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RESEARCH FROM THE NH AGRICULTURAL EXPERIMENT STATION

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NH Agricultural Experiment Station

MESSAGE FROM
UNIT LEADERSHIP

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Dear members of the New Hampshire dairy community and beyond:

We are delighted to share with you the latest research from our colleagues at the University of New Hampshire. The briefs in this report cover a diverse set of issues facing the dairy sector in the Granite State and northern New England. The topics range from feed production strategies to feed additive assessments, calf health and methane emission reduction, to name just a few. Each piece offers a snapshot of the rigorous science as well as the practical takeaways that can make individual dairy operations and the collective industry more economically resilient and environmentally sustainable.

The report also exemplifies the integrated nature of the research conducted at UNH. The scientists, post-doctoral scholars and graduate and undergraduate students represent multiple departments within the College of Life Sciences and Agriculture and Cooperative Extension. Additionally, in numerous projects, our research teams worked directly with industry partners, who helped inspire the questions, assist with the research and implement the findings. These partnerships included dairy producers, animal nutritionists, feed suppliers, and even a brewery. It is exceedingly rewarding to know that New Hampshire's dairy sector and supporting industries understand the value that UNH's dairy science research and Extension programs bring and that they are willing to commit time, resources and expertise to enable us to strengthen the Granite State through science.

As you learn about the research completed over the past several years, also know that there are always continued efforts underway. The science isn't always fast. It's never easy. But it always reflects the tenets that have made UNH's agricultural research and Extension trusted for more than 130 years: addressing locally inspired questions, implementing rigorous and objective analysis, and delivering data-informed recommendations.

Thank you for supporting our efforts to improve the lives of every Granite Stater.

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INSPIRED CONTENTS

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LOCALLY INSPIRED. GLOBALLY IMPORTANT.

High-Stakes Issues
World-Class Science
Sustainable Advancement

At your New Hampshire Agricultural Experiment Station (NHAES), our mission is to ensure the resiliency of the Granite State's diverse communities and local economies. For more than 130 years, we've served the state as the agricultural, food, natural resource and environmental research arm of the UNH land-grant mission. From the lab to the field, forest and sea, our researchers push scientific frontiers in pursuing sustainable food production and natural resource management across New Hampshire and beyond.

As New Hampshire's complex modern food system continues to face new challenges and opportunities, the NHAES's research serves as the frontline of data-driven, objective solutions for the economic, environmental and societal good. Part of the UNH College of Life Sciences and Agriculture, the NHAES leads scientific innovations that are critical to sustainable lives and livelihoods.

Fairchild Dairy Research and Teaching Center (left), Organic Dairy Research Farm (center), and Kingman Research Farm (right)

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The majority of the research you'll read about was conducted at one of the New Hampshire Agricultural Experiment Station campus-area research farm and dairy facilities. Our field facilities include the horticulture and agronomy farms, a typical New England Holstein dairy, a diversified organic dairy farm, the research and teaching greenhouses and equine complex. Additional field sites adjacent to or near the UNH campus are used independently for research, teaching and engagement while directly contributing to the farm operations by producing required dairy and equine feed.

Many activities conducted at these locations support the core institutional mission and goals of research, teaching and outreach to support the Granite State. The facilities support approximately half of the 50 ongoing experiment station research projects, provide opportunities for hands-on training for future scientists and experiential learning for undergraduate students and offer space for public–private partnerships. The farms, dairies and greenhouses also host field days and are used by UNH Cooperative Extension to engage with New Hampshire communities and communicate state-of-the-art knowledge.

IS INCREASING HEIFER CALVES WITHOUT USING SEXED-SEMEN POSSIBLE?

A.J. MENDES, M.R. MURPHY, D.P. CASPER AND P.S. ERICKSON

Having adequate numbers of heifer calves to replace cows that are culled is essential for the continual success of any dairy farm. There has been much animal research examining the likelihood of female or male offspring. Sexed-semen has resulted in many heifer calves on dairy farms. Is there a way in which dairy producers can increase the number of heifers born without using it?

Darwin suggested that some animal species can exhibit significant shifts in the proportions of male and female offspring that are born, though environmental conditions and mechanisms that cause these changes are unclear (Rosenfeld and Roberts, 2004). Trivers and Willard (1973) noted that in polygymous species a small proportion of males, typically the larger and more aggressive ones, share most of the lifetime reproductive success. Lower-ranking males often sire no offspring at all. However, a majority of females, regardless of social ranking or body condition, will be impregnated by that select group of males.

The hypothesis suggested by Travers and Willard (1973) states that females in the best body condition would tend to produce offspring of the gender that favors the sex of greater variance, namely males. The male offspring would benefit from greater parental investment and most likely as adults join the elite group of breeding males. As a consequence, the females are likely to pass on their genes to more of their offspring's progeny. Conversely, females lower in the social structure or poorer body condition would invest more in female progeny because their daughters rather than their sons are likely to have greater lifetime reproductive success (Rosenfeld and Roberts, 2004).

Data from the University of Illinois and the University of New Hampshire dairy herds were collected and summarized for calf sex, the number of services to achieve conception, and the lactation number of the lactating dairy cow when she conceived. Logistic regression procedures were used to analyze the data.

KEY TAKEAWAYS

Data from this experiment indicated that older cows tend to produce more heifer calves than younger cows. Thus, finding ways to reduce the culling rate such as improving footing, reducing mastitis, and keeping cows healthy should lower the cull rate resulting in an older herd and an increase in the chances of heifers being born. These data demonstrate that increasing the number of services to achieve conception and age of the cow increases the probability of getting a heifer calf. The earlier days in milk or age a cow conceives will increase the odds of the dairy producer getting a male calf. These data do not imply that farmers should wait to breed their cows, but it does suggest that reducing the culling rate may increase the chances of having more heifer calves born.

The data set was edited to delete those cow observations when the number of services to achieve conception (n = 6) or lactation number (n = 2) were greater than 9. These cows would typically be classified as “do not breed” and sold for harvest. The final data set contained 2,987 calvings, which consisted of 1,406 females and 1,581 males (47.1 and 52.9% for females and males, respectively).

The frequency distribution of the number of services to achieve conception was highest for the first service and progressively declined with increasing services (Table 1). Logistic stepwise regression indicated that the number of services to achieve conception was statistically significant ($P < 0.02$) in predicting the ratio of female to male calves. Calculation of odds ratios indicated that as the lactation number increased the likelihood of getting a bull calf decreased.

The frequency distribution of calvings by lactation number was highest for 1st lactation cows becoming pregnant with their 2nd calf and declined with increasing lactation number (Table 2). Calculation of odds ratios indicated that as the lactation number increased the likelihood of getting a bull calf decreased (Table 3).

The results also indicated that as the lactation number increased the likelihood of getting a bull calf decreased (Table 3, Table 4). There were no differences between universities ($P = 0.58$), but as parity increased and AI service increased the likelihood of a heifer calf being born was significant ($P < 0.05$) resulting in an interaction between parity and AI service.

Table 1: Frequency distribution and odds ratio of services per conception

AI Service	*Frequency*	*Percent*	*Odds Ratio Estimate*
1	1555	52.1	1.052
2	647	21.7	1.016
3	321	10.8	0.983
4	199	6.7	0.950
5	126	4.2	0.918
6	139	4.7	0.887

Notes: AI Service is number of artificial insemination services; frequency is the number of conceptions at a given service; Percent is proportion of total calvings (2,987). Odds ratios greater than 1 indicate a higher chance of male.

Table 2: Frequency distribution and odds ratio of calvings by lactation number

Lactation number	*Frequency*	*Percent*	*Odds Ratio Estimate*
1	1060	35.5	1.080
2	843	28.2	1.044
3	508	17.0	1.009
4	287	9.6	0.975
5	150	5.0	0.943
6	75	2.5	0.911
7	34	1.1	0.881
8	21	0.7	0.851
9	9	0.3	0.823

Notes: Frequency is the number of conceptions at a given service; Percent is proportion of total calvings (2,987). Odds ratios greater than 1 indicate a higher chance of male.

Table 3: Number of male and female calves by artificial insemination and lactation number

	AI Service											
	1		2		3		4		5		6	
Lactation number	M	F	M	F	M	F	M	F	M	F	M	F
1	334	321	117	99	56	40	34	21	19	9	6	2
2	213	212	97	96	52	37	35	21	24	16	6	15
3	116	102	57	54	37	30	27	21	12	10	10	10
4	71	64	36	29	12	18	13	7	7	8	5	4
5	30	29	19	15	11	8	4	5	5	6	1	2
6	22	15	5	7	8	3	2	0	3	3	1	0
7	11	4	6	2	2	0	2	1	1	2	1	1
8	3	5	4	2	3	2	1	0	1	0	0	0
9	2	1	1	1	1	1	1	1	0	0	0	0

Notes: AI Service is number of artificial insemination services; M and F represent the number of male and female calves, respectively.

Table 4: Analysis of maximum likelihood estimates

Parameter	*Estimate*	*Wald Chi-square*	*P-value*
Intercept	-0.067	0.156	0.693
Univ Illinois vs UNH	-0.056	0.301	0.583
Cow parity	0.084	4.209	0.040
AI service	0.111	4.832	0.028
Parity-by-AI service	-0.034	4.802	0.028

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REVISITING PERENNIAL RYEGRASS AS A FORAGE SPECIES IN NEW HAMPSHIRE

R. SMITH, N. WARREN AND C. MAJEWSKI

Certain cultivars of perennial ryegrass (*Lolium perenne* L.) can provide some of the highest quality forage in addition to being productive and easy to establish. While these qualities make it an attractive prospect for U.S. forage producers, its susceptibility to winterkill has prevented it from being fully integrated into pastures in the Northeast. We revisited research conducted several years ago at UNH and other collaborating states to evaluate what traits contributed to ryegrass productivity and longevity and to better assess whether perennial ryegrass is a good choice for New Hampshire producers.

Perennial ryegrass is a widely distributed and versatile species, with cultivars specialized for turf, lawns, and forage production. Perennial ryegrass offers a lot of potential advantages to dairy and livestock producers: it's vigorous as a seedling and tolerates grazing well, has strong yield potential, and is a nutritious and palatable forage. These are great qualities for any grass-based operation looking to make the best use of farm-grown forages.

However, these benefits are offset by traits that make perennial ryegrass a less than perfect fit in northern New England: a lack of tolerance to moisture stress and only minimal winter hardiness. These issues can lead to low yields, lower quality forage and create opportunities for weeds to establish.

In this study, we measured the performance of 13 perennial ryegrass cultivars in four sites across the Northeast: The Penn State Russell E. Larson Agricultural Research Center (PA, Hardiness Zone 6b), the University of Vermont Miller Research Farm (VT, Zone 5a), the University of Maine Rogers Farm Forage and Crop Research Facility (ME, Zone 5a), and the University of New Hampshire Organic Dairy Research Farm (NH, Zone 5b).

KEY TAKEAWAYS

High moisture stress and low winter hardiness have prevented widespread use of perennial ryegrass in permanent pastures and hayfields in New Hampshire and other areas that experience hot, dry summers and cold winters. This study's results show that these remain serious issues for perennial ryegrass. However, some opportunities exist. Perennial ryegrass can provide high yields of quality forage in short-term pastures in rotation with other crops. It may also be viable on the increasing number of diversified farms that include both livestock and crop production. Lastly, the rapidly growing perennial ryegrass might serve as a viable emergency option, providing high quality forage for another season and buying farms time to reconfigure their cropping plans.

We sowed perennial ryegrass (20 lbs. per acre) with white clover (cv. 'Alice') (3 lbs. per acre) in late summer of 2012 and harvested from 2013–2015 with no supplemental fertility. Harvesting was based grass reaching the boot stage, resulting in a varied number of harvests across sites (Table 1). At each harvest we separated ryegrass, white clover, and broadleaf and grass weeds, then dried and weighed them.

Table 1: Number of harvests at research sites, 2013–2015

Experiment Site	*USDA Hardiness Zone*	*2013*	*2014*	*2015*
Maine	5a	4	2	0
New Hampshire	5b	5	4	2
Pennsylvania	6b	5	3	1
Vermont	5a	3	3	0

Perennial ryegrass productivity was highest in the first year. Yields approached 3.5–4 tons of dry matter per acre at some sites but decreased markedly over the next two seasons. Lack of persistence led to a decline in the number of harvests at all sites in the second year, and only two of the four sites had healthy enough stands to harvest in the third year of the study (Figure 1).

White clover played an important role in stabilizing total productivity at the New Hampshire and Pennsylvania sites after the first year, becoming the dominant forage species as perennial ryegrass became less abundant in 2014 and 2015. At the New Hampshire site, perennial ryegrass accounted for more than 70% of the harvested forage in 2013 but dwindled to less than one-third of the total dry matter in 2014 and 2015 (Figure 2).

Perennial ryegrass does best in cool, moist climates, and it's the dominant forage grass in parts of the world characterized by mild winters and cooler growing seasons—Ireland and the UK, coastal northern Europe, and New Zealand. While those conditions are common throughout spring and fall in the Northeast, the region also is more likely to see hot, dry weather in late summer and deep freezes without adequate snow cover in the winter, affecting performance and survival across seasons. According to the Northeast Region Climate Center, precipitation was close to normal during the 2013–2015 growing seasons, but summer temperatures were higher than normal and winter temperatures were lower than normal, possibly further affecting yield and persistence.

These results illustrate why perennial ryegrass is not common in permanent grasslands in our region. However, there are some ways to work with perennial rye grass' limitations while still taking advantage of its best qualities. While it is not persistent, it could still provide high yields of quality forage in short-term pastures, called leys, in rotation with other crops. The practice is not as common in the United States as it is in other countries, and it may not hold much appeal for someone with pastures located on steep and rocky upland soils. However, it might be viable on the increasing number of diversified farms that include both livestock and crop production.

A combination of mild temperatures and a lack of snow cover has led to extensive winterkill in forages across our region on several occasions over the past few years. Farms may not notice this damage until large swaths of their stands aren't greening up alongside the rest of the field in late April, leaving little time to make new plans. With its rapid growth, perennial ryegrass might serve as a viable emergency option, providing high quality forage for another season and buying farms a little time to reconfigure their cropping plans.

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Figure 1: Seasonal total dry matter

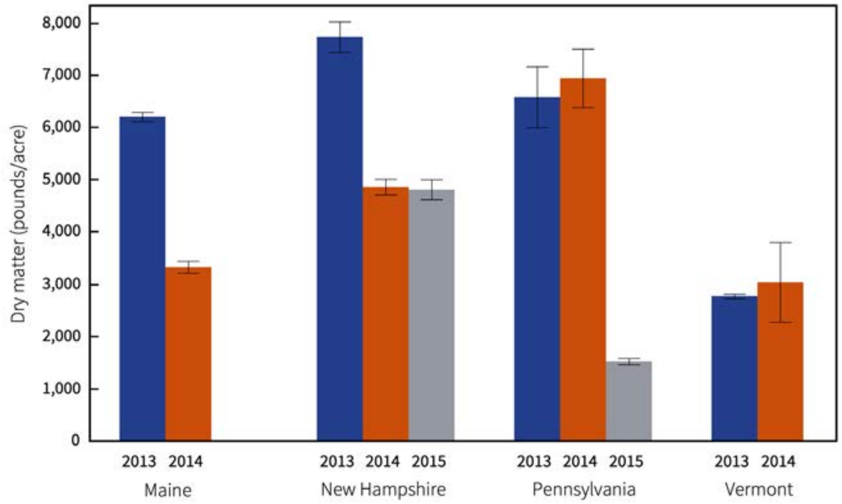
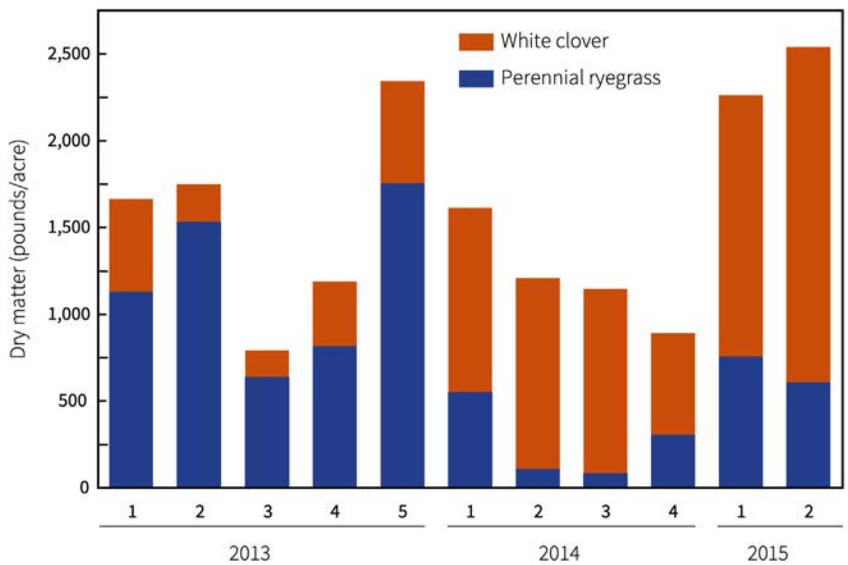


Figure 2: Perennial ryegrass proportion of each harvest in New Hampshire



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EFFECT OF SELISSEO ON SELENIUM IN MILK AND IN BLOOD FOR MID AND LATE LACTATION HOLSTEIN COWS

N. WHITEHOUSE AND J. SEXTON

Selenium (Se) is an essential trace mineral that, if deficient in soil, will be deficient in diets fed to dairy cows. Adequate Se is important for animal health to support immune functions and efficiently fight oxidative stress and pathogens. Standard farm practice is to supplement Se in the diet either in mineral form (sodium selenite) or organic forms. The objective of this study was to compare the bioefficacy of two organic Se sources (Hydrox-selenomethionine and seleno-yeasts) in mid-lactating dairy cows based on the Se transfer into plasma and milk.

Organic forms of Se include seleno-yeasts (SY) or pure forms such as selenomethionine or hydroxy-selenomethionine (HMSeBA). In monogastric organic Se forms, pure forms (like SeMet or HMSeBA) are described to have an additional bioefficacy compared to seleno-yeasts attributed to the presence of only about 60% of Se as SeMet in those yeasts, the rest being other organic Se forms (Briens et al., 2014; Zhao et al., 2017).

HMSeBA has been widely shown to improve the relative bioavailability of Se compared with inorganic forms or SY in broiler chickens (Briens et al., 2013, 2014). Sun et al. (2017) and Li et al. (2019) demonstrated that the HMSeBA improves Se bioavailability in milk and plasma and enhances the activities of antioxidant enzymes in dairy cows. Still, limited research has been conducted regarding the effects of the HMSeBA on dairy cow production. Therefore, we compared the effect of the HMSeBA and the SY supplementation on performance, biochemical parameters and selenium bioavailability in mid-lactation dairy cows.

All procedures related to animal care were conducted with the approval of the University of New Hampshire Institutional Animal Care and Use Committee. Cows were housed at the Fairchild Dairy Teaching and Research Center in a naturally ventilated tie-stall barn, fed individually, and had continuous access to water. Twenty-four lactating Holstein cows, 12 multiparous and 12 primiparous were used in a 91 day experiment.

KEY TAKEAWAYS

Limited knowledge exists about the effects of organic Se additives— OH-SeMet (HMSeBA) and SY—on dairy cow production. This study compared the effect of the supplementation on performance, biochemical parameters, and selenium bioavailability in mid-lactation dairy cows. Findings indicate that organic Se forms can increase milk and plasma Se concentrations. The high transfer of Se from OH-SeMet to milk could reflect transfer to other tissue. When administered at the same level of supplementation, OH-SeMet showed to be more efficient than SY to improve those Se concentrations.

The four treatments were: 1) basal diet as a total mix ration (TMR) with an expected Se background of 0.2 mg/kg TMR as-fed (control), 2) basal diet + 0.3 mg Se/kg TMR as-fed from Seleno-Yeast (SY), (SY-0.3), 3) and 4) basal diet + 0.1 or 0.3 mg Se/kg TMR as-fed from Hydroxy-selenomethionine (OH-SeMet), (OH-SeMet-0.1 or OH-SeMet-0.3). The basal diet was formulated to meet the requirement (NRC 2001) of the dairy cow and was fed as a TMR.

Cows were milked twice daily and milk weights were recorded. Milk and blood samples were obtained from each cow during the morning and afternoon on the last 3 days of weeks 1, 2, 3, 4, 6, 8, 10 and 12 of the study. Samples were analyzed for fat, true protein, lactose, milk urea nitrogen (MUN), somatic cells and total Se.

Table 1: Differences in outcomes under alternative Se forms and concentrations

Parameter	*Control*	*SY-0.3*	*OH-SeMet-0.1*	*OH-SeMet-0.3*
Dry matter intake, kg/d	24.0	24.0	23.8	23.9
Milk yield, kg/d	31.8b	33.8a	33.6a	32.9a
Milk fat, %	4.45	4.32	4.34	4.35
Milk protein, %	3.43ab	3.39b	3.43ab	3.45a
Milk lactose, %	4.78	4.75	4.77	4.76
Somatic cell counts, x 1000	59b	81a	70ab	29c
Linear somatic cell score	1.7a	2.1a	1.9a	1.0b
Milk urea nitrogen, mg/dL	13.2	13.6	13.9	13.7
4% Fat corrected milk, kg/d	36.4b	38.4a	38.3a	38.3a
Energy corrected milk, kg/d	36.6b	38.5a	38.4a	38.4a
Milk Se (µg/L)	56.9d	97.3b	77.6c	116.9a
Milk Se (µg/d)	1823c	3195a	2670b	3827a
Plasma Se (µg/L)	120.0d	134.1b	122.5c	141.4a
Se bioavailability (%)	15.2c	23.4b	21.6b	27.6a
Milk Se:Plasma Se ratio	47.4d	72.2b	63.0c	83.9a

Table 1 shows that dry matter intake overall was not affected by treatment. Milk yield, fat corrected milk and energy corrected milk were significantly higher in the Se treatments versus the control. There was a trend for decreased fat percentage when the Se treatments were fed. There was no effect of Se concentration or source on milk urea nitrogen or lactose percentage. Milk protein percentage in this trial was significantly decreased for SY-0.3 compared to OH-SeMet-0.3 but was not different from the control or OH-SeMet-0.1. T. Milk somatic cell counts (SCC) and linear somatic cell score (LSCS) were significantly lower in the OH-SeMet 0.3 group. The supplementation of Se in diet from SY or OH-SeMet, with both levels of OH-SeMet, significantly increased the average plasma and milk Se concentration, with OH-SeMet-0.3 being the highest followed by SY-0.3 and then OH-SeMet-0.1. In comparison to the control group, SY-0.3, OH-SeMet-0.1, OH-SeMet-0.3 increased Se bioavailability in milk by 171, 136 and 205% respectively.

For plasma Se concentration, the OH-SeMet-0.3 and SY-0.3 significantly increased Se level in plasma after the second week of the study and until the end of the study. Furthermore, OH-SeMet-0.3 induced significantly higher plasma Se concentrations by 7–9% compared to SY-0.3 from week four until week twelve. The control group constantly declined but supplementation with 0.1 of the OH-SeMet maintained the plasma Se at high level but is not sufficient to completely reach the level obtained by the supplementation of 0.3ppm. Selenium was greatest for OH-SeMet-0.3 and lowest for control with the SY-0.3 and OH-SeMet-0.1 being in between. Selenium bioavailability was greatest for the OH-SeMet-0.3 (27.6%), then SY-0.3 (23.4%) and OH-SeMet-0.1 (21.6%).

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SUPPLEMENTAL MYCOTOXIN DEACTIVATOR: EFFECTS ON LACTATION PERFORMANCE AND RUMEN PARAMETERS

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Mycotoxins are toxic compounds naturally produced by certain types of molds and pose a serious risk to both humans and animals. Heat, humidity, and rainfall contribute to the growth and spread of mycotoxins. This makes managing and removing mycotoxins from animal feeds difficult. When feed is high in mycotoxin contamination, the overall health and production of dairy cattle are adversely impacted. Two trials were conducted to measure the effect of a mycotoxin deactivator binder, which can negate the toxic effects on lactating dairy cattle when fed a diet high in mycotoxin contamination.

Mycotoxins are toxic secondary metabolites of fungus naturally found throughout the world and in animal feeds (Lagrieco, 2018). They are molecules of low molecular weight that can present toxic responses in both humans and vertebrate animals (Gallo et al., 2015). These fungal toxins are chemically diverse. There are hundreds of known mycotoxins, but only a few have been intensely studied and researched. Mycotoxins exist naturally in the environment, particularly in molds present in forages and silage, however the incidence of mycotoxins throughout a region can vary (Gallo et al., 2015). Fungi present on crops can produce them pre-harvest or post-harvest, during handling and transport, storage, ensiling, processing or feeding. Notable mycotoxins include aflatoxins, trichothecenes and fumonisins.

These groups of mycotoxins primarily reside in the kernels of mold-affected grain. They detract from the overall nutritional content by lowering the fat, protein and vitamin content of the grain. In addition to degrading the feed value, these molds can also change the texture, color of the kernels and, in the process, emit odors that cause feed refusal. Mycotoxin deactivators are fed to negate the toxic effects of consuming mycotoxins.

KEY TAKEAWAYS

Mycotoxins are toxic compounds that can adversely affect health and milk production in dairy cows that consume myxotoxin-contaminated feed. A mycotoxin deactivator binder added to animal feed can negate the toxic effects. This could enable producers to safely use poorer quality feed, increasing efficiency and decreasing potential economic losses brought on mycotoxins. Study results indicate that rumen parameters can be restored by a dietary mycotoxin deactivator, resulting in an improvement of the production of beneficial metabolites and enhancing health and performance of the cows. However, further research needs to be conducted to look at the modes of action for the deactivators.

This study tests the effectiveness of a mycotoxin deactivator. All procedures related to animal care were conducted with the approval of the University of New Hampshire Institutional Animal Care and Use Committee. Cows were housed at the Fairchild Dairy Teaching and Research Center in a naturally ventilated tie-stall barn, fed individually, and had continuous access to water. For both trials, 24 multiparous Holstein cows were used with 9 cows being equipped with ruminal cannulas and 15 noncannulated cows. The treatments were: 1) control diet (Low DDGS), 2) control diet + distillers grains with a high mycotoxin load (High DDGS), and 3) control diet + distillers grains with high mycotoxin load + mycotoxin deactivator (High DDGS+D). Blood, rumen, and milk samples were collected on the last three days of weeks 3 and 6 for trial 1 and weeks 2, 4, 6, 8, and 10 for trial 2. Blood and milk samples were collected from the coccygeal vein at 1000 hours and analyzed for hematological and biochemical parameters.

Table 1 shows the results across treatments. The total mixed ration (TMR) in the High DDGS diets increased zearalenone and deoxynivalenol compared to Low DDGS diets. Cows fed High DDGS had elevated somatic cell score (SCS) compared to Low DDGS, but High DDGS+D showed low SCS in Trial 2. Results show mixed outcomes between trials on leukocytes and monocytes. The rumen parameters showed a significant increase for butyrate and isobutyrate and isovalerate with supplementing High DDGS+D compared to High DDGS. Bacteria and archaea relative abundance were also affected by the mycotoxin contamination, resulting in a higher bacteria:archaea ratio. In Trial 2, the contaminated diets had higher acetate concentrations compared to Low DDGS, and the propionate concentration was lower for the High DDGS+D compared to the Low DDGS and High DDGS diets. This may be due to the longer length of Trial 2, different modes of action that deactivators have, or that mycotoxin T2 and HT2 were present in higher amounts than in Trial 1. The microbial DNA is still being processed at publication.

Table 1: Effects of mycotoxin contamination and deactivation on cow performance

Parameter	*Low DDGS*	*High DDGS*	*High DDGS+D*	*Low DDGS*	*High DDGS*	*High DDGS+D*
	Trial 1			Trial 2		
Dry matter intake, kg/d	25.3	23.3	24.1	26.2	26.0	25.5
Milk yield, kg/d	41.6	40.7	40.9	42.4	42.7	41.7
ECM, kg/d	40.5	39.2	40.1	44.4	43.5	43.9
Somatic cell counts	1.3b	1.8a	1.8a	2.2b	2.7a	2.3b
Neutrophils, cells/uL	4,543	4,125	4,739	4587	4369	4778
Lymphocytes, cells/uL	3,316	2,871	3,338	3737a	3439b	3433.9b
Monocytes, cells/uL	351a	272b	368a	566.8a	545.8ab	497.1b
Leukocytes, K/uL	8.5	7.6	8.7	9.2a	8.6b	9ab
pH	5.56	5.46	5.54	6.06	6.03	6.03
VFA, µM						
Total VFA	137.7	149.6	134.6	89.7	92.3	89.5
Individual	—	—	—	27.2	26.9	28.3
Acetate (A)	63.8	65.3	64.6	10.7b	11.1ab	11.5a
Propionate (P)	25.4	24.7	24.4	084a	0.84a	0.75b
Butyrate	9.2a	8.5b	9.2a	0.43	0.43	0.43
Valerate	1.1	1.0	1.1	0.17	0.17	0.16
Isobutyrate	0.35a	0.31b	0.36a	89.7	92.3	89.5
Isovalerate	0.22ab	0.19b	0.25a	—	—	—
A:P ratio	2.6	2.7	2.7	3.30	3.47	3.19
Bacteria:archaea ratio	76.1b	91.1a	96.6a	—	—	—

REFINING PLASMA DOSE RESPONSE TECHNIQUES FOR BIOAVAILABILITY OF RUMEN PROTECTED AMINO ACIDS

N. WHITEHOUSE

Lysine (Lys) and methionine (Met) are the two most limiting amino acids (AAs) in typical North American dairy diets (NRC, 2001). Several rumen-protected Lys (RP-Lys) and rumen-protected methionine (RP-Met) feed supplements are available in the marketplace for increasing concentrations of Lys and Met in metabolizable protein. However, successful use of rumen protected AA products requires accurate and reliable estimates of AA bioavailability because RP-AA nutrients are expensive. This study refines the plasma-free dose response technique to get reliable estimates of relative bioavailability of RP-AA supplements.

Limited research indicates that the apparent availability of Lys and Met to ruminants (i.e., bioavailability) from RP-AA supplements varies widely (Berthiaume et al., 2000; Ji et al, 2015), making reliable estimates of Lys and Met bioavailability essential when considering the purchase and use of these products. Rulquin and Kowalczyk (2003) were the first researchers to suggest using a plasma free AA dose response method to determine bioavailability of AA in RP-AA.

Although most suppliers provide estimates of Lys and Met bioavailability for their RP-AA supplements, these bioavailability values were not obtained using standardized techniques or methodologies. Without a standardized procedure for differentiating RP-AA supplements under feeding conditions closer to commercial practices, producers and industry personnel have no reliable information to make decisions about which RP-AA supplement to use based on price and amount of absorbable Lys and/or Met.

All procedures related to animal care were conducted with the approval of the University of New Hampshire Institutional Animal Care and Use Committee. Cows were housed at the Fairchild Dairy Teaching and Research Center in a naturally ventilated tie-stall barn, fed individually, and had continuous access to water.

KEY TAKEAWAYS

Rumen-protected amino acid products have been documented to have animal performance and nutritional benefits of optimizing concentrations of amino acids. This is needed to improve lactational performance, health and reproduction, dairy nutritional models and emissions footprint. As more rumen-protected amino acid supplements come into the marketplace, this study provides estimates of lysine and methionine bioavailability from numerous tested RP-AA concentrations in those supplements. Of the tested products, Smartamine M provides the highest relative bioavailability of both amino acids.

High producing lactating multiparous Holstein cows were fitted with ruminal cannula to allow for abomasal infusion of the "unprotected" AA. Experiments with a minimum of seven-day periods were used. RP-AA supplements were mixed in a portion of the total mix ration 8 hours before feeding. Blood samples are collected the last three days of each period at 2, 4, 6, and 8 hours after morning feeding. Deproteinized plasma samples are pooled within day (across four sampling times) for each cow before AA analysis. The data represent 20 Lys experiments involving 40 products and 11 Met experiments involving 21 products. Tables 1 and 2 show the relative bioavailabilities for the tested RP-Lys and RP-Met products.

Table 1: Relative bioavailability of RP-Lys

Product	Lys, % of product	Lys relative bioavailability
Smartamine ML	44	80
AjiPro-L 3G	40	47
AjiPro-L 1G	40	31
AjiPro-L 2G	40	38
Bovi-Lysine	48	27
Metabolys	30	26
LysiPEARL 1G	40	9
LysiPEARL 2G	40	15
AminoShure L 2G	52	10
LysiGEM	54	7

Table 2: Relative bioavailability of RP-Met

Product	Met, % of product	Met relative bioavailability
Smartamine M	75	80
AminoShure M	73	17
AminoShure XM	68	28
EB-Met	34	17
Mepron	86	22
MetiPEARL	48	8
Timet	55	19
Kessent M	75	69

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THE IMPACT OF DIRECT-FED ENZYMES AND MICROBIALS ON THE HEALTH AND PERFORMANCE OF DAIRY COWS

S.B. ORT, K.M. ARAGONA, C.E. CHAPMAN, A.F. BRITO AND P.S. ERICKSON

Dairy farmers have been using direct-fed microbials for several years in the feeding of dairy cattle. Results include increased feed intake, reduced incidence of ketosis and increased blood antibody concentrations. Supplementing feed with certain enzymes has been shown to increase fiber digestibility, resulting in greater rumen function through enhanced volatile fatty acid production. However, few studies consider the effect of the enzymes cellulases and amylases—with bacteria and yeast supplementation—on colostrum quality and yield.

KEY TAKEAWAYS

This experiment evaluated Immunoglobulin G and A production and their subsequent effect on the cow's milk production and performance after feeding cattle enzymes and direct-fed microbials (DFMs). Results indicated little benefit of supplementing cows with enzymes and DFM during the pre-peak period (up to eight weeks post-partum), with a lesser yield of IgA in the colostrum of cows fed the DFM. There was no effect on the blood concentrations of IgG in calves fed their respective dam's colostrum. There were no differences in any performance parameters with the cows up to eight weeks postpartum. Under these conditions, feeding the DFM and enzymes in this study was not beneficial.

In this study, we used 36 multiparous Holstein cows (12 per treatment). Cows received either 0 (C), 45.4 g/day of a DFM containing Enterococcus faecium and Saccharomyces cerevisiae (D) or D + 18.2 g/day of an enzyme containing cellulase and amylase.

Cows began the study three weeks before calving and continued for eight weeks postpartum. The prepartum diet was 68.5% forage with approximately 2/3 of the forage being corn silage. This diet averaged 15.8% CP and 42.3 % NDF. The lactating cow diet consisted of a transition diet that was approximately 62% forage, primarily corn silage. This diet was fed for 14 days postpartum. The nutrient analysis was 15.6% CP and 40.6% NDF and 22.5% starch. Beginning on day 15, the lactating cow diet was fed 50% forage (mostly corn silage). This diet contained approximately 16% CP and 38% NDF with 25% starch. Daily feed intakes were taken every day. On the day of calving, calves were weighed. Blood was sampled for IgG at birth and at one day of age. Colostrum quality (IgG) was determined, and calves were fed their respective dam's colostrum. Colostrum yield varied, ranging from the control cows averaging 10.7 L and the D cows averaging 6.6 L. All colostrum was considered good quality (>50 g IgG/L). However, IgA was different with the D fed cows, producing the least IgA content of 36.8 g/L, in comparison to the C cows, producing 65.6 g/L. Immunoglobulin A is beneficial in fighting against intestinal pathogens. There were no effects of cow treatment on the calf on the day of birth, suggesting that feeding DFM and enzymes did not affect in utero calf development. Milk yield was variable ranging from 96 pounds/day for D cows to 107 pounds/day for the C cows.

These results indicate that, at least in this study, no beneficial effects of DFM and enzyme supplementation were observed from the prepartum period until eight weeks postpartum.

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FEEDING NICOTINIC ACID: EFFECTS ON PREPARTUM COW HEALTH, COLOSTRUM AND CALF PERFORMANCE

K.M. ARAGONA AND P.S. ERICKSON

Colostrum is essential for calf health from the increase in protein content (antibodies and growth factors). However, about 60% of the colostrum produced in the United States fails to meet quality standards. Since nicotinic acid increases blood flow and potentially rumen bacteria growth, adding this to the diet of dry cows could enhance the quality of colostrum for calves. Previous research showed that supplementing dry cows with 48 g/day nicotinic acid for four weeks prepartum resulted in better quality colostrum. In this study, we further determine the optimal amount to feed cows and study its effect on the dam's calves and their performance.

The experiment was conducted at the University of New Hampshire Fairchild Dairy Teaching and Research Center. Thirty-six Holstein cows were used in the experiment, beginning four weeks before scheduled calving. There were four treatments with nine cows per treatment. Treatments were 0, 16, 32, or 48 g of nicotinic acid per cow per day. Cows entered the experiment when they were four weeks before the predicted calving date. First-calf cows were not used in this experiment. Feed intake and the bodyweight of the cows were monitored. To determine if the niacin increased bacterial counts, urine samples were taken from the cows three times per week and analyzed for purine derivatives which are positively correlated with rumen microbial protein production.

At calving, colostrum was harvested, and the calves received one gallon of colostrum. Colostrum quality and yield were measured. Twenty-four hours after birth, a blood sample was taken to determine the uptake of the immunoglobulin-IgG—the primary antibody for ruminants. On day two, calves received free choice calf starter, free-choice water and four quarts of a conventional milk replacer. Daily feed and water intakes were tracked. Growth measurements were taken at birth and then weekly for six weeks.

KEY TAKEAWAYS

The nicotinic acid form of the vitamin niacin has been supplemented to dairy cows for several years. Results have indicated that it can reduce incidence rates of ketosis, can alleviate heat stress through increased blood flow and may increase rumen bacteria growth. Feeding prefresh Holstein cows 32 grams per day of the nicotinic acid form of niacin for four weeks before calving results in higher quantity of colostrum and better feed efficiency in the cow's calves. Niacin is a cost-effective supplement because it costs about one cent per gram. Therefore, producers should expect to pay an additional $0.32/cow per day. However, care in handling nicotinic acid must be taken by wearing a mask to prevent inhalation of the material.

Cows fed the various amounts of nicotinic acid reacted similarly across treatments (Table 1). Cows fed increasing amounts of nicotinic acid produced more purine derivatives daily, indicating a greater rumen microbial protein production. This protein would be digested post-ruminally resulting in more amino acids for absorption and production of IgG and other proteins. Results indicated that cows produced similar amounts of colostrum. While there are numerical differences, there was large variability in the data and no statistical differences were observed. However, nicotinic acid supplementation increased colostrum quality (linear effect). But it must be considered that the 48 g/d treatment numerically produced the least amount of colostrum and that the increase in concentration is due to the reduced amount of colostrum produced. This fact comes into focus when we look at IgG yield which peaked (quadratic effect) at the 32 g/d treatment. This value takes into account the concentration of IgG and the yield of colostrum. Protein content increased as nicotinic acid supplementation increased (linear effect). However, the protein yield peaked at the 32 g/d treatment (quadratic effect). Fat content and yield increased quadratically both peaking at the 32 g/d treatment. Therefore, for better quality colostrum 48 g/d supplementation of nicotinic acid is recommended.

All calves received a 20/20 milk replacer at one pound of powder per day. All calves had free choice water and calf starter, both removed and replaced daily. While calves consumed similar amounts of calf starter per day, their average daily gain resulted in a trend for a quadratic effect with the greatest response in calves born of cows fed 32g/d nicotinic acid. This response carried over into feed efficiency. This is a measure of how much growth the calf puts on its body per unit of feed consumed. Calves born of dams fed the 32 g/d treatment resulted in a better feed efficiency response than calves born of dams fed the other treatments. Upon further investigation, most of this response occurred in the first three weeks of life when the calves are getting most of their nutrients from milk and their rumen has yet to develop. Therefore, it appears that there is some component in colostrum that was enhanced by feeding the 32 g/d treatment to their mothers resulting in greater intestinal development. The small intestine is where most nutrients are absorbed at this time in the calf's life.

Table 1: Colostrum yield, quality, and calf performance of cows fed various amounts of nicotinic acid (niacin)

Parameter	*0g/d*	*16 g/d*	*32 g/d*	*48 g/d*	*SEM*	*Linear Probability*	*Quadratic Probability*
Colostrum yield, lb	25.1	23.9	27.0	18.8	3.4	0.29	0.30
IgG, g/L	57.6	72.2	67.8	83.5	7.4	0.02	0.95
IgG yield, g	548.9	768.4	807.5	577.7	99.0	0.77	0.03
Protein content, %	13.7	15.1	14.8	16.4	0.89	0.05	0.92
Protein yield, lb	3.28	3.90	3.88	2.69	0.42	0.35	0.05
Fat content, %	4.51	7.30	6.90	6.10	0.90	0.28	0.05
Fat yield, lb	1.39	1.87	2.03	1.06	0.35	0.60	0.05
Calf starter DMI, lb/day	1.54	1.41	1.44	1.20	0.15	0.13	0.67
Calf ADG, lb	1.06	1.00	1.17	0.81	0.08	0.12	0.07
Gain/Feed	0.36	0.36	0.50	0.34	0.04	0.63	0.03

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USING AN NSAID IN NEWBORN CALVES: EFFECTS ON IgG UPTAKE AND PREWEANING CALF PERFORMANCE

M.O.C. CLARK, T.C. STAHL AND P.S. ERICKSON

Calving can be a stressful time, especially in calves that experience a difficult birth. When a calf experiences dystocia due to stress and potential hypoxia, immunoglobulin (Ig) absorption can be compromised. The NSAID meloxicam has been shown to improve calf vigor, milk intake, weight gain and health due to its ability to relieve the impacts of diarrhea, inflammation, and stress. However, there were no effects on immunoglobulin uptake (Murray et al., 2015 a, b, c). Therefore, this study evaluated adding meloxicam to a colostrum-based colostrum replacer and dosing them separately.

In this study, 30 newborn Holstein calves (16 bulls and 14 heifers) were immediately removed from their dam at calving and fed a colostral-based colostrum replacer (CR) to provide 180 g of IgG. Calves then were separated into three treatment groups, with 10 calves per treatment. The first treatment group received no meloxicam (C). The second received 1 mg/ 2.2 lb. body weight of meloxicam in pill form before CR feeding (PL). The third had 1 mg/2.2 lb. of body weight of meloxicam added to the CR (S). Blood samples were taken at birth, 6, 12, 18 and 24 hours after birth to evaluate IgG uptake. Beginning on day two, calves received a milk replacer containing 24% CP at 12% solids (1.8 L/ feeding, two feedings per day, 432 g of powder per day). Calf starter was available free-choice along with free-choice water. Calves had milk replacer, starter and water intakes measured daily. Weekly body weights and skeletal measures were taken. The study was ended on day 42 of life.

Meloxicam did not affect IgG uptake at 6, 18, and 24 hours of age, but it reduced IgG uptake at 12 hours compared to the calves that did not receive meloxicam. No other effects were noted for the IgG data on day one of life. Of interest, the PL treatment resulted in longer calves compared to the S calves. Researchers did not

KEY TAKEAWAYS

Calves are the future of a dairy herd. Producers choose bull and dam matings and rely on genomics to help determine which cows to breed to which bulls. However, calves that are sick or born through difficult calvings often do not respond well after birth. Therefore, reducing stress immediately postpartum should improve future calf performance. Meloxicam did not affect IgG uptake at 6, 18 and 24 hours of age, but it reduced IgG uptake at 12 hours compared to the calves that did not receive meloxicam. No other effects were noted for the IgG data on day one of life. Researchers did not observe any effects of meloxicam treatment on body weight, total feed intake or feed efficiency. However, calves provided with meloxicam tended to consume more starter than the calves that did not receive it.

observe any effects of meloxicam treatment on body weight, total feed intake or feed efficiency. However, calves provided with meloxicam tended to consume more starter (1.23 pounds/day (PL) and 1.13 pounds/day (S)) than the calves that did not receive it (1.00 pounds/day (C)).

Supporting this observation, weekly blood ketone concentrations tended to be greater in meloxicam-treated calves (0.16 mmol/L vs. 0.12 mmol/L). Increasing ketone concentration in adequately fed calves is indicative of enhanced rumen development. This is interesting as meloxicam only has a 26-hour half-life in the body. There may have been some other effect of the meloxicam treatment that was not detected in the parameters measured. More research is necessary to determine the long-term effects of meloxicam supplementation in dairy calves.

Meloxicam is not approved for use without a veterinary prescription in U.S. dairy cattle.

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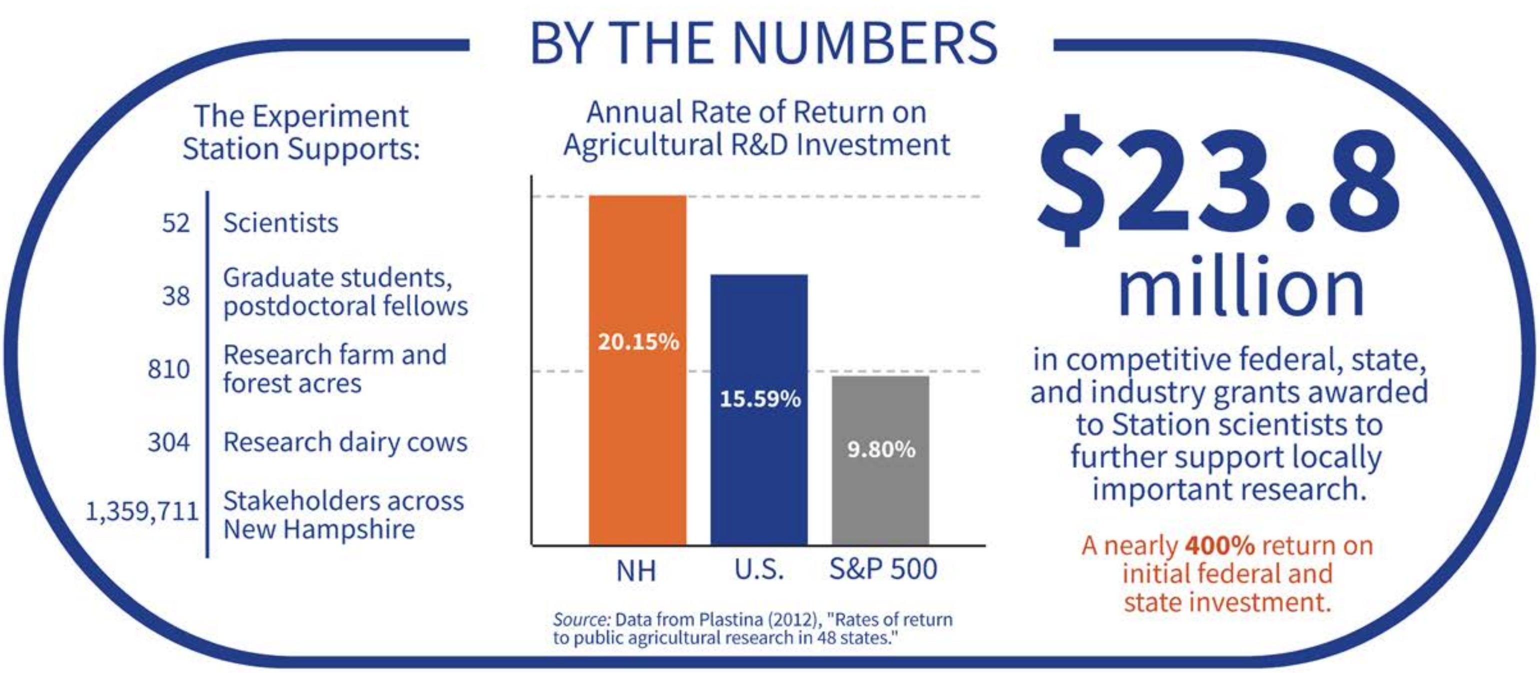

FEEDING SODIUM BUTYRATE TO POST-WEANED REPLACEMENT HEIFERS: EFFECTS ON GROWTH PERFORMANCE AND HEALTH

T.C. STAHL, E. RICE AND P.S. ERICKSON

Raising replacement heifers is one of the largest expenses on the farm. Thus, it is important to closely manage youngstock with adequate nutrition to ensure those animals reach developmental maturity. Performance can be affected through diet manipulation, such as changing the volatile fatty acid proportions in the rumen. Specifically, establishing a well-developed, functional rumen is essential for improving growth performance and feed efficiency.

The proportions of three volatile fatty acids—acetate, propionate, and butyrate—can be altered by feeding additives such as ionophores. Monensin, an ionophore, is approved by the U.S. Food and Drug Administration for growing heifers for improved feed efficiency, increased rate of weight gain, and reduced coccidiosis. However, ionophores have been banned by the European Union since 2006. With that in mind, supplementation research started in young calves focused on sodium butyrate (Górka et al., 2018).

The rumen uses butyrate to increase the absorptive capabilities. Other than the rumen, butyrate also can enhance lower gastrointestinal tract function. It does this by improving the absorptive function, reducing inflammation from coccidiosis and increasing the secretion of juices that aid in the digestion of feeds in the small intestine. There have been two research studies conducted at UNH regarding feeding sodium butyrate to post-weaned heifers. The first experiment was performed after UNH was approached by a company to investigate dosing and how it affects the growth performance and health of these older animals. From that, we took the best dose and compared it to monensin.

Both experiments were at the UNH Fairchild Dairy Teaching and Research Center and used 40 Holstein heifers that began study at approximately three months of age. In the first study, heifers stayed on study for 14 weeks. In the second, heifers stayed on study for 12 weeks. Both trials had four treatments, with 10 heifers per treatment.

KEY TAKEAWAYS

Overall, additive supplementation can help the development of animals post-weaning. If starter intake is lower at weaning, rumen development will be low in these heifers post-weaning. Feeding additives in the post-weaned period helps promote growth and improvement in overall health. Sodium butyrate fed post-weaning helps increase rumen development, thus increasing the absorptive function and aid in the ability for increased nutrient absorption and utilization for growth and health. Scientists found that sodium butyrate is an adequate replacement for monensin in the diets of postweaned heifers for both growth and reduction in coccidiosis. Sodium butyrate could potentially be fed from birth to first calving for increased nutrient use, growth and improved health.

For the first experiment, the best dose of sodium butyrate (SB) was fed to post-weaned heifers. The treatments were: (1) 100 g of soybean meal carrier (control); (2) 0.11 g of SB/lb. of body weight (BW); (3) 0.23 g of SB/lb of BW; (4) 0.34 g of SB/lb. of BW. Feed intake, body weight, skeletal measurements (hip and withers height, heart girth and body length), blood samples (for glucose, BHB and plasma urea nitrogen), and fecal grab samples (for bi-weekly coccidia counts) were taken prior to the start of treatment and then weekly for the duration of the study.

As sodium butyrate increased from 0.11 g/lb. of body weight to 0.34 g/lb. of body weight, average body weight increased, final body weight tended to increase, feed efficiency tended to increase and there was a reduction in coccidia at 0.11 g sodium butyrate/lb. of body weight.

In the second experiment, sodium butyrate (SB) was compared to monensin in the diets of post-weaned heifers. We aimed to see if there were improvements in body weight gain, a reduction of coccidia levels and improvement in dairy heifers when feeding any additive over nothing at all and if there were differences among the additives. The treatments were: (1) 100 g of soybean meal carrier (control); (2) 0.34 g of SB/lb. of BW + carrier (SB); (3) 0.45 mg of monensin/lb. of BW + carrier (MON); (4) 0.45 mg of MON/lb. of BW + 0.34 g SB/lb. of BW (MSB). Feed intake, body weight, skeletal measurements (heart girth, paunch girth and body length), blood samples (for glucose, BHB and plasma urea nitrogen), and fecal grab samples (for coccidia counts) were taken prior to the start of treatment and then weekly before feeding.

Researchers observed a tendency for increased average body weight, final body weight, and heart girth in heifers fed additives. There was a significant response for increased dry matter intake and metabolizable energy, both of which were driven by SB. Due to the additional sodium provided in the diet (by SB), heifers on study likely consumed more water, which ultimately led to an increased rate of passage and increased dry matter intake. An increase in dry matter intake also can be supported by the feed efficiency response seen in monensin fed animals, which is probably due to the size of the dose and the diet fed. In addition to growth benefits, both SB and monensin also have been shown to affect the overall health of the animal through the prevention of coccidiosis. Scientists saw that, as compared to the control, any additive resulted in the reduction of coccidian oocysts and the incidence rate of coccidian oocysts present in the feces. Monensin is a known anticoccidial and acted as expected in the prevention of coccidiosis. Previous work with SB (Rice, 2019) supports the results seen in this study; however it is not currently understood how exactly the SB is able to affect the coccidia.

In summary, the results of the two experiments indicate that:

1. Sodium butyrate supplementation offers positive results in growth performance and feed efficiency of post-weaned heifers.
2. Sodium butyrate could provide a reduction in coccidiosis for improved health.
3. Feeding any additive is better than not feeding any additives.
4. Sodium butyrate is similar to monensin for its effects on growth and reduction in coccidiosis.

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EFFECTS OF INCREMENTAL AMOUNTS OF RED SEAWEED ON MILK PRODUCTION, COMPOSITION AND METHANE EMISSIONS

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N. PRICE, C. QUIGLEY AND A.F. BRITO

Enteric fermentation by ruminants is the largest source of methane emissions in the US (approximately 25% of total methane emissions), corresponding to approximately 2.7% of human activity greenhouse gas emissions. Improving feed efficiency is likely the most effective methane mitigation strategy at the global scale. Recently, algae-based feeds have gained attention because they may be able to not only suppress methane emissions, but also to improve animal feed efficiency. Our objective was to evaluate how incremental increases of the seaweed *Chondrus crispus* affects milk and methane production in organic dairy cows.

KEY TAKEAWAYS

Adding seaweed to diets of dairy cows could have positive milk production and methane emission outcomes. Inclusion of the red seaweed *Chondrus crispus* in the diet of organic cows reduced dry matter intake and methane production linearly without negative effects on milk production and composition. However, the 8.4% reduction in methane production was modest, and the addition of red seaweed did not change methane yield and intensity. Further research is needed with red seaweed and other locally available seaweeds to better understand their impacts on suppressing enteric methane emissions in lactating dairy cows.

There is growing interest in feeding seaweeds to dairy cows because of their effects on methane suppression (Machado et al., 2014) while improving animal health (Antaya et al., 2015). The red seaweed species *Asparagopsis taxiformis* showed up to a 99% reduction in methane emissions (Machado et al., 2014; Kebreab et al., 2019). However, this seaweed species does not grow in colder climates, has been shown to be highly invasive and to produce poor biomass.

Brown seaweed (i.e., kelp meal) is widely available and commonly fed in organic dairies across the US (Hardie et al., 2015; Antaya et al., 2015). However, feeding kelp meal to organic dairy cows during the grazing season had minor effects on suppressing methane emissions. The red seaweed *Chondrus crispus* is available locally and research showed that small amounts (i.e., 0.5% of the diet dry matter) of this species reduced methane emissions by over 12%.

Our research was conducted at the UNH Organic Dairy Research Farm where eighteen mid-lactation organic certified Jersey cows were used in a replicated Latin square design. Cows were blocked by parity and days in milk and, within block, randomly assigned to diet sequences. Cows were fed diets containing (dry matter basis) 0, 3 or 6% *Chondrus crispus*. Each experimental period last 24 days, with 14 days for diets adaptation and 10 days for data and sample collection (total = 72 days). Diets were fed as total mixed rations, with the control treatment (0% *Chondrus crispus*) consisting of (dry matter basis) 65% grass-legume baleage and 35% concentrate mix; baleage was replaced with 3 or 6% C. crispus in the remaining 2 diets. Diets averaged 16% crude protein, 35% neutral detergent fiber, and 19% starch (dry matter basis).

Dry matter intake decreased linearly and quadratically in cows fed incremental amounts of red seaweed (Table 1). However, production of milk, 4% fat-corrected milk, and energy-corrected milk were not affected by diets. Decreased dry matter intake without a change in the production of energy-corrected milk resulted in a tendency to improve feed efficiency linearly with feeding increasing levels of the seaweed. We observed no effects of diets in the percentage and production of milk fat and protein. In contrast, milk urea nitrogen responded quadratically by decreasing from 12.2 to 11.1 mg/dL when comparing the control diet (0% seaweed) with the 3% *Chondrus* diet and went back up to 12.2 mg/dL in cows receiving 6% *Chondrus*. It is not clear why this quadratic response was observed.

Enteric methane production decreased linearly from 383 to 351 g/d in cows fed incremental amounts of seaweed. This 8.4% reduction was likely caused by the observed decrease in dry matter intake due to a positive correlation between feed intake and methane emissions. Contrarily, methane yield and intensity were not affected by differential seaweed diets.

Table 1: Effects of feeding increasing incremental amounts of red seaweed

Product	***Dietary Level of Seaweed***		
	0%	3%	6%
Dry matter intake, lb/day	**43.7**	**41.2**	**40.3**
Milk production, lb/day	41.4	39.7	40.3
4% FCM production, lb/day	50.5	48.5	49.6
ECM production, lb/day	54.7	52.0	53.4
Feed efficiency (ECM/DMI)	1.28	1.31	1.37
Milk fat, %	5.48	5.41	5.63
Milk fat, lb/day	2.25	2.18	2.25
Milk protein, %	3.72	3.55	3.65
Milk protein, lb/day	1.52	1.46	1.46
Milk urea N, mg/dL	**12.2**	**11.1**	**12.2**
Methane production, g/d	**383**	**352**	**351**
Methane yield, g/kg of DMI	19.7	19.6	19.7
Methane intensity, g/kg of ECM	15.7	15.2	14.6

Notes: Bolded values indicate statistically significant difference at a 5% or less for linear and/or quadratic effects.

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MILK PRODUCTION AND METHANE EMISSIONS IN ORGANIC COWS THAT GRAZE FORAGE CANOLA DURING FALL

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Focus group interviews and surveys indicate that profitable strategies to maximize forage utilization are challenging to 75% of organic dairy farmers. Moreover, there continue to be knowledge gaps about optimal annual species or rotations for milk production and farm profitability. Forage canola seems to be an excellent candidate to be tested in grazing studies because it led to the highest N use efficiency in cows and ability to mitigate methane emissions in lactating dairy cows. Our objective was to investigate how grazing forage canola affected milk production, milk composition, nutrient digestibility and enteric methane emissions during the fall season.

Brassicas, which collectively include turnip, swede, rapeseed, kale, canola, among others, have emerged as promising annual crops for grazing because of their high productivity, digestibility, nutritional value (>20% crude protein; Dillard et al., 2018), winter hardiness, and decreased enteric methane emissions in sheep (Sun et al., 2012). Brassicas can also extend the grazing season during the fall, thus offering a unique opportunity for dairy farmers to capitalize on cheaper high-forage diets.

However, forage-based diets have been shown to result in greater methane emission intensity than typical total mixed rations (TMR) fed across the United States (Hristov et al., 2013). Enteric fermentation is the largest source of human derived methane emissions in the country, accounting for approximately 25% of the total (EPA, 2019). Recently, a rumen-simulated in vitro study done at the USDA ARS Pasture Lab in Pennsylvania showed up to an 84% reduction in methane emissions when using canola, rapeseed, and turnip brassicas in feed (Dillard et al., 2018).

Our research was conducted at the UNH Organic Dairy Research Farm where twenty organic Jersey cows were paired by parity, milk production, or days in milk and, within pair, randomly assigned to a control (CTRL) or a forage canola (CAN) diet in a randomized

KEY TAKEAWAYS

The growing season in the northeast United States is relatively short and characterized by periods of low forage biomass production during early spring, mid-summer, and late fall. Therefore, opportunities exist to fill gaps in forage productivity by growing nutritious, high yielding annual crops such as brassicas. Our study showed that forage canola resulted in high biomass production and exceptional nutritive value, thus emerging as an attractive option for dairy farmers in the region. We also showed substantial reduction in enteric methane emissions in cows grazing forage canola, with marginal reduction in milk production and milk fat.

complete block design. Cows in the CTRL group (n = 10) were kept in the barn all day long and were fed TMR, while CAN cows (n = 10) stayed in the barn during the day receiving a TMR and had access to canola pasture from 6 p.m. to 5 a.m. next day. Diets were formulated to contain (dry matter basis) a 60:40 forage:concentrate ratio. In the canola diet, 67% of the TMR baleage was replaced by grazed canola resulting in approximately 40% of canola in the total ration dry matter. The experiment lasted seven weeks, with the first two weeks used for baseline data collection (all cows received the same TMR) followed by five weeks of measurements with sample collection during weeks three and five. Two forage canola fields were established and cows grazed within a strip grazing management. A fresh strip of forage canola pasture was offered daily immediately after the pm milking for cows assigned to the canola diet.

Forage canola mass yield averaged 6,016 lb/acre and had a nutritional value averaging (dry matter basis) 24.1% crude protein, 16.6% neutral detergent fiber, 2.6% starch, and 17.7% total sugars. These results indicate that forage canola is an excellent feed source.

As expected, intake of TMR was 53% greater in cows assigned to the control diet compared with those assigned to the CAN diet (Table 1). Intake of forage canola via grazing averaged 14.2 lb. Diets did not affect intake of pellet grain and total dry matter intake. Milk production and 4% fat-corrected milk production indicated some tendency to increase in control cows, which may be explained by decreased digestibility of neutral detergent fiber in cows grazing forage canola. Milk fat yield tended to be lower in cows fed canola, but milk protein percentage was greater, likely caused by a dilution effect.

Table 1: Effect of feeding a total mixed ration indoors (Control) or partially replacing grazed forage canola

Product	***Control***	***Canola***
Total mixed ration intake, lb/day	**44.1**	28.8
Forage canola intake, lb/day	–	14.2
Pellet intake, lb/day	2.81	2.40
Total dry matter intake, lb/day	47.0	45.3
Milk production, lb/day	46.6	44.3
4% fat-corrected milk, lb/day	54.6	50.9
Energy-corrected milk, lb/day	59.0	55.8
Milk fat, %	5.24	5.09
Milk fat, lb/day	2.39	2.22
Milk protein, %	3.88	**4.03**
Milk protein, lb/day	1.75	1.75
Milk urea N, mg/dL	13.7	13.8
Dry matter digestibility, %	67.3	**70.6**
NDF digestibility, %	**47.0**	41.3
Methane production, g/d	**436**	295
Methane yield, g/kg of DMI	**20.0**	14.1
Methane intensity, g//kg of ECM	**16.0**	11.5

Notes: Bolded values indicate statistically significant difference at a 5% or less.

Enteric methane production, yield and intensity decreased by 32%, 30%, and 28%, respectively, in canola diets. These reductions were likely due to the presence of glucosinolates in forage canola, which have been shown to be negatively correlated with methane production in the rumen. Canola fed cows also had a greater rumen proportion of propionate, known to be a hydrogen sink resulting in less substrate for methanogenesis in the

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FEEDING WET BREWERS' GRAINS TO HEIFERS

E. HATUNGIMANA, T.S. STAHL AND P.S. ERICKSON

For many years, it has been a common practice to feed wet brewers' grains (WBG) to dairy cows, but no data were available indicating how to feed it to post-weaned heifers. Therefore, researchers conducted three experiments: 1) evaluate use in limit fed heifer diets with various amounts of salt added as a preservative; 2) evaluate storage properties and their effects on nutrient digestibility; and 3) evaluate use as a total replacement for corn meal and soybean meal. Wet brewers' grains have a propensity to spoil. Therefore, this research determined how preservation can be increased and whether there are positive or negative effects on performance as compared to heifers fed a conventional diet.

In experiment 1, scientists evaluated a preservative or salt and evaluated how it impacted mold and yeast counts nutrient changes and nutrient along with digestibility. This brief will focus only on the salt treatment. For the study, researchers evaluated 8 tubs of fresh WBG, with 107 pounds of WBG per tub. In duplicate, they added and mixed either 0, 1.4%, 2.6% or 3.8% salt. Tubs were kept under cover with temperatures ranging from 55^{0}F to 58^{0}F. Tubs were stored for 28 days with samples taken every other day for mold and yeast counts. Samples also were taken every seven days for analysis of laboratory nutrient digestibility using rumen fluid in an artificial rumen. Using three ruminally cannulated cows, researchers evaluated dry matter, neutral detergent fiber, acid detergent fiber and protein digestibilities from dacron bags suspended in the rumen. Results indicated that adding 3.8% salt to the WBG reduced mold counts. Salts also increased in vitro digestibility (artificial rumen) and great protein digestibility when evaluating rumen and intestinal digestibility.

In experiment 2, WBG was stored with 0, 0.8%, 1.6% or 2.4% salt for four days. The objective of this experiment was to evaluate the

KEY TAKEAWAYS

Wet brewers' grain can spoil fairly easily, especially during the warm summer months. Adding an inexpensive preservative such as salt can reduce the chance of mold formation, decrease spoilage loss, and ultimately improve animal performance. Although New Hampshire is in a grain deficit area, there are close to 100 breweries in the state. Adding up to 2.4% salt to WBG can reduce mold counts and spoilage while replacing corn and soybean meal up to 20% of the dry matter, saving $0.19 per pound of gain in growing heifers. Thus, this co-product is readily available at inexpensive prices and can be used in heifer diets to replace the more costly corn and soybean meal. Recommendations from this work are to work with your nutritionist to make sure that salt is not overfed.

effects of salt treatment on total tract nutrient digestibility and rumen microbial protein synthesis. Heifers were fed the diets for 21 days with the last 7 days for the collection of data. The study was designed as a replicated 4 × 4 Latin square using eight, limit-fed, 8-month-old heifers. The diet was balanced for 5.00 Mcal/lb. metabolizable energy and 14% CP on a dry basis. This experimental design dictates that each animal receives each treatment for one 21-day period. Yeast and mold counts along with storage loss were estimated over 11 days. Yeast counts did not vary among treatments, while mold counts tended to be lower for the 0.8 and 1.6% salt treatments. There were trends for reduced nutrient digestibilities as salt increased, but storage loss was reduced—the highest storage loss was with the 0.8% salt treatment (11.02%) while the lowest loss was with the 2.4% treatment (5.12%). There was a trend for increased purine derivative secretion for the 0.8% and 1.6% salt treatments. Purine derivatives were present in the urine and are indicative of rumen bacteria synthesis. Therefore, rumen bacteria populations would have increased with the presence of 0.8 and 1.6% salt. While not the primary purpose of the study, average daily gain and feed efficiency improved as salt inclusion increased. General conclusions are that the addition and mixing of salt up to 2.4% in the WBG improved storage life and performance in limit-fed 8-month-old heifers.

In experiment 3, researchers evaluated replacing corn meal and soybean meal-based energy and protein mixes with either 10 or 20% WBG on a dry matter basis. The objective was to determine if conventionally raised yearling heifers could perform as well as heifers raised on a corn/soybean meal-based diet. We used 30 yearling heifers (10 per treatment) fed one of the aforementioned treatments. Diets were limit-fed at 5.00 Mcal/lb. of metabolizable energy, and 15% CP on a dry matter basis. Diets were fed for 12 weeks with the total tract nutrient digestibility determined during week 12. Body weights and skeletal measures were taken every two weeks. There were no statistical differences among treatment groups on dry matter intake, body weight, or average daily gain. With dry matter intakes ranging from 19 pounds to 19.8 pounds/day, average body weight ranged from 892, 907, and 902.5 pounds, and average daily gain was 2.27, 2.29, and 2.12 pounds per day for 0%, 10%, and 20% WBG respectively. Digestibilities varied somewhat and were similar for the 0 and 20% WBG treatments. Dry matter intake tended to be greater during the digestibility phase for the 10% WBG treatment resulting in a greater rate of passage through the gut thus reducing digestibilities.

From an economic standpoint, the costs of the energy mix (corn meal based) and protein mix (soybean meal based) were $228.57 and $351.02 per ton (dry basis) respectively. The WBG cost was $172.34 (dry basis) per ton. Therefore, adjusting for corn and soybean meal prices, the costs per pound of dry matter were $0.11, $0.10, and $0.09 for the 0, 10% and 20% WBG, respectively. The cost /gain was $1.00, $0.86 and $0.81 for the 0, 10% and 20% WBG, respectively.

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ALFALFA-GRASS OR RED CLOVER-GRASS: EFFECTS ON MILK PRODUCTION, COMPOSITION, NITROGEN AND ENERGY UTILIZATION

A.F. BRITO ET AL.

Research has shown that dairy cows fed legume silages consumed more dry matter (DM) and produced more milk than those receiving grass silages. However, across northeastern U.S. dairies, legumes only contributed to 26% of grazed forage. Research to improve legume persistence while closing knowledge gaps about which legume-grass mixtures are best suitable for producing profitable milk (i.e., higher butterfat and protein) is needed to make organic and conventional dairies in New England more competitive in the long run.

Alfalfa has become the "gold standard" for production of silage, baleage, and hay in the United States, but a large proportion of alfalfa protein is broken down to non-protein N (i.e., ammonia, amino acids, and peptides) during ensiling, thus reducing the efficiency of protein utilization when cows are fed alfalfa silage.

In contrast, protein from red clover is protected against degradation in the silo due to the presence of the enzyme polyphenol oxidase in red clover tissues. Previous research demonstrated that red clover silage was comparable to alfalfa silage in terms of DM intake, milk production, and percentage of milk fat (Johansen et al., 2018). Cows fed red clover silage had lower concentrations of milk urea N (MUN) and excreted less N than those fed alfalfa silage (Broderick et al., 2007), thus showing improved use of dietary protein with red clover.

Our research compared the effects of alfalfa- and red clover-grass mixtures on feed intake, milk production and composition, and dietary utilization of N and energy in dairy cows. The work was conducted the UNH Organic Dairy Research Farm, where twenty mid-lactation organic certified Jersey cows were assigned to one of two diets in a randomized complete block design.

KEY TAKEAWAYS

Cows fed alfalfa-grass produced more 4% fat-corrected milk, energy-corrected milk, and milk fat than cows fed red clover-grass. However, feeding red clover-grass decreased milk urea N, indicating that red clover-based diets may be more environmentally friendly. Red clover-grass also produced milk with a healthier fatty profile for human consumption compared with cows fed alfalfa-grass. Although, red clover-grass decreased enteric methane production, this was not consistent over time. Partially replacing red clover-grass baleage with alfalfa/white clover-grass reduced dry matter intake, but dry matter digestibility, organic matter, net energy of lactation were lower. However, cows fed red clover-grass did not produce more milk or milk fat and protein than those fed an alfalfa/white clover-grass mixture.

Study 1: Full diet adjustment for red clover-grass

M.J. LANGE, L.H.P. SILVA, M. GHELICHKHAN, A. ZAMBOM AND A.F. BRITO

Two fields were planted with alfalfa- or red clover-grass mixture with a 79:14:7 legume:meadow fescue:timothy seeding rate (% total) in 2017. Second- and third-cut legume-grass mixtures used in this study were harvested as baleage in 2018. The botanical composition (DM basis) of fields from which second cut alfalfa- or red clover-grass averaged: 65 vs. 80% legumes, 17 vs. 15% grasses, and 18 vs. 5% weeds, respectively. Third cut alfalfa- or red clover-grass mixture botanical composition (DM basis) averaged 84 vs. 96.5% legume, 3 vs. 2.3% grasses, and 13 vs. 1.2% weeds, respectively. Diets were fed as total mixed ration and contained (DM basis): 65% second- and third-cut alfalfa or red clover-grass (32.5% of each cut) baleage and 35% of a ground corn-soybean meal-based mash concentrate. The study lasted seven weeks, with sample collection done at weeks four and seven. Diets averaged 18.7 vs. 18% crude protein and 30 vs. 31% neutral detergent fiber for alfalfa- vs. red clover-grass mixtures, respectively.

Diets did not affect DM intake, production of milk and milk protein, and percentages of milk fat and protein (Table 1). Production of 4% fat-corrected milk increased in cows fed alfalfa- vs. red clover-grass, while production of energy-corrected milk and milk fat tended to increase with feeding alfalfa-grass. Cows fed red clover-grass had lower MUN than those receiving red alfalfa-grass, indicating improved utilization of dietary protein. Milk proportion of α-linolenic acid, which is the major omega-3 fatty acid present in milk fat, was greater in cows fed red clover-grass than alfalfa-grass diet. Likewise, milk proportion of total omega-3 fatty acids increased with feeding red clover-grass vs. alfalfa-grass. In addition, the omega-6/omega-3 ratio was lower with feeding red clover-grass compared with alfalfa-grass diet.

Table 1: Effect of feeding diets containing alfalfa-grass or red clover-grass mixture

Product	*Alfalfa-grass*	*Red clover-grass*
Dry matter intake, lb/day	45.2	46.3
Milk production, lb/day	47.8	46.5
4% fat-corrected milk, lb/day	**60.4**	57.5
Energy-corrected milk, lb/day	61.9	58.2
Milk fat, %	5.48	5.30
Milk fat, lb/day	2.62	2.43
Milk protein, %	3.70	3.63
Milk protein, lb/day	1.74	1.68
MUN, mg/dL	**13.1**	10.2
Milk α-linolenic acid, %	**0.64**	0.85
Milk omega-3 fatty acids, %	**0.70**	0.94
Milk omega-6/omega-3 ratio	**3.13**	2.62

Notes: Bolded values indicate statistically significant difference at a 5% or less.

Our results showed that plasma methionine, lysine and isoleucine did not differ between diets. However, even though production of milk protein was not affected by diets, red clover-grass appears to be more effective than alfalfa-grass to increase plasma concentration of essential amino acids. We also observed an interaction between diet and sampling week for methane production. Cows fed red clover-grass had lower methane emissions than cows fed the alfalfa-grass in week four of the study, but no difference was observed when measurements were taken on week 7. Methane yield and methane intensity were not affected by diets.

Study 2: Partial replacement of red clover-grass mixture with an alfalfa/white clover-grass mixture

J.P. SACRAMENTO, L.H.P. SILVA, D.C. REYES, Y. GENG AND A.F. BRITO

Two fields were planted with alfalfa- or red clover-grass mixture with a 79:14:7 legume:meadow fescue:timothy seeding rate (% total) in 2017. Second- and third-cut legume-grass mixture used in this study were harvested as baleage in 2019. The botanical composition (DM basis) of fields from which the second and third cut red clover-grass averaged: 75 vs. 62% red clover, 4 vs. 11% grasses, and 21 vs. 10% weeds, respectively. Note that 17% (DM basis) of white clover was present in the red clover-grass field from the third cut. The botanical composition of the second cut alfalfa-grass field harvested as baleage averaged (DM basis): 40% alfalfa, 2% red clover, 26% white clover, 9% grass and 23% weeds. Compared with 2018, the botanical composition of the alfalfa-grass field changed, with some alfalfa being replaced by white clover due to alfalfa winter kill. Diets were fed as total mixed ration and contained (DM basis): (1) 60% second and third cut red clover-grass baleage (30% of each cut) and 40% of a ground corn-soybean meal-based mash concentrate (high red clover-grass mixture diet = HRC-M), and (2) 30% second and third cut red clover-grass baleage (15% of each cut), 30% second cut alfalfa/white clover-grass baleage and 40% of a ground corn-soybean meal-based mash concentrate (low red clover-grass mixture diet = LRC-M) Diets averaged 17.8 vs. 17.2% crude protein and 31.7 vs. 31.3% neutral detergent fiber (NDF) for HRC-M vs. LRC-M, respectively.

Cows fed the HRC-M diet had greater DMI than those receiving the LRC-M diet (Table 2). However, milk production did not differ between diets. Likewise, production of 4% fat-corrected milk and energy-corrected milk were not impacted by either feeding HRC-M or LRC-M. Milk fat percentage increased, and milk protein tended to increase in cows fed the LRC-M diet possibly caused by a dilution effect due to a 0.9-lb numerical reduction in milk production. The concentration of plasma urea N was lower with feeding HRC-M, perhaps due to red clover containing the enzyme polyphenol oxidase that acts to reduce the breakdown of protein during ensilage. The observed drop in the plasma concentration of urea N with the HRC-M diet suggests improved N use efficiency, but the fact the MUN concentration was not changed indicates that the response was not consistent.

Table 2: Effect of feeding diets containing high red clover (HRC) and alfalfa/white clover-grass (LRC) mixtures

Product	HRC-M	LRC-M
Dry matter intake, lb/day	**46.3**	45.0
Milk production, lb/day	47.0	46.1
4% fat corrected milk, lb/day	55.1	55.8
Energy corrected milk, lb/day	59.7	60.2
Milk fat, %	5.21	**5.46**
Milk fat, lb/day	2.43	2.49
Milk protein, %	3.66	3.71
Milk protein, lb/day	1.70	1.70
Milk urea N, mg/dL	11.7	12.3
Plasma urea N, mg/dL	15.6	**17.0**
DM digestibility, %	**68.4**	64.0
Organic matter digestibility, %	**70.4**	66.0
NDF digestibility, %	**47.9**	39.7
Crude protein digestibility, %	60.9	57.8
Methane, g/d	389	397
Methane yield, g/kg of DMI	18.8	**19.6**
Methane intensity, g/kg of ECM	14.5	14.8
NEL intake, Mcal/day	**29.7**	25.8

Notes: Bolded values indicate statistically significant difference at a 5% or less.

The apparent total-tract digestibility of DM, organic matter and neutral digestible fiber (NDF) increased, and that of crude protein tended to increase in cows fed HRC-M versus LRC-M. Increased digestibility with the HRC-M resulted in improved intake of net energy of lactation (NEL). However, milk production was not significantly changed, suggesting that additional dietary NEL intake was not used to produce milk. Methane yield was lower in the HRC-M vs. LRC-M diet because of decreased DM intake in cows fed the HRC-M diet. In contrast, methane intensity did not change.

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