “Are All Clays Created Equal? Clay Utilization in Diets for Dairy Cows”. Approximately 550 participants. June 14 and 15, 2017, Dubuque, IA.
12. IL Dairy Summit. Title: “The 10 Steps for a Successful Transition Period”. Approximately 300 participants. February 21, 22, and 23, 2017, Freeport, Bloomington, and Centralia, IL.
13. Northwest Illinois Dairy Update Barn Meeting at Berning Acres. Title: “The Economics & Milk Quality Benefits of Three Time a Day Milking”. Approximately 50 participants. March 21, 2017, East Dubuque, IL.

**Publications**

**Full-Length Articles related to the project**

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| 1. Haerr, K.J., A. Pineda, N.M. Lopes, J.D. Weems, C.A. Bradley, M.N. Pereira, M.R. Murphy, G.M. Fellows, **F.C. Cardoso**. (2016). Effects of corn treated with foliar fungicide on in situ corn silage degradability in Holstein cows. Animal Feed Science and Technology. 222:149-157*.*
 |
| 1. Sulzberger, S., S. Melnichenko, and **F.C. Cardoso**. (2017). Effects of clay after an aflatoxin challenge on aflatoxin clearance, milk production, and metabolism of Holstein cows. Journal of Dairy Science. 100:1856-1869.
 |
| 1. Derakhshani, H, H.M. Tun, **F.C. Cardoso**, J.C. Plaizier, E. Khafipour, and J.J. Loor. (2017). Linking peripartal dynamics of rumen microbiota to dietary changes and production parameters. Frontiers in Microbiology. 12 January. <https://doi.org/10.3389/fmicb.2016.02143>.
 |
| 1. Kalebich, C.C., M.E. Weatherly, K.N. Robinson, G.M. Fellows, M.R. Murphy, and **F.C. Cardoso**. (2017). Foliar fungicide (pyraclostrobin) application effects on plant composition of a silage variety corn. Animal Feed Science and Technology. 225:38-53*.*
 |
| 1. Rivelli, M.I., S.Y. Morrison, K.J. Haerr, S. Rodriguez-Zas, and **F.C. Cardoso**. (2017). Nutrition, reproduction, and young stock performance in dairy farms throughout Illinois: a Dairy Focus Team approach. The Professional Animal Scientist. 33:409-419.
 |
| 1. Kalebich, C.C., M.E. Weatherly, K.N. Robinson, G.M. Fellows, M.R. Murphy, and **F.C. Cardoso**. (2017). Foliar fungicide (pyraclostrobin) application on corn and its effects on corn silage composition. Animal Feed Science and Technology. 229:19-31*.*
 |
| 1. Kalebich, C.C. and **F.C. Cardoso**. (2017). Review: Effects of foliar fungicide application on corn plants on the composition of corn silage for ruminant diets. Journal of Animal Nutrition. *In press.*
 |
| 1. Heinrichs, A. J., B. S. Heinrichs, C. M. Jones, P. S. Erickson, K. F. Kalscheur, T. D. Nennich, B. J. Heins, and **F. C. Cardoso.** (2017). Verifying Holstein heifer heart girth to body weight prediction equations. Journal of Dairy Science.  *In press.*
 |
| 1. Guagnini, F. S., A. Pineda, R. S. Gonçalves, R.S., L. DalPizzol, D. Driemeier, F. Gonzalez, and **F.C. Cardoso.** (2017). The effect of early postpartum oral drench solution on blood b-Hydroxybutyrate concentration, milk yield, and milk composition in Holstein cows. J. Dairy and Vet. Sci. 1:1-6.
 |
| 1. C.S. Skenandore and **F.C. Cardoso.** (2017). The effect of tail paint formulation and heifer behavior on estrus detection. International Journal of Veterinary Science and Medicine. *In press.*
 |
| 1. Acosta, D.A., A. Schneider, C.B. Jacometo, J.A. Rincon, **F.C. Cardoso**, and M.N. Corrêa. (2017). Effect of somatotropin injection in late pregnant Holstein heifers on metabolic parameters and steroidogenic potential of the first postpartum dominant follicle. Theriogenology.  *In press.*
 |

**Popular Press** Articles in Hoards Dairyman, Progressive Dairymen, Midwest Forage Association, Illinois Milk Producer’s Association Newsletter, and Dairy Focus Newsletter (More at: <http://dairyfocus.illinois.edu>)

**NC 2042: 10/01/2016-09/30/2017 Louisiana State University Station Report**

 **A. PROJECT NAME**: **Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises**

**B. COOPERATING AGENCY and personnel: Louisiana State University** C.C. Williams

**Project Objectives**

**Main objective:** To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

1) To analyze management and nutrition strategies for replacement heifers as they pertain to production and profitability (heifers)

2) To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows)

3) To evaluate system components and integration of information into decision-support tools and whole farm analyses to improve efficiency, control variation, and enhance profitability, and environmental sustainability (whole farm)

**C. WORK PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

**Under Objective 1 of Project:**

**Effect of timing of local anesthesia on physiological responses in calves after dehorning.**

Dehorning is a painful animal management procedure that is commonly performed in dairy calves. The combination of non-steroidal anti-inflammatory drugs (NSAID) and local anesthesia lessens the physiological and behavioral effects of dehorning in calves. Twenty-four Holstein heifer calves, approximately 6-8 weeks of age at dehorning, were used to evaluate effects of timing of local anesthesia on physiological indicators of stress associated with pain of dehorning. Calves were assigned to one of four treatment groups: anesthesia without dehorning (CON); dehorning without anesthesia (NO\_ANET); anesthesia followed by immediate dehorning (ANET\_0); and anesthesia with a 10 minute delay prior to dehorning (ANET\_10). Approximately 3 hours before dehorning, calves were restrained with a rope halter. Calves in CON, ANET\_0, and ANET\_10 received 5 mL of 2% lidocaine hydrochloride (Lidocaine HCL 2% (20 mg/ml) VetOne, Boise, ID) for each horn bud as previously described (Stock et al., 2013). Calves in NO\_ANET received 0.9% saline in the same manner as those calves that received lidocaine. Horn buds were then removed via hot iron, as previously described (Heinrich et al., 2010). Calves were administered local anesthesia and NSAID immediately prior to sham dehorning, dehorning, or the 10 minute delay prior to dehorning. Blood samples were collected approximately 10 min prior to treatment administration (-10 min), immediately prior to anesthesia administration (0 min), and at 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 40, 50, 60, 90, and 120 after dehorning. To maintain consistency the same veterinarian performed all nerve blocks and dehornings. After the 2h sample was collected, calves received gelatin capsules containing meloxicam (Meloxicam Tablets USP 15 mg, Unichem Pharmaceuticals USA Inc., Rochelle Park, NJ), an NSAID, at a dose of 1 mg/kg of body weight. To maintain consistency the same veterinarian performed all nerve blocks and dehorning. All blood samples were analyzed for cortisol, and samples collected from -10 through 30 minutes post-dehorning were analyzed for ACTH. Based on the results of this study, it is inconclusive as to whether or not there is a benefit to waiting 10 minutes after the administration of lidocaine to dehorn calves. Calves dehorned after a 10-minute waiting period had a significantly lower peak in ACTH than ANET\_0 and NO\_ANET and reached baseline levels for both plasma ACTH and cortisol concentrations before the ANET\_0 and NO\_ANET treatment groups. However, the observed differences in plasma ACTH concentrations dissipate within 5 minutes, and plasma cortisol concentrations in all calves returned to pretreatment levels within an hour of dehorning. These findings are significant because no previous research has reported the effects of time of lidocaine administration on ACTH and cortisol after cautery dehorning.

**D. USEFULNESS OF FINDINGS:** Results of these projects should provide useful information for dairy producers throughout the United States. Interest in animal welfare, particularly pain associated with routine procedures, has increased among consumers. Determining the optimal time to administer anesthesia when dehorning calves can save time during the procedure, thus allowing more efficient use of labor resources in performing management practices.

**E. PUBLICATIONS:**

**Non-peer reviewed (e.g., proceedings articles, abstracts, articles for client and lay audiences:**

**F. IMPACT STATEMENT**

Continued emphasis on growth and development of heifers will ultimately add to improved production efficiency in dairy operations. These animals are the future milking cows, and research must continue to identify management strategies that can improve performance of these valuable animals.

Dehorning is a routine practice used in the dairy industry. Although there are benefits to this procedure, it is painful to calves. Approximately 12.4% of producers use local anesthesia and 1.8% use analgesics when dehorning calves. With increasing concerns over pain and distress, it is important to investigate strategies to alleviate this pain and distress during routine management procedures.

**G.** **Leverage**

**NC 2042: 2017 Station Report**

**A. PROJECT NAME:** Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises (Rev. NC 1119).

 **B. COOPERATING AGENCY:** Maryland Agricultural Experiment Station, College Park.

 **Personnel:** K.M. Moyes1, Li Ma1, Dale M. Johnson2, Stanley W. Fultz2, and R. R. Peters1. Department of Animal and Avian Sciences1 and University of Maryland Extension2 .

**Project Objectives addressed in Maryland:**

***Main objective:*** *Provide for collaborative research leading to dairy management strategies and systems to facilitate sustainable and profitable decisions by managers of milking cow and heifer enterprises.* **Objective 3:** Analyze whole farm system components and integrate information into decision-support tools to improve efficiency, enhance profitability, and environmental sustainability. **Sub-objective C.,** Precision Dairy

C. WORK PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

**Under Sub-objective 3C:**

This is a progress report of unpublished results from a case study of four dairy herds in New York State that have transitioned from conventional to automatic milking systems (AMS). Farms are identified as Farm C, D, E, and F, to comply with Institutional Review Board guidelines for safeguarding the anonymity of the participants. The primary objective of this study was to estimate and quantify the economic impacts, animal health, productivity and lifestyle changes for small-to medium sized dairy farms regarding the transition from conventional to AMS. This preliminary report includes analysis of some animal health, productivity and lifestyle changes. The analysis of economic changes are still pending.

Data were collected both before and after transition and information sources included personal interview, DHIA data, and bulk tank milk culture. For the statistical analysis, SAS version 9.3 was using the mixed model. The class variable was AMS.Differences were declared at p <= 0.05 with trends discussed at p<= 0.10. Statistical analysis was completed on one year of data starting from date of AMS transition. The results available thus for these sources are summarized for these herds.

The owner of Farm C reported that the three most important reasons for installing AMS was to reduce labor, improve personal health, and to upgrade dairy facilities. Farm C transitioned to AMS on Jan. 5, 2016 with eight DeLaval robot units in new barn and discontinued production testing on DHIA. The herd size (480 cows) remained the same before and after transition. The owner retained the original milking parlor and milks sick and fresh cows in this facility.

On Aug. 3, 2016, the owner of Farm C was interviewed post transition. He reported that compared to before transition, hoof health improved with less cows sold for lameness, cull rate improved decreasing from 41 to 30% and treatment for disease did not change. Grain is fed at 1.5 lb per visit. Milk yield has improved and reproduction has not changed. Number of employees has been reduced from 5 to 1 full time person. Maintenance of the robots requires approximately 2.5 hours per day. The management factors for successful operation of the robots were cleanliness, especially for the photo cell to identify teat location, regular singing of udders, and completing required maintenance. There has been no change in prevalence of coliforms, Streptococci agalactiae, or Streptococci species bacterial in bulk tank cultures.

At the Aug. 3, 2016 interview, the owner of Farm C reported his financial investment had not been a good immediate investment to date due to lower milk prices but overall has been a good investment. For example, from a management standpoint, he has been able to spend more time with the cows. Further, he reported that the AMS has been a good personal investment due to having more time at night to spend with family, not feeling as worn out, and with fewer employees to manage, mental health has improved.

Farm D stated the three most important reasons for transitioning to AMS were to increase precision management via the data generated from the AMS, to increase labor flexibility, and to reduce labor. The owners of Farm D transitioned to two Lely AMS units on June 15, 2015, in a completely new barn. The owners of this operation intended to maintain both conventional milking and AMS herds and to grow into the AMS barn. The milking herd size before and after the transition was 164 and 183 cows. At the time of the transition, only stocked with 36 cows per AMS unit with the plan to grow internally to fully utilize the AMS.

On August 10, 2015, the owner of Farm D was interviewed per the changes that had transpired post transition two months previously. The sick and fresh cows continue to be milked in the conventional parlor. Training cows to use the AMS required about one week and no cows were culled for failure to adapt to AMS. Bedding frequency with sawdust has decreased from three times per week to once per week with the new barn.

Using DHIA data, Farm D has observed an increase in milk yield and no change in somatic cell count. Day’s open and predicted calving interval have increased but pregnancy rate has not changed. Cull rate has not changed but the reasons for leaving the herd have tended to change. For example, cull rate for reproduction decreased and mastitis increased. There was no change in prevalence of coliforms, Streptococcus agalactiae, or streptococcus species.

Farm D considered continued cow care and general barn presence as key factors for successful operation of robots. Due to the short time since transition, the owner of Farm D indicated that it is to be determined whether the robots have been a good investment but that from a management perspective, the investment has been positive. Further, the owner felt the AMS has slightly improved flexibility of his operation but overall, there has not been an improvement in quality of life to this point and he feels it remains to be determined whether the robot has been a good investment overall.

Farm E transitioned to AMS on Oct. 29, 2014, using remodeled facilities, and initially installed four Lely robots, and subsequently increased the number to six robots in 2016. The herd size (340) was not changed with AMS adoption. The stated reasons for transitioning were to reduce labor, interest in technology, and to improve lifestyle. Initially part of the herd was milked in the conventional parlor, and sick and fresh cows continue to be milking in the conventional parlor. . It was estimated that two percent of the cows were culled due to not adapting to AMS although the cull rate would have been higher if 100 percent of the herd was milked robotically at the start of transition. Training cows to use the AMS was approximately one week.

From DHIA data, milk yield and days open has increased. Somatic cell count, predicted calving interval, and cull rate has not changed. Results from bulk tank culture indicated that coliforms and Streptococcus agalactiae prevalence has not changed, however, streptococcus species prevalence has increased.

Farm E was interviewed on Aug. 10, 2015, or approximately one year post transition. Management factors that were considered key factors for transition to robotic milking were patience and faith in equipment. Farm E has been very satisfied with the overall decision to invest in AMS, from a financial and a management perspective as well as personal For example the owners of Farm E has 10 to 30 hours of increased time to spend with his family. The owner of Farm E, however, does not find that AMS increased cash flow or profitability. The primary reason is that he had to hire an extra person part-time to milk the cows in the conventional parlor. The owner indicated if he had fully transitioned 100% of his herd initially, the profitability of AMS investment would have increased.

Farm F, a grazing herd, transitioned to AMS on March 18, 2015 and installed a Galaxy model consisting of one robot with two stalls in retrofitted facilities. Herd size was 160 cow before transition and increased to 170 cows after transition. The reasons Farm F installed robots were to reduce labor with more consistent milking, increase interest from family and employees for continued farm longevity, and upgrade equipment. Sick and fresh cows continue to be milked in the conventional parlor. Training to adapt to AMS milking required about 1 one week and maintenance of the AMS consumes one hour per day.

DHIA data indicates that milk yield, predicted calving interval, and days open have increased with AMS. There has been no change in somatic cell count or cull rate. The reasons for culling, however, have changed with more culling for low production and less culling for reproduction, mastitis, and other reasons.

The owners of Farm F have reported that AMS has been a good financial and management investment, and has increased the quality of life.

From these preliminary results, it is concluded that AMS consistently increased milk production in three herds that continued with DHIA production records. In DHIA herds, cull rates and somatic cell count did not change after transition. Maintenance of AMS ranged from 2.5 to 1 hour per day depending on herd size. Training required one week for transitioning the herd to a new AMS. All farms listed reduced labor as a primary reason for installing AMS and all farms continued to use their conventional milking parlor for milking sick and fresh cows. All farms owners agreed that AMS had been a good management investment and three of the four agreed that AMS had increased the quality of life.

**D. USEFULNESS OF FINDINGS:**

The high cost of land, low profits, and labor availability are the primary reasons for lack of expansion of small to medium-sized (i.e. 30-200 milking cows) in the Northeastern (NE) United States. . As herd size continues to increase globally, new technology that allows NE farmers to remain sustainable is greatly desired. Automatic milking systems (AMS) represent the most recent technology available by offering improved management and production efficiency, quality of life and attractiveness to potential successors. However, the financial investment is substantial ($minimum of $200,000 to 500,000) and farmers lack decision-making tools regarding the challenges and opportunities associated with the transition from conventional to AMS. This research will help to identify the management, financial, and lifestyle adjustments that producers will need to be aware of for using AMS technology. Results will also serve as the basis for education programs designed to provide farmers with the decision-making tools required to estimate and quantify economic impacts, performance outcomes and lifestyle changes associated with AMS.

**E. PUBLICATIONS:**

**Peer reviewed (e.g., proceedings articles, abstracts, articles for client and lay audiences:**

**None**

**F. IMPACT STATEMENT** *(in lay language for government agencies and elected representatives)*

Four dairy farms in New York are currently participating in this three-year case study research project. Survey work has been completed to enroll the producer participants and a one year follow-up survey has been completed on all four farms.

**G. Leverage (***dollars and other resources – because of your work in this project you’ve been able to leverage resources from what other sources, amounts?*): 1) $30,500 Integrated Maryland Agricultural and Experiment Station and University of Maryland Extension Competitive Grant Program. Title of Grant Proposal: Estimating and quantifying the economic impacts, production outcomes and lifestyle changes for small-to medium sized dairy farms regarding the transition from conventional to Automatic Milking Systems in the Mid-Atlantic region.

###### MINNESOTA

**OBJECTIVE 1**

**Annual Project Report – Cooperative Regional Project NC-2042**

# **Year ending September 30, 2017**

 **(Not for Publication)**

**A.** **Project Title: “Management Systems to Improve the Economic and**

#  **Environmental Sustainability of Dairy Enterprises”**

**Project Objectives**

**Objective 1**: Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability**.**

**Objective 2:** Improve dairy cow management decisions through nutrient utilization, well-being and profitability.

**Minnesota contribution at Waseca to Objective 1.**

**B. Cooperating Agencies:** Dept. of Animal Science , University of Minnesota,

St. Paul; University of Minnesota Research and Outreach Centers at Morris (WCROC) and Waseca (SROC); South Dakota State University, Hubbard Feeds Inc., Mankato, MN; Milk Products, Chilton, WI; Milk Specialties, Eden Prairie, MN; Paradox Nutrition, Fencrest LLC. IRTA University of Barcelona.

 **Personnel:** H. Chester-Jones, M. Endres, B, Heins, D.M. Ziegler, B. Ziegler,

 David Casper, Mary Raeth, Greg Golombeski, N. Broadwater, G. Maynou,

 A. Bach, and M.Terre.

###

1. **Progress of Work and Accomplishments:**

Brief overview - Program focus with the SROC Calf and Heifer Research and Extension Facility (CHREF) since 2004 has been with commercial dairy heifer calves from 3 dairies representing over 2,000 dairy cows. Calves are picked-up twice weekly at 2-4 days of age. All calves receive 3 feedings of colostrum by 24 hours of age. During the project year 2016-2017, 1,265 heifers were raised at SROC. The death loss for this project year was 2.5% as we have had some challenges with clostridia perfringens. One of the unique aspects of the project is the development of Excel spreadsheets for each dairy tracking every calf that enters and leaves SROC then follow them back to the dairies for first lactation production data. A data set from 37 nursery studies representing 2,880 complete lactations is complete and a paper published. A second analysis has focused on the intake of Protein and Energy during the nursery period. Forty-five studies are included in this data set plus over 3,600 first lactation data which is part of a MS project for graduate student Jessica Rauba.

**Target goals for calf nursery studies and Automatic calf feeding system (AFR) in a renovated calf room** See Minnesota 2016 NC-2042 report for an overview.

 **Presentations at the 2017 ADSA Meetings in Pittsburgh.**

**Abstract 324 -** Relationships between **protein and energy consumed from milk replacer and starter and first lactation production performance of Holstein dairy cows.** J. Rauba, B.J. Heins, and H. Chester-Jones.

The objective was to determine relationships between protein and energy consumed from milk replacer and starter and first lactation performance of Holstein dairy cows. Data were collected from 4,535 Holstein animals from birth year of 2004 through 2014. Calves were received from 3 commercial dairy farms and assigned to 45 different calf research trials at the University of Minnesota Southern Research and Outreach Center from 3 to 195 d. A majority of calves were fed a 20% CP and a 20% fat milk replacer at a rate of 0.57 kg/calf per day. Milk replacer (MR) metabolizable energy (ME), starter ME, MR protein intake, and starter protein intake consumed from 0-6 weeks were (mean ± SD): 102.1 ± 12.4 Mcal/kg, 57.8 ± 24.6 Mcal/kg, 4.7 ± 0.1 kg, and 3.6 ± 1.5 kg, respectively. The MR ME, starter ME, MR protein intake, and starter protein intake consumed from 0-8 weeks were (mean ± SD): 102.7 ± 13.2 Mcal/kg, 151.0 ± 42.2 Mcal/kg, 4.8 ± 1.0 kg, and 9.5 ± 2.7 kg, respectively. First lactation production data was analyzed for 2,881 cows from the data set, which included 305-d milk, fat, and protein kg. Separate mixed model analyses were conducted with SAS to determine the effect of protein or energy consumed on first lactation production of milk, fat, and protein yield. Birth season, year, six-week ADG class, and herd were included in the model with calf trial as a random effect. Early life MR and starter ME consumed positively affected 305-d milk and components (*P*<0.02; Table 1). Early life MR and starter protein intake positively affected 305-d milk and components (*P*<0.03; Table 1). Greater ME and protein intake in the first 8 weeks of life resulted in increased first lactation milk and milk components yield.

**Table 1. Effect of combined protein and starter energy (Mcal/kg) and protein (kg) consumed 0-8 weeks on first lactation 305-d milk, 305-d fat, and 305-d protein yield (kg; n=2,880).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Item | Variable | Estimate | SE | P-value |
| 305-d milk | MR and Starter ME 0-8wk | 4.03 | 1.55 | 0.009 |
| MR and Starter Protein 0-8wk | 25.65 | 10.12 | 0.011 |
| 305-d fat | MR and Starter ME 0-8wk | 0.17 | 0.06 | 0.005 |
| MR and Starter Protein 0-8wk | 0.91 | 0.40 | 0.022 |
| 305-d protein | MR and Starter ME 0-8wk | 0.14 | 0.04 | 0.001 |
| MR and Starter Protein 0-8wk | 0.87 | 0.29 | 0.003 |

**Abstract 325 - Relationships between protein and energy consumed from milk replacer and starter and growth for Holstein dairy calves.** J. Rauba, B.J. Heins H. Chester-Jones, D. Ziegler, and N. Broadwater.

 The objective was to determine relationships between protein and energy consumed from milk replacer and starter and calf growth for Holstein dairy calves. Data were collected from 4,534 Holstein animals from birth year of 2004 through 2014. Calves were received from 3 commercial dairy farms and assigned to 45 different calf research trials at the University of Minnesota Southern Research and Outreach Center from 3 to 195 d. Calves were returned to their farms upon completion of the trial. A majority of calves were fed a 20% CP and a 20% fat milk replacer at a rate of .57 kg/calf per day. Milk replacer metabolizable energy (ME), starter ME, milk replacer protein intake, and starter intake consumed from 0-6 weeks were (mean ± SD): 102.1 ± 12.4 Mcal/kg, 57.8 ± 24.6 Mcal/kg, 4.7 ± 0.1 kg, and 3.6 ± 1.5 kg, respectively. Milk replacer ME, starter ME, milk replacer protein intake, and starter intake consumed from 0-8 weeks were (mean ± SD): 102.7 ± 13.2 Mcal/kg, 151.0 ± 42.2 Mcal/kg, 4.8 ± 1.0 kg, and 9.5 ± 2.7 kg, respectively. Separate mixed model analysis were conducted with SAS to determine the effect of actual ME consumed from both milk replacer and starter and actual protein consumed from both ME and starter and average daily gain of the calves. Year of birth, season of birth and six-week ADG class (<0.23, 0.23-0.34, 0.34-0.45, 0.45-0.57, 0.57-0.68, 0.68-0.79, >0.79 kg/d) were included in the model with trial and herd as a random effect. Calves that had greater intake of protein and energy during the first 8 weeks of life resulted in greater growth (*P*<0.01; Table 1).

**Table 1. Least Square Means of ADG Class and MR and Starter ME and Protein consumed 0-8 weeks (n=4534 cows).**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | P-Value | < 0.23 kg | 0.23 -0.34 kg | 0.34 -0.45 kg | 0.45 – 0.57 kg | 0.57 – 0.68 kg | 0.68 – 0.79 kg | >0.79 kg |
| **MR ME 0-8wk kg** | <.0001  | 104.2 | 103.3 | 100.8 | 101.3 | 102.0 | 104.1 | 113.1 |
| **Starter ME 0-8wk kg** | <.0001  | 52.0 | 79.8 | 113.4 | 143.0 | 170.9 | 198.9 | 224.7 |
| **MR Protein 0-8wk kg** | <.0001  | 4.7 | 4.7 | 4.6 | 4.7 | 4.7 | 4.9 | 5.5 |
| **Starter Protein 0-8wk kg** | <.0001  | 3.3 | 5.0 | 7.1 | 9.0 | 10.7 | 12.5 | 14.2 |

**Abstract M304 Pre- and post-weaning performance and health of dairy calves fed complete pelleted calf starters formulated for three different starch levels.** D. Ziegler, H. Chester-Jones, B. Ziegler,

and S. Schuling.

One-hundred twelve (2 to 5 d old) individually fed Holstein heifer calves (38.6 ± 0.56 kg) from 3 commercial dairies were randomly assigned to 1 of 4 calf starter (CS) treatments formulated for varying starch levels to evaluate pre- (d 1–42) and post weaning (d 43–56) calf performance and health. The study was conducted between August and October, 2016. All treatment diets included a non-medicated 20% CP:20% fat milk replacer (all milk protein) fed at 0.28 kg in 2 L of water 2× daily from d 1 to d 35 and 1x daily from d 36 to weaning at d 42; supplemented daily with neomycin sulfate and oxytetracycline at 22mg/kg BW for 14 d. Calf starter treatments were as follows 1) texturized starter (TS) formulated for 30% starch DM basis, (TS30); 2) complete pelleted starter (CPS) formulated for 18% starch DM basis, (CPS18); 3) CPS formulated for 24% starch DM basis, (CPS24); 4) CPS formulated for 30% starch DM basis, (CPS30); Water and CS were offered free choice from d 1 to 56. Pre-weaning (d 1–42), 0.55 vs. 0.48 kg/d and post weaning gains (d 43–56) 1.03 vs. 0.83 kg/d were greater for calves fed TS30 (*P* < 0.05) vs. CPS18, CPS24 and CPS30. Overall 56 d gain was greater for TS30 vs. CPS18, CPS24 and CPS30, 0.67 vs. 0.57 kg/d. Gain/feed

(d 1–42) was greater for TS30 vs. CPS18, CPS24 and CPS30, 0.62 vs. 0.56 kg/d (*P* < 0.05). Overall gain/feed (d 1–56) was greater for TS30 vs CPS18, CPS24 and CPS30, 0.57 vs. 0.52 kg/d. There were no differences in daily fecal scores or health costs. Under conditions of this study, calf performance was reduced with a CPS regardless of starch level compared with TS30. Cost savings with a CPS may still provide economical gains over TS30.

**Abstract M66 - Pre- and postweaning performance and health of dairy calves fed milk replacers supplemented with various additives.** D.

Ziegler, H. Chester-Jones, A. Geiger, J. Olson, B. Ziegler, and

D. Shimek.

One hundred and nine (2 to 5 d old) individually fed Holstein heifer calves (39.2 ± 0.65 kg) from 3 commercial dairies were randomly assigned to 1 of 4 milk replacer (MR) treatments to evaluate pre- (d 1–42) and post weaning (d 43–56) calf performance and health when supplemented with various additives. The study was conducted between

March and June 2016. Treatments included (1) all-milk protein, nonmedicated MR 24% CP: 20% Fat fed at 0.34 kg in 2.38 L of water 2× daily from d 1 to d 35 and 1× daily from d 36 to d 42 (CON); (2) CON supplemented with neomycin sulfate and tetracycline (NT) at a rate of 22 mg/kg of body weight for 14 d (MRNT); (3) CON supplemented with 6 g of dried colostrum powder providing 3 g of IgG per feeding for 14 d (MRCP); and (4) CON supplemented with an additive blend of animal plasma, Bio-Mos, microalgae meal (All-G Rich, *Schizochytrium limacinum*), essential oils (Apex) and multiple direct fed microbial strains including *Lactobacillus* and *Bacillus* from d 1–42 (MRAB). Calf starter (18% CP as fed) and water were fed free choice d 1–56. There were no differences in pre weaning gain (d 1–42; *P* > 0.05) averaging 0.57 kg/d. Post-weaning gains (d 43–56) did not differ and averaged 0.90 kg/d. Overall gain was similar (*P* > 0.05) and averaged 0.62, 0.68, 0.63 and 0.66 kg/day for CON, MRNT, MRCP, and MRAB, respectively.

There was no difference in hip height gain, which averaged 11.4 cm for all treatments. There was no difference in MR solids intake, which averaged 27.7 kg for 42 d. Calf starter intake from d 1- 56 was similar (*P* > 0.05) for all treatments, averaging 37.1, 40.9, 35.6, and 40.9 kg for CON, MRNT, MRCP, and MRAB, respectively. There were no differences in daily fecal scores, scouring days, or treatment costs. Under conditions of this study, calves fed milk replacers with alternative additives for health and growth can perform similarly to calves fed NT.

**Abstract M68 - Pre- and postweaning performance and health of dairy calves fed milk replacers supplemented with different strains of direct-fed microbials.** H. Chester-Jones, D. Ziegler, E. Davis,

J. O’Neill, and S. Hayes.

One hundred and thirty-five (2 to 5 d old) individually fed Holstein heifer calves (38.8 ± 0.62 kg) from 3 commercial dairies were randomly assigned to 1 of 5 milk treatments to evaluate pre- (d 1–42) and post weaning (d 43–56) calf performance and health when fed milk replacers supplemented with a direct-fed microbial (DFM) or neomycin sulfate

and oxytetracyline (NT). The study was conducted between June and September 2016. Treatments included 1) all-milk protein, non-medicated milk replacer (MR) 20% CP: 20% Fat fed at 0.28 kg in 2 L of water 2× daily from d 1 to d 35 and 1× daily from d 36 to weaning at d 42, (CON); 2) MR as in CON supplemented with NT at a rate of 22mg/kg

BW for 14 d, (MRNT); 3) MR as in CON supplemented with 5 g of DFM containing *Bacillus subtilis* strain 747 (1 × 109 cfu) per feeding for 42 d, (MRDFM); 4) MR as CON supplemented with 5 g of DFM containing B. *subtilis* strains 747+1781 (1 × 109 cfu) per feeding for 42 d, (MRDFM2); 5) MR as CON supplemented with 5 g DFM as in RDFM2 plus *Lactobacillus plantarum* (5 × 108 cfu) per feeding for 42 d, (MRDFM3). Calf starter (18% CP as fed) and water were fed free choice from d 1 to 56. There were no differences in pre- or postweaning average daily gains (ADG) averaging 0.42 kg/d and 0.88 kg/d respectively. Overall 56 d ADG tended to be greater (*P* = 0.06) for calves

fed MRNT and MRDFM, 0.57 kg/d vs. those fed CON, 0.52 kg/d and MRDFM3, 0.50 kg/d with MRDFM2, 0.54 kg/d being intermediate. Calf starter and MR intake were similar (*P* > 0.05) across treatments averaging 35.9 and 20.8 kg total intake, respectively. There were no differences in daily fecal scores, scouring days or treatment costs. Under conditions of this study, calves fed milk replacers with MRDFM can perform as well as calves fed MRNT.\*

**Current studies where data has not been summarized or recently completed.**

**1. Performance and health of calves pre- and post-weaning fed milk replacers formulated with moderate (5%) or high (10%) levels of spray dried bovine plasma** (still to be analyzed).

|  |  |
| --- | --- |
| **Animals**  |  |

105 two to 5 day-old Holstein heifer calves from the SROC Calf & Heifer Research are being used in this study. Study on going since July 2017 will be completed in October. Milk replacer fed at 1.50 lbs/day.

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **1** | **2 -BP5%** | **3 – BP10%** |
| **Milk Replacers** |  **Waseca #1 24:20 AM NM** |  **Waseca #2 BP5% 24:20 NMd**  | **Waseca #3 BP10%****24:20 NMd** |
| **Protein Sources** | All Milk | 5% (100 lbs/ton)APC Spray Dried Bovine Plasma (Nutrapro B) | 10% Nutrapro B (plasma) &  |
| **Milk Replacer Solids %** | 12.5% | 12.5% | 12.5% |
| **Starter Crude Protein** | 18% | 18% | 18% |

1. The calf starter will be medicated with Decoquinate at 45.4 grams/ Ton.
2. On days 1-35 all calves fed 6 lbs of milk fluid 2x per day. Days 36-42, all calves will be fed 6 lbs milk fluid 1x per day.
3. Milk replacer feeding rate will be adjusted based on outside temperature (near calf barns) determined every day at 8am. If temperature is -10 to -19o F , the milk replacer solution feeding rate will be increased by 20% then 40% if -20° F or <.
4. Amino Acid balanced to be similar to treatment 1.

**2. Performance of Calves Pre- and Post-Weaning Fed Texturized Calf Starters with Differing Protein Levels on a higher protein milk replacer in the First Two Months of Life (**completed and currently being re-analyzed).

Animals - 105 Holstein heifer calves from the SROC Calf & Heifer Research Facility were used in this study. All heifer calves were housed individually in one of the four nursery rooms for the entire 56-day nursery trial period. Study conducted October 2016 to January 2017.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **1** | **2** | **3** | **4** |
| Starters | **Elite 18% DX** | **Elite 22% DX**  | **Elite 22% DX RB1X #3** | **Elite 22% DX RB2X #4** |
| Additive Level gm/ton | 45.4 | 45.4 | **45.4**  | **45.4**  |
| Roasted Beans, lb/ton |  |  | 135 | 270 |
| Active Ingredient | decoquinate | decoquinate | decoquinate | decoquinate |
| Milk Feeding Program | Moderate Feeding Programc |

1. Milk replacer feeding rate will be adjusted based on outside temperature (near calf barns) determined every day at 8 am. Increased feeding rates will start when temperature is -10 to -19°F, with the milk replacer solution feeding rate increased 20% over values listed in the above chart for the next two feedings. If temperature is -20°F or less, the milk replacer solution feeding rate will be increased 40% over values listed in the above chart for the next two feedings.
2. All calves will be medicated with neomycin sulfate and oxytetracycline per label instructions for the first 14 days on trial.
3. Moderate Feeding Program- calves will be fed 1.31 lb. of milk replacer powder reconstituted to a 13.0% milk replacer solution (10 lbs of milk solution) split in two 2 feedings daily from 1-7 days on trial, then will be fed will be fed 1.5625 lb. of milk replacer powder reconstituted to a 13.0% milk replacer solution (12.0 lb.) split in two 2 feedings daily from day 8 to 35 days on trial and be fed according to the feeding schedule chart above. On days 36-42, all calves will be fed 0.78125 lb. of milk replacer reconstituted to a 13.0% solution and be fed 1x per day. (6.0 lb. solution)

**3. Pre- and post weaning performance and health of nursery dairy calves when fed a proprietary direct-fed microbial (DFM) supplemented into the milk replacer** (still to be analyzed).

100 Holstein heifer calves from the SROC Calf & Heifer Research Facility were used in this 56 day study (pre-weaning days 1 to 42 and post weaning days 43 to 56). Studied completed July, 2017.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** |  **CON-1** | **NT - 2** | **Calsporin- 3** | **Calsporin/NT - 4** |
| **Milk Replacers** | **20-20 NM** | **20-20 NM** | **20-20 NM**  | **20-20 NM** |
| **NTc and DFM and egg proteins** | 0 | 23 g | 0 | 23 g |
| **DFM Calsporinad per feeding**  | 0 | 0 |  4 g | 4 g  |
| **Day 1-35Milk Replacer lbs** | 1.25 | 1.25 | 1.25 | 1.25 |
| **Water lbs**  **Day 1-35** | 8.75 |  8.75 |  8.75 |  8.75 |
| **Total Milk Solution Fed Day 1-35, lbs** | 10 | 10 | 10 | 10 |
| **Day 36-42b Milk Replacer lbs** | 0.625 | 0.625 | 0.625 | 0.625 |
| **Milk Solution lb Day 36-42** | 5.0 | 5.0 | 5.0 | 5.0 |
| **Milk Replacer Solids %** | 12.5% | 12.5% | 12.5% | 12.5% |

aDFM (Calsporin - based on viable spores of a non-GM strain, Bacillus subtilis C-3102) was stored in a separate container and mixed into the milk replacer solution at each feeding.

bAll calves were fed their allotted milk replacer fluid split into two equal feeding in the morning and evening from day 1 through 35 day on trial. On days 36-42, all calves were fed at half rate 1x per day.

cTreatment #2 calves were medicated with neomycin sulfate and oxytetracycline per label instructions for the first 14 days on trial.

dDFM (Calsporin) was fed for 42 days while on milk at 3 gm/feeding.

1. **Publications submitted, published or in press.**

Raeth, M., H.Chester-Jones, D. Ziegler, B. Ziegler, D. Schimek, D.L. Cook, G. Golombeski, and A.V. Grove. 2016. Pre- and postweaning performance and health of dairy calves fed milk replacers with differing protein sources. Prof. Anim. Sci. 32: 833-841. (calf studies conducted at SROC 2004-2014).

Chester-Jones,H., B. J. Heins, D. Ziegler, D. Schimek, S. Schuling, B. Ziegler, M. B. de Ondarza, C. J. Sniffen, and N. Broadwater. 2017. Relationships between early-life growth, intake, and birth season with first-lactation performance of Holstein dairy cows. J. Dairy Sci. 100:3697-3704. <https://doi.org/10.3168/jds.2016-12229>.

(All SROC calf studies 2004 to 2012).

Maynou, G., L. Migura-Garcia, H. Chester-Jones, D. Ziegler, A. Bach, and M. Terré. 2017. Effects of feeding pasteurized waste milk to dairy calves on phenotypes and genotypes of antimicrobial resistance in fecal *Escherichia coli* isolates before and after weaning. J. Dairy Sci. 100:7967–7979. <https://doi.org/10.3168/jds.2017-13040> (calf study conducted at SROC).

Jorgensen, M.W., A. Adams-Progar, A. M. de Passillé, J. Rushen, S. M. Godden, H. Chester-Jones, and M. I. Endres. 2017. Factors associated with dairy calf health in automated feeding systems in the Upper Midwest United States J. Dairy Sci. 100:5675–5686. https://doi.org/10.3168/jds.2016-12501.

Kienitz, M.J., B. J. Heins, and H. Chester-Jones. 2017. Growth, behavior, and economics of group-fed dairy calvesfed once or twice daily in an organic production system. J. Dairy Sci. 100:3318–3325.

[https://doi.org/10.3168/jds.201 11885](https://doi.org/10.3168/jds.201%2011885).(Work conducted at the West Central Research and Outreach Center)

Strayer, B., D. Ziegler, D. Schimek, B. Ziegler, M. Raeth-Knight, H. Chester-Jones, and D.P. Casper. 2017. Growth performance of newborn calves fed a milk replacer with two protein concentrations and two feeding rates. J. Dairy Sci. submitted and in 2nd revision (conducted at SROC).

Strayer, B., D. Ziegler, D. Schimek, B. Ziegler, M. Raeth-Knight, H. Chester-Jones, and D.P. Casper. 2017. Growth performance of new born calves fed a 24% crude protein, 20% fat milk replacer at different feeding rates. J. Dairy Sci, submitted and in 2nd revision (conducted at SROC).

Strayer, B., D. Ziegler, D. Schimek, B. Ziegler, H. Chester-Jones, J. Anderson, K. Kalscheur, and D.P. Casper*.* 2017.Dairy calf growth performance when fed a modified accelerated milk replacer program. Internal review complete to be submitted to J. Dairy Sci. in Ocrober (conducted at SROC).

**E. IMPACT STATEMENT:** The use of commercial dairy calves for nutritional and management studies up to 6 months of age and the ability to follow these calves back to their respective dairy herds for first lactation performance provides a critical base towards attaining objective 1 of the NC-1042 project. In terms of application of the results to the field, benchmarks have been developed for calf performance parameters that have been used for on-farm comparisons. Goals for calf performance in the nursery have been attained by both conventional, moderate intensive or intensive programs. Optimum calf starter intake compliments changes in liquid feeding programs to ensure calves meet their goals. Good quality calves and health management have been important keys to success. Post weaning programs have maintained calf performance which has exceeded initial expectations. The 3 cooperating dairy producers who have supported this effort have helped to improve the programs for their heifer calves from 2 to 5 days up to 6 months of age which is a critical phase for growing dairy heifers. Detailed records for each calf that arrives at SROC has helped both the dairy managers and SROC management. The unique partnership between the University of Minnesota, the commercial dairy producers and allied industry collaborators has allowed many options to be considered for calf raising operations.

**F. LEVERAGE:** The current work with SROC**,** allied industry and commercial dairy partnership has leveraged interest from non-partner collaborators to maintain the level of support needed to keep the project viable.

**APPENDIX D**
**SAES-422
Format for Multistate Research Activity
Accomplishments Report**

**Project/Activity Number: NC2042**

**Project/Activity Title:**

**Period Covered:** October 2016 to September 2017

**Date of This Report:** Sept 15, 2017

**Annual Meeting Date(s):** Oct 12-14, 2017

**Participants:**  Marcia Endres (to be combined with other reports from the U of MN by Chester-Jones and Heins)

**Accomplishments:**

**Short-term Outcomes:** Automated technologies to milk, feed, or monitor cattle behavior are becoming more common in the USA. University of Minnesota research has helped improve the use of automated milking and calf milk feeding systems, which can result in improved cattle productivity and wellbeing. It was found that cow milking speed, milking frequency, use of a robotic feed pusher, cow comfort index, amount of concentrate consumed at the milking station, and cows per robot were associated with greater daily milk production per cow and per robot. Overall median annual mortality rate of preweaned calves fed with automated milking systems was 2.6% and 57% of farms reported mortality rates below 3%/yr. Mortality rate was associated with navel disinfection, farm size, age range in calf groups and serum total protein concentration. Calf health scores were associated with season of measurement, bacterial counts in the milk, peak milk allowance, time to reach peak milk allowance, space per calf, group size, and use of positive pressure ventilation system. Validation of a cow sensor technology helped the industry better understand the need for considering aspects of the environment like fly pressure when developing algorithms for activity behavior. A study with 82 randomly selected dairy farms in Minnesota compared top 25th percentile farms for milk production with other farms and found that factors such as stall comfort, pen design, dry matter intake, forage management, cow time budget, milking frequency, use of bST, footbath management and cow grouping differed between the two categories for milk production. Factors influencing feed cost per cwt and energy-corrected milk production per cow were also evaluated.

**Outputs:** University of Minnesota research results on dairy automation, health and wellbeing were presented at ADSA meetings in Pittsburgh, ISAE International meeting in Denmark, various conferences in the US, and also used for teaching of undergraduate students. University of Kentucky and University of Minnesota co-organized the 3nd US Precision Dairy Farming Conference in Lexington, KY where many precision dairy technologies were discussed and Endres presented results of a study on automated milk feeders for preweaned calves. Endres authored two book chapters in the Large Dairy Herd Management ADSA publication.

**Publications:**

Endres, M.I. 2017. The relationship of cow comfort and flooring to lameness disorders in dairy cattle. Vet. Clin. North Am. Food Anim. Pract. 33:227–233.

Jorgensen, M.W., A. Adams-Progar, A.M.de Passillé, J. Rushen, S.M. Godden, H. Chester-Jones, and M.I. Endres. Factors associated with dairy calf health in automated feeding systems in the Upper Midwest United States. J. Dairy Sci. 100:5675-5686

Salfer, J.A., K. Minegishi, W. Lazarus, E. Berning, and M.I. Endres. 2017. Finances and returns for robotic dairies. J. Dairy Sci. 100:7739-7749.

Sjostrom, L.S., B.J. Heins, M.I. Endres, R.D. Moon and J.C. Paulson. 2016. Relationship of activity and rumination to abundance of pest flies among organically certified cows fed 3 levels of concentrate. J. Dairy Sci. 99:9942-9948.

Luchterhand, K.M, P.R.B. Silva, R.C. Chebel and M.I. Endres. 2016. Association between prepartum feeding behavior and periparturient health disorders in dairy cows. Front.Vet.Sci:3:1-8 (article 65).

Chebel, R.C., P.R.B. Silva, M.I. Endres, M.A. Ballou, and K.L. Luchterhand. 2016. Social stressors and their effects on immunity and health of periparturient dairy cows. J. Dairy Sci. 99:3217-3228.

Orman, A. and M.I. Endres. 2016. Use of thermal imaging for identification of foot lesions in dairy cattle. Acta Agric. Scandin. DOI:10.1080/09064702.2016.1179785.

Endres, M.I. and J.A. Salfer. 2017. Feeding cows in a robotic milking system. In Proc. Tri-State Dairy Nut. Conf., pg 61-67.

Peiter, M, M. Jorgensen, and M. I. Endres. 2017. Daily milk consumption, number of visits, drinking speed and weight gain of preweaned calves in Midwest US farms with automated feeders. J. Dairy Sci.100 (Suppl. 2):137.

Pereira, G., B. Heins, and M. Endres. 2017. Validation of an accelerometer to monitor rumination, eating and activity in an organic grazing dairy herd. J. Dairy Sci.100 (Suppl. 2):355.

Siewert, J.M., J. A. Salfer, and M.I. Endres. 2017. Daily milk production, number of milkings, feed consumption and rumination time for cows in robotic milking systems in the United States. J. Dairy Sci.100 (Suppl. 2):355

Medrano-Galarza, C., S. J. LeBlanc, A. Jones-Bitton, T. J. DeVries, A. M. de Passillé, J. Rushen, M.I. Endres, and D.B. Haley. 2017. Associations of management practices and calf health on dairy farms using automated milk feeders in southern Ontario. J. Dairy Sci.100 (Suppl. 2):340

Medrano-Galarza, C., S. J. LeBlanc, A. Jones-Bitton, T. J. DeVries, A. M. de Passillé, J. Rushen, M.I. Endres, and D.B. Haley. 2017. Which data recorded by automated calf feeders can help to detect sick calves? J. Dairy Sci.100 (Suppl. 2):137.

Endres, M., M. Peiter, and M. Jorgensen. 2017. Feeding behavior of group-housed calves in Midwest US farms with automated feeders. In Proc. 51th Congress ISAE, Aarhus, Denmark, pg 68.

**NC 2042: 2016-2017 Station Report – Minnesota (Obj 1, 2, 3)**

**Annual Project Report – Cooperative Regional Project NC-2042**

# **Year ending September 30, 2017**

 **(Not for Publication)**

Bradley Heins, West Central Research and Outreach Center, Morris and

Department of Animal Science

1. **Progress of Work and Accomplishments:**

**Verifying Holstein heifer heart girth to body weight prediction equations**

The estimation of Holstein heifer body weight (BW) from heart girth measurements is needed, as many farms do not have animal scales to make the management decisions that require BW. The correlation between heart girth and BW is known to vary with differing animal conformation. The previous equation to correlate the 2 measures for Holstein dairy heifers was done 25 yr ago. Data were derived from 6 US experiment stations that are part of Regional Research Project NC-2042: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises. After deriving a new equation from a data set of observations and using a second validation data set, it was determined that the equation developed in 1992 was still valid and further equation development was not needed at this time.

**Forage quality and herbage mass of two different pasture systems incorporating cool season and warm season forages for grazing organic dairy cattle.**

Two pasture systems (cool season perennial and warm season annual grass species) with enhanced in-field and landscape level species diversity were analyzed for yield, forage quality, and mineral characteristics across the grazing season at the West Central Outreach and Research Center organic dairy in Morris, MN from 2013 to 2015. System 1 was a diverse-mixture of cool season grasses and legumes [perennial ryegrass (Lolium perenne), white clover (Trifolium repens), red clover (Trifolium pretense), chicory (Cichorium intybus), orchardgrass (Dactylis glomerata), meadow bromegrass (Bromus biebersteinii), alfalfa (Medicago sativa), meadow fescue (Festuca pratensis)]. System 2 was a combination of the same perennial grasses and legumes as System 1, but included annual-warm season grasses (brown midrib sorghum-sudangrass (BMRSS) and teff grass). Grazing of lactating cows was initiated when forages were 20-30 cm tall and strip size was adjusted to leave 7-13 cm of refusals. Three random samples of pasture forage were clipped every two days, before grazing, in a 0.23 m2 square of pasture when a group of cows moved to a new paddock. Forage samples were sent to Rock River Laboratory, Inc., Watertown, WI and were analyzed with NIR spectrophotometry for DM, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and total tract NDF digestibility (TTNDFD). Data were analyzed using the MIXED procedure of SAS. Independent variables for analyses were the fixed effects of system (1: cool season perennial pasture or 2: cool season perennial pasture and warm season annual grasses), month (June to October), forage (perennial cool season pasture, BMRSS or teff), year (2013, 2014, 2015) and their interactions, and date of harvest was a random variable. Herbage mass was greater in system 2 (2,788 kg DM/ha) than system 1(2,259 kg DM/ha), due to greater herbage mass for warm season grasses (3,088 kg DM/ha) than cool season perennials (2,228 kg DM/ha) across the grazing season. The BMRSS had greater yield (3,455 kg DM/ha) compared to cool season pasture (2,228 kg DM/ha) and teff grass (2,722 kg DM/ha). The CP for cool season pasture was 20.9% in 2013, 23.2% in 2014, and 24.7% in 2015. The CP for warm season annual grass was 14.6% in 2013, and 18.9% in 2014, and 20.5% in 2015. The TTNDFD was 63.8% in 2013, 48.0% in 2014, 51.9% in 2015 for cool season pasture, and 59.3% in 2013, 46.3% in 2014, and 59.0% in 2015 for warm season annual grass. In summary, yearly effects, soil fertility, and weather patterns may affect forage quality in for both cool season perennial pasture and warm season annual grasses.

**Milk production, body measurements, activity, and rumination of organic dairy cattle grazing two different pasture systems incorporating cool and warm season forages.**

Organic dairy cows (n = 90) of Holstein and crossbred genetics were used to evaluate the effect of two pasture production systems (cool season perennial and warm season annual grass species) across 2 grazing seasons (May to October of 2014 and 2015) on milk production, milk components (fat, protein, MUN, SCS), body weight, body condition score (BCS), and activity and rumination (min/d). Cows were assigned to 1 of 2 replicated pasture systems: 1) System 1 was a diverse-mixture of cool season grasses and legumes [perennial ryegrass (Lolium perenne), white clover (Trifolium repens), red clover (Trifolium pretense), chicory (Cichorium intybus), orchardgrass (Dactylis glomerata), meadow bromegrass (Bromus biebersteinii), alfalfa (Medicago sativa), meadow fescue (Festuca pratensis)] or 2) System 2 was the same combination of perennial grasses and warm season annual grasses (BMR sorghum-sudangrass (Sorghum × drummondii; BMRSS) and teff (Eragrostis tef) grass). There were 3 replicates of each system, and therefore, 6 total cow groups. Cows rotationally grazed pasture and moved to a new paddock every 2 days, were provided free-choice mineral, and were supplemented with corn (2.27kg/day) to manage MUN levels. Weekly milk production, and bi-weekly milk components, body weight and BCS were recorded for each of the 6 replicate groups. Activity and rumination time (daily) were monitored electronically using HR-LD Tags (SCR Engineers Ltd., Netanya, Israel) during the grazing season. The PROC MIXED of SAS was used for statistical analysis, and independent variables were fixed effects of system (1 or 2), forage (perennial grass, BMRSS or teff) nested within system, year (2014 or 2015), system nested within year, and week nested within system, with replicate group nested within system as a random effect with repeated measures. System 1 and system 2 cows had similar milk production (14.7 and 14.8 kg/d), fat percentage (3.92% vs. 3.80%), protein percentage (3.21% vs. 3.17%), MUN (12.5 and 11.5 mg/dl), and SCS (4.05 and 4.07), respectively. For yearly effects, milk production was greater in 2015 compared to 2014 (15.6 vs 13.9 kg/d. The BW (485 and 497 kg) and BCS (3.10 and 3.06) were similar for system 1 and 2, respectively. Cows in system 1 had greater daily rumination (530 min/d) compared to cows in system 2 (470 min/d). In summary, warm season annual forages may be incorporated into grazing systems for organic dairy cattle while maintaining milk production and quality.

**Dual flow continuous culture fermentation of organic BMR sorghum-sudangrass and teff grass to determine digestibility of forages in an organic dairy grazing system.**

The objective of this study was to compare 2 warm-season annual grasses to cool season perennial pasture (CSP) and alfalfa for ruminal nutrient digestibility and nitrogen synthesis in a dual-flow continuous culture rumen fermentation system. Eight dual flow continuous culture fermenters were used during 2 consecutive 10-d periods. Dietary treatments were 1) alfalfa, 2) CSP, 3) brown midrib sorghum-sudangrass (BMRSS), and 4) teff grass from the organic dairy production system at the University of Minnesota organic dairy in Morris, MN. The CSP was comprised of orchardgrass, meadow fescue, bromegrass, red clover, and white clover. Treatments were randomly assigned to fermenters with 7 d for diet adaptation and 3 d for data and sample collection. Fermenter samples for pH, NH3-N, and VFAs were collected on day 8, 9, and 10. Apparent dry matter, organic matter, neutral detergent fiber, and acid detergent fiber digestibility were lower (P < 0.05) for BMRSS, teff, and CSP, (49.8%, 33.3%, 58.4%, and 60.8%, respectively) compared to alfalfa (69.4%, 54.1%, 75.5%, and 75.5%, respectively). The BMRSS, teff grass, and CSP were not different from each other. True dry matter and organic matter digestibility were lower (P < 0.05) for BMRSS, teff, and CSP (65.4% and 47.2%, respectively) compared to alfalfa (85.8% and 69.2%, respectively). Fermenter pH and total volatile fatty acids were not affected by forage. Ammonia N concentrations (mg/dl) were greater (P < 0.05) for alfalfa (22.5) compared to CSP (7.5), BMRSS (7.4), and teff (8.9), respectively. Crude protein degradation was not affected by forage treatment. The flow of NH3-N was greatest (P < 0.05) for alfalfa (26.5 %) compared to the other forages (11.6%), reflecting the greatest NH3-N concentration. The flow of total N was greatest (P < 0.05) for alfalfa (1.99 g/d), lowest for CSP (1.50 g/d) and BMRSS (1.51 g/d), and intermediate for teff grass (1.70 g/d). Overall, the fermentation of the warm season grasses was similar to the CSP, indicating the potential for successful use of warm season grasses for grazing systems.

**Forage herbage mass and quality of two different cover cropping systems for grazing organic dairy steers**

Integrating crops and livestock on a multi-function operation could have multiple benefits and the potential to improve the profitability of these kinds of operations. A long-term, organic, integrated crop-livestock rotation design was established at the West Central Outreach and Research Center organic dairy in Morris, MN during 2015. The objective of this study was to compare forage quality and herbage mass of winter wheat and winter rye for grazing dairy animals. Winter wheat and winter rye forages were planted on Sept. 11, 2015, for grazing during spring 2016. During the spring, 12-month old organic dairy steers were randomly assigned to replicated groups (winter wheat or winter rye), but balanced by breed group to reduce potential breed bias. Grazing of dairy steers was initiated on April 25, 2016 when forages were 20-30 cm tall and strip size was adjusted to leave 7-13 cm of refusals. Random samples of pasture forage were sampled every 3 days when a group of steers moved to a new paddock. Pasture clippings were randomly collected in a 0.76 m2 square of pasture. Forage samples were sent to Rock River Laboratory, Inc., Watertown, WI and were analyzed with NIR spectrophotometry for DM, CP, and total tract NDF digestibility (TTNDFD). Data were analyzed using the MIXED procedure of SAS. Independent variables for analyses were the fixed effects of forage (winter wheat or winter rye), date of clipping, and the interaction of date and forage, and replicate paddock was a random variable. Winter rye (2,944 kg DM/ha) had greater (P < 0.05) herbage mass compared to winter wheat (2,266 kg DM/ha). The DM was lower (P < 0.05) for winter rye (18.9%) compared to winter wheat (20.8%). The CP was 17.6% and 19.3% for winter rye and winter wheat, respectively (P < 0.01). The TTNDFD was 56.3% for both winter rye and winter wheat, respectively (P=0.99). In summary, CP was greater for winter wheat compared to winter rye; however, TTNDFD did not differ between cover cropping grazing systems. Winter rye and winter wheat may provide adequate forage for during the spring grazing season.

**Validation of an accelerometer to monitor rumination, eating and activity in an organic grazing dairy herd**

The objective of this study was to validate an accelerometer (CowManager SensOor, Agis Automatisering BV, Harmelen, the Netherlands) by direct visual observation in an organic grazing dairy herd. The sensor detects and identifies ear movements and through algorithms can classify data as ruminating, eating, resting or active behaviors. Pasture-based lactating Holstein and crossbred cows (n = 24) were observed for 12 h each by a single trained observer who recorded cow behaviors every min for 6 h/ per d. The study was conducted at the University of Minnesota West Central Research and Outreach Center organic dairy in Morris, Minnesota from June to September 2016. Direct visual observation was compared to CowManager sensor data during June and July 2016 (early summer; before a software system update) and during August and September 2016 (late summer; after a software system update) having each minute classified with only one of the following categories: ruminating, eating, resting or activity. Pearson correlations and concordance correlation coefficient (PROC CORR of SAS), bias correction factors (Cb), location shift (V) and scale shift (µ) (epiR package of R software) evaluated associations between sensor data and direct visual observations. Furthermore, pasture fly counts of horn, face and stable flies were used to evaluate associations with sensor data. Correlations between CowManager sensor and visual observations for all 4 behaviors were greater for late summer compared to early summer. For late summer, visual observation correlations were mostly moderate to high c (0.72, P < 0.01 for ruminating,;0.88, P < 0.01 for eating; 0.65, P < 0.01 for resting; 0.20;, P < 0.01 for activity) compared to sensor data. The active behavior was the most associated with and affected by pasture fly populations (0.22; P < 0.01). The results suggest the CowManager sensor may accurately monitor rumination and eating behavior of grazing dairy cattle. However, it appears that sensor accuracy may be affected by the fly pressure in grazing dairy cattle.

**Evaluation of a Commercial Vacuum Fly Trap for Controlling Flies on Organic Dairy Farms.**

 The objective of this study was to evaluate the efficacy of a commercial vacuum fly trap (TRAP; CowVac, Spalding Laboratories, Reno, NV) in on-farm organic dairy production systems to control horn flies, stable flies, and face flies. The TRAP utilized a chute apparatus and powerful vacuums to suction flies off the cows as they walked through the system before milking. The study utilized 8 organic dairy farms during the summer of 2015 in Minnesota, and herds ranged from 30 to 350 cows in size. The farms were divided into pairs by location and during the first period of the summer (June to July) the TRAP was set up on one farm and during the second period of the summer (August to September) the TRAP was sent to its paired farm. Farms were visited once per week to collect and count flies from the TRAP, as well as count and record flies on cows. Bulk tank milk, fat, and protein production and SCC were collected on farms during the entire study period. Data were analyzed using the GLM procedure of SAS. Independent variables for analyses were the fixed effects of farm, TRAP presence, housing scenario, and summer period. Horn fly numbers on cows were lower by 44% on farm in the presence of a TRAP (11.4 vs. 20.5 flies/cow-side) compared to the absence of a TRAP. Stable fly (5.4 vs. 7.1 flies/leg) and face fly (1.0 vs. 1.0 flies/cow) numbers were similar on farm whether the TRAP was present or absent on farms, respectively. Milk production was similar for farms with the TRAP (15.5 kg/d) compared to without (15.3 kg/d) the TRAP. Both bulk tank milk, milk components, and SCC were statistically similar in the presence and absence of the TRAP, so benefits of the TRAP were too small to measure. The presence of a TRAP on farm reduced horn fly population growth rates (-1.01 vs. 1.00 flies/d) compared to the absence of a TRAP. Cows on farms with no housing (100% pasture) tended to have reduced horn fly numbers (11.7 vs. 28.3 flies/cow-side) in the presence of a TRAP compared to the absence of a TRAP on farm. Cows on farms with housing had similar horn fly numbers (11.2 vs. 14.8 flies/cow-side) in the presence of a TRAP compared to the absence of a TRAP on farm. In summary, these results indicate the TRAP was effective in reducing horn fly numbers on cows and reduced horn fly growth rates during the pasture season in organic dairy production systems but benefits in improved milk production were not evident.

**Effects of winter housing systems on production, body weight, BCS, and bedding cultures of organic dairy cows.**

Certified-organic dairy cows (n = 268) were used to evaluate the effect of two winter (December to April) housing systems on milk production, SCS, body weight, and BCS across 3 winter seasons (2013, 2014, and 2015). Bedding cultures from the housing systems were also evaluated. Cows were assigned to two treatments (two replicates per group): 1) outdoor (straw pack, n = 140) or 2) indoor (3-sided compost-bedded pack barn, n =128). There were 21 to 27 cows per replicate per year for the outdoor housing and 21 and 22 cows per replicate per year for the indoor housing. Cows calved during two seasons (spring or fall) at the University of Minnesota West Central Research and Outreach Center, Morris, Minnesota, organic dairy. Organic wheat straw was used as bedding for the 2 outdoor bedded packs, which were 12 m wide by 27 m long, and maintained by farm management to keep cows dry and absorb manure throughout the winter. They were surrounded by established conifer trees as windbreak. The open-front compost-bedded pack barn (2 pens in the barn) was bedded with organically approved sawdust, and the bedding material was stirred twice per day with a small chisel plow. Cows were fed a TMR that included organic corn silage, alfalfa silage, corn, expelled soybean meal, vitamins and minerals. Milk, fat and protein production and SCS were recorded from monthly DHIA testing. Body weight and BCS were recorded bi-weekly as cows exited the milking parlor. Bedding cultures from the housing systems were also evaluated. The PROC MIXED of SAS was used for statistical analysis, and independent variables were fixed effects of year and housing system, with replicate as a random effect. Energy-corrected milk and SCS was not different for the outdoor (15.3 kg/d, 3.11) and indoor (15.7 kg/d, 2.93) housing systems, respectively. In addition, outdoor and indoor housing systems were not different for body weight (522 vs. 527 kg) and BCS (3.25 vs. 3.28), respectively. Daily DMI was 19.1 kg/d for the outdoor cows and 19.6 kg/d for indoor cows. The total bacteria count tended to be lower in the outdoor (13.0 log10 CFU/ml) compared to the indoor (14.9 l log10 CFU/ml) system. In summary, cows housed outdoors on straw-bedded packs did not differ from cows housed in an indoor compost-bedded pack barn for production and SCS, as well as body weight, BCS, or DMI.

**Effects of winter housing systems on hygiene, udder health, frostbite and rumination of organic dairy cows.**

Certified-organic cows (n = 268) were used to evaluate the effect of two winter housing systems (December to April) on hygiene scores, frostbite, teat condition, clinical mastitis, and activity and rumination across 3 winter seasons. Cows were assigned to two treatments (two replicates per group): 1) outdoor straw pack, or 2) indoor (3-sided compost-bedded pack barn). There were 21 to 27 cows per replicate per year for the outdoor housing and 21 and 22 cows per replicate per year for the indoor housing. Cows calved during two seasons (spring or fall) at the University of Minnesota West Central Research and Outreach Center, Morris, Minnesota, organic dairy. Organic wheat straw was used as bedding for the 2 outdoor bedded packs and were maintained by farm management to keep cows dry and absorb manure throughout the winter. The open-front compost-bedded pack barn (2 pens in the barn) was bedded with organic approved sawdust, and the bedding material was stirred twice per day with a small chisel plow. Hygiene scores were recorded bi-weekly as cows exited the milking parlor. Incidence of clinical mastitis was recorded in a binary manner as treated (1) or not treated (0) during a lactation. Frostbite incidence was collected monthly. Activity and rumination time (daily and 2-h periods) were monitored electronically using HR-LD Tags from SCR Dairy. Indoor cows had greater udder hygiene scores (1.7 vs. 1.4) and greater abdomen hygiene scores (1.8 vs. 1.4) compared with outdoor cows. Additionally, the indoor cows had greater upper and lower leg hygiene scores compared to outdoor cows. Incidence of clinical mastitis was greater for indoor cows compared with outdoor cows (27.5% vs. 15.4%, respectively). Frostbite incidence was not different between indoor (34.3%) and outdoor (21.1%) cows. Daily rumination was 510 min/d for indoor cows and 531 min/d for the outdoor cows. In summary, cows housed outdoors on straw-bedded packs had cleaner udders and improved udder health compared with cows in a compost-bedded pack barn.

**Evaluation of winter housing systems for effects on profitability of organic dairy cows.**

Certified-organic cows (n = 268), according to the USDA-National Organic Program rules, were used to evaluate the profitability of two winter housing systems (December to April). Cows were assigned to two treatments (two replicates per group): 1) outdoor (straw pack, n = 140) or 2) indoor (3-sided compost-bedded pack barn, n =128). There were 21, 22, or 27 cows per replicate per year for the outdoor housing and 20, 21, or 22 cows per replicate per year for the indoor housing. Cows calved during two seasons (spring or fall) at the University of Minnesota West Central Research and Outreach Center, Morris, Minnesota, organic dairy. Organic wheat straw was used as bedding for the 2 outdoor bedded packs, which were 12 m wide by 27 m long. The straw packs were maintained by farm management to keep cows dry and absorb manure throughout the winter. The open-front compost-bedded pack barn (2 pens in the barn) was bedded with organic approved sawdust, and the bedding material was stirred twice per day with a small chisel plow. Cows were fed a TMR that included organic corn silage, alfalfa silage, corn, expelled soybean meal, vitamins and minerals. Daily feed consumption by each replicated group was monitored as the difference between feed offered and refused. Milk production was quantified with monthly DHI measures of milk, fat, protein, SCC, and milk urea nitrogen. Costs for key inputs and the price received for milk were monitored over the study period and averaged for use in the profitability analysis. The 'lsmeans' package from the R software system was used for statistical analysis. Independent variables were fixed effects of year and housing system, with replicate as a random effect. Milk production, milk revenue, DMI, and feed cost were not different for the outdoor and indoor housing systems. Labor cost and bedding cost were significantly lower and net return was significantly higher for the outdoor housing system. In summary, the outdoor straw pack system has a $1.42/cow/day net return advantage over indoor compost bedded pack barn system.

1. **Publications submitted, published or in press.**

Chester-Jones,H., B. J. Heins, D. Ziegler, D. Schimek, S. Schuling, B. Ziegler, M. B. de Ondarza, C. J. Sniffen, and N. Broadwater. 2017. Relationships between early-life growth, intake, and birth season with first-lactation performance of Holstein dairy cows. J. Dairy Sci. 100:3697-3704. <https://doi.org/10.3168/jds.2016-12229>.

Heinrichs, A.J., B.S. Heinrichs, C.M. Jones, P.S. Erickson, K.F. Kalscheur, T.D. Nennich, B.J. Heins, and F.C. Cardoso. 2017. Short communication: Verifying Holstein heifer heart girth to body weight prediction equations. Journal of Dairy Science 100:8451–8454. doi:10.3168/jds.2016-12496.

Kienitz, M.J., B. J. Heins, and H. Chester-Jones. 2017. Growth, behavior, and economics of group-fed dairy calves fed once or twice daily in an organic production system. J. Dairy Sci. 100:3318–3325. [https://doi.org/10.3168/jds.201 11885](https://doi.org/10.3168/jds.201%2011885).

**E. IMPACT STATEMENT:**

Outwintering of organic dairy cattle in the Upper Midwest is being explored mostly for its potential to improve animal health and well-being and reduce labor costs on farm. Organic dairy cows housed on outdoor straw packs had improved udder health compared to cows housed indoors. Organic dairy producers who can tolerate colder temperatures in the Northern part of the US, may benefit from housing cows outdoors to reduce farm expenses, without sacrificing production and animal health and well-being. Additionally, our project found that horn fly numbers on cows and horn fly population growth were reduced with the use of a commercial vacuum trap on organic dairy farms in Minnesota. However, benefits of improved milk production with the TRAP were not evident on a herd-basis in this study, so it remains to be determined if the use of the vacuum trap will improve dairy farm profitability. For grazing cattle, our project demonstrated that BMR sorghum sudangrass and teff grass may be successfully grazed by organic dairy cattle and that warm-season annuals can provide favorable forage yields with similar nutritional quality to cool-season pasture. The opportunity to extend the grazing season is extremely valuable for organic farmers and may make it easier to comply with the organic pasture rule, as well as make it easier to provide quality nutrition to animals in pasture.

**NC 2042: 2016-2017 Station Report**

1. **Project Name:** Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.
2. **Cooperating Agency:** University of Missouri, Columbia.

**Personnel:** H.D. Naumann, Division of Plant Sciences.

**Objective 2)** Improve dairy cow management decisions through nutrient utilization, well-being and profitability.

Focus is on use of novel forages to improve nutrient utilization, animal efficiency and environmental sustainability.

1. **Work progress and principal accomplishments under Objective 2:**

Work is focused on use of novel forages, including but not limited to condensed tannin producing legumes, to improve nutrient utilization, animal efficiency and environmental sustainability.

**1)** **Evaluating nutritive value, yield, condensed tannins and protein binding ability of condensed tannins from three varieties of annual lespedeza.** *H.D Naumann and R.L. Kallenbach.* An experimental genotype of annual lespedeza (MU 3993), *Kummerowia* *striata* (Thunb.) Schindl., has been identified for its characteristic drought tolerance. We evaluated yield, nutritive value and polyphenolic characteristics of MU 3993 compared to two additional genotypes of annual lespedeza, Korean and Legend at two locations in Missouri. MU 3993 and Korean grown at Linneus and Mt. Vernon in 2015 had the greatest yield (>5480 kg/ha), whereas MU 3993 and Legend grown at Mt. Vernon in 2014 yielded the least (<1872 kg/ha). Yield was greater at both locations in 2015 than in 2014. There was no difference in CP, ADF or IVTD among genotypes. Legend had less NDF than Korean (47.7 and 49.9%, respectively), whereas that of MU 3993 (49.1%) was intermediate and undifferentiated from Legend or Korean. However, Korean and MU 3993 had greater dNDF than Legend (20.2, 20.0 and 17.6%, respectively). Legend had the greatest concentrations of total phenolics (77.9 g/kg DM), protein precipitable phenolics (22.5 g/kg DM) and condensed tannins (34.4 g/kg DM), and all were greater at Mt. Vernon as compared to Linneus. Results suggest that ‘Legend’ annual lespedeza is a lower yielding genotype with lower NDF and lower dNDF than the other genotypes evaluated. However, ‘Legend’ produced greater concentrations of condensed tannins, total and protein-precipitable phenolics with the greatest amount of protein precipitated. The abstract was presented at CSSA meetings in 2016. The manuscript is in progress.

**2) Dose-response effect of *Acacia* condensed tannins on ruminal methane emissions.** *H.D. Naumann and M.A. Fonseca*. We have determined that condensed tannins from *Acacia angustissima* are potent reducers of ruminal methane production. In an effort to identify the concentration of condensed tannin from *Acacia angustissima* that inhibits some ruminal methane production without inhibiting total gas production, we have conducted an experiment consisting of fermentations of alfalfa with inclusions of *Acacia* condensed tannin at concentrations of 0, 5, 10, 15 and 20% CT. Fermentation data have been collected and data analysis is underway.

**3) Evaluating suitability of sunn hemp (*Crotalaria juncea* L.) as a summer forage legume in tall fescue-based systems.** *H.D. Naumann.* Sunn hemp is a warm-season tropical annual legume with potential to produce high yielding and high nutritive value forage during the summer months when cool-season species are less productive. We are evaluating method of establishment (mow and drill; herbicide strip kill and drill), yield and nutritive value (NDF, dNDF, ADF, CP and IVTD) of sunn hemp interseeded into tall fescue pasture. Forage DM yield for strip kill (3.1 Mg ha-1) and mow drill (2.7 Mg ha-1) were similar but strip kill yield was greater than for pure tall fescue (2.5 Mg ha-1 at 65 DAP). Crude protein concentrations were similar among strip kill and mow and drill (153 and 157 g kg-1, respectively) but greater than for pure tall fescue (135 g kg-1) at 45 DAP. Neutral detergent fiber and acid detergent fiber were greatest for tall fescue followed by strip kill and mow and drill (503 and 494 g kg-1 NDF, and 299 and 296 g kg-1 ADF, respectively). In vitro true digestibility was similar for MD and SKD (833 and 824 g kg-1 respectively) and lowest for TF (806 g kg-1) at 45 DAP. An abstract of these preliminary data is being presented at the CSSA meeting in 2017.

**4) Developing NIRS techniques for measuring total and protein-precipitable phenolics in forage legumes.** *H.D. Naumann and C.A. Roberts.* There is a need to develop methods of identifying biologically active phytochemicals that offer greater sample throughput and minimize the use of chemical reagents. This experiment involves the collection of diverse populations of annual lespedeza, Illinois bundleflower, panicled tick trefoil and roundhead lespedeza, determination of total and protein precipitable polyphenols using traditional wet-chemistry methods followed by analysis by NIRS. Plant sampling is underway.

**D**. **Usefulness of findings:**

**Experiment 1)** Nutritive value of genotype MU 3993 and Korean lespedeza may be more desirable than ‘Legend’ lespedeza based on greater dNDF and lesser concentrations of biologically active polyphenolic compounds. However, ‘Legend’ is superior if the objective is to exploit condensed tannins and their protein binding ability for potential benefits of rumen bypass protein.

**Experiment 2)** Data are yet to be analyzed. However, we believe that knowing the optimum concentration of CT to be incorporated into the ruminant diet to decrease ruminal methane and increase metabolizable energy will be useful.

**Experiment 3)** Preliminary results suggest that sunn hemp can be established in tall fescue pasture by mowing or grazing followed by drilling and by herbicide strip killing followed by drilling. In addition, interseeding sunn hemp into tall fescue is a viable means of improving DM yield and nutritive value during summer.

**Experiment 4)** Sample collection in progress.

**E. Publications:**

**Peer-reviewed:** none.

**Abstracts:**

**H.D. Naumann**, Kallenbach, R.L. and Lock, T.R. Yield, Nutritive Value and Condensed Tannins are Affected by Cultivar of Annual Lespedeza. Proc. International Annual Meetings of the ASA, CSSA, and SSSA. 2016 Nov 6-8. Phoenix, AZ.

Lepcha, I. and **Naumann H.D.** Interseeding sunn hemp (*Crotalaria juncea* L.) into existing tall fescue pasture for improved forage productivity and nutritive value. Proc. International Annual Meetings of the ASA, CSSA, and SSSA. 2017 Oct. 23-25. Tampa, FL.

**F. M.S. Thesis:** none.

**G. Ph.D. Dissertations:** none.

**H. Leverage:**

$298,669; Managing nutrient inputs to enhance sustainability of forage-based livestock systems; USDA/NIFA/Capacity Building Grants for Non-Land Grant Colleges of Agriculture (NLGCA) Program

**I**. **Related** **Grants Pending:**

USDA-NIFA/CARE; $300,000; Investigation and dissemination of information related to value added processing of a bioactive forage

USDA-NIFA; $960,064; Using legumes to enhance pollinator health in pasture habitats

**NC 2042: 2016-2017 Station Report**

1. **Project Name:** Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.
2. **Cooperating Agency:** New Hampshire Agricultural Experiment Station, Durham.

**Personnel:** P.S. Erickson, Department of Biological Sciences.

**Objective 1)** Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.

**Objective 2)** Improve dairy cow management decisions through nutrient utilization, well-being and profitability

1. **Work progress and principal accomplishments**

**Under Objective 1:**

 **1)** **Nicotinic acid or β- carotene supplementation to prepartum dairy cows**. *K.M. Aragona, and P.S. Erickson.* The objectives of this experiment were to determine the effects of nicotinic acid (NA) supplementation to 45 prepartum Holstein dairy cows and the effects on their calves. Cows received 0, 16, 32, 48 g/d of NA or β- carotene for 4 wk prepartum. There was a linear (P = 0.03) decrease in dry matter intake (DMI) as NA increased (16.08 to 14.78 kg/d). Linear (P = 0.02) increases in IgG concentration (57.6 g/L to 83.5 g/L) and a quadratic response (P = 0.03) with the 32 g treatment yielding the greatest amount of IgG (549, 768,807, and 577 g respectively). Solids (22.5% to 26.1%) and ash (1.03% to 1.24%) percentages increased linearly as NA dose increased (P < 0.05). Calf average daily gain was similar across treatments, but DMI had a linear tendency to decrease (1.12, 1.1, 1.1, 1.0 kg/d) in calves whose dams were fed increasing amounts of NA. Since average daily gain was similar across treatments and DMI was reduced, there was a quadratic effect on feed efficiency with calves born of cows fed 32 g/d NA being the most efficient. These data indicate that calves born of cows fed NA are more efficient (at doses up to 32 g/d).

Cows receiving 700 mg/d β- carotenehad a greater concentration of IgG than control cows (P<0.01) but produced about 4.5 kg less colostrum (11.4 vs.6.9 kg; P =0.04). As would be expected cows supplemented with β- Carotene tended (P = 0.07) to have greater concentrations of protein and fat and a greater (P <0.01) concentration of solids (22.5% vs 27.4%). As observed with the NA portion of the study, calves born from dams fed β- carotene gained 0.44 g/g of DMI, while control calves gained 0.32g/g DMI (P =0.03).

These data suggest that there may be an alteration in colostrum that enhances digestibility and nutrient uptake in calves born of cows fed either NA or β- carotene. *Project in preparation for journal submission.*

 **2). Addition of sodium butyrate to heifer diets: Effects on rumen development, growth and health.** *E. M. Rice and P.S. Erickson*. The objective of this research is to investigate the effects of sodium butyrate (SB) supplementation in the diet of post-weaned calves. It compares the growth rates, rumen development, and nutrient digestibility of the calves being fed 4 different treatment concentrations of the supplement. Subsequently, the information will be used to determine the most beneficial feeding rate of sodium butyrate and what effects it has on dairy calves. .

 This experiment will utilize 40 Holstein heifer calves from immediate postweaning (week 13-week 24). The study will continue until d 150 of life. Calves were be assigned 1 of 4 treatments in a randomized complete block design to test linear and quadratic effects. Treatments were: 1) control: 0 grams SB (Con) 2) 0.25g SB/kg BW 3) 0.5g SB/kg BW 4) 0.75g SB/kg BW. Calves were fed these amounts of SB once daily as a TMR. They will be supplied with free choice water. Weekly BW, hip and withers heights, body length (withers to tail head), and hip width measurements will be recorded for each calf. Daily dry matter intake and weekly blood analyses for glucose, plasma urea N and β-hydroxybutyrate were measured. Weekly composites of TMR will be analyzed for CP, NDF, ADF, Starch, and minerals Orts will be collected and composited by treatment weekly and analyzed for the same nutrients. During 1 period, from d 103- d113 4 g/d chromium oxide was dosed to determine nutrient digestibility (CP, starch, NDF, ADF, and minerals). Fecal samples will also be analyzed weekly for the presence of coccidia to determine if SB can reduce the incidence of coccidiosis.

Results of this study indicated no differences on average DMI, and no effects of treatment by week on DMI. Calves tended to be more efficient as SB dose increased (0.24, 0.26, 0.23, 0.28 kg/kg DMI; P = 0.08). Average body weight (BW) tended to increase (157.5, 159, 160.4, 164.4 kg; P=0.08) as SB increased, and final BW tended to increase as SB increased (214.2, 213.8, 215.5, 222.5 kg; P = 0.08). There were no differences across treatments for skeletal measurements. Biweekly coocidia counts resulted in a quadratic effect (P =0.03) with the lowest count being the 0.25 g/kg treatment (359 oocysts/150 g feces) and the highest being the control heifers (573 oocysts/150 g of feces). Nutrient digestibilities were similar across the treatments except for a linear tendency for improved acid detergent fiber and ash digestibility (P < 0.08) and a concomitant tendency for a reduction in organic matter digestibility (P = 0.07). These data suggest that SB has growth promoting traits in post-weaned heifers. *Project is in preparation for manuscript submission.*

**3. Addition of sodium butyrate and monensin for postweaned heifers.** *T. Stahl and P. Erickson.* This study is based on experiment 2. The study will be set up with a similar number of heifers as experiment 2. Treatments will be 0 g SB (control), 0.75 g/kg BW SB, 1 mg/kg monensin (M) and the combination of SB and M. The experimental design will be a randomized complete block design with a 2 by 2 factorial arrangement of treatments. Unlike experiment 2, there will be two nutrient digestibility periods, and coccidia counts will be weekly instead of bi-weekly. *Project is underway*

**4. The use of wet brewers grains as a replacement for corn and soybean meal in the ration of yearling dairy heifers.** *E. Hatungimana and P. Erickson*

Forty yearling Holstein dairy heifers will be fed four levels of wet brewers grains to replace up to 40 % of the corn and soybean meal in the diet of heifers. The study will be a randomized complete block design with treatments designed to measure linear and quadratic effects. Heifers will be fed a TMR daily with daily intakes and weekly growth measurements taken over the twelve-week study. Nutrient digestibility using chromium oxide as an external marker will be determined twice over the twelve-week study *Project is underway*

**Under Objective 2**

**1) Effect of cinnamaldehyde on nutrient digestibility on late lactation Holstein dairy cows.** *C.E. Chapman and P.S. Erickson.* The objectives of this experiment were to investigate the feeding of the essential oil cinnamaldehyde on nutrient digestibility utilizing six late lactation Holstein cows in a replicated Latin square designed to test for residual effects. Cinnamaldehyde was fed at 0, 2 or 4 mg/kg body weight. Acid-insoluble ash was an internal digestibility marker used with the non-cannulated cows. No differences were observed for DMI, milk yield or composition. There were no effects of cinnamaldehyde on rumen volatile fatty acid concentration or rumen pH. Dry matter digestibility resulted in a quadratic trend (P = 0.09) with digestibility of DM being the greatest for the 2 mg/kg BW dose. *Project in preparation for journal submission.*

**D**. **Usefulness of findings:**

**Experiment 1)** Nicotinic acidsupplementation improves colostrum quality and may enhance feed efficiency in calves. β- carotenemayact in a similar way, but there is a decrease in colostrum yield in cows supplemented with fedβ- carotene.

**Experiment 2)** Sodium butyrate supplementation improves feed efficiency and coccidian counts in postweaned heifers.

**Experiment 3)** Research is underway

**Experiment 4)** Research is underway.

**Under Objective 2**

**Experiment 1)** Cinnamaldehyde supplementation does not affect performance in late lactation dairy cows.

 **E. Publications:**

**Peer-reviewed**

1. Heinrichs, A.J. B. S. Heinrichs, C. M. Jones, P. S. Erickson, K. F. Kalscheur, T. D. Nennich, B. J. Heins, and F. C. Cardoso. 2017. Verifying Holstein heifer heart girth to body weight prediction equations. J. Dairy Sci. (Accepted).
2. Ort, S.B., A. Brito, D. J. Schauff, and P. S. Erickson. 2017.The impact of direct-fed microbials and enzymes on the health and performance of dairy cows with emphasis on colostrum quality and serum immunoglobulin concentrations in calves. J. Anim. Phys. Anim. Nutr. (Accepted).
3. Chapman, C.E., H. Chester-Jones, D. Ziegler, J. A. Clapper and P. S. Erickson. 2017. Effects of cinnamaldehyde or monensin on performance of weaned Holstein dairy heifers. J. Dairy Sci. 100:1712-1719.
4. Chapman, C.E., P. Wilkinson-Stone, M. R. Murphy, and P. S. Erickson. 2017. Technical Note: Evaluating nuclear magnetic resonance spectroscopy for determining body composition in Holstein dairy calves using deuterium oxide dilution methods. J. Dairy Sci. 100:2807-2811.
5. Fouladgar, S., .A.D. Foroozandeh, Shahraki, G.R. Ghalamkari, M. Khani, F. Ahmadi, and P.S.Erickson. 2016. Performance of Holstein calves fed whole milk with or without kefir. J. Dairy Sci. 99:8081-8089.

**Abstracts:**

1. Aragona K., E. Rice, M. Engstrom, and P. Erickson. 2017. Effects of supplemental β-carotene to prepartum dairy cows on colostrum quality and the pre-weaned calf. J. Dairy Sci. 100 (Suppl. 2):88-89.
2. Aragona, K., E. Rice, M. Engstrom, and P. Erickson. 2017. Feeding incremental levels of nicotinic acid to prepartum dairy cows increases colostral immunoglobulin concentration. J. Dairy Sci. 100 (Suppl. 2): 88.
3. Chapman, C., S. Ort, K. Aragona, R. Cabral, and P. Erickson. 2017Effect of cinnamaldehyde on feed intake, rumen fermentation, nutrient digestibility, and milk components in lactating dairy cows. J. Dairy Sci. 100 (Suppl.2): 307.

 **Non-Peer Reviewed:**

# Erickson, Peter. 2016. Rearing Youngstock for Dairy and Beef Production. University of Nebraska, Cooperative Extension - Calf Nutrition: Post-weaning and Starter Feeding.

1. Erickson, Peter. 2016. Rearing Youngstock for Dairy and Beef Production. University of Nebraska, Cooperative Extension- Feeding the Pre-Weaned Calf.

# Erickson, Peter. 2017. Using Milk Urea Nitrogen to Calculate Urine and Urinary Nitrogen Output. UNH Dairy, Livestock and Forage Newsletter.

# Erickson, Peter. 2017. Utilizing uNDF in Dairy Cow Diets. UNH Dairy, Livestock, and Forage Newsletter.

**F. M.S. Thesis:** Supplementation of Sodium Butyrate to Post-weaned Heifer Diets: Effects on Growth Performance, Nutrient Digestibility, and Health- Emily Rice.

**G. Ph.D. Dissertations** – none.

**H. Leverage-**

 1) $21,000 Effects of β-carotene on microbial crude protein- George Walker Milk Fund (Aragona, Ph.D. project)

2) $55,000 Na-butyrate and monensin for post-weaned heifers (Stahl, MS project)

**I. Grants Outstanding:**

USDA NIFA AFRI Prepartum Supplementation Of Nicotinic Acid: Effects On Colostrum Quality And Subsequent Calf Health And Growth Through The First Lactation -$498,804

**J**. **Grants In Progress:**

Na-butyrate for the prepartum cow- effects on colostrum quality and calf performance. (in discussion with Nutriad)

**K. Patent submitted**

UNH 17\_001  “Method and Apparatus for Using Nuclear Magnetic Resonance Spectroscopy to Determine Body Composition of Dairy Calves” US Provisional Patent Application # 62/497,257, filed November 14, 2016.

**NC 2042: 10/01/2016-09/30/2017 Pennsylvania State University Station Report**

 **A. PROJECT NAME**: **Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises**

**B. COOPERATING AGENCY and personnel: Penn State University** A. J. Heinrichs,L. A. Holden, C. A. Jones, , S. L. Gelsinger, L A. Mitchell, E. Ranck D. Saldana, G. A. Chishti.

**Project Objectives**

**Main objective:** To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

1) To analyze management and nutrition strategies for replacement heifers as they pertain to production and profitability (heifers)

2) To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows)

3) To evaluate system components and integration of information into decision-support tools and whole farm analyses to improve efficiency, control variation, and enhance profitability, and environmental sustainability (whole farm)

**C. WORK PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

**Under Objective 1 of Project:**

**Effects of different heat treatments in high, medium and low quality colostrum on IgG absorption and subsequent health in dairy calves**

The objective of this study is to determine the ideal temperature and time to reduce pathogens in different IgG concentration colostrum samples (low, mid-range, and high) without affecting passive immunity. By knowing this, farmer may be able to have a more successful calf raising program and have healthier calves. Batches of low (<50 mg/mL) medium (between 50 to 80 mg/mL) and high (> 80 mg/mL) IgG colostrum concentration were made. Each batch was divided into three subgroups either heated to 60 Celsius for 60 minutes, heated to 60 Celsius for 30 minutes, or not heated before returned to storage at -20 Celsius. One hundred eight Holstein heifer and bull calves from the Pennsylvania State University dairy herd was utilized for the research. Colostrum was thawed and the calf will receive 3.78 L of colostrum using an esophageal feeder in one feeding. After 24 hours, a jugular blood sample was taken. Colostrum and plasma IgG concentration will be measured using. Plasma IgG values will be used to calculate apparent efficiency of absorption (AEA). Samples will be tested for coliform and noncoliform gram-negative bacteria, environmental and contagious streptococci, standard plate count, CNS count, *Streptococcus agalactiae* and *Staphylococcus aureus*.

**Effect of Yeast and Frequency of Milk Feeding on Rumen and Liver Gene Expression Changes in the Developing Calf**

Pre-weaning calf growth is expensive in terms of both feeding cost and management time. Early weaning through increased solid feed intake has remained core research area for scientists from many years. For this purpose, various feeding strategies and feed additives have been used. Yeast has been the most common feed additive used in calf research for quite some time. Its impact on calf rumen development has varied from positive to no effect. Generally, yeast works best in the most stressful period and compromised managemental conditions. Apart from a desire for increased solid feed intake, milk is the major component of calf diet in pre-weaning period. Most of the time milk has been fed twice daily to calves. Few scientists have tested once a day milk feeding with no negative impact on calf health or growth compared to twice a day milk feeding. Even though once a day milk feeding makes calf management a lot easier it is still not well accepted by farmers and among scientific community and on the contrary in last decade there is a resurgence among scientist advocating ad-libitum milk feeding during pre-weaning period. There have been no studies carried out to see the impact of yeast in combination with once a day milk feeding on rumen and liver gene expression changes in the calf. The parameters will be measured during this study are rumen BHBA, liver PUN, glucose and haptigen. Treatments will be with yeast and without with once daily milk feeding or twice (same total amount) and 4 calves will be used at 7 weeks of age.

**Evaluating the impact of various forages on post-weaned calf performance and rumen fermentation**

The goal of this study is to identify forage(s) that post-weaned calves perform best on and the impact on rumen fermentation. At 7 weeks of age, calves will be assigned to a diet consisting of component feeding a grower and one of 3 forages (corn silage, alfalfa haylage or grass hay). At 9 weeks calves will be converted to a TMR consisting of the grower and forage they were assigned to and fed at 7 weeks. 60 total calves will be used with 12 bull calves rumen cannulated at 8 weeks of age. At 13 and 15 weeks cannulated calves will be moved to the intensive barn for total collection and rumen sampling. Growth will be measured weekly along with feed refusals to determine DMI. Furthermore, rumen samples will be used to determine rumen pH and VFAs. At the conclusion of this study our measurements should include growth, digestibility of NDF and DM, as well as impacts on rumen pH and VFA concentration.

**Objective 3-**

**Advancing Sustainable Cropping Systems for Dairy Farms in the Northeastern US**

To assess the performance of the dairy cropping and feeding systems, we will utilize three case farms to quantify the inputs of seed, fertilizer, lime, pesticides, fuel, and labor and the outputs of crop yield and quality as well data for feeding and animal performance and health. The use of enterprise budgets and overall assessment of farm profitability will also be measured in order to determine to economic impact of double cropping on the overall dairy profitability. Data from the case farms will also be used in the Integrated Farm Systems Model (IFSM) in order to test whether high and low animal stocking density and high and low corn silage usage impacts farm productivity or profitability.

**D. USEFULNESS OF FINDINGS:**

Newly weaned calves offer a much needed area of research. Often calves are well grown at weaning and recent research has demonstrated various systems to accomplish well-grown calves at 6 to 8 weeks of age. However, after this period, many farms struggle with maintaining optimum growth rates of calves during the transition from monogastric calves to ruminant heifers. Little research is in the literature related to calves of this age group. Therefore there is great need for this type of research to be done to provide nutrient recommendations as well as feeding system that generally allow these young calves to continue their track to growing enabling them to reach 55%Vof mature body weight by 12to 13 months of age.

Data from four case farms using double cropping showed a variety of management practices that impacted the quality harvest of winter annuals. The farm sizes ranged from 65 to 1200 acres with 45 to 700 cows. Double cropped acres represented 28% of the total acreage for land limited farms and 5% of the total acreage for farms with adequate land base. Initial results from spring crops showed variability in costs and yield per acre bur relatively similar forage quality at harvest. Further data with corn silage harvest and whole farm systems modeling in underway to determine what key strategies lead to successful incorporation of double cropping into the feeding and dairy system.

**E. PUBLICATIONS:**

**Peer-reviewed/ research and extension.**

Lascano, G. J., L. E. Koch, and A. J. Heinrichs. 2016. Precision-feeding dairy heifers a high rumen-degradable protein diet with different proportions of dietary fiber and forage-to-concentrate ratios. J. Dairy Sci. 99:7175-7590.

Van De Stroet, D. L., J. A. Calderón Díaz, K. J. Stalder, A. J. Heinrichs, and C. D. Dechow. 2016. Association of calf growth traits with production characteristics in dairy cattle. J. Dairy Sci. 99:8347-8355.

Kljak, K., F. H. Pino, and , A. J. Heinrichs,. 2017. Effect of forage to concentrate ratio with sorghum silage as a source of forage on rumen fermentation, N balance, and purine derivative excretion in limit-fed dairy heifers. J. Dairy Sci. 100:213-223.

Pino, F. H., A. J. Heinrichs,. 2017. Sorghum forage in precision-fed dairy heifers. J. Dairy Sci. 100:224-235.

Kljak, K., F. H. Pino, K. J. Harvatine, and , A. J. Heinrichs,. 2017. Analysis of selected rumen microbial populations in dairy heifers limit fed diets varying in trace mineral form and starch content. Livestock Science. 198:93-96.

Pino, F. H., A. J. Heinrichs,. 2017. Effect of trace minerals and starch on digestibility and rumen fermentation in diets for dairy heifers. J. Dairy Sci. 99:2797-2810.

Zanton, G. I., and A. J. Heinrichs. 2017. Short communication: Glucose kinetics in dairy heifers limit-fed a low- or high-forage ration at 4 levels of nitrogen intake. J. Dairy Sci. 100: 3718-3724.

Gelsinger, S. I., A. J,. Heinrichs. 2017. Comparison of immune responses in calves fed heat-treated or unheated colostrum. J. Dairy Sci. 100: 4090-4101

Gelsinger, S. I., A. J,. Heinrichs. 2017. A review: The immune system of the dairy calf and the importance of colostrum IgG. J. Dairy, Vet. & Animal Res. 5:144-147.

 Heinrichs, A. J., B.S. Heinrichs, C.M. Jones, P.S. Erickson, K.F. Kalscheur, T.D. Nennich, B.J. Heins, F.C. Cardoso. 2017. Short communication: Verifying Holstein heifer heart girth to body weight prediction equations. J. Dairy Sci. 100:8451–8454.*Note: this was a collaborative work of 6 NC 2042 Stations*

**Non-peer reviewed (e.g., proceedings articles, abstracts, articles for client and lay audiences:**

Heinrichs, A. J., and C. M. Jones. 2016. Monitoring dairy heifer growth. <https://extension.psu.edu/monitoring-dairy-heifer-growth> (major revision)

Maulfair, D. M., and A. J. Heinrichs. 2016. Methods used to measure forage and ration particle size. <https://extension.psu.edu/methods-used-to-measure-forage-and-ration-particle-size>  Includes companion video series on particle size methods:
\*         ASABE particle separator. <https://extension.psu.edu/asabe-particle-separator>
\*         Penn State particle separator. <https://extension.psu.edu/penn-state-particle-separator>
\*         Ro-Tap particle separator. <https://extension.psu.edu/ro-tap-particle-separator>
\*         Wet sieving to measure particle length. <https://extension.psu.edu/wet-sieving-to-measure-particle-length>

Gelsinger, S. L. and A. J. Heinrichs. 2017. Differences in duodenal protein expression in dairy calves at birth and 48h of age. J Dairy Sci. 100 Suppl 2:280.

Gelsinger, S. L., L. L. Hernandez, and A. J. Heinrichs. 2017. Expression of IgG receptor and tight junction protein in neonatal calf intestinal sections. J Dairy Sci. 100 Suppl 2:283.

Gelsinger, S. L., and A. J. Heinrichs. 2017. Economics and effects of accelerated calf growth programs. <https://extension.psu.edu/economics-and-effects-of-accelerated-calf-growth-programs>

Jones, C. M., and A. J. Heinrichs. 2017. Video: Determining forage dry matter. <https://extension.psu.edu/determining-forage-dry-matter>

Jones, C. M., and A. J. Heinrichs. 2017. Table: Comparison of commercial electrolyte products. <https://extension.psu.edu/catalog/product/view/id/3739/>

Gelsinger, S. L., A. J. Heinrichs, and C. M. Jones. 2017. Video: Using a Brix refractometer. <https://extension.psu.edu/using-a-brix-refractometer>

Gelsinger, S. L., A. J. Heinrichs, and C. M. Jones. 2017. Video: Using a Colostrometer. <https://extension.psu.edu/using-a-colostrometer>

**F. IMPACT STATEMENT**

Dairy heifers can be fed in a manner that is more environmentally and cost efficient with no adverse effects.

The profitable use of double cropping in a dairy feeding system depends on some key aspects of whole farm management that impact cost per acre as well as intensity of use within the farm system.

**G.** **Leverage**

Karsten, H. D. et al. (Holden, L. A.) 2016. Advanced Sustainable Cropping Systems for Dairy Farms in the Northeastern US. Northeast Sustainable Agricultural Research and Extension. $400,000.

Key words – best management practices, dairy profitability, calf management, heifer nutrition, sustainable dairy cropping systems, by-product feeds

## South Dakota

*Objective 1 & 2*

**Annual Project Report**

**North Central Cooperative Research Project NC-2042**

**Year ending September 30, 2017**

**A. Project** Management Systems to Improve Economic and Environmental Sustainability of Dairy Enterprises

**B. Cooperating Agency:** South Dakota State University, Brookings, SD 57007

 **Personnel:** J.L. Anderson, Assistant Professor

 Dairy and Food Science Department

 **Project Objectives**

Main objective: To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

1) To analyze management and nutrition strategies for replacement heifers as they pertain to production and profitability (heifers)

2) To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows)

3) To evaluate system components and integration of information into decision-support tools and whole farm analyses to improve efficiency, control variation, and enhance profitability, and environmental sustainability (whole farm)

**C. Work progress and principal accomplishments:**

***Under Objective 1:***

**1. Evaluation of solubles syrup from microbially-enhanced soy protein production as a supplement for growing dairy heifers. C. R. Schossow and J. L. Anderson**

The objective of this research was to conduct a preliminary study to determine if solubles syrup from a microbially-enhanced soy protein (MSP) production process has potential as a supplement for growing dairy heifers. A 6-wk randomized complete block design study was conducted using 14 Holstein and 4 Brown Swiss heifers [310 ± 16.4 d of age; body weight (BW) 337.6 ± 33 kg] to evaluate effects of diet on growth performance. Treatments were: 1) a control total mixed ration (TMR) with corn, soybean meal and distillers dried grains with solubles as concentrate ingredients (**CON**) and 2) a TMR with 6.5% MSP solubles syrup (DM basis) in partial replacement of soybean meal and corn (**SYP**). Both diets contained 34% corn silage, 35% grass hay, and 2.6% mineral mix and were isonitrogenous and isocaloric. Heifers were individually fed TMR for ad libitum intakes using a Calan gate feeding system. Frame sizes, BW, and body condition score (BCS) were measured on 2 d during wk 0, 2, 4, and 6 of the feeding period. Rumen fluid was sampled via esophageal tube 2 d during wk 0 and 6 and 1 d during wk 2 and 4 at 4 h post-feeding. Data were analyzed with MIXED procedures with repeated measures in SAS 9.4. There were no interactions of treatment by wk for any of the parameters evaluated. Treatments had similar (*P* > 0.05) DMI (9.9, and 9.7 kg/d for CON and SYP, respectively; SEM = 0.49), body weight (366.2, and 365.3 kg; SEM = 2.73), ADG (1.00 and 0.97 kg/d; SEM = 0.09), gain:feed (0.11, and 0.13; SEM = 0.02) and BCS (3.10, and 3.10; SEM = 0.30). Frame growth measures including hip height (134.9, and 131.3 cm; SEM = 1.92), withers height (131.0, and 131.0 cm; SEM = 0.40), heart girth (156.7, and 160.7 cm; SEM = 3.21), body length (124.5 and 129.2 cm; SEM = 2.64) and hip width (41.8 and 41.7; SEM = 0.38) and their rates of change were the same between treatments. Rumen pH (6.9, and 6.9; SEM = 0.072) was not affected by treatment. Results demonstrated that partially replacing soybean meal and ground corn with MSP solubles syrup maintained heifer growth performance with a similar gain:feed.

**2. Dairy heifer growth performance when fed hydroponically grown barley sprouts. R.D. Lawrence and J.L. Anderson.**

Our objective was to determine the effects of feeding hydroponically grown barley sprouts (HydroGreen Inc., Renner, SD) to dairy heifers on growth and rumen fermentation. A 12-wk randomized complete block design study was conducted using 20 Holstein and 4 Brown Swiss heifers [215.1 ± 25 d of age; body weight (BW) 229.7 ± 39 kg]. Treatments were: 1) control (**CON**) diet which was a total mixed ration (TMR) with grass hay, corn silage, and ground corn and soybean meal as major concentrate ingredients and 2) a TMR with 14% (DM basis) hydroponic barley sprouts (**HYD**) replacing a portion of the concentrate mix. Diets were fed for ad libitum intakes and formulated to be isonitrogenous and isocaloric (DM basis), although the CON was 66 % DM and HYD was 44 % DM. Intakes were measured using the Calan gates. Frame sizes, BW, and body condition scores (BCS) were measured on 2 d during wk 0, 2, 4, 6, 8, 10, and 12. Rumen fluid was collected 4 h post feeding via esophogeal tube every 4 wk. Data were analyzed in MIXED procedures of SAS 9.4 with repeated measures. Heifer DMI was greater (*P* < 0.01) for HYD (7.5, and 8.0 kg/d for CON and HYD, respectively; SEM = 0.42). Heifer ADG tended (*P* = 0.07) to be greater for the CON treatment (1.2, and 1.0 kg/d; SEM = 0.06). Body weight (289.7, and 282.4 kg; SEM = 2.02) and gain: feed (0.16, and 0.13; SEM = 0.01) were greater (*P* < 0.01) for the CON treatment. Withers height (121.7 and 121.9 cm; SEM = 0.54) and hip width (37.3 and 37.1 cm; SEM= 0.57) and BCS (3.11, and 3.10; SEM = 0.02) were similar (*P* > 0.05), but heart girth was greater (*P* < 0.01) for the CON heifers (146.0 cm, and 145.0 cm; SEM = 0.62). Rumen Ammonia-N (21.0, and 24.5 mg/dL; SEM = 2.15), pH (6.75, and 6.70; SEM = 0.06), total volatile fatty acids (95.0, and 98.0 mM; SEM = 2.32) and acetate to propionate ratio (3.4, and 3.3; SEM = 0.13) were similar. Results indicated that replacing ground corn and some soybean meal with hydroponic fresh barley sprouts maintained rumen fermentation and heifer body frame growth with slightly decreased gain:feed. The decreased gain:feed was most likely because of the overall high moisture content in the HYD TMR.

 **3. Growth performance of dairy calves fed microbially-enhanced soy protein in starter pellets with pasteurized milk. N.D Senevirathne., J.L. Anderson, and W.R. Gibbons.**

Our objective was to investigate feeding microbially (fungal)-enhanced soy protein (MSP) in dairy calf starter pellets on growth performance, health, and nutrient utilization. Thirty-eight Holstein calves (2 d old; 25 females, 13 males) in individual hutches were used in a 12-wk randomized complete block design study. Treatments were two starter pellets including: a control (CON) versus 8 % MSP (DM basis). Calves were fed 2.83 L of pasteurized milk 2×/d during wk 1 to 5 and 1×/d during wk 6. Pellets and water were fed ad libitum. Fecal scores (0 = firm, 3 = watery) and respiratory scores (healthy ≤ 3, sick ≥ 5) calculated from the sum of scores for rectal temperature, cough, ocular, and nasal discharge were recorded daily. Body weights (BW) and frame growth were measured 2 d and jugular blood samples were taken 1 d every 2 wk at 3 h post morning feeding. Fecal grab samples were collected in wk 12 for analysis of total tract digestibility. Results were analyzed using MIXED procedures with repeated measures in SAS 9.4. Significant differences were declared at *P <* 0.05 and tendencies were 0.05 *≤ P <* 0.10. Total DMI (1,522 and 1,470 g/d; SEM = 48.62) was greater (*P* = 0.02) in CON than MSP. Calf BW (75.4 and 75.0 kg; SEM = 2.39), ADG (0.77 and 0.75 kg/d; SEM = 0.05), and withers height (89.1 and 90.1 cm; SEM = 0.86) were similar. Gain:feed (0.62 and 0.60 kg/kg; SEM = 0.03) was similar; however there was an interaction of treatment by wk (*P* < 0.01). Plasma urea nitrogen (12.6 and 11.1 mg/dl; SEM = 0.39) was less (*P* < 0.01), but β- hydroxyl butyrate (31.1 and 34.5 mg/dl; SEM = 1.28) was greater (*P* = 0.04) in calves fed MSP. Glucose (124.3 and 123.6 mg/dl; SEM = 2.59) and triglycerides (31.5 and 30.1 mg/dl; SEM = 1.19) were similar. Calves fed MSP had greater (*P* < 0.05) CP, NDF and ADF and tendency (*P* = 0.06) for greater DM total tract digestibility. Fecal scores were similar with an interaction of treatment by wk (*P* < 0.01). Body temperature and respiratory scores were similar (*P* > 0.05). Results demonstrated that feeding calves MSP improved total tract digestibility of nutrients, fecal consistency, and maintained growth performance.

**4. Growth performance and metabolic profile of Holstein heifers fed carinata meal compared with DDGS. K. Rodriguez-Hernandez and J. L. Anderson.**

Carinata meal (**CRM**) is an oilseed meal that is a quality source of protein, but contains high concentrations of glucosinolates, especially sinigrin. Glucosinolates limit dietary inclusion rates as they may cause issues with thyroid gland function which may negatively influence heifer growth performance; however, in previous results we demonstrated growth performance was maintained when heifers were fed CRM. Therefore, our objective was to determine effects of feeding CRM compared to distillers dried grains with solubles (**DDGS**) to peripubertal dairy heifers on the metabolic profile. A 16-week randomized block design experiment with 24 Holstein heifers (6.6 ± 0.7 mo and 218 ± 27 kg of BW) was conducted. Heifers were blocked by age. Treatments diets were: 1) 10% cold-pressed CRM (glucosinolates at 2.06 g/kg of diet DM) and 2) 10% DDGS on a DM basis. The remainder of the diets consisted of grass hay, ground corn, soybean meal and mineral mix, and diets were formulated to be isonitrogenous and isocaloric. Heifers were individually fed using a Calan gate feeding system and the rations were limit-fed at 2.65% of BW on DM basis. Jugular blood samples were collected 3-4 h post-feeding on 2 d during wk 0, 4, 8, 12, and 16 for metabolite and metabolic hormone analyses. Frame sizes, BW, and body condition scores (**BCS**) were measured at 4 h post feeding on 2 consecutive d during wk 0 and then every 2 wk thereafter throughout the feeding period. Data were analyzed using MIXED procedures with repeated measures in SAS 9.4. Significance was declared at *P* < 0.05. There were no significant interactions of treatment by wk. Heifer DMI (6.55 and 6.42 kg/d; SEM = 0.16 for CRM and DDGS, respectively), BW (269.9 and 268.9 kg; SEM = 1.47), ADG (0.837 and 0.825 kg/d; SEM = 0.029), and gain:feed (0.131 and 0.130 kg/kg; SEM = 0.004) were similar (*P* > 0.05) between treatments. There were no differences (*P* > 0.05) in withers height (122.8 and 122.4 cm; SEM = 0.53), hip height (126.0 and 126.4 cm; SEM = 0.27), hearth girth (145.6 and 145.2 cm; SEM = 0.53), hip width (37.98 and 38.26 cm; SEM = 0.28), and BCS (3.01 and 2.99; SEM = 0.01). There were no interactions of treatment by wk for any of the metabolites and metabolic hormones measured. Glucose (84.0, and 82.3 mg/ dL; SEM = 1.25 for CRM and DDGS, respectively), plasma urea nitrogen (19.8, and 19.77 mg/dL; SEM = 0.48), IGF-1 (117.1, and 105.0 ng/mL; SEM = 4.9), triiodothyronine (140.2, and 154.7 ng/dL; SEM = 5.3), and thyroxine (6.3, and 6.6 μg/dL; SEM = 0.23) concentrations were similar (*P* > 0.05) among treatments. Cholesterol concentration was greater (*P* < 0.05) in the CRM heifers than DDGS heifers (89.9, and 78.2 mg/dL; SEM = 2.6). This research demonstrates that carinata meal, despite the glucosinolate content, can be fed at the inclusion rate of 10% diet DM to growing dairy heifers and maintain DMI, ADG, and frame growth compared to DDGS without negative effects on the thyroid hormones and metabolic status.

**5**. **Evaluation of the effects of carinata meal on growth performance of dairy heifers compared with canola meal and a control diet (In-progress). K. Rodriguez-Hernandez and J. L. Anderson.**

Thirty-six Holstein heifers [6.3±0.7 mo of age, and 206±12 kg of body weight (**BW**)] were used in a 16-week randomized complete block design with three treatment diets. Treatments were: 1) a control diet (**CON**) with soybean meal, 2) carinata meal (**CAR**), and 3) canola meal (**CAN**). Both the solvent-extracted CAR and CAN were included at 10% of diet dry matter (**DM**). The remainder of the diets were comprised of grass hay and other concentrate ingredients to meet nutrient requirements and formulated to allow for similar intakes of protein and energy among treatments. The dietary inclusion of 10% as carinata meal was used as it is the limit established by the FDA for rapeseed meals, which are from a similar plant family and have similar glucosinate concentrations (Benz, 2010). The three treatment diets were all limit-fed at 2.4% of BW. Heifers were fed using a Calan gate feeding system (American Calan, Inc. Northwood, NH) to measure daily individual intakes and regulate the amount of feed offered to each heifer. Heifers were blocked by age in groups of three and then randomly assigned to treatments within blocks. Start dates of the blocks were staggered according to birthdate of the heifers. Every two weeks, on two consecutive days, heifers were weighed and measured for skeletal frame size (withers height, heart girth, paunch girth, hip width, and body length) to assess growth performance. Body conditions scores (**BCS**) were observed by four independent individuals on a scale of 1 to 5 with 1=emaciated and 5=obese. All data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, NC). Heifer dry matter intake (**DMI**), gain:feed, growth data, and ADG data were analyzed as a randomized complete block design with week as the repeated measure and the term heifer nested within block as the subject using PROC MIXED procedures of SAS (Littell et al., 2006). Initial (week 0) BW and frame measurements were used as covariate terms for each respective variable. The model included treatment, week, and treatment x week interactions. Significant differences among treatments were declared at P ≤ 0.05 and tendencies were declared at 0.05 < P ≤ 0.10. Least squares means are reported for each treatment in the tables. The slice option was used to determine if differences between treatments were significant at individual weeks or time points of measurements. There were no effects of treatment for any frame growth measurements. There were no treatment by week interactions found for any of the frame growth measurements. There were no effects of treatment for DMI, ADG and BCS. It should be noted that ADG was high for heifers of this age for all treatments. There was an increase over the time for the all frame growth measurements, DMI, ADG and BCS, as expected in growing animals. There were no effects of treatment in change per day for the growth variables measured except for heart girth. Heifers fed CAR tended to have a lesser change in heart girth than heifers fed CAN or CON diets; however, the differences among treatments were numerically small and of questionable biological significance. Overall, these preliminary results demonstrate that dairy heifers fed carinata meal at 10% of the diet (DM basis) have comparable growth performance and intakes to heifers fed the control or canola meal diets. Therefore, carinata meal is a suitable competitor and can effectively replace canola meal or a portion of the protein provided from soybean meal in rations for growing dairy heifers.

**Table 1.** Frame size measurements, BCS, DMI, BW, ADG, and gain:feed ratios for heifers fed a control (CON) diet or diets with carinata meal (CRM) and canola meal (CAN).

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Treatment | SEM | *P*-value |
| CON | CAR | CAN |  | Treatment | Week | Treatment x Week |
| DMI, kg/d | 6.05 | 6.31 | 6.16 | 0.114 | 0.29 | <0.01 | 0.99 |
| ADG, g/d | 1.03 | 1.01 | 1.02 | 0.033 | 0.85 | 0.04 | 0.86 |
| Gain:Feed | 0.18 | 0.17 | 0.18 | 0.004 | 0.23 | <0.01 | 0.97 |
| BW, Kg | 277 | 279 | 277 | 2.9 | 0.96 | <0.01 | 0.80 |
| Withers Height, cm | 122.4 | 122.2 | 122.6 | 0.34 | 0.80 | <0.01 | 0.50 |
| BCS1 | 3.05 | 3.06 | 3.06 | 0.020 | 0.87 | <0.01 | 0.95 |

1Body condition scoring was on a scale of 1 to 5 with 1 being emaciated and 5 being obese (Wildman et al., 1982).

The feeding study (farm work portion) of this research project was just completed in the end of August 2017. Over the next few months we will be focused on completing the laboratory analyses on feed, blood, rumen and fecal samples collected during the feeding study.

***Under Objective 2:***

**1. Milk production and composition of dairy cows fed hydroponic barley sprouts. R.D. Lawrence and J. L. Anderson.**

Our objective was to determine the effects on milk production and rumen fermentation of feeding cows hydroponically grown barley sprouts (HydroGreen Inc., Renner, SD). Twenty mid-lactation Holsteins (DIM 205 ± 47.4) were used in a 6-wk randomized complete block design study. Treatments included: 1) control diet with ground corn and soybean meal as major concentrate ingredients (**CON**) and 2) 8% (DM basis) as hydroponic barley sprouts replacing some corn and soybean meal (**HYD**). Both diets were individually fed as total mixed rations using Calan gates and were isocaloric and isonitrogenous. Cows were milked 2×/d. Body condition scores (BCS) and body weight (BW) were measured and rumen fluid was collected via esophogeal tube at 4 h post feeding on 2 d during wk 0, 2, 4, and 6. Milk samples were taken on the same days. A blind triangle taste test was done on 2 d in wk 6 with 25 volunteers. Data were analyzed using MIXED procedures of SAS 9.4 with repeated measures and the triangle test was analyzed using a Chi-squared test in R. Dry matter intake (23.0, and 23.0 kg/d, for CON and HYD, respectively; SEM = 0.54) was similar (*P* > 0.05) between treatments. Treatments had similar BW (690.0, and 680.5 kg; SEM = 3.72). Body condition score (3.09, and 3.08; SEM = 0.03) was greater (*P* = 0.03) for CON fed cows. Milk production (30.6, and 31.5 kg/d; SEM = 1.60) and feed efficiency (1.33 and 1.40; SEM = 0.046) had treatment by wk interactions (*P* = 0.01). Milk protein (0.94 and 0.94 kg/d; SEM=0.03) and fat (1.10 and 1.07, SEM =0.06) yields were similar (*P* > 0.05). Rumen pH (6.53, and 6.60; SEM = 0.11), ammonia-N (12.72, and 13.90 mg/dL; SEM = 1.00), total volatile fatty acids (95.6, and 95.0 mM; SEM = 1.81) and acetate to propionate ratio (3.0, and 3.1; SEM = 0.11) were similar. Triangle test participants were unable to discern a taste difference between milk from CON vs. HYD on day 1 (Chi-squared = 0.55; *P* = 0.46) and day 2 (Chi-squared = 1.67; *P* = 0.20). Milk fatty acid profile was also similar between treatments. Results demonstrate that hydroponic barley sprouts can replace a portion of the corn and soybean meal and maintain rumen fermentation and lactation performance.

**D. Usefulness of findings:**

**Objective 1:**

* Research demonstrated that partially replacing soybean meal and ground corn with solubles syrup from the production of microbial-enhanced soy protein (fungal treatment) maintained heifer growth performance with a similar gain:feed and improved nutrient digestibility.
* A calf feeding study found that including Microbially-enhanced soy protein in the starter pellets in rep improved total tract digestibility of nutrients, fecal consistency, and maintained growth performance.
* It was found that replacing ground corn and some soybean meal with hydroponic fresh barley sprouts maintained rumen fermentation and heifer body frame growth with slightly decreased gain:feed. The decreased gain:feed was most likely because of the overall high moisture content in the TMR containing the barley sprouts.
* Carinata meal, despite the glucosinolate content, can be fed at the inclusion rate of 10% diet DM to growing dairy heifers and maintain DMI, ADG, and frame growth compared to DDGS without negative effects on the thyroid hormones and metabolic status.
* Preliminary results demonstrated that dairy heifers fed carinata meal at 10% of the diet have comparable growth performance and intakes to heifers fed the control or canola meal diets. Therefore, carinata meal is a suitable competitor and can effectively replace canola meal or a portion of the protein provided from soybean meal in rations for growing dairy heifers.

**Objective 2:**

* Research demonstrated that hydroponically grown fodder or barley sprouts can be used to replace a portion of the traditional concentrate ingredients (corn and soybean meal) in lactating cow diets and maintain lactation performance and milk composition. Hydroponically grown feeds may become more important and increasingly used with increasing emphasis on environmental footprint and land shortages for agriculture.

**E. Publications:**

***Peer-reviewed Journal Articles (\*=corresponding author/PI)***

1. Senevirathne, N. D, **J. L. Anderson\***, W. R. Gibbons, and J. A. Clapper. 2017. Growth performance of calves fed microbially-enhanced soy protein in pelleted starters. J. Dairy Sci. 100: 199-212.
2. Manthey, A. K., **J. L. Anderson\***, G.A. Perry and D.H. Keisler. 2017. Feeding distillers dried grains in replacement of forage in limit-fed dairy heifer rations: Effects on metabolic profile and onset of puberty. J. Dairy Sci.100:2591-2602.
3. Lawrence, R. D., **J. L Anderson\***, A.K. Manthey, and K.F. Kalscheur. 2017. Growth performance and total tract nutrient digestion for Holstein heifers limit-fed diets high in distillers grains with different forage particle size. Prof. Anim. Sci. 33:2591-2602.
4. Ranathunga, S. D.\*, K. F. Kalscheur, **J. L. Anderson**, and K.J. Herrick. 2017. Evaluation of a modified method to measure total starch in animal feeds. Anim. Feed Sci. Tech. 226:124-132.
5. Manthey, A. K., and **J. L. Anderson\***. 2017*.* Short communication: Feeding distillers dried grains in replacement of forage in limit-fed dairy heifer rations: Effects on post trial performance. J. Dairy Sci.100:3713–3717.
6. Manthey, A. K., and **J. L. Anderson\***. 2017. Growth performance, rumen fermentation, nutrient utilization, and metabolic profile of dairy heifers limit-fed distillers dried grains with ad libitum forage. J. Dairy Sci. *Accepted.*
7. Rodriguez-Hernandez, K. and **J. L. Anderson\***. 2017. Evaluation of carinata meal as a feedstuff for growing dairy heifers: Effects on growth performance, rumen fermentation, and total tract digestibility of nutrients. J. Dairy Sci. *Accepted.*

***Abstracts***

1. Manthey, A. K., and **J. L. Anderson**. 2017. INVITED -Young Scholar Presentation: Feeding peripubertal dairy heifers diets high in distiller’s grains with varying forage-to-concentrate ratios. J. Dairy Sci. 100: Suppl. 1:183. (Abstr. 378). (MW ASAS/ADSA)
2. Rodriguez-Hernandez, K., **J. L. Anderson**., and M. A. Berhow. 2017. Preference of carinata meal compared with other oilseed meals and distiller’s dried grains by dairy heifers. J. Dairy Sci. 100, Suppl 1: 178 (Abstr. 366). (MW ASAS/ADSA)
3. Rodriguez-Hernandez, K. and **J. L. Anderson**. 2017. Growth performance of dairy heifers fed carinata meal. J. Dairy Sci. 100: Suppl. 1: 181. (Abstr. 374). (MW ASAS/ADSA)
4. Lawrence, R.D. and **J. L. Anderson**. 2017. Dairy heifer growth performance when fed hydroponically grown barley sprouts. J. Dairy Sci. 100: Suppl. 2: 328. (Abstr:T275) (ADSA Annual Meeting)
5. Lawrence, R.D., **J. L. Anderson**, S. I. Martinez Monteagudo, and L. Metzger. 2017. Milk production and composition of dairy cows fed hydroponic barley sprouts. J. Dairy Sci. 100: Suppl. 2: 400. (Abstr: 437) (ADSA Annual Meeting)
6. Rodriguez-Hernandez, K., **J. L. Anderson** and J. A. Clapper. 2017. Metabolic profile of Holstein heifers fed carinata meal. J. Dairy Sci. 100: Suppl. 2: 399-400. (Abstr: 436) (ADSA Annual Meeting)
7. Schossow, C. R. and **J. L. Anderson**. 2017. Evaluation of solTbles syrup from microbially enhanced soy protein production as a supplement for growing dairy heifers. J. Dairy Sci. 100: Suppl. 2: 328. (Abstr: T274) (ADSA Annual Meeting)
8. Senevirathne, N.D., **J. L. Anderson**, and W. R. Gibbons. 2017. Growth performance of dairy calves fed microbially enhanced soy protein in starter pellets with pasteurized milk. J. Dairy Sci. 100: Suppl. 2: 400-401. (Abstr: 439) (ADSA Annual Meeting)

***Dissertation/Thesis***

1. Aubrey, T.C. 2017. M.S. Thesis: Evaluation of concentrated brewer’s yeast as a feed supplement for lactating dairy cows. South Dakota State University. Brookings, SD.

***Extension Articles***

1. Rodriguez-Hernandez, K., **J. Anderson**, M. Berhow. 9/4/2017. Taste preference of carinata meal compared with different oilseed meals by dairy heifers. iGrow.org- Livestock – Dairy – Innovation/Research. <http://igrow.org/livestock/dairy/dairy-heifer-taste-preference-carinata-meal-vs.-different-oilseed-meals-and/>
2. Manthey, A. and **J. Anderson**. 8/21/2017. Limit feeding DDGS with free choice hay to maintain growth performance and feed efficiency in growing heifers. iGrow.org- Livestock – Dairy – Innovation/Research. <http://igrow.org/livestock/dairy/heifer-growth-performance-feed-efficiency-limit-feeding-ddgs-with-free-choi/>
3. Schossow, C., **J. Anderson**, and W. Gibbons. 8/4/2017. Solubles Syrup from Microbially-Enhanced Soy Protein Processing: A potential protein supplement. iGrow.org- Livestock – Dairy – Innovation/Research. <http://igrow.org/livestock/dairy/solubles-syrup-from-microbially-enhanced-soy-protein-processing-a-potential/>
4. Rodriguez-Hernandez, K. and **J. Anderson**. 10/24/2016. Carinata Meal: Potential as a feedstuff for growing dairy heifers. iGrow.org- Livestock – Dairy – Innovation/Research. <http://igrow.org/livestock/dairy/carinata-meal-potential-as-a-feedstuff-for-growing-dairy-heifers/>
5. Manthey, A. and **J. Anderson**. 9/26/2016. Feeding DDGS in Increasing Dietary Proportions: Rumen fermentation & total tract digestibility. iGrow.org- Livestock – Dairy – Innovation/Research. <http://igrow.org/livestock/dairy/feeding-ddgs-in-increasing-dietary-proportions-rumen-fermentation-total-tra/>
6. Manthey, A., **J. Anderson**, G. Perry, and D. Keisler (University of Missouri). 9/26/2016. Greater DDGS Dietary Proportions: Impact on metabolic profile & puberty in growing dairy heifers. iGrow.org- Livestock – Dairy – Innovation/Research. <http://igrow.org/livestock/dairy/greater-ddgs-dietary-proportions-impact-on-metabolic-profile-puberty-in-gro/>

**F. Impact statement:**

* Research with calves on a developmental feedstuff, microbial-enhanced soy protein, found improved total tract digestibility of nutrients, fecal consistency, and maintained growth performance. In other research with growing heifers it was found that a solubles syrup that is a by-product of the manufacturing process could be fed and maintained growth performance with a similar gain:feed and improved nutrient digestibility. This research was on a very new developing feedstuff and by-product and is important as it present a new option to increase nutrient digestibility in both calf and heifer diets.
* Research with cows and heifers on feeding hydroponically grown barley sprouts found that lactation performance or growth performance was maintained when the sprouts replaced corn and some soybean meal in the diet. Hydroponically grown feeds may become more important and frequently used with increasing emphasis on environmental footprint and land shortages for agriculture; however, the decision to use it or not should be based on the economics of the individual farm and region.
* Carinata is a new oilseed that is a promising feedstock for biodiesel production. Two research projects have demonstrated that carinata meal (leftover after fat extraction), despite the glucosinolate content, can be fed at the inclusion rate of 10% diet DM to growing dairy heifers and maintain DMI, ADG, and frame growth without negative effects on the thyroid hormones and metabolic status. Therefore, carinata meal is a new and alternative protein and energy source for growing heifers.

**G. Leverage:** The current work at South Dakota State University has leverage and support from governmental and commercial partnership to maintain the level of support needed to keep the project viable.

## USDA-ARS, USDFRC

*Objective 2*

**Annual Project Report**

**North Central Cooperative Research Project NC-2042**

**Year ending September 30, 2017**

**A. Project** Management Systems to Improve Economic and Environmental Sustainability of Dairy Enterprises

**B. Cooperating Agency:** USDA-ARS, U.S. Dairy Forage Research Center, Madison, WI 53706

 **Personnel:** K. F. Kalscheur, NC-2042 member
USDA-ARS, USDFRC, Madison, WI

**Project Objectives**

Main objective: To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

1) To analyze management and nutrition strategies for replacement heifers as they pertain to production and profitability (heifers)

2) To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows)

3) To evaluate system components and integration of information into decision-support tools and whole farm analyses to improve efficiency, control variation, and enhance profitability, and environmental sustainability (whole farm)

**C. Work progress and principal accomplishments:**

***Objective 2: To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows).***

1. **Impact of dietary starch concentration formulated with two types corn silage on the performance of dairy cows.**  This study explored the effect of feeding different starch concentrations and conventional or brown midrib corn silage on the performance of lactating dairy cows. Forty-eight Holstein cows were assigned to 1 of 4 diets using a randomized complete block design with a 2-wk covariate period followed by 8-wk experimental period. Experimental diets were arranged as a 2 × 2 factorial with 2 types of corn silages [conventional (CS) and brown midrib (BMR) corn silage] and 2 dietary starch concentrations (19 and 25% of DM). Diets were formulated to contain 60.7% forage and 39.3% concentrate on DM basis. Dried corn grain was replaced with soyhulls and beet pulp to decrease dietary starch concentration. Cow was the experimental unit. Silage × starch interactions were detected (P≤0.05) for milk yield, energy-corrected milk (ECM), and feed efficiency (ECM/DMI). Milk yield was similar between cows fed BMR-25% starch and CS-19% starch, but was greater than for cows fed other diets. ECM was greatest for cows fed BMR-25% starch compared to the other 3 diets. Feed efficiency was greatest for cows fed CS-19% starch and BMR-25% starch and least for cows fed BMR-19% starch. Milk protein percentage was affected by starch concentration, resulting in greater protein concentration for cows fed 25% starch compared to cows fed the 19% starch diet. There was no effect of diet on DMI, milk fat percentage, milk fat and protein yield, and MUN. Overall, the milk and ECM of lactating dairy cows was superior when feeding BMR-25% starch, but cows fed BMR-19% starch responded similarly to cows fed CS diets at either 19 or 25% starch.

**Table 1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | CS |  | BMR |  |  |
| Item | 19% | 25% |  | 19% | 25% | SEM | *P˃F*1 |
| DMI, kg/d | 25.9 | 26.8 |  | 27.0 | 26.8 | 0.54 | NS |
| Milk, kg/d |  44.1ab |  43.4b |  | 43.4b |  45.7a | 0.69 | I |
| ECM, kg/d | 45.1b |  44.9b |  | 44.2b |  46.8a | 0.71 | I |
| ECM/DMI |  1.76a |  1.69ab |  |  1.66b |  1.76a | 0.04 | I |
| Fat, % |  3.83 |  3.89 |  |  3.87 |  3.88 | 0.09 | NS |
| Fat, kg/d |  1.66 |  1.68 |  |  1.63 |  1.73 | 0.05 | NS |
| Protein, % |  2.91 |  3.00 |  |  2.90 |  2.98 | 0.04 | S |
| Protein, kg/d |  1.27 |  1.27 |  |  1.23 |  1.32 | 0.02 | NS |
| MUN, mg/dL |  11.1 |  10.5 |  |  11.4 |  11.0 | 0.35 | NS |

abMeans with different superscripts differ (P≤0.05).

1S = starch effect; I = silage by starch effect; NS = not significant.

1. **Impact of dietary starch concentration formulated with two types of corn silage on methane and ammonia emissions in dairy cows.** The objective of this study was to evaluate methane (CH4) and ammonia (NH3) emissions of lactating dairy cows fed different starch level and corn silage type. After the completion of an 8-wk production study, 48 Holstein cows were allocated to 1 of 4 air-flow controlled chambers (2 cows/chamber) for 6 d in a randomized complete block design. Chamber was the experimental unit. Cows were fed 1 of 4 diets arranged as a 2 × 2 factorial with 2 corn silage hybrids [conventional (CS) and brown midrib (BMR) corn silage] and 2 dietary starch concentrations (19 and 25% of DM). Performance data from the last 6 days and emission measurements last 3 days were recorded and used for analysis. Soyhulls and beet pulp replaced corn grain in the diet to decrease starch concentration. There was no effect of dietary starch concentration and corn silage on DMI, ECM, ECM/DMI, and milk protein percentage, however milk fat percentage was greater (P<0.05) for cows fed diets formulated at 25% starch rather than diets with 19% starch. An interaction of silage × starch (P<0.05) was observed for CH4 expressed as per unit of DMI and for MUN. Cows fed CS-25% starch had the lowest MUN. Cows fed BMR-25% starch produced 1.3 g CH4 less per unit of DMI than cows fed CS-25% starch, but were similar to cows fed 21% starch for any silage type. Emissions of CH4 and NH3 (g/d), and CH4/ECM did not differ among treatments. It was concluded that cows fed the BMR-25% starch have the potential to reduce CH4 emissions per unit of DMI even though productive performance was not improved.
2. **Performance of dairy cows fed conventional sorghum or corn silages compared to brown midrib sorghum silage: a meta-analysis.** A meta-analysis was conducted to compare the effects of feeding dairy cows conventional sorghum (CSS) or corn silages (CCS) vs. brown midrib sorghum silage (BMRSS) on dry matter intake (DMI), milk yield, and milk composition. Data from nine published articles (1984-2015) were used to contrast CSS (7 comparisons; 104 cows) or CCS (13 comparisons; 204 cows) vs. BMRSS. Statistical analysis was performed using fixed or random effects models in R. The degree of heterogeneity was measured with I2 statistic and publication bias was determined with funnel plots and Egger´s regression test. Other sources of heterogeneity of response were analyzed through meta-regression. Estimated effect size was calculated for DMI, milk yield, and milk composition. No evidence of publication bias was observed for all variables tested. DMI and milk yield had the highest (I2=41.5 [CSS vs. BMRSS]; I2=72.6% [CCS vs. BMRSS]) and lowest (I2=0%) degree of heterogeneity, respectively. Compared to CSS, cows fed BMRSS tended to increase DMI (0.83 kg/d; P=0.09), and significantly increased milk yield (1.64 kg/d; P<0.001), milk fat (0.09%; P=0.03), and yields of milk fat (0.08 kg/d; P<0.001), protein (0.04 kg/d, P<0.001), and lactose (0.16 kg/d; P=0.02). No differences were observed for milk protein and lactose percentage (P>0.05). Compared to CCS, cows fed BMRSS increased milk fat (0.10%; P=0.009), but decreased milk protein (0.06%; P=0.03). There were no effects on DMI, milk yield, yields of milk fat, protein, and lactose, and lactose percentage between CCS and BMRSS. Meta-regression indicated that days in milk affected DMI and milk production when CSS was compared to BMRSS and DMI when CCS was compared to BMRSS. Overall, lactation performance improved when cows were fed diets formulated with BMRSS compared to cows fed diets formulated with CSS, however, performance was not different between cows fed BMRSS and CCS. Future research comparing BMRSS with CSS or CCS needs to consider days in milk since cows respond differently throughout their lactation according to meta-regression analysis.
3. **Replacing conventional or brown midrib corn silage with brown midrib sudangrass silage in the diets of lactating dairy cows.** Forages that use less water, but are high in digestibility, are sought as alternatives to traditional forages such as corn silage. Brown midrib (BMR) sudangrass is an example of alternative forage for corn silage. The objective of this study was to evaluate whether BMR sudangrass silage (SS) can replace 2 types of corn silage with differing fiber digestibilities [conventional (CONV) or BMR corn silage (CS)] in the diets of lactating dairy cows. Forty-eight Holstein cows in mid- to late-lactation were assigned to 1 of 4 treatments in a randomized complete block design. Cows were fed a common covariate diet for 2 weeks followed by 8 weeks of experimental diets. Diets were formulated to contain 40% CS, 20% alfalfa silage, and 40% concentrate on DM basis. Sudangrass silage was included in experimental diets at either 0 or 10% of the diet DM replacing either 10% CONV or BMR CS. All other ingredients (high moisture corn, canola meal, roasted soybeans, soyhulls, and minerals and vitamins) were included equally for all diets. Cow was the experimental unit. Dry matter intake (DMI) averaged 25.2 kg/d and was not affected by the type of CS used nor by the inclusion of SS in the diets (P>0.05). Similarly, milk production (averaged 40.0 kg/d) and was not affected by type of CS nor SS inclusion. Milk fat percentage increased 0.15% for cows fed the addition of 10% SS compared to cows fed 0% SS. Milk protein, lactose, and total solids percentage was not affected by dietary treatments. Milk protein yield was greater (0.054 kg/d; P=0.03) for cows fed 0% SS compared to cows fed 10% SS. Because the dietary CP% was slightly greater for diets containing 10% SS compared to 0% SS (17.2 vs 16.2%), MUN responded similarly (11.1 vs. 9.6 mg/dL; P=0.001). Energy-corrected milk (ECM) and feed efficiency (defined as ECM/DMI) was not affected by changes in diet because of similar intake and performance. Overall, the inclusion of 10% SS as a replacement for either CONV or BMR CS did not negatively affect lactation performance. BMR SS can be a successful replacement for CS where CS availability is limited.

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| **Table 1.** |
|  |  CONV CS |  | BMR CS  |  |  |
| Item | 0 SS | 10 SS |  0 SS | 10 SS | SEM | Pa |
| DMI, kg/d | 25.7 | 25.1 | 25.2 | 24.8 | 0.53 | NS |
| Milk, kg/d | 39.8 | 39.3 | 40.5 | 40.3 | 0.93 | NS |
| Fat, % |  3.66 |  3.78 |  3.63 |  3.81 | 0.08 | SS |
| Protein, % |  2.99 |  2.97 |  2.96 |  2.95 | 0.03 | NS |
| ECM, kg/d | 41.3 | 40.9 | 41.0 | 40.4 | 0.88 | NS |
| FE (ECM/DMI) |  1.65 |  1.61 |  1.59 |  1.64 | 0.06 | NS |
| aSS=Effect of sudangrass silage inclusion (P<0.05); NS=No significant effect (P>0.05). |

**D. Usefulness of findings:**

Milk production of lactating dairy cows was superior when feeding the combination of BMR corn silage and 25% starch in the diet, but cows fed BMR corn silage at 19% starch in the diet responded similarly to cows fed conventional corn silage at either 19 or 25% starch.

Cows fed BMR corn silage at 25% starch in the diet had lower CH4 emissions per unit of DMI while maintaining productive performance.

Lactation performance improved when cows were fed diets formulated with BMR sorghum silage compared to cows fed diets formulated with conventional sorghum silage. Lactation performance for cows fed BMR sorghum silage compared to cows fed conventional corn silage was not different.

Inclusion of 10% BMR sudangrass silage as a replacement for either conventional or BMR corn silage did not negatively affect lactation performance. BMR sudangrass silage can be a successful replacement for corn silage where corn silage availability is limited.

**E. Publications:**

*Journal*

Herrick, K.J., A.R. Hippen, K.F. Kalscheur, D.J. Schingoethe, D.P. Casper, S.C. Moreland, and J.E. van Eys. 2017. Single-dose infusion of sodium butyrate, but not lactose, increases plasma β-hydroxybutyrate and insulin in lactating dairy cows. J. Dairy Sci. 100:757-768.

Lawrence, R.D., J.L. Anderson, A.K. Manthey, and K.F. Kalscheur. 2017. Growth performance and total-tract nutrient digestion for Holstein heifers limit fed diets high in distillers grains with different forage particle sizes. Prof. Anim. Sci. 33:230-240.

Su, H., M.S. Akins, N.M. Esser, R. Ogden, W.K. Coblentz, K.F. Kalscheur, and R. Hatfield. 2017. Effects of feeding alfalfa stemlage or wheat straw for dietary energy dilution on nutrient intake and digestibility, growth performance and feeding behavior of Holstein dairy heifers. J. Dairy Sci. 100:7160-7115.

*Abstracts/Popular Press*

Brink, G., K. Kalscheur, and L. Bocher. 2017. Comparing sudangrass and sorghum-sudangrass in the field and in dairy cow diets. Forage Focus. March 2017. pp. 16-17.

Kalscheur K.F. and G. E. Brink. 2017. Replacing conventional or brown-mid rib corn silage with brown-mid rib sudangrass silage in the diets of lactating dairy cows. J. Dairy Sci. 100 (Suppl. 2):114-115.

Moore, S.A.E. and K.F. Kalscheur. 2017. Circulating blood metabolites in early lactation dairy cows fed canola or soybean meals. J. Dairy Sci. 100 (Suppl. 2):111.

Moore, S.A.E. and K.F. Kalscheur. 2017. (Invited ADSA Young Dairy Scholar) Manipulating early lactation energy and protein balances using canola meal as a protein source. J. Anim. Sci. 95 (Suppl. 2):182.

Sanchez-Duarte, J.I. and K.F. Kalscheur. 2017. Impact of dietary starch concentration formulated with two types corn silage on the performance of dairy cows. J. Dairy Sci. 100 (Suppl. 2):398.

Sanchez-Duarte, J., K. Kalscheur, and A. Garcia. 2017. Brown midrib sorghum deserves a look. Hoard’s Dairyman. 162(14):510-511.

Sanchez-Duarte, J.I., K.F. Kalscheur, A.D. Garcia, and F.E. Contreras-Govea. 2017. Performance of dairy cows fed conventional sorghum or corn silages compared to brown midrib sorghum silage: a meta-analysis. J. Dairy Sci. 100 (Suppl. 2):109-110.

Sanchez-Duarte, J.I., K.F. Kalscheur, and J.M. Powell. 2017. Impact of dietary starch concentration formulated with two types of corn silage on methane and ammonia emissions in dairy cows. J. Dairy Sci. 100 (Suppl. 2):108.

Su, H., M. Akins, N. Esser, W. Coblentz, R. Ogden, K. Kalscheur, and R. Hatfield. 2017. Utility of alfalfa stemlage for feeding dairy heifers. Forage Focus. March 2017. p. 20.

**F. Impact statement:**

Research conducted at US Dairy Forage Research Center (USDA-ARS) demonstrated that:

* Diets formulated with increased fiber digestibility and increased starch availability resulted in the greatest lactation performance. Cows fed these same diets had lower CH4 emissions per unit of DMI indicating less loss of methane emissions.
* Brown midrib sorghum silage is a potential alternative forage that uses less water compared to corn silage. Past research demonstrated that BMR sorghum silage fed to dairy cows resulted in improved production compared to conventional sorghum silage, but performed similarly to cows fed brown mid corn silage.
* The inclusion brown midrib sudangrass silage did not affect intake or milk production when included at 10% of the diet. BMR sudangrass silage can be a successful replacement for corn silage where corn silage availability is limited.

**NC-2042 – 2016 Station Report, Virginia Tech**

A. **Project:** Management Systems to Improve Economic and Environmental Sustainability of

Dairy Enterprises

***Main objective*.** To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

- *Objective 1*. To analyze management and nutrition strategies for replacement heifers as they pertain to production and profitability (heifers)

- *Objective 2*. To optimize lactating and dry cow decision-making as it relates to animal health, nutrient utilization, milk production, reproduction, and profitability (cows)

- *Objective 3*. To evaluate system components and integration of information into decision support tools and whole farm analyses to improve efficiency, control variation, and enhance profitability, and environmental sustainability (whole farm)

B. **Cooperating Agency:** Virginia Polytechnic Institute and State University; Gonzalo Ferreira

**C. Work progress and principal accomplishments**

**Economic analysis of feeding costs for diets including corn silage or sorghum silage as the main forage source (Objectives 2 and 3).** E. S. Richardson and G. Ferreira.

The objective of this study was to evaluate the cost of diets for high-producing cows including either corn silage (CS) or sorghum silage (SS) as the main forage source. A database was generated for the nutritional composition of SS, and included: dry matter (DM; n = 22), ash (n =

16), crude protein (CP; n = 23), ether extract (EE; n = 13), neutral detergent fiber (NDF; n = 25), acid detergent fiber (ADF; n = 21), acid detergent lignin (ADL; n = 18), starch (n = 11), and in vitro dry matter digestibility (IVDMD; n = 5). The nutritional composition of CS was obtained from the dairy NRC (2001). Diets were formulated with CPM Dairy Ration Analyzer using least cost optimization. Diets were formulated for a 635-kg Holstein cow producing 40 kg of milk (3.5% fat, 3.1% protein). Formulation constraints included 100% of predicted DM intake, 100 to 110% of metabolizable energy requirement, 95 to 103% of metabolizable protein requirement, 28 to 33% dietary NDF, 30 to 40% dietary non-fiber carbohydrates, and 50 to 60% dietary forage. Ration formulation was performed under 7 scenarios (Table below): very low, low, middle, and high grain prices, and considering the price of SS to be either 85, 70, or 55% of the price of CS. When the price of SS was 85% of that of corn, it was cheaper to include CS in the diets, likely explained by the greater inclusion of expensive grain in diets including SS. When the price of SS was 70% of that of CS, marginal differences in diets costs were observed between CS and SS. When the price of SS was 55% of that of corn, it was more expensive to include CS in the diets. In conclusion, SS had to be 30% cheaper than CS to obtain diets of similar composition and cost.

**Effects of feeding hulless barley on production performance, milk fatty acid composition, and nutrient digestibility of lactating dairy cows (Objective 2).** Y. Yang, G. Ferreira, C. L. Teets, B. A. Corl, W. E. Thomason, and C. A. Griffey*.* The objectives of this study were to evaluate production performance, milk fatty acid composition, and nutrient digestibility in high-producing dairy cows consuming diets containing corn or hulless barley. Eight primiparous (580 ± 41 kg of BW and 49 ± 18 DIM) and 16 multiparous (650 ± 60 kg of BW and 59 ± 25 DIM) Holstein cows were assigned to 1 of 4 diets in a replicated 4x4 Latin square design with 21-d periods. Cows were fed once daily (1200 h) by means of a Calan gate system. Treatments consisted of diets containing 100% corn (0B), 67% corn and 33% hulless barley (33B), 33% corn and 67% hulless barley (67B), and 100% hulless barley (100B) as the grain source. Total-tract nutrient digestibility was estimated using lanthanum chloride (LaCl3) as an external marker. The statistical model included the effects of square (fixed; df = 5), treatment (fixed; df = 3), square by treatment interaction (fixed; df = 15), period (random; df = 3), and cow within square (random; df = 18), and the random residual error. Dry matter intake differed quadratically among treatments (*P* < 0.01), being lowest for 67B (24.3 kg/d) and highest for 0B (26.9 kg/d). Feeding hulless barley did not affect milk yield (41.4 kg/d, *P* < 0.98). Milk fat concentration differed cubically among treatments (*P* < 0.03), being lowest for 0B (3.43%) and highest for 67B (3.91%). Neither the concentrations in milk of protein (3.02%, *P* < 0.33) and lactose (4.82%, *P* < 0.58) nor the yields of protein (1.24 kg/d, *P* < 0.23) and lactose (1.98 kg/d, *P* < 0.30) differed among treatments. The proportion of de novo synthesized fatty acids in milk did not differ among treatments (*P* < 0.43). The apparent total-tract digestibility of dry matter (61.5%, *P* < 0.82), crude protein (61.1%, *P* < 0.28), and neutral detergent fiber (37.3%, *P* < 0.38) did not differ among treatments. The apparent total-tract digestibility of starch increased quadratically

(*P* < 0.02), being lowest (97.3%) for 0B and highest (97.9%) for 67B, although these differences are biologically minor. In conclusion, hulless barley grain is as good as corn grain as an energy source when formulating diets for high-producing dairy cows.

**Cell wall composition between and within phytomers of corn plants (Objective 2).** A. N. Brown, G. Ferreira, W. A. Thomason, and B. A. Corl. The objective of this study was to determine the cell wall (CW) composition along the corn stalk. Three phytomers of corn plants from 8 corn hybrids were used (2 replicates per hybrid). A center phytomer (C) corresponded to the phytomer of ear insertion. Upper (U) and lower (L) phytomers corresponded to 3 phytomers above and below, respectively, relative to phytomer C. Each phytomer was cut into 4 sections: top internode (T), middle internode (M), bottom internode (B), and node (N). For each replicate of each hybrid, sections within phytomers from 5 plants were composited, and the CW concentration and composition were determined. For CW composition, the concentrations of uronic acids (UA), arabinose (ARA), xylose (XYL), and glucose (GLU) were determined. Data were analyzed as for a randomized complete block design with repeated measures (subject = phytomer). The CW concentration did not change between phytomers (*P* <

0.34) but increased from B to T within the phytomer (30.3 to 35.1% DM, respectively; *P* < 0.01).

Section N had the highest concentration of CW (37.2% DM). The UA concentration did not change between phytomers (*P* < 0.69) but decreased from B to T within the phytomer (4.2 to 3.3% CW, respectively; *P* < 0.01). Section N had the highest concentration of UA (5.7% CW). The concentration of ARA was greater in the U than in the L phytomers (3.0 vs. 2.1% CW; *P* < 0.01) and increased from B to T within the phytomer (1.8 to 2.2% CW, respectively; *P* < 0.01). Section

N had the highest concentration of ARA (3.3% CW). The concentration of XYL was greater in the

U than in the L phytomers (20.9 vs 18.9% CW; *P* < 0.01) and increased from B to T within the

phytomer (18.7 to 19.8% CW, respectively; *P* < 0.01). Section N had the highest concentration of XYL (20.1% CW). The concentration of GLU did not change between phytomers (*P* < 0.12) but decreased from B to T within the phytomer (36.2 to 34.9% CW, respectively; *P* < 0.01). Section N had the lowest concentration of GLU (31.8% CW). Concentrations of UA, ARA, and XYL decrease and the concentration of GLU increases in more mature sections of the phytomer of the corn plant, showing changes in nutritional quality.

**Production performance of high-producing Holstein cows consuming diets containing hulled or hull-less barley as the grain source in diets containing different forage to concentrate ratios (Objective 2).** Y. Yang, G. Ferreira, C. L. Teets, B. A. Corl, W. E. Thomason, W. Brooks, and C. A. Griffey*.* The objective of this study was to evaluate production performance in high-producing cowsconsuming diets containing hulled or hull-less barley as the grain source combined with low orhigh forage concentrations. The experiment was designed as a replicated 4 × 4 Latin square with 21-d periods and a 2 × 2 factorial arrangement of treatments (45 vs. 65% forage and hulled vs. hull-less barley). The cultivars utilized were Thoroughbred and Amaze 10 for the hulled and hullless grains, respectively. Eight primiparous (610 ± 40 kg BW and 72 ± 14 DIM) and 16 multiparous (650 ± 58 kg BW and 58 ± 16 DIM) Holstein cows were fed once daily (1100 h) by means of a Calan gate system. Treatments consisted of: 1) 45% forage and hulled barley, 2) 65% forage and hulled barley, 3) 45% forage and hull-less barley, 4) 65% forage and hull-less barley. All variables were analyzed using the MIXED procedure of SAS. The statistical model included the effects of square, treatment, square by treatment interaction, period, cow within square, and the random residual error. Milk yield (41.8 kg/d; *P* < 0.76), milk lactose percentage (4.84%; *P* < 0.19), milk lactose yield (2.05 kg/d; *P* < 0.29), and body weight gain (0.64 kg/d; *P* < 0.79) did not differ among treatments. Dry matter intake tended to be lower for high-forage diets (25.4 vs. 26.8 kg/d; *P* < 0.07) and was not affected by grain type (*P* < 0.47). Milk fat percentage (3.91 vs. 3.50%; *P* < 0.01) and yield (1.60 vs. 1.49 kg/d; *P* < 0.03) were greater for high-forage than for low-forage diets but were not affected by grain type (*P* > 0.17). Milk protein percentage (3.13 vs. 3.07%; *P* < 0.01) and yield (1.33 vs. 1.26 kg/d; *P* < 0.03) were greater for high-forage than for low-forage diets but were not affected by grain type (*P* > 0.48). Milk urea nitrogen was reduced when feeding low-forage diets (15.4 vs. 14.1 mg/dL; *P* < 0.01) and hull-less barley (15.6 vs. 13.9 mg/dL; *P* < 0.01). Their interaction was not significant. In conclusion, feeding either hulled or hulless barley as the energy source in high- or low-forage diets resulted in similar production performance in high-producing cows.

**Holistic management and risk assessment workshops for dairy farmers in the Southern region**

**(Objective 3).** G. Ferreira.Dairy farming can be (wrongly) considered a lifestyle more than a business. It is not strange that dairy farmers have long and exciting discussions about the quality of their cows, how difficult is to milk a cow with mastitis, or about how well the crops are performing. However, when asked about their business management farmers frequently do not dominate or understand these concepts. Helping farmers building a holistic management strategy will help them to successfully manage their agricultural operations through periods of high risk, volatility, and financial stress. Therefore, for this extension project *we delivered educational workshops about dairy enterprise management to farmers, extension agents, and loan officers*. For this extension project farmers, extension agents, and loan officers discussed business strategic plans, including concepts like vision, mission, and goal statements. The attendants also calculated key financial indicators, such as solvency, liquidity, return over assets, and break-even milk price among other topics. Finally, farmers discussed the importance of building a transition plan for the operations. These workshops were interactive, with short presentations and hands-on exercises using spreadsheets with real examples. The impact of this project can be viewed from its metrics and from the evaluations. These workshops were delivered at Lincoln, NE and Jackson, MS in collaboration with their respective extension services.

**D. Useful findings**

1) Sorghum silage has to be >30% cheaper than corn silage to increase income over feed costs when formulating diets for high-producing cows. A holistic vision is needed to ensure adequate decisions when defining the feeding program of your farm. Dairy managers should be aware that cheap forages might not necessarily translate into increased income over feed costs or increased cash flows. Therefore, an adequate balance between costs, nutritional composition, and availability of ingredients is always necessary when deciding on your feeding program.

2) Hulless barley grain is as good as corn grain as an energy source when formulating diets for high-producing dairy cows. Also, feeding either hulled or hulless barley as the energy source in high- or low-forage diets resulted in similar production performance in high-producing cows.

3) At advanced maturity stages the composition of the cell wall within the corn plant varied less than anticipated. There is still considerable variation among plant tissues.

4) Deciding which species to plant can be difficult when speaking about winter crops for silage in dairy farming systems. From a nutritional perspective, including legumes can improve the nutritional composition of the silage, especially in mixtures with barley, rye and triticale. For high quality forages, such as ryegrass, the improvements are marginal.

**E. Publications**

*Journals*

1. Ferreira, G., and C.L. Teets. 2017. Concentrations of Biotin in Blood of Holstein Bull Calves

Supplemented with Biotin and Pantothenic Acid. Prof. Anim. Sci. 33:285-288.

2. Yang, Y., G. Ferreira, C.L. Teets, B.A. Corl, W.E. Thomason, and C.E. Griffey. 2017. Effects of feeding hulless barley on production performance, milk fatty acid composition, and nutrient digestibility of lactating dairy cows. J. Dairy Sci. 100:3576–3583.

3. Ferreira, G., and C.L. Teets. 2017. Effect of planting density on yield, nutritional quality, and ruminal in vitro digestibility of corn for silage grown under on-farm conditions. Prof. Anim.

Sci. 33:420-425.

*Book Chapters*

1. Ferreira, G., and W.P. Weiss. 2017. Vitamin Nutrition. In Large Dairy Herd Management. 3rd ed. D.K. Beede, ed. American Dairy Science Association, Champaign, IL.

*Abstracts*

1. E. S. Richardson, and G. Ferreira. 2017. Economic analysis of feeding costs for diets including corn silage or sorghum silage as the main forage source. J. Dairy Sci. 100:22 (Suppl. 1).

2. Y. Yang, G. Ferreira, C. L. Teets, B. A. Corl, W. E. Thomason, and C. A. Griffey. 2017. Effects of feeding hull-less barley on production performance, milk fatty acid composition, and nutrient digestibility of lactating dairy cows. J. Dairy Sci. 100:134 (Suppl. 1).

3. A. N. Brown, G. Ferreira, W. A. Thomason, and B. A. Corl. 2017. Cell wall composition between and within phytomers of corn plants. J. Dairy Sci. 100:266 (Suppl. 1).

4. Y. Yang, G. Ferreira, C. L. Teets, B. A. Corl, W. E. Thomason, W. Brooks, and C. A. Griffey. 2017.

Production performance of high-producing Holstein cows consuming diets containing hulled or hull-less barley as the grain source in diets containing different forage to concentrate ratios. J. Dairy Sci. 100:397 (Suppl. 1).

*Educational Videos*

1. Ferreira, G., A.N. Brown, W.E. Thomason, and C.D. Teutsch. 2017. Comparative Nutritional Quality of Winter Crops for Silage. Virginia Cooperative Extension, DASC-93P.

2. Ferreira, G., and C.L. Teets. 2017. Extension Bulletin: Previniendo accidentes de trabajadores rurales ligados al manejo de silajes. Virginia Cooperative Extension DASC-102NP.

3. Ferreira, G., and C.L. Teets. 2017. Extension Bulletin: Preventing silage-related injuries and fatalities among farm workers. Virginia Cooperative Extension DASC-103NP.

**F. Impact statements**

- Dairy farming can be (wrongly) considered a lifestyle more than a business. It is not unusual for dairy farmers to have long and exciting discussions about the quality of their cows, how difficult it is to milk a cow with mastitis, or about how well crops are performing. However, when asked about their business management, farmers frequently do not dominate or understand these concepts. Helping farmers build a holistic management strategy will help them to successfully manage their agricultural operations through periods of high risk, volatility, and financial stress. For this extension project, we delivered educational workshops about dairy enterprise management to >80 farmers, extension agents, and loan officers. The attendants discussed strategic business plans, including concepts like vision, mission, and goal statements. The attendants also calculated key financial indicators, such as solvency, liquidity, return over assets, and break-even milk price, among other topics. Finally, farmers discussed the importance of building a transition plan for the operations. These workshops were interactive, with short presentations and hands-on exercises using spreadsheets with real examples. The impact of this project can be viewed from its metrics and from the evaluations. From its metrics, >80 attendants (mostly farmers) learned how to calculate, analyze, and interpret several key financial indicators. Several farmers were absolutely naïve and uncomfortable about these topics before the workshop. From the evaluations after the workshop, comments such as “The best workshop I ever attended” or “I wish I would have attended this workshop in 2013” (referring to the pre-raise of milk prices) nicely reflect the success of the workshop.

- Cereal grains are a major energy source in diets for lactating dairy cows. Cereal grains contain high concentrations of starch, a component that is almost completely and uniformly digested in the gastrointestinal tract when adequately processed. The NRC 2001 established that the NDF requirement for dairy cows should be increased to 34% NDF when feeding diets containing barley as the grain source. For other starch sources, however, insufficient information exists to give specific recommendations. hull-less barley is one starch source for which insufficient production performance information exists to provide specific dietary recommendations. The inclusion of hull-less barley grain (cultivar Amaze 10) as an energy source in diets for high-producing dairy cows resulted in similar production performance and nutrient utilization as for corn grain. Contrary to our expectations, hull-less barley did not affect milk fatty acid composition, suggesting that rumen metabolism did not differ when replacing corn with hull-less barley. Overall, this study indicates that hull-less barley grain is as good as corn grain as an energy source, and that there is no need to increase the concentration of NDF when formulating diets for high-producing dairy cows including hullless barley.

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**G. Leverage**

- Hanigan, M.D., R. White, and G. Ferreira. 2017. A field application model for lactation responses to amino acids. USDA – NIFA. Total: $480,000.

- Ferreira, G. 2017. Integrating cropping practices to improve nutrient management plans and ensure environmental and economic sustainability in dairy farming systems. Southern SARE. Total: $15,000.

- Tejeda, H., M. Chahine, and G. Ferreira. 2017. Risk assessment and management education for dairy producers in the western region. Western Extension Risk Management Education Program from USDA – NIFA. Total: $37,073.

- Ferreira, G. 2017. Effect of feeding xylanase on performance and nutrient utilization of dairy cattle. DSM Nutritional Products. Total: $16,000.

- Ferreira, G. 2017. Evaluation of POLYHALITE as an anionic source for pre-partum dairy cows. Sirius Minerals. Total: $44,997.

- Ferreira, G. 2017. Developing educational tools to prevent injuries among Spanish-speaking Hispanic operators during harvesting and ensiling. Central Appalachian Regional Education and Research Center and National Institute for Occupational Safety and Health (NIOSH). Total: $11,530.

**Cooperative Regional Project NC2042**

**2016-2017 Annual Report**

**Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises**

**University of Wisconsin-Madison**

**Personnel:** Matt Akins (project leader), Elizabeth Remick (MS student), Kalyanna Williams (MS student), Abbey Grisham (MS student), Huawei Su (Post-doc researcher)

**Collaborators:** Kent Weigel, Pat Hoffman, Nancy Esser, Heather Schlesser, University of Wisconsin; Wayne Coblentz, Mark Borchardt, William Jokela, USDA Dairy Forage Research Center

**Project Objectives:**

1. Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.
2. Improve dairy cow management decisions through nutrient utilization, well-being and profitability.
3. Analyze whole farm system components and integrate information into decision-support tools to improve efficiency, enhance profitability, and environmental sustainability

**Work progress and principal accomplishments:**

*Under objective 1*

**Yield of Photoperiod-Sensitive Sorghum and Sorghum-Sudangrass in Central Wisconsin**

**E. Remick, M. Akins, H. Su, A. Grisham, R. Ogden, and W. Coblentz**

A 2-year study (2015, 2016) was conducted at 2 sites (Marshfield, Hancock) in central WI to assess yield and quality of photoperiod sensitive (PS) and non-PS sorghums in relation to corn planted on 2 dates and harvested once or twice. At each site, treatments were arranged in a split-split plot in a randomized complete block with 4 replications. Main plots of planting date (early or mid-June) were randomized within block. Subplots of harvest strategy were randomized within planting date. Within harvest strategy, 8 forages were assigned (corn, PS sorghum, PS sorghum-sudangrass, sorghum, BMR sorghum, sorghum-sudangrass, BMR sorghum-sudangrass, or PS-BMR sudangrass). Multiple harvests occurred in late July or early August and in fall after a killing frost. The single harvest was based on maturity (1/3 to 1/2 milk-line for corn and soft to hard dough for sorghum) or after a killing frost if the variety did not reach maturity for harvest. Data were analyzed using the Mixed procedure of SAS 9.4. Single harvest plots had greater yields than multi-harvest (18,961 vs 9,970 kg DM/ha). Yield was also affectect by a site by harvest interaction with the multi-harvest strategy being more similar to a single harvest at Marshfield than at Hancock. Yields were consistently greater at Hancock than at Marshfield (16,562 vs 12,370 kg DM/ha; *P*<0.01). The early June planting had greater yields than mid-June (15,320 vs 13,612 kg DM/ha; *P*=0.02) but had less of an impact on yield than did the harvest strategy. There was a harvest x variety interaction with single harvest PS varieties and non-PS sorghum-sudangrass yielding more than BMR varieties with corn and non-PS forage sorghum being intermediate. Also, sorghum-sudangrass and sudangrass had more similar yields using either a 1 or 2 harvest strategy than the other varieties. Overall, sorghum can provide high yields of moderate quality forage in the Midwest US.

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| --- |
| Table 1. DM yields (kg/ha) for sorghums and corn using single or multiple harvests at Hancock and Marshfield in 2015 and 2016 |
|  | Harvest |
| Forage | Single | Multi |
| Corn | 17.5 | 5.2 |
| PS forage sorghum1 | 23.6 | 9.0 |
| PS sorghum-sudan | 25.2 | 13.8 |
| Forage sorghum | 18.0 | 10.7 |
| Sorghum-sudan | 21.1 | 14.4 |
| BMR forage sorghum2 | 16.4 | 8.1 |
| BMR sorghum-sudan | 14.9 | 9.2 |
| PS BMR sudangrass | 14.9 | 9.3 |
| SEM | 1.04 |
| Variety x Harvest (*P*=) | <0.01 |
| 1PS=Photoperiod sensitive; 2BMR=Brown midrib |

**Implications**: Forage sorghums and sorghum-sudangrass can be grown with comparable yields to corn silage when planted in June, while these forage will also better meet the energy needs of pregnant dairy heifers compared to corn silage. Producers can grow sorghums for lower cost due to lower seed costs, lower nutrient application needs, and lower water needs which is especially important in Central WI and other areas in the US where crop production is dependent on irrigation and have ruminant livestock feeding operations. Sorghums could be considered a part of a double cropping system after a cereal grain (rye, wheat, triticale) forage harvest to maximize yield of moderate quality in designated farm acreage for dairy heifers or dry cows.

**Nitrogen Fertilization Effects on Sorghum Forage Yield**

***A. Grisham, M.S. Akins, E. Remick, H. Su, R. Ogden, W. Coblentz***

The study objective was to determine the effect of nitrogen fertilization on yield of photoperiod sensitive (PS) and non-PS sorghums compared to corn. This study was a randomized complete block design with treatments arranged in a 4 x 8 factorial with 3 replicate blocks. Within each block, N rates (0 kg N/ha, 56 kg N/ha, 112 kg N/ha, 168 kg N/ha) were randomized with 7 kg N applied as urea by hand at planting and the remaining N at the 4-6 leaf stage. The 0 kg N/ha rate did not receive pre-plant N. Within each N rate, varieties (corn, PS forage sorghum, PS sorghum-sudangrass, forage sorghum, BMR forage sorghum, sorghum-sudangrass, BMR sorghum sudangrass, PS BMR sudangrass) were randomly assigned. The plots were planted June 3, 2016 and harvested at 1/3 to 1/2 kernel milk-line for corn, soft to hard-dough for sorghum, or after a killing frost. Data were analyzed using MIXED procedure of SAS 9.4. The interaction of variety and N rate was not significant (*P*=0.67). Nitrogen rate affected yield (Table 1; *P*=0.02) with reduced yield for 0 kg N/ha plots compared to 56 kg N/ha, 112 kg N/ha, and 168 kg N/ha plots (11,375 vs 17,199, 16,627, 18,981 kg DM/ha respectively). However, no significant differences in yield were found across N rates of 56, 112, and 168 kg N/ha (*P*>0.21). Yield was affected by variety (Table 1; *P*<0.01) with PS varieties, forage sorghum, and BMR forage sorghum having greater yields than BMR sorghum-sudangrass, sudangrass, and corn. Overall, some sorghum varieties can provide high yields of forage with less N fertilization.

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| DM yields (Mg/ha) for sorghums and corn using nitrogen rates in Marshfield ARS  |
|  | Nitrogen Rate (kg/ha) |
| Variety | 0 | 56 | 112 | 168 |
| Corn | 12.4 | 11.5 | 14.1 | 15.7 |
| PS forage sorghum1 | 10.0 | 21.4 | 21.9 | 25.1 |
| PS sorghum-sudan | 11.7 | 18.7 | 21.3 | 23.6 |
| Forage sorghum | 13.4 | 20.7 | 19.1 | 20.3 |
| Sorghum-sudan | 13.8 | 17.3 | 15.3 | 20.1 |
| BMR forage sorghum2 | 14.2 | 24.3 | 17.2 | 21.3 |
| BMR sorghum-sudan | 8.6 | 14.9 | 12.6 | 13.3 |
| PS BMR sudangrass | 6.8 | 8.9 | 11.5 | 12.4 |
| SEM | 3.18 |
| Variety x Irrigation (*P*=) | 0.67 |
| 1 PS=Photoperiod sensitive, 2 BMR=Brown midrib |

**Implications:** Forage sorghums and sorghum-sudangrass can be grown with reduced N fertilization rates and have higher yields of forage than corn. All forage sorghums (photosensitive, non-photosensitive, and BMR) and photosensitive and non-photosensitive sorghum-sudangrass appear to be more responsive than corn to N fertilizer with numerically higher yields at the lower N rates of 56 and 112 kg/ha. Producers could use lower N fertilizer rates for these sorghums while still having greater yields when using a June planting in a double cropping system such as after a cereal grain forage harvest.

**Effects of Irrigation on Sorghum Forage Yield and Quality in the Central Sands Region of Wisconsin**

A. Grisham, M.S. Akins1,Elizabeth Remick1, Huawei Su2, Robin Ogden3, Wayne Coblentz3

A study was conducted to assess effects of irrigation on yield of photoperiod sensitive (PS) and non-PS forage sorghums in comparison to corn in Central WI. Treatments were arranged as a split-plot with a randomized complete block design with 3 replications. Five irrigation rates (0, 25, 50, 75, and 100%) relative to corn water needs were applied using a linear irrigation system with each rate applied as one strip. For practical purposes, the 0% rate was in a different field at the station with a similar soil type. Irrigation rates were attained using irrigation nozzles with different flow rates. Within irrigation rate strip, cultivars (corn, PS forage sorghum, PS sorghum-sudangrass, forage sorghum, BMR forage sorghum, sorghum-sudangrass, BMR sorghum sudangrass, PS BMR sudangrass) were randomly assigned within 3 replicate blocks. Plots were established June 2, 2016 and harvested using a single harvest at 1/3 to 1/2 corn kernel milk-line, soft to hard-dough stage for sorghums or after a frost. Data were analyzed using the MIXED procedure of SAS 9.4. Precipitation as rain was 62.2 cm with irrigation totals of 7.4, 14.9, 22.4, and 29.8 cm for 25, 50, 75, and 100% rates, respectively. Cultivars interacted with irrigation rate (*P*=0.04) with PS varieties and BMR forage sorghum most responsive to greater irrigation rates, corn having moderate responses, and forage sorghum, sorghum-sudangrass and sudangrass being less responsive. This may be due to PS varieties having vegetative growth until harvest with other sorghums reaching yield potential at maturity with no additional yield thereafter. Sorghum-sudangrass and forage sorghum have potential to be grown with less irrigation and maintain high forage yields.

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| DM yields (Mg/ha) for sorghums and corn at various irrigation rates at Hancock ARS |
|  | Irrigation Rate (% of corn rate) |
| Variety | 0 | 25 | 50 | 75 | 100 |
| Corn | 15.5 | 15.0 | 17.3 | 19.3 | 22.4 |
| PS forage sorghum1 | 20.4 | 23.5 | 35.4 | 39.8 | 37.4 |
| PS sorghum-sudan | 21.1 | 26.9 | 31.7 | 38.7 | 44.4 |
| Forage sorghum | 26.1 | 24.7 | 25.2 | 26.8 | 31.5 |
| Sorghum-sudan | 19.8 | 19.2 | 25.1 | 26.0 | 21.7 |
| BMR forage sorghum2 | 15.9 | 22.6 | 21.3 | 29.8 | 34.8 |
| BMR sorghum-sudan | 18.5 | 18.9 | 19.4 | 18.7 | 24.6 |
| PS BMR sudangrass | 21.3 | 23.4 | 19.7 | 28.4 | 24.6 |
| SEM |  |  | 3.53 |  |  |
| Variety x Irrigation (*P*=) |  |  | 0.04 |  |  |
| 1PS=Photoperiod sensitive, 2BMR=Brown midrib |

**Implications:** Forage sorghums and sorghum-sudangrass when grown in areas needing irrigation can be irrigated with lower rates of irrigation and still have higher yields than corn silage. Sorghums were generally more responsive to water but there appears to be diminishing yield increases with higher irrigation rates at approximately 50-75% of corn water needs. Dairy and beef producers in areas requiring irrigation can reduce their water usage and still maintain forage yield, thus lower production costs and reducing their impact on water resources. In addition, sorghum forages provide a more suitable forage than corn silage for ruminant livestock with moderate energy needs such as dairy heifers and dry cows, and beef cows.

**Effect of diet energy level and genomic residual feed intake on pre-bred dairy heifer feed intake and growth**

K.T. Williams, K.A. Weigel, W.K. Coblentz, N.M. Esser, P.C. Hoffman, H. Su, M.S. Akins

The objective of this study was to determine the growth, feed intake, and feed efficiency of pre-bred dairy heifers with different predicted genomic residual feed intake (RFI) as a lactating cow, and offered diets with different energy levels. Pre-bred Holstein heifers (128, ages 4-9 months) were blocked by body weight (high, 286 kg; medium-high, 241 kg; medium-low, 205 kg; and low, 168 kg) with 32 heifers per block. Heifers within each weight block were sorted by genomic RFI to obtain 2 pens of high (HiRFI) and 2 pens of low RFI (LoRFI) for each block with 8 heifers per pen. Heifers with LoRFI were expected to have greater feed efficiency than HiRFI heifers. Dietary treatments were a high energy diet (HiE; 66.6% TDN, 14.0% CP, and 36.3% NDF, DM basis) and a low energy diet (LoE; 63.8% TDN, 13.5% CP, and 41.2% NDF, DM basis). Each pen of heifers was randomly allocated to treatments to obtain a 2x2 factorial arrangement of treatments (2 RFI levels and 2 diet energy levels). Diets were offered in a 120 day feeding trial. Statistical analyses were performed using a MIXED procedure in SAS 9.3 with pen as experimental unit. Dry matter intake was not affected by diet (7.38 vs. 7.83 kg DM for HiE and LoE, respectively; *P*=0.14), or by RFI (7.40 vs. 7.81 kg DM for HiRFI and LoRFI, respectively; *P*=0.17) or by their interaction (P=0.66). Average daily gain was affected by diet with heifers fed the HiE diet having greater gains than heifers fed the LoE diet (1.14 vs. 0.97 kg/d; *P*<0.01). Residual feed intake also affected ADG with LoRFI heifers having greater ADG than HiRFI heifers (1.09 vs. 1.02 kg/d; *P*=0.03), however the interaction of RFI and diet was not significant (P>0.10). Feed efficiency was improved for heifers fed the HiE diet (6.44 vs. 8.02 kg DMI/kg gain for HiE and LoE, respectively; *P*<0.01), but was not affected by RFI (*P*=0.48) or the interaction of diet energy and RFI (*P*=0.62). Overall, feed efficiency of pre-breeding heifers was not dependent on genomic RFI. Heifers with LoRFI had improved ADG, but this effect was likely due to a numerical increase in feed intake. Feed efficiency of heifers was reduced when heifers were fed the LoE diet, but pragmatically feeding heifers a low energy diet resulted in more optimal ADG for pre-breeding heifers than feeding a higher energy diet ad-libitum.

**Implications:** Based on this study, pre-breeding heifer feed efficiency may not be improved by breeding for cows with lower RFI. This disagrees with a previous study and another study in this report using bred/pregnant heifers which showed improved feed efficiency for heifers with a lower RFI, thus the effect may be dependent on age and diet fed.

Feeding of a high energy diet for ad libitum intakes resulted in excessive gains and should be avoided by producers, or producers should use a limit-feeding strategy to control intake and gains if using high quality forages.

**Effect of limit feeding and genomic residual feed intake on dairy heifer growth and feed efficiency**

M.S. Akins, K.T. Williams, H. Su, W.K. Coblentz, N.M. Esser, P.C. Hoffman, and K.A. Weigel

The objective of this study was to evaluate growth and feed efficiency of dairy heifers differing in predicted genomic residual feed intake as a lactating cow (RFI) and either fed ad-libitum or limit-fed. Post-bred Holstein heifers (128, ages 14-20 months) were blocked by BW (heavy, 516 kg; medium-heavy, 485 kg; medium-light, 457 kg; and light, 420 kg) with 32 heifers per block. Heifers within block were sorted by genomic RFI to obtain 2 pens of high and 2 pens of low RFI within each weight block (8 heifers per pen). Diet treatments were i) a control diet (CON) comprised of corn silage and alfalfa silage (59.2% TDN, 12.7% CP, and 47.8% NDF, DM basis), and ii) a diet limit-fed (LIMIT) to 90% of CON intakes (62.4% TDN, 13.4% CP, and 42.7% NDF, DM basis). The LIMIT diet contained the same forages as CON but included corn and soybean meal to obtain similar nutrient intakes as CON. Treatments were randomly allocated to obtain a 2x2 factorial arrangement and implemented within a 120-d trial. Data were evaluated using the MIXED procedure in SAS 9.4 with pen as experimental unit. Feed intake was greater (*P*=01) for heifers fed CON diets (11.0 vs. 9.98 kg DM/d). Feed intake was unaffected (*P*>0.34) by RFI with no interaction between diet and RFI. Protein intake was greater (*P*=0.04) for heifers fed CON compared to heifers fed LIMIT (1.41 vs. 1.33 kg CP/d). Intake of dietary ME tended to be greater for CON fed heifers (*P*=0.07); but intakes of NEm and NEg were similar (*P*>0.28) between diets. The ADG of heifers was affected by diet (*P*<0.01) with CON fed heifers having greater ADG than LIMIT (0.88 vs 0.80 kg/d) potentially due to greater digesta fill for CON. The ADG of heifers was also affected *(P*<0.01) by RFI with Low RFI heifers gaining more than High RFI heifers (0.86 vs. 0.83 kg/d). Feed efficiency of heifers was unaffected by diet (*P*=0.70), but was improved (*P*=0.01) in Low RFI heifers compared to High RFI heifers (12.1 vs. 12.8 kg DM/kg gain). Body condition gain was unaffected by RFI or diet (*P*>0.36). Overall, heifers with Low genomic RFI had improved feed and growth efficiency whether fed ad-libitum or limit-fed diets.

**Implications:** Genomic RFI affected feed efficiency of bred heifers (5% improvement) whether limit-fed or for ad-libitum intakes. Dairy producers could improve both lactating cow and heifer efficiency by using genomic RFI to select for more feed efficient animals. Limit-feeding did not improve feed efficiency in this study due to lower daily gains for limit-fed heifers than for ad-libitum fed heifers. The lower gains may be due to lower protein intake or lower digesta fill for limit-fed heifers.

*Under objective 2*

**Assessment of different bedding systems for lactating cows in freestall housing**

**H. Su, N. M. Esser, W. K. Coblentz, M. A. Borchardt, W. Jokela, M. Akins**

The objective of this study was to compare different bedding systems for lactating cows in freestall housing. Bedding systems included new sand (NS), recycled byproducts of manure separation (organic solids [OS] and recycled sand [RS]), and foam-core mattresses with a shallow layer of OS (MS). The experimental barn contained 128 freestalls that were divided into four equal quadrants with one bedding system for each quadrant. All animals included in this study were first lactation cows, randomly assigned to different quadrants as cows calved. This experiment was conducted between January 2014 and December 2016 with 3 periods (one calendar year for each period). Bedding systems were changed the last week of the first period. Milk yield data was recorded daily and milk samples were collected monthly for milk composition and somatic cell count (SCC). Cow’s behavior, hygiene, and hock score were collected monthly. Clinical mastitis and hoof trimming cases were summarized based on veterinary records. Quadrant (pen) was considered the experimental unit with all data averaged by quadrant before analysis. Results are presented as means ± SD based on monthly averages during the 3 year study (Table 1); therefore comparisons of means are numerical only, and do not imply statistical significance. The average milk yield over the 3 years had minimal differences across treatments averaging 37.5 kg energy corrected milk/day. The SCC was the highest for the OS group but minimal difference was found for somatic cell score. The monthly data shows that the OS group has spikes in SCC typically in July and August when the weather is warm potentially causing increased bacterial growth in the organic solids bedding. Comfort and stall usage indexes were fairly similar across treatments, however the RS, OS, and NS were cleaner (lower flank score) than cows in MS stall and had the less hock lesions (lower hock score) than the MS group. Greater incidence (total cases over 3 yr) of clinical mastitis was observed for cows with OS freestalls. Cows housed in NS and RS stalls needed fewer hoof trimmings than cows housed in OS and MS stalls possibly due to the wear of the sand on the hoof which could be also detrimental issue with more cases of thin soles for the RS group. Based on the means data, NS and RS seems to be the best bedding material for lactating cows based on milk performance, behavior, hygiene, and health data. However, OS bedding is an option if mastitis incidence could be reduced by adequate drying of the bedding before use.

|  |  |
| --- | --- |
|  Item | Bedding type\* |
| RS | OS | NS | MS |
| ECM, lbs/d | 37.3 ± 1.17 | 37.9 ± 1.00 | 37.6 ± 1.21 | 37.2 ± 1.21 |
| SCC, ×1000 cells/mL | 73.1 ± 12.31 | 137.0 ± 74.92 | 67.6 ± 21.29 | 99.2 ± 42.94 |
| SCS | 1.73 ± 0.18 | 1.71 ± 0.23 | 1.70 ± 0.27 | 1.68 ± 0.27 |
| Cow comfort index, % | 86.5 ± 13.2 | 86.6 ± 6.9 | 87.8 ± 8.9 | 84.1 ± 11.4 |
| Stall usage index, % | 70.0 ± 13.4 | 72.3 ± 10.0 | 76.0 ± 13.9 | 76.3 ± 11.2 |
| Flank score | 1.71 ± 0.19 | 1.67 ± 0.18 | 1.70 ± 0.17 | 2.33 ± 0.14 |
| Hock score | 1.03 ± 0.03 | 1.09 ± 0.06 | 1.04 ± 0.04 | 1.46 ± 0.20 |
| Clinical mastitis cases | 27 | 73 | 30 | 48 |
| Hoof trimming cases | 283 | 346 | 257 | 348 |

**Table 1.** Milk performance, behavior, hygiene and health indicators of cows housed in different bedding systems

\* Bedding type included new sand (NS), recycled sand (RS), organic solids (OS) and mattresses (MS).

**Implications:** Cows produced similar milk yield whether new sand, recycled sand, deep bedded organic solids, or mattresses were used. However, greater mastitis occurred for cows using stalls bedded with organic solids. Also, cows housed with mattresses had the poorest hygiene and increased lameness.

**Usefulness of findings:**

Forage sorghums and sorghum-sudangrass have potential for use in dairy heifer rations to better meet heifer energy needs than corn silage while still maintaining high forage yields. Some sorghum types had increased response to irrigation and N fertilization which could reduce impacts on water resources and reduce N needs for forage production ultimately lowering costs of forage production. Genomic predicted residual feed intake (feed efficiency) did not affect feed efficiency of pre-breeding dairy heifers conflicting previous data with bred heifers; thus the effect may be age and/or diet dependent. Use of deep-bedded new sand or recycled sand as freestall bedding resulted in similar milk production and comfort, but less mastitis than deep-bedded organic solids. Bedding with mattresses resulted in more lameness and poor hygiene scores than deep-bedded sand or organic solids.

**Publications**

Abstracts:

* Remick, E., H. Su, W. K. Coblentz, and M. S. Akins. 2017. Evaluation of yield and quality of photoperiod-sensitive sorghums in central Wisconsin. J. Dairy Sci 100(E Suppl. 2):64 Abstract M160
* Grisham, A., M. Akins, E. Remick, H. Su, R. Ogden, and W. Coblentz. 2017. Effects of irrigation on sorghum forage yield and quality in the central sands region of Wisconsin. J. Dairy Sci 100(E Suppl. 2):66 Abstract M166
* Grisham, A., M. Akins, E. Remick, H. Su, R. Ogden, and W. Coblentz. 2017. Nitrogen fertilization effects on sorghum forage yield and quality. J. Dairy Sci 100(E Suppl. 2):67 Abstract M168
* Williams, K., K. Weigel, W. Coblentz, N. Esser, P. Hoffman, H. Su, and M. Akins. 2017. Effect of diet energy level and genomic residual feed intake on pre-bred dairy heifer feed intake and growth. J. Dairy Sci 100(E Suppl. 2):271 Abstract T126
* Akins, M.S., K.T. Williams, H. Su, W.K. Coblentz, N.M. Esser, P.C. Hoffman, and K.A. Weigel. 2017. Effect of limit feeding and genomic residual feed intake on dairy heifer growth and feed efficiency. J. Dairy Sci 100(E Suppl. 2):272 Abstract T127

Journal Articles:

* Su. H., M.S. Akins, N. M. Esser, R. Ogden, W. K. Coblentz, K. F. Kalscheur, R. D. Hatfield. 2017. Effects of feeding alfalfa stemlage or wheat straw for dietary energy dilution on nutrient intake and digestibility, growth performance, and feeding behavior of Holstein dairy heifers. J. Dairy Sci 100:7106-7115.

**NC 2042: 2016 - 2017 Station Report**

**A. PROJECT NAME**: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises (Rev. NC-1119)

**B. COOPERATING AGENCY and personnel:** *UNIVERSITY OF WISCONSIN, Dairy Science,* ***Victor E. Cabrera***

**C. WORK PROGRESS AND PRINCIPAL ACCOMPLISHMENTS and**

**D. USEFULNESS OF FINDINGS:**

***Invited review: Helping dairy farmers to improve economic performance utilizing data-driving decision support tools***

V. E. Cabrera

This review paper describes the development and application of a suite of more than 40 computerized dairy farm decision support tools contained at the University of Wisconsin-Madison Dairy Management website <http://DairyMGT.info>. These data-driven decision support tools are aimed to help dairy farmers improve their decision-making, environmental stewardship, and economic performance. Dairy farm systems are highly dynamic in which changing market conditions and prices, evolving policies and environmental restrictions together with every-time more variable climate conditions determine performance. Dairy farm systems are also highly integrated with heavily interrelated components such as the dairy herd, soils, crops, weather, and management. Under these premises, it is critical to evaluate a dairy farm following a dynamic integrated system approach in which it is crucial use meaningful data records, which are every time more available, within decision support tools for optimal decision making and economic performance. Decision support tools in the UW-Dairy Management website <http://DairyMGT.info> had been developed using combination and adaptation of multiple methods together with empirical techniques always with the primary goal for these tools to be: 1) highly user-friendly, 2) using the latest software and computer technologies, 3) farm and user specific, 4) grounded on the best scientific information available, 5) remaining relevant throughout time, and 6) providing fast, concrete, and simple answer to complex farmers’ questions. DairyMGT.info is a translational innovative research in various areas of dairy farm management that include nutrition, reproduction, calf and heifer management, replacement, price risk, and environment. This paper discusses the development and application of 20 selected <http://DairyMGT.info> decision support tools.

***Robotic milking: Feeding strategies and economic returns***

A. Bach, and V. E. Cabrera

Cows in herds equipped with conventional milking parlors follow a structured, consistent, and social milking and feeding routine. Furthermore, in most cases cows in conventional herds receive all their nutrients from a total mixed ration, whereas in herds equipped with robotic or automatic milking systems (AMS) a fraction of their nutrients is provided during milking, mainly as a means to attract cows to the milking sys- tem. In this regard, AMS present both a challenge and an opportunity for feeding cows. The main challenge resides in maintaining a minimum and relatively constant milking frequency in AMS. However, milking frequency is dependent on many factors, including the social structure of the herd, the farm layout design, the type of traffic imposed to cows, the type of flooring, the health status of the cow (especially lameness, but also mastitis, metritis, among others), the stage of lactation, the parity, and the type of ration fed at the feed bunk and the concentrate offered in the AMS. Uneven milk frequency has been associated with milk losses and increased risk of mastitis, but most importantly it is a lost opportunity for milking the cow and generating profit. On the other hand, the opportunity from AMS resides in the possibility of milking more frequently and feeding cows more precisely or more closely to their nutrient needs on an individual basis, potentially resulting in a more profitable production system. But, feeding cows in the parlor or AMS has many challenges. On one side, feeding starchy, highly palatable ingredients in large amounts may upset rumen fermentation or alter feeding behavior after milking, whereas feeding high- fiber concentrates may compromise total energy intake and limit milking performance. Nevertheless, AMS (and some milking parlors, especially rotary ones) offer the possibility of feeding the cows to their estimated individual nutrient needs by combining different feeds on real time with the aim of maximizing profits rather than milk yield. This approach requires that not only the amount of feed offered to each cow but also the composition of the feed vary according to the different nutrient needs of the cows. This review discusses the opportunities and pitfalls of milking and feeding cows in an AMS and summarizes different feeding strategies to maximize profits by managing the nutrition of the cows individually.

***Developing a feed allocation model to maximize income over feed cost considering farmer’s risk preferences***

D. Liang, T. F. Rutherford, B. L. Jones, R. D. Shaver, and V. E. Cabrera

We developed a nonlinear programming model that selects the optimal cropping plan and diet formulation to maximize farm income over feed cost (**IOFC**) in a representative 200-lactating cow, 100-ha south-central Wisconsin farm. Nutrition requirements for 6 cow-groups were formulated according to the NRC equations. Then, model selected group production level towards maximum IOFC, which included milk and surplus feed sale, feed production cost, and feed purchasing cost. In each weather scenario, farm-produced feed, forage quality, and feed production costs were simulated with the Integrated Farm System Model using 25-year daily weather data (1986 to 2010). Feed prices were collected as the monthly market prices from the Understanding Dairy Market website during 2015 and 2106, randomly assigned to each yearly scenario. The model contained three sections: 1. Maximizing total IOFC under a fixed or flexible cropping plan; 2. Minimizing farm greenhouse gas (**GHG**) emission under the fixed cropping plan; 3. Maximize IOFC by constraining the GHG emissions. Commodity hedging decisions were included in the first section to compare the difference from contracting feed or milk prices with different cropping plans. The optimal solution maximized the total IOFC across 25 scenarios through the expected utility theory. Aggregated IOFC across 25 scenarios was $8.31/cow per d with the original cropping plan of 54.6 ha of corn and 45.4 ha of alfalfa while the GHG emission was 1.33 kg CO2 eq. per kg of FPCM. The model chose to produce at the highest production for all 25 scenarios with the original cropping plan. Diet formulation and purchasing strategies changed for each weather scenario to maximize IOFC according to farm-grown feed quantity and quality. Flexible optimal cropping plans for each scenario improved IOFC slightly (0.2%-0.4% depending on risk attitude and elasticity); however, incorporating both flexible cropping plan and commodity hedging improved farm IOFC by 16%. The minimum GHG emission was 1.20 kg CO2 eq. per kg of FPCM with IOFC at $7.04/cow per d. The farm reduced milk production and changed the rations in some groups and weather scenarios to minimize GHG emission. By increasing the upper limit of GHG emission from the minimum emission in the third section, farm IOFC increased with a declining rate.

***Effect of feeding strategies and cropping systems on greenhouse gas emission from Wisconsin certified organic dairy farms***

D. Liang, F. Sun, M. A. Wattiaux, V. E. Cabrera, J. L. Hedtcke, and E. M. Silva

Organic agriculture continues to expand in the United States, both in total hectares and market share. However, management practices used by dairy organic producers, and their resulting environmental impacts, vary across farms. This study used a partial life cycle assessment approach to estimate the effect of differ- ent feeding strategies and associated crop production on greenhouse gas emissions (GHG) from Wisconsin certified organic dairy farms. Field and livestock-driven emissions were calculated using 2 data sets. One was a 20-yr data set from the Wisconsin Integrated Cropping System Trial documenting management inputs, crop and pasture yields, and soil characteristics, used to estimate field-level emissions from land associated with feed production (row crop and pasture), including N2O and soil carbon sequestration. The other was a data set summarizing organic farm management in Wisconsin, which was used to estimate replacement heifer emission (CO2 equivalents), enteric methane (CH4), and manure management (N2O and CH4). Three combinations of corn grain (CG) and soybean (SB) as concentrate (all corn = 100% CG; baseline = 75% CG + 25% SB; half corn = 50% CG + 50% SB) were assigned to each of 4 representative management strategies as determined by survey data. Overall, GHG emissions associated with crop production was 1,297 ± 136 kg of CO2 equivalents/t of ECM without accounting for soil carbon changes (ΔSC), and GHG emission with ΔSC was 1,457 ± 111 kg of CO2 equivalents/t of ECM, with greater reliance on pasture resulting in less ΔSC. Higher levels of milk production were a major driver associated with reduction in GHG emission per metric tonne of ECM. Emissions per metric tonne of ECM in- creased with increasing proportion of SB in the ration; however, including SB in the crop rotation decreased N2O emission per metric tonne of ECM from cropland due to lower applications of organically approved N fertility inputs. More SB at the expense of CG in the ration reduced enteric CH4 emission per metric tonne of ECM (because of greater dietary fat content) but increased N2O emission per metric tonne of ECM from manure (because of greater N content). An increased reliance on pasture for feed at the expense of grain resulted in decreased in milk production, subsequently leading to substantially higher emissions per metric tonne of ECM.

***Maximizing income over feed cost by grouping cows with mixedinteger***

***programing.***

Y. Wu, V. E. Cabrera, and R. A. Shaver

The objective of this study is to maximum Income Over Feed (IOFC) using Mixed-integer programing (MIP), which is an optimization solver to find the value approaching optimal value which maximum the objective function: $IOFC= \sum\_{i=1}^{N}g\_{1i}\*MY\_{i}\*P-\sum\_{i=1}^{N}g\_{1i}\*DMI\_{i}\*p\_{ath}\left(g\_{1i}\*NEC\_{i}\right)\*C\_{2}-\sum\_{i=1}^{N}g\_{1i}\*DMI\_{i}\*p\_{bth}\left(g\_{1i}\*CPC\_{i}\right)\*C\_{2}+\sum\_{i=1}^{N}g\_{2i}\*MY\_{i}\*P-\sum\_{i=1}^{N}g\_{2i}\*DMI\_{i}\*p\_{ath}\left(g\_{2i}\*NEC\_{i}\right)\*C\_{2}-\sum\_{i=1}^{N}g\_{2i}\*DMI\_{i}\*p\_{bth}\left(g\_{2i}\*CPC\_{i}\right)\*C\_{2}$ , subjects to $g\_{ji}\in \left(0, 1\right);g\_{1i}+g\_{2i}=1; even grouping has\sum\_{i=1}^{N}g\_{1i}=\sum\_{i=1}^{N}g\_{2i}$. Where, j is group number, i is observation number, N is cows number, $g\_{ji}$is binary variable. $MY\_{i}$ is milk yield of cow i, which is considered as constant. NECi, CPCi and DMIi are cow i’s NE requirement (Mcal/kg DM), CP requirement (%/kg DM) and daily dry matter intake (kg/cow/day) respectively, calculated according to NRC. $p\_{ath}$() is “a” percentile of the vector. P, C1 and C2 are the milk price (0.35 $/kg), NE price (0.07 $/Mcal) and CP price (0.4 $/kg) respectively. Cluster strategy use the same IOFC function, corresponding groups size and percentiles of NE and CP. The daily data of 417 cows from Dairy Science of University of Wisconsin-Madison (BW=604.6$\pm $28.9kg, DIM=152$\pm $103days, Milk yield =43.1$\pm $10.4kg/day) are applied in even and uneven grouping with both strategies. The BW was calculated with Korver function as described by van Arendonk (1985). Results show MIP strategy have high average IOFC than cluster strategy in even grouping (10.175 vs. 9.996 $/cow/d) and uneven grouping (10.383 vs. 10.193 $/cow/d). Compared with Cluster strategy, MIP have 202 (42.89%) and 150(31.85%) cows grouped differently in even and uneven grouping. FCM, FE and IOFC are significant different in even grouping. In conclusion, MIP strategy may have better performance in nutritional grouping, but animal experiments are needed to verify this conclusion.

**E. PUBLICATIONS:**

**Peer-reviewed research and extension Journal papers**

1. **Cabrera, V. E.** 2017. Helping dairy farmers to improve economic performance utilizing data-driving decision support tools. Animal 00:00-00.
2. Bach, A., and **V. E. Cabrera**. 2017. Robotic milking: feeding strategies and economic returns. Journal of Dairy Science 100:7720-7728.
3. Liang, D. F. Sun, M. A. Wattiaux, **V. E. Cabrera**, J. L. Hedtcke, and E. M. Silva. 2017. Effect of feeding strategies and cropping systems on greenhouse gas emission from Wisconsin certified organic dairy farms. Journal of Dairy Science 100:5957-5973.
4. López-Gatius, F., C. Andreu-Vázquez, R. Mur-Novalesd, **V. E. Cabrera**, R. H. F. Hunter. 2017. The problem of twin pregnancies in dairy cattle. A review on practical prospects. Livestock Science 197:12-16.

**Chapters in books**

1. Overton, M. W., and **V. E. Cabrera**. 2017. Monitoring and quantifying value of change in reproductive performance. In: Large Dairy Herd Management Book. American Dairy Science Association.

**Contributed papers or abstracts research and extension**

1. Liang D., T. F. Rutherford, B. L. Jones, R. D. Shaver, and **V. E. Cabrera**. 2017. Trade-off between farm profitability and greenhouse gas emission. Journal of Dairy Science 100 (Suppl. 2):M147.
2. Wu, Y., **V. E. Cabrera**, and R. A. Shaver. 2017. Maximizing income over feed cost by grouping cows with mixed-integer programing. Journal of Dairy Science 100 (Suppl. 2): 228.
3. Santana, R. A. V., A. F. Brito, **V. E. Cabrera**, F. A. Barbosa, A. K. Hoshide, A. F. Benson, A. N. Hafla, H. M. Darby, K. J. Soder, and R. Kersbergen. 2017. Journal of Dairy Science 100 (Suppl. 2): 332.
4. Liang, D., J. Tricarico, K. Weigel, and **V. E. Cabrera**. 2017. Evaluating the effect of herd structure and milk production improvement on farm profitability and enteric methane emission. Journal of Dairy Science 100 (Suppl. 2): 412.

**F. IMPACT STATEMENT (in lay language for government agencies and elected representatives)**

*Management information systems and artificial intelligence are increasingly important for helping in the decision-making of dairy systems. Dairy farming is a decision-intensive enterprise where profitable decisions cannot be made without the use of decision aids. The dynamics of dairy farm systems warrants the utilization of sophisticated techniques to assess the impacts of management strategies to farm economics, which at the same time need to be user-friendly and ready to be applied at the farm level. Simulation techniques help to overcome these shortcomings assessing cost-efficiency, profitability, and environmental performance even under highly uncertain scenarios. Wisconsin’s applied research and extension programs are committed to provide relevant, up-to-date, research based, and field-tested decision aids to farmers, extension agents.*

**G. LEVERAGE (***dollars and other resources – because of your work in this project you’ve been able to leverage resources from what other sources, amounts?***):**

**Cabrera, V.E.**, and R. D. Shaver. 2015-2019. Nutritional grouping strategies for feeding dairy cattle to improve health, profit, and environmental outcomes of dairy farms. USDA Hatch Multistate Interdisciplinary. $140,000.

**Cabrera, V.E.** 2013-2017. Improving long-term dairy farm sustainability applying whole-farm best management practices that enhance profitability and decrease environmental impacts: A high-level integrated assessment. USDA Hatch Multistate Single Investigator. $165,000.

**Cabrera, V.** **E.** 2017-2018. Continue delivering high-impact dairy farm decision support tools. University of Wisconsin-Madison Graduate School. $51,000.

**Cabrera**, **V. E.,** K. Weigel, H. White, M. Ferris, M. Livny, J. Patel. 2017-2019. A virtual dairy farm brain. University of Wisconsin-Madison 20/20 Competitive Initiative. $500,000.