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Pasture quality and nutrient requirements of dairy cows

Feeding strategy and pasture quality relative to nutrient requirements of dairy cows in the northeastern U.S.

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ABSTRACT

Pasture samples (n = 380) collected during the grazing season on 14 dairy farms from 2012 to 2014 were analyzed for nutritional composition to determine the frequency of pasture samples that met minimum NE_l, CP, and macro-mineral requirements according to the NRC (2001) model for Holstein and Jersey cows (milk production of 25 kg/d). The Large Ruminant Nutrition System model was used to evaluate feeding strategies that accompanied grazing. If pasture was the only dietary component, energy was limiting, as 36 and 86% of pastures failed to meet minimum NE_l requirements for Holstein and Jersey cows, respectively. On average, pasture samples lacking in energy contained only 88% of NE_l required for either breed. Nine and 21% of pastures did not meet the minimum CP requirements, while Ca, P, and S did not meet minimum NRC requirements in 31 and 22, 19 and 26, and 11 and 7% of samples, for Holstein and Jersey cows, respectively. Magnesium and K in pastures sampled were 56 and 1017% in excess of dietary requirements, respectively. Farms were categorized as having low, moderate, or high conserved feed input (**LC, MC, HC**). Milk production was numerically lowest for LC farms, (16.8 kg/d) and greater for MC and HC farms (20.0 and 21.3 kg/d, respectively). Average DMI from pasture was 90%, 46%, and 26% for LC, MC, and HC farms, respectively. Overall, forage quality of pastures was high. Varying feeding strategies allow farmers to use resources such as pasture, homegrown forages, and concentrates to meet individual production goals.

Keywords: dairy, grazing, pasture quality

INTRODUCTION

The number of dairies practicing a significant level of grazing in the U.S. has been on the rise within the last 10 years, particularly in the northeastern U.S. A survey of 987 northeastern dairy farmers found that 20% of Vermont farms, 7% of Pennsylvania farms, and 11% of New York and Maryland farms used management-intensive or rotational grazing prior to 2010 (Winsten et al., 2010). A report from University of Wisconsin-Madison found in 2002 that 44% of WI dairy farms feed some level of pasture to lactating to cows, with 23% of WI dairies practicing managed intensive grazing (Taylor and Foltz, 2006). As some dairy farmers look to utilize pasture as a significant source of nutrients for lactating cows, it is important to understand the nutritive quality of pasture relative to cow requirements. Limited research from 15 years ago in Pennsylvania showed that energy is the most limiting dietary component for high-producing lactating dairy cows in grazing systems (Kolver and Muller, 1998; Bargo et al., 2002). However, forages, environment and management have significantly changed since then, and may be different in different parts of the northeastern U.S. Soder and Stout (2003) concluded that forage testing is necessary to ensure proper mineral nutrition of grazing livestock as forage mineral concentrations varied greatly on farms in Pennsylvania. However, only a minority of grazing farms forage test their pastures (Soder and Muller, 2007).

Feeding strategies accompanying grazing on dairy farms in the northeastern U.S. vary greatly as these systems range from pasture as the sole source of nutrients to pasture only as a supplemental source of nutrients to other feeds. Supplementation of grazing with concentrates or part-time grazing coupled with conserved forages have been cited as strategies to allow lactating dairy cows to satisfy energy requirements and maintain performance but also benefit from access to pasture (Peyraud and Delagarde, 2011). Much of the current information regarding supplementation of grazing dairy cows compare organic and conventional systems; however, little information is available evaluating current common feeding strategies that accompany grazing on organic dairy farms.

The objectives of this study were to determine how frequently pastures in the northeastern U.S. met minimum energy, protein, and macro-mineral requirements of lactating dairy cows and to describe a sample of the feeding strategies accompanying grazing on these farms utilizing grazing as a significant source of feed.

METHODS AND MATERIALS

Fourteen certified organic dairy farms (3 in Pennsylvania, 3 in New York, 3 in Vermont, 3 in Maine, and 2 in New Hampshire) participated in this study during the grazing seasons of 2012, 2013 and 2014 (Table 1). At the initiation of the study in the spring of 2012, the farmers were surveyed to describe their farms and management practices.

Farm visits occurred twice monthly during each grazing season of each sample year, except on the Vermont farms, where farm visits occurred weekly. As expected, the duration of the grazing season varied by farm and region. In Maine, the grazing season lasted from June 14 to October 25, in New Hampshire from May 30 to October 11, in Vermont from May 15 to October 31, in New York from May 2 to October 15, and in Pennsylvania from May 5 to November 16. Data collection during each farm visit included pasture samples and samples of any conserved feeds (concentrates and forages) being fed. At each visit, fifteen plant biomass samples were collected from the pasture by clipping a 15 x 100 cm sward at ground level to determine quality of available forage. The pasture samples and conserved feeds from each farm were dried in a forced-air oven for 48 h at 60^{o}C. Pasture samples were composited by farm visit. Pasture samples and conserved feeds were ground before shipment to an independent laboratory for nutrient analysis (Dairy One Forage Analysis Laboratory, Ithaca, NY) including CP, ADF, NDF, NE_l, Ca, P, Mg, K, and S. Additionally, during each visit, farmers were surveyed about their grazing management, current feeding strategies and quantities of conserved feeds being fed in addition to grazing, and milk production and components. When reliable data for milk production and components were not available from the farmer, Dairy Herd Information Association (http://www.dhia.org) data from a sample date not exceeding 7 days from the farm visit was used. At the initiation of the grazing season, body condition score (Wildman et al., 1982) and body weights (Weight-By-Breed Tape, Nasco, Fort Atkinson WI) were recorded at 60-day intervals on 20% of the total milking herd or 20 cows, whichever number was larger.

The MIXED procedure of SAS (SAS Inc., Cary, NC) was used to test effect of year of sampling, month of sampling, and farm on CP, ADF, NDF, NE_l, Ca, P, Mg, K, and S. Least square means are presented and differences considered significant at $P < 0.05$. Frequency analysis was used to determine the proportions of pasture samples that met minimum energy, CP and macro-mineral requirements, according to the Dairy NRC (2001) for a 680 kg Holstein producing 25 kg milk/day, DMI of 20.3 kg/day with 3.5% milk fat and 3.0% milk protein and a 454 kg Jersey producing 25 kg milk/day, DMI of 18.0 kg/day with 4.2% milk fat and 3.6% milk protein. While 25 kg/d would typically be considered higher than normal for grazing herds, the example in the Dairy NRC for Holstein and Jersey cows, which was complete with energy, protein, and macro-mineral requirements, was the lowest milk production available in the NRC (2001). The example for both breeds included cow and environmental parameters of a BCS of 3.0, age of 65 months, tie stall housing, and consumption of a TMR.

One year was chosen to use as a snapshot to describe feeding strategies on grazing dairy farms. Since 2013 had the most complete data set for the individual farm parameters, it was used to evaluate the feeding strategies that accompany grazing. The nutrient concentrations of pastures and conserved feeds were compiled for each farm and values were entered into The Large Ruminant Nutrition System model version 1.0.32 (Cornell University; **LRNS**). The LRNS ration evaluation program uses the Cornell Net Carbohydrate and Protein System model version 5.0.40 to model ruminant diets under specific parameters such as environmental conditions, animal type, and nutrient parameters of feeds. Nutrient concentrations of pastures for each farm were averaged across the grazing season to form a snapshot of pasture quality in 2013. Additionally, nutrient concentrations and feed quantities of each feed ingredient used (if any) were averaged together for the same period of time to form a snapshot of nutrient concentration and quantity of conserved feeds used in addition to grazing in 2013. Finally, milk yield, % milk fat, % milk protein, BCS, and cow BW data were averaged across the 2013 grazing season and entered into the LRNS model. The LRNS was used to model total DMI and DMI from pasture (by difference) using parameters specific to each farm. For discussion purposes, the farms were classified into 3 categories by level of conserved feeds used during the grazing season. The 3 categories included low conserved feed farms (< 30% diet DM not from pasture; LC), farms with moderate conserved feed input (> 30% and < 60% of diet DM not from pasture; MC), and farms with high conserved feed input (> 60% of diet DM not from pasture; HC).

RESULTS AND DISCUSSION

General Farm Information

The number of milking cows on each farm ranged from 12 to 66 (mean = 44). Holstein-

Jersey crossbred, Holstein, and Jersey were the 3 predominant breeds used on the farms in this study, however Dutch Belted, Milking Shorthorn, Ayrshire, Guernsey and Brown Swiss cows were represented in smaller numbers, mostly as cross-bred cows. Milk production during the grazing seasons averaged 19.5 kg and ranged from 11.3 to 29.7 kg across all farms. Furthermore, milk fat % averaged 3.97% and ranged from 3.23 to 4.63%. Milk protein averaged 3.14% and ranged from 2.85 to 3.44%, across all farms.

Farmers participating in this study reported owning an average of 85 total ha of land (ranging from 0 to 306 ha) with 1 farm renting all land. All farmers, except 2, reported renting some additional land, with an average of 53 ha rented (ranging from 16 to 121 ha for farms using rented land). On average, farmers reported using management intensive grazing for 14 years (ranging from 2 to 30 years).

The farmers indicated that grasses made up the majority of the grazing species (67%) within pastures used for grazing. Grass species included orchard-grass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), timothy (*Phleum pretense* L.), Kentucky-blue grass (*Poa pratensis* L.), tall fescue (*Festuca arundinacea* S.), and festulolium (*Festulolium* spp.). Clovers made up approximately 26% of the grazing species within the pastures, including red clover (*Trifolium pretense* L.) and white clover (*Trifolium repens* L.).

Nutrient Composition of Pastures

Summary statistics of forage quality and macro-mineral concentration and the effect of year, month, and farm of forage quality and macro-mineral concentration found in pastures from 2012-2014 are presented in Table 2. Overall, pasture quality was moderate to high (Bargo et al., 2003) and reflected the typical wide variation in pasture quality frequently seen across the farms and throughout the grazing season. It is well established that pasture nutritive quality decreases as plants mature (Buxton, 1996). As expected, overall CP and NE_l declined and NDF and ADF increased with the advancing grazing season in 2013 ($P < 0.01$ for all variables; month by month data not shown). Mean CP (19.5%), NDF (51.0%), ADF (31.4%) and energy (NE_l, 1.39 Mcal/kg) values are within range of previous data reported from studies evaluating pasture quality in areas of the northeastern U.S. under various grazing practices (Soder and Muller 2007; Sanderson, 2010; Hafla et al., 2014).

Crude protein, fiber (NDF and ADF), energy (NE_l) and macro-mineral recommendations for lactating dairy cows and the frequency in which pastures did not meet the minimum dietary requirements are presented in Table 3. Intensively managed pastures in the northeastern U.S. are typically high in CP (Soder and Muller 2007; Sanderson, 2010; Hafla et al., 2014), and as expected, the majority of pasture samples met or exceeded minimum CP requirements for lactating Holstein and Jersey cows (90.8 and 79.2% in excess of CP requirements, respectively). Unsurprisingly, energy was observed to be a significantly limiting nutritional component, with 35.5 and 85.8% of pasture samples evaluated failing to meet the minimum energy requirements of lactating Holstein and Jersey cows, respectively. On average, the pastures found to be lacking in energy only provided 88% of NE_l required for both breeds, while up to 121% of CP was provided. In addition to the observation of low energy concentration of many of the pasture samples, it is important to note that DMI is the central driver to overall nutrient (including ME) intake. Kolver and Muller (1998) reported that compared with cows consuming a TMR, cows grazing high quality pasture had lower DMI (23.4 vs. 19.0 kg/d) and produced less milk (44.1 vs. 29.6 kg/d). Furthermore, the authors estimated that 61% of the reduced milk production of the grazing cows could be explained by lower DMI and subsequently decreased total ME intake, despite the high energy value of the pasture used in the study (NE_l of 1.65 Mcal/kg). Bargo et al. (2003) suggested that supplementing lactating dairy cows in a grazing system is intended to increase total DMI and subsequently ME intake relative to what would be consumed from a pasture-only diet, allowing cows to come closer to their genetic potential regarding milk production.

Of the macro-minerals, Ca, P, and S were found to be limited in the pasture samples, while K and Mg were rarely deficient. Calcium and P failed to meet minimum requirements of lactating Holstein cows in 30.8 and 19.2% of pasture samples and of lactating Jersey cows in 22.1 and 26.1% of pasture samples. Calcium concentration of northeastern U.S. pastures have been found to be inadequate for lactating dairy cows in relation to NRC (2001) recommendations in previous studies (Stout et al., 1977; Soder and Stout, 2003). Calcium content in pasture forages is depend on soil type, fertilization and plant species composition, with legumes typically containing greater Ca concentrations compared to grass species. Furthermore, Soder and Stout (2003) found that P concentrations in forages in Pennsylvania were generally adequate for a lactating dairy cow producing 35 kg milk/d, while others have reported forage P to be generally inadequate for lactating dairy cows (Stout et al., 1977). Phosphorus has more known biological functions than any other mineral and is critical in energy transactions, acid-base buffering, cell differentiation, and an essential component in cell wall contents (NRC, 2001), therefore providing adequate phosphorus relative to animal requirements is vital to optimizing milk production.

Sulfur was marginally deficient, with only 11.1 and 6.58% of pasture samples failing to meet minimal NRC recommendations for lactating Holstein and Jersey cows, respectively. Magnesium failed to meet requirements for lactating dairy cows in only 2.9% of pasture samples tested, while K was found to be excessive relative to animal requirements. Average concentrations of Mg and K in pastures sampled were in excess of 56 and 1017% of dietary requirements. Increases in forage K and decreases in forage Ca and Mg have been reported with increasing dairy slurry application to grazing lands, which is a common practice on many northeastern U.S. dairy farms (Soder and Stout, 2003). Excessive K relative to marginal Mg and Ca (often observed in lush spring pasture growth) are of importance to dairy farmers as this combination may predispose lactating cows to metabolic challenges. Grass tetany (hypomagnesemia) and milk fever (hypocalcemia) may occur when excess K concentrations in forages result in antagonisms with the availability and resorption of Mg and Ca, respectively (Van Soest, 1994; Goff and Horst, 1997; Ball et al., 2007). However, Hardeng and Edge (2001) noted that the lower milk production typically observed in grazing herds resulted in reduced metabolic strain (reduced Ca depletion) compared to non-grazing herds resulting in less incidences of milk fever than may be expected, based on the K concentration of the forage consumed.

Feeding Strategies during the Grazing Season

Results of the LRNS model output for feeding strategies that accompanied grazing on each farm for the grazing season of 2013 are presented in Table 4. For numeric comparison, farms were classified into 3 groups based on the average percentage of conserved feed used in the diet during the grazing season. Conserved feed included the total of any conserved or fermented forages (corn silage, haylage, baleage, dry hay) and grains and grain mixes (corn, wheat, barley, spelt, soybeans, roasted soybeans). No macro- or trace-mineral intakes were considered due to lack of sampling and records for these components. Four farms used a low level of conserved feeds during the 2013 grazing, 5 farms had moderate conserved feed input, and 5 farms had high conserved feed input. Of the 4 LC farms, 2 provided forage-only to lactating cows and used no concentrates at any point during the year (Farms 3 and 14). Two farms in this study used a pTMR (partial TMR) during the grazing season, and used moderate (Farm 9) and high (Farm 4) amounts of total conserved feeds during the 2013 grazing season. The remaining 10 farms used a combination of concentrate mixes and conserved forages throughout the grazing season.

In 2010 the USDA-National Organic Program (USDA-NOP) implemented the "Pasture Rule", requiring that ruminant livestock raised as certified organic obtain a minimum of 30% of dry matter intake from pasture or rangeland for a minimum of 120 days each year (Rinehart and Baier, 2011). As such, all farms in this study were required to rely on a significant amount of DMI from pasture during the grazing season, despite variations in feeding strategies. On average during the grazing season, LC farms provided 10% of diet DM in the form of conserved feeds (90% of diet was pasture), MC farms provided 54% of diet DM from conserved feeds (46% of diet was pasture), and HC farms provided 74% of diet DM from conserved feeds (26% of diet was pasture). The LRNS diet model indicated that the HC farms only obtained an average of 26% of diet DM from pasture, as several farms fell below the 30% USDA-NOP required average for the grazing season. This is likely due to the way the LRNS model was used to evaluate the diets and should not be used to indicate that the farms were not meeting organic requirements. The model was used to predict total DMI based on performance (milk yield and components) and environmental conditions, known feed components were entered and DMI of pasture was figured as the difference. Therefore, this scenario may not account for possible pasture intake that would increase DMI above 100% of what the model predicts. Furthermore, it is important to recognize that the NRC and LRNS models discussed in this paper were developed largely using information from confinement diets and may not precisely model the complexity of DMI in grazing situations. All farms were regularly inspected and were within compliance with the requirements of the USDA-NOP. Nutritive quality and DM production of pasture is highly variable throughout the year and across different years, creating periods of deficit or surplus nutrients. Successfully managing these fluctuations relative to animal requirements is accomplished through supplementary feeding of conserved forages, concentrates and by-product feeds (Jacobs, 2014). The variability in nutritive value of pastures across the northeastern U.S. is highlighted in Table 2, with considerable ranges for key nutritive parameters (CP ranged from 6.60 to 32.4%; NE_l ranged from 0.77 to 1.76 Mcal/kg). The challenge is to formulate rations or supplementation strategies to complement constantly changing pasture quality while optimizing milk production. When considering supplementation of grazing cows it is important to consider the amount of pasture and supplement consumed, pasture nutritive quality, feeding strategy, type of supplement, substitution of supplement for grazed herbage, nutrient synchrony and the associative effects between ration components (Soder and Muller, 2007; Jacobs, 2014).

Numerically, the LC farms had the lowest average milk production (16.8 kg/d), while the MC and HC farms had higher but similar levels of milk production (20.0 and 21.3 kg/d, respectively). Additionally, total diet concentration of energy was numerically lower on LC farms (NE_l=1.58 Mcal/kg) compared to MC and HC farms (NE_l = 1.63 and 1.62 Mcal/kg, respectively), due to the increased supplementation with conserved forages and grains in the MC and HC farms. In a comprehensive analysis of previous grazing studies, Bargo et al. (2003) found that compared to pasture-only diets, increasing concentrate supplementation up to 10 kg DM/d increased total DMI by 24% and milk production by 22%. However, the economic benefit of this increase in milk production relative to potential cost of supplementation will vary across farms, depending on milk price offered (premiums for value-added product, including grass-fed milk), milk components, pasture cost (rental or owned), and cost of supplement (homegrown or purchased). Hill et al. (2014) noted that increased use of supplements to accompany grazing requires a greater level of management to achieve increased returns from the use of purchased feeds while maintaining pasture utilization by cows. This would be particularly true for farms required to use certified organic ingredients, as organic soybean meal averaged $1,112 USD per ton and organic feed corn averaged $12.30 USD per bushel during 2013 (USDA-ERS, 2014). Most of the feed ingredients used on the farms in this study were homegrown, particularly the conserved forages (baleages, haylages, corn silages) and small grains (barley, wheat, spelt), while some of the oilseeds were purchased from local mills (soybean meal, roasted beans, linseed meal). The diverse supplementation strategies observed on these farms allow farmers to use feed resources such as pasture and homegrown forages and grains to meet the goals of milk production for their farm.

On average, the LRNS model predicted slightly more milk from ME and MP compared to actual milk production. This is likely due to the additional energy expenditures that were not accounted for, including but not limited to; varying distances walked to and from the parlor, slope of pastures, heat/cold stress, fly pressure and any unknown health challenges. Individual data on pasture size, slope, and distance to parlor were not collected for individual farms; therefore the "intensive grazing" setting was used for each farm in the LRNS model to adjust for the potential energy expenditure from grazing. As expected, rumen nitrogen balance exceeded 100% of requirements for all but one farm (Farm 1). This is unsurprising, as total dietary CP amounts were typically high in the pasture samples and supplements provided, however Farm 1 did demonstrate low dietary CP (CP =13.4%).

IMPLICATIONS

The overall nutritional quality of pastures in the northeastern U.S. was high. Energy was the most limiting dietary component with pastures lacking in energy only providing 88% of NE_l required, while CP generally met or exceeded animal requirements. Macro-mineral supplementation of Ca, P, and S should be considered for lactating cows in grazing systems, as these minerals were frequently deficient. Percent of DMI from pasture ranged from 14 to 100%. High quality pasture and diverse supplementation strategies allow farmers to use resources such as pasture and homegrown forages and grains to meet goals of milk production for their farm. Previous research has confirmed that some degree of supplementation of grazing dairy cows will result in a profitable increase in milk production, however it is important to recognize that markets currently exist that pay premiums for value-added milk products (e.g., grass-fed milk) which may negate the economic benefits of supplementation.

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Table 1. Number of farms sampled, number of pasture samples collected, and pasture sampling frequency described by year.

	No. farms sampled (No. samples)				
	2012	**2013**	**2014**	**Total no. samples**	**Sampling frequency**
State					
Pennsylvania	3 (22)	3 (30)	3 (30)	82	2x mo
New York	3 (12)	3 (22)	2 (18)	52	2x mo
Vermont	3 (62)	3 (38)	3 (30)	130	weekly
New Hampshire	2 (10)	2 (13)	1 (8)	31	2x mo
Maine	3 (27)	3 (31)	3 (27)	85	2x mo

Table 2. Summary statistics (n = 380) of forage quality parameters[1] and macro-minerals and the effect of year, month, and farm on forage quality and macro-mineral concentration of pastures in 2012, 2013, and 2014.

Item	Mean[2]	SD[2]	Min[2]	Max[2]	*P*-value Year	*P*-value Month	*P*-value Farm
Forage quality							
CP, %	19.5	4.10	6.60	32.4	0.25	<0.01	<0.01
ADF, %	31.4	4.79	18.0	73.0	0.75	<0.01	<0.01
NDF, %	51.0	8.67	24.2	71.0	<0.01	<0.01	<0.01
NE_l, Mcal/kg	1.39	0.15	0.77	1.76	0.03	<0.01	<0.01
Macro-minerals[1]							
Ca, %	0.76	0.25	0.19	1.66	<0.01	<0.01	<0.01
P, %	0.36	0.08	0.07	1.04	0.23	<0.01	<0.01
Mg, %	0.28	0.06	0.10	0.46	<0.01	<0.01	<0.01
K, %	2.68	0.60	0.26	4.69	0.02	0.03	<0.01
S, %	0.28	0.05	0.09	0.44	0.14	<0.01	<0.01

[1]NIR analysis for sodium missing on many samples, therefore it is not included.

[2]Mean, standard deviation (SD), minimum (Min), and maximum (Max) values across all farms and all months sampled in 2012, 2013, 2014.

Table 3. Crude protein, fiber, energy and macro mineral recommendations for lactating dairy cows and the frequency of pastures that did not meet minimum dietary requirements.

	Animal requirements (% of total diet), Dairy NRC 2001		% of samples not meeting minimum animal requirements	
	680 kg Holstein[1], 25 kg/d milk	**454 kg Jersey[2], 25 kg/d milk**	**680 kg Holstein[1], 25 kg/d milk**	**454 kg Jersey[2], 25 kg/d milk**
Forage quality				
CP, %	14.1	16.1	9.21	20.8
ADF, %	17-21 min	17-21 min	0.00	0.00
NDF, %	25-33 min	25-33 min	0.00	0.00
NE_l, Mcal/kg	1.37	1.54	35.5	85.8
Macro-minerals[3]				
Calcium, %	0.62	0.57	30.8	22.1
Phosphorus, %	0.32	0.33	19.2	26.1
Magnesium, %	0.18	0.18	2.89	2.89
Potassium, %	0.24	0.24	0.00	0.00
Sulfur, %	0.22	0.20	11.1	6.58

[1]Additional cow parameters used in NRC model to estimate requirements: BCS = 3.0, 65 mo of age, milk fat = 3.5%, milk protein 3.0%, default environmental conditions (confinement, tie stall, TMR)
[2]Additional cow parameters used in NRC model to estimate requirements: BCS = 3.0, 65 mo of age, milk fat = 4.2, milk protein 3.6, default environmental conditions (confinement, tie stall, TMR)

Table 4. Results of Large Ruminant Nutrition System (LRNS) model output for feeding strategies that accompany grazing.

	Actual milk, kg/d	ME allowable milk[2], kg/d	MP allowable milk[3], kg/d	Rumen nitrogen balance[4], %	% Conserved feed in diet (DM)	% Pasture in diet (DM)	Total diet CP[5], % (DM)	Total diet NE_l[6], Mcal/kg (DM)
LC Farms[1]								
Farm 3	17.7	14.8	24.5	169	1.00	99.0	21.8	1.70
Farm 6	13.4	19.1	20.6	108	11.0	89.0	15.0	1.65
Farm 12	20.2	17.6	21.0	122	28.0	72.0	15.8	1.52
Farm 14	16.1	20.2	11.2	202	0.00	100.0	17.1	1.43
Average	16.8	17.9	19.3	150	10.0	90.0	17.4	1.58
MC Farms[1]								
Farm 7	19.8	19.9	22.0	114	44.0	56.0	17.4	1.72
Farm 8	21.9	24.9	27.9	131	53.0	48.0	17.7	1.68
Farm 9	29.7	31.7	32.7	130	59.0	41.0	18.2	1.70
Farm 10	17.2	21.4	25.7	103	59.0	41.0	14.8	1.63
Farm 13	11.7	12.3	13.5	150	55.0	45.0	16.9	1.43
Average	20.0	22.0	24.3	126	54.0	46.0	17.0	1.63
HC Farms[1]								
Farm 1	23.6	25.5	25.4	97	64.0	36.0	13.4	1.63
Farm 2	22.8	23.6	20.5	128	72.0	28.0	15.8	1.61
Farm 4	26.2	29.9	24.6	112	72.0	28.0	14.5	1.72
Farm 5	15.8	18.5	15.6	115	78.0	22.0	13.9	1.52
Farm 11	18.1	16.6	14.1	152	86.0	14.0	19.9	1.63
Average	21.3	22.8	23.1	121	74.0	26.0	15.5	1.62

[1]LC Farms = low conserved feed farms, < 30% conserved feed in total diet; MC Farms = medium conserved feed farms > 30 < 60% conserved feed in total diet; HC Farms = high conserved feed farms > 60% conserved feed in total diet.
[2]ME allowable milk = milk production based on metabolizable energy in the diet as predicted by the LRNS.
[3]MP allowable milk = milk production based on metabolizable protein in the diet as predicted by the LRNS.
[4]Rumen nitrogen balance = balance of nitrogen in the rumen, on a 100% basis, as predicted by the LRNS.
[5]Total diet CP as predicted by LRNS, to include pasture and any conserved forages and grains (if used).
[6]Total diet NE_l, as predicted by LRNS, to include pasture and any conserved forages and grains (if used).