Supplementing Grazing Lactating Cows Require Different Thinking*

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Because of lactation demands, the forage made available for grazing cows needs to be of the highest quality and available in dense swards in quantity. Given good seasonal conditions, this is not too difficult with a mixture of cool season grasses and clovers or alfalfa when intensive rotational grazing practices are followed. Because of the frequency of droughts a number of grazers may plan on sorghum-sudan or other brown mid rib species to make it through the growing season. Compared to cool season species, these are higher in fiber (~36.0% ADF) and lower in protein (~10%) and NE_{lact} (0.67 Mcal lb^{-1}), so probably need concentrate supplemented similar to feeding stored forages. Our grazing studies, other than with alfalfa have been with cool season grasses and clovers and the following information reflects that.

In this talk, it is assumed that quality forage is available in quantity. To assure quality, forage must be young and actively growing. This results in less fiber, more available nutrients and more digestibility. It must be dense and abundant if a cow is to eat as much as possible. Ideal height is about 6 to 8 inches.

<u>Composition of cool season grass</u>

Table 1 summarizes composition of cool-season grasses from a series of experiments at Penn State plus a study by Rayburn (1991) conducted at Cornell.

Table 1. Average nutrient composition for cool-season grass pasture over a grazing season. Modified from Muller and Fales (1998).

Nutrient	Spring	Summer
Crude protein %	21.0-25.0	18.0-22.0
RUP, % of CP	20.0-25.0	25.0-30.0
Sol. P, % of CP	30.0-35.0	25.0-30.0
ADF %	24.0-28.0	28.0-34.0
NDF %	40.0-45.0	48.0-55.0
NE, Mcal lb^{-1}	0.73-0.77	0.70-0.75
Non-fibre carbohydrate (NFC), % DM	15.0-20.0	12.0-15.0
Ca %	0.50-0.70	0.50-0.70
P %	0.30-0.35	0.30-0.35
Mg %`	0.15-0.20	0.15-0.20
K %	2.00-3.50	2.00-3.50

Except for the possible slower growing part of mid-summer, crude protein exceeds 20% up to 25%. This agrees well with our Blacksburg data, where in 1995 grass crude protein was not below 22.0%. The clover portion of our pasture always exceeded 25% crude

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protein. In the Table, NDF was at a low of 40% in the spring and increased to a high of 48 to 55% in the summer. In Blacksburg, NDF ranged from 46 to 53% by hand sampling. Non-fibrous carbohydrates (NFC), composed of mostly plant sugars, often reach or exceed 15% in spring growth.

As a result of low fiber and high sugar and protein, NE_L varies from 0.7 to 0.77 Mcal/lb. Compare that to recommended dietary NE_L of 0.78 for the heavily lactating cow or to corn silage, considered a high energy forage, of 0.72, it is easy to conclude that high quality pasture should support high levels of milk production. When animal selection is considered, forage consumed is even higher in quality than that measured by hand sampling. This has been proven to be the case in a number of studies.

<u>Limits on pasture</u>

Given the potential NEL of high quality immature grazed forages, one would expect that relatively high amounts of milk production would be maintained by grazing alone. Grazing studies outside the U.S. show that spring grazing will support 50 to 55 lb milk per day (Muller and Fales, 1998).

At Penn State (Kolver and Muller, 1998), early lactation cows fed only high quality ryegrass pasture produced 65 lb of milk daily while counterparts fed a TMR in confinement produced 97 lb daily. The vast difference in production can largely be explained by one factor; intake. The grazing cows consumed 41.8 lb of DM (3.4% BW, ~ 20 lb from grain) while TMR-fed cows consumed 51.5 lb of DM (3.9% BW).

Why don't grazing cows consume as much dry matter as cows fed TMR? There is no clear answer. If pasture is available for an excessive period throughout the day, then time spent grazing is dependent on the behavior of the cow. Voisin (1998) wrote that cows must belong to a labor union because they eat (work) no more than 8 h per day whether or not this provides maximum fill. Intake per bite is the major factor influencing pasture intake and it is maximized on dense, leafy swards. Biting rate seems to be greater in cows during times of high rates of milk production. So, the manager can have a major impact on intake by providing ideal sward density. Mayne et al. (1997) found similar dry matter intakes when sward heights were near 7 inches with either high, medium, or low density stands. As height decreased, intake decreased at a greater rate for low density stands.

Therefore, potential energy intake from only pasture severely limits milk production, perhaps to 50 to 55 lbs of milk per day. The annual lactational performance for cows under good grazing practices with essentially no supplementation in Ireland is about 11,000 lb milk on average. Some would produce more, except in their system, the cows are dried off when the quota is made.

The bottom line is, grazing cows are limited first in energy intake for high amounts of milk production, even though the energy concentration may be above 0.7 Mcal/lb. Crude protein availability is in excess in most cases in cool season pastures. Any steps taken to enhance intake would be economically sound.

Pasture protein: asset or liability

Although cool season grasses and clovers are a rich source of crude protein, a great deal of the protein is highly soluble in the rumen, promoting release or production of large quantities of ammonia nitrogen in the rumen. Ammonia nitrogen can be either a nutritional asset or liability depending on other dietary components.

Microbial growth in the rumen is driven by fermentable carbohydrates. Supplementation of ground or high moisture corn or a similar fermentable starchy feed source accelerates microbial growth and utilizes more ammonia nitrogen with less ammonia reaching the blood stream. We have confirmed that blood urea decreased in grazing cows when the amount of ground corn fed was increased.

Using continuous culture fermenters, energy supplementation of corn to grass-legume pasture reduced pH, NH_3N flow and increased bacterial N flow as percentage of intake (Bach et al., 1999). In a similar study by Hoover, Polan and co-workers (Loor et al., 2000) corn substituted for orchardgrass or red clover (equivalent to 10 or 20 lb/d in a diet) compared to no corn progressively increased microbial dry matter yield 1.4 to 1.5 fold in orchardgrass and red clover diets. pH was significantly reduced but not seriously with corn addition.

Excessive ammonia entering the blood stream may create functional costs to the animal. Ammonia is converted to urea in the liver, a process that requires energy. Energy costs related to elimination of ammonia (urea) in intensively grazed animals can be equivalent to energy required to produce 3 to 6 lb of milk (Kolver, 1997).

Excessive ammonia may also have an adverse effect on reproduction. Ammonia apparently creates a toxic environment in the reproductive tract that results in instability for a developing embryo. High milk urea nitrogen (MUN) is a monitor to determine if circulating urea may result in a nutritional nitrogen loss to the animal or may be a reproductive risk. I have some concern about this reproductive risk because conception does not seem to be a big problem in beef cattle. Milk values exceeding 15-16 mg/dl indicates inefficient nitrogen utilization.

So, it makes sense from a metabolic standpoint to supplement pasture with readily fermentable carbohydrates, either starchy sources such as corn or soy hulls.

How much grain?

In our studies, to measure responses to amount of supplement, ground corn with mineral supplementation has been the standard basal supplement. But higher fiber diets or different forms of corn (high moisture, coarse or fine grind) have been compared. Table 2 shows the results of five different studies, each with some comparison of amount or kind of energy supplement. This data illustrates well the responses in milk production observed under the management we have practiced at Virginia Tech.

In general, small, if any, increases in milk yield have occurred in increments of grain intake above 10 lb daily. Usually, there is some decline in milk fat content with greater amounts of corn.

Table 2. Summary of Grazing Studies in Lactating Cows When the Supplemented Energy Differed

Year	Length of Study	Cows	Supplement	Milk Yield	Fat %	Protein %
1978-79	’78 - 16 wk	13 Holsteins per	8# corn – mineral	51.5	3.5	3.2
	’79 - 20 wk	treatment	12# corn – mineral	52.4	3.3	3.1
			16# corn – mineral	54.5	3.2	3.2
1980	18 wk	8 Holsteins per	16# corn – mineral	51.5	3.1	2.9
		treatment	TMR (50# limit)	49.7	3.2	2.8
1994[1]	8 wk	5 Holsteins &	10# corn-soy w/ clover-grass	54.1	3.7	3.2
		3 Jerseys per	15# corn-soy w/ clover-grass	54.8	3.6	3.2
		treatment	20# corn-soy w/ clover-grass	54.1	3.8	3.3
			15# corn-soy w/ Alfagraze	56.1	3.8	3.3
1995[2]	14 wk	8 Holsteins	12# high fiber	61.4	3.6	3.0
		8 Jerseys	12# high fiber	51.0	4.8	3.4
		8 Holsteins	20# high fiber	67.8	3.6	2.9
		8 Jerseys	20# high fiber	52.4	4.5	3.5
1997	10 wk	9 Holsteins per	15# coarse corn	66.2	3.2	3.0
		treatment	15# fine corn	65.3	2.9	3.0
			17# high-moisture corn	67.8	3.1	3.0
			11# high-moisture corn	67.1	3.1	3.0

[1]Corn-soy supplement contained 16% CP
[2]All cows on bST; high fiber supplement contained 12% ADF and 14% CP

In 1995 (Table 2), there was a significantly greater (6.4 lb) milk yield in Holsteins that received 20 lb compared to 12 lb of supplement (high fiber) daily. Jerseys responded with only 1.4 lb milk per day to the additional supplement. This mix (14% CP) contained 41% ground corn, 25% dried brewers grains and 18.7% whole cottonseed.

Jones-Endsley et al., (1997), compared supplements containing 12 or 16% crude protein (corn, soy hulls, SoyPlus) offered at 14 or 21 lb/d while grazing alfalfa and orchardgrass. With higher protein, ruminal NH_3N increased and the flow of microbial N to the duodenum was unaffected. Milk yield (55.2 lb) or composition were not different due to CP content or amount of supplement.

Reis and Combs (2000) got a positive milk yield and milk protein response to a ground corn based concentrate (12% CP) when supplemented at 0, 11, or 22 lb/d to cows grazing a grass legume pasture. Milk production and protein percentage were 48.0, 59.0 and 66.9 lb/d, and 2.85, 2.95 and 3.05% for increasing amounts of concentrate respectively. Total dry matter intake increased with supplementation without causing negative effects in forage digestion.

Bargo, et. al. (2002) of Penn State recorded milk response in cows with grazing allowances of 55 or 58 lb/d and concentrate allowances of zero (~2lb/d corn-molasses mineral mix) or 1 unit of concentrate per 4 units of milk (1:4 ratio). Concentrate (13.4% CP) was 62% corn with barley, roasted soybeans, molasses, corn gluten meal and mineral and vitamin supplements. Cows fed no concentrate produced 42 lb. and 48.8 lb milk daily for low and high pasture allowance respectively. However, with fed concentrates (1:4) milk averaged 65.5 lb with no difference for pasture allowance. Supplement intake was about 19 lb per day. Milk fat declined about 0.5 percent with concentrate supplement, but milk protein increased 0.1 to 0.2 percentage units.

Workers at Penn State (Muller, 1998) have developed a table of feeding guidelines for grass based dairying (Table 3). These workers have not shown that these supplemental amounts are effective for milk yield response, but point out that grain feeding for high producing cows on pasture results in greater DMI which translates into more milk production and improved body condition. Muller stated that Australian workers indicated the greatest benefit to grain supplementation was improved body condition with subsequent improved conception.

Table 3. Grain (DM) feeding guidelines for a grass based pasture system[ab] (Muller, 1998)

4% FCM	Spring		Summer		Fall	
Production (lb/day)	lb	G:M[c]	lb	G:M[c]	lb	G:M[c]
>80	20	1:4 to 1:5	25-27	1:3	20	1:4 to 1:5
70	16-18	1:4 to 1:5	21-23	1:3 to 1:4	16-18	1:4 to 1:5
60	12-14	1:5	15-18	1:3 to 1:4	12-14	1:5
50	8-10	1:5 to 1:6	10-12	1:4 to 1:5	8-10	1:4 to 1:5
>40	6-8	1:6 to 1:7	8-10	1:5 to 1:6	6-8	1:6 to 1:7

[a]Assume 1300 lb. bodyweight
[b]These guidelines are based on high quality grass pasture available in adequate quantities assuming the approximate DMI. Lower quality forage will require more grain. Maximum grain DM fed should be equivalent to about 2% of bodyweight. Some adjustment of grain should be made based on body condition scores and stage of lactation. Lower amounts are likely needed when the pasture contains legumes.
[c]Grain:milk ratio

Synchrony

Synchronizing the availability of nitrogen and fermentable energy sources to rumen microorganisms may improve the capture of ammonia (Kolver, 1997). Providing grain more times throughout the day or feeding after animals have grazed for a while or even feeding grains with different rates of carbohydrate availability are approaches that have been proposed or tried to achieve results in milk yield from synchrony. However, results have not been promising.

Clemson workers (Vaughan et al., 2002) reported that feeding a partially mixed ration immediately after grazing maintained a higher BUN than cows fed a partially mixed ration before grazing. Feeding before grazing resulted in more effective capture of ruminal N, but there was no effect on yield of milk or milk components.

<u>Substitution</u>

Generally, when a quantity of supplement is fed, some reduction in pasture intake will occur. However, total intake will likely increase (Reis and Combs, 2000). Penn State has estimated that for each pound of grain fed, intake of pasture dry matter is reduced by 0.5 to 0.8 lb (Muller and Fales, 1998).

In Virginia Tech 1978-79 studies (Table 2), the increment in milk production was 3 lb when grain was increased from 8 to 16 lb. By feeding more grain, less grass would be consumed, therefore more cows could graze the same area. This might be advantageous, at least in droughty times or with limited grazing area.

A common method of supplementation of pasture in Virginia is a partial TMR. This may be the TMR routinely fed or one that is modified to account for pasture intake and nutrient contribution. With silage, TMR or other forage bases, the substitution rate for pasture is 1:1.

<u>Supplementing with mixed diets</u>

In my estimation, the biggest advantage to feeding a partial TMR is that the animal has the opportunity to adjust intake of TMR for intake variations of pasture due to either quantity or quality. In short, the partial TMR provides a stable base to the diet with less adjustment by the animal. There are at least two disadvantages: a TMR mix has to be made; and silage, especially from bunkers, may spoil during warm weather with the reduced daily removal.

We have compared supplementation from TMR (~ 50#/d) with supplements high in ground corn (16#/d). We found no differences in milk yield. In another experiment, cows that were fed a TMR while confined to dry lot between midnight and noon and grazed the other half day consumed 2/3 as much TMR as cows fed totally on TMR. The TMR contained alfalfa and corn silage, high-moisture corn, barley, soybean meal, whole cottonseed, Prolak, plus minerals and vitamins. It was formulated to supply 0.76 Mcal/lb NEL, 18% CP, 28.9% NDF and 40.7% non-fibrous carbohydrate. For 12 wk, cows fed only TMR produced 64.0 lb/d, cows that partially grazed produced 62 lb/d.

A partial TMR makes sense if it supplies 60% or more of the dry matter intake or if the pasture is available for only a short time and is variable in quantity.

Protein supplementation

There has been some indication that protein in the grain (14-16% mixtures) may enhance intake, but this has not consistently resulted in more milk production. Sources of bypass protein in the supplement has given mixed results in milk yield.

In our study for 1990-91, a positive response was obtained in milk yield in both years (Table 4) by replacing some corn with soybean meal (18% crude protein) and a further milk yield response occurred by substituting for soybean meal protein, protein equally from dried brewers grains and corn gluten meal. The first step response was about 2.5 lbs and the additional response was about 4 lbs of milk/d. In 1998, old process soybean meal (SoyPlus) subjected to added heat to cause bypass, resulted in more milk yield than soybean meal (Table 4). We have never gotten a clear yield response from fishmeal, often considered a good bypass source to supply limiting amino acids.

Table 4. Summary of Grazing Studies in Lactating Cows When the Supplement Differed in Bypass Protein

Year	Length of Study	Cows	Supplement	Milk Yield	Fat %	Protein %
1990-91[1]	'90 – 14 wk '91 – 12 wk	8 Holsteins per treatment	14# corn – mineral	54.9	3.2	2.9
			14# corn – soy	57.4	3.1	2.8
			14# corn – DBG-CGM	61.6	3.2	2.9
1994[2]	10 wk	4 Holsteins & 4 Jerseys per treatment	16# corn – soy	60.1	3.6	3.2
			16# Synergy – fishmeal	60.3	3.7	3.2
			16# Fishmeal - cottonseed	56.6	3.8	3.2
1998	12 wk	12 Holsteins per treatment	16# corn – soy	67.1	3.3	2.7
			16# corn – SoyPLUS	71.5	3.3	2.7
			16# corn – SoyPLUS - Alimet	71.5	3.3	2.7

[1] Corn-soy and corn-dried brewers grain/corn gluten meal supplements contained 18%CP
[2] Corn-soy supplement contained 18%CP

Schroeder and Gagliostro (2000) compared fishmeal with pelleted sunflower meal in grazing cows. Eleven pounds of concentrate was fed daily containing either 1.6 lb fishmeal or 2.7 sunflower meal. Milk yield (59.0 vs 55.4 lb) was greater for the fishmeal diet.

Bargo et al. (2001) compared sunflower meal with feather meal as a bypass source. Higher rumen undegradable protein intake did not increase milk production.

McCormick and associates (2001) compared three supplements for grazing cows: solvent extracted soybean meal mix (22.8% CP), soybean meal mix (16.6% CP), and a corn gluten meal-blood meal mix (16.2% CP) and 10.8% RUP. Cows were supplemented 1:3 grain:milk ratio. Increasing crude protein or supplementing additional RUP did not increase milk yield in these cows.

All of this indicates that responses to bypass protein may occur, but not in a very predictable fashion. This may indicate that energy is still first limiting to milk production in lactating cows. Therefore, nutritional efforts must be focused more on trying to enhance intake.

A Comment on Minerals

It goes without saying that salt must be provided. What about calcium and phosphorous? With all the recent emphasis on phosphorus, algae bloom and cleaning the Chesapeake Bay, phosphorus recommendations are now 0.33-0.35%. Calcium is around 0.5%. These are both in the range of that listed in Table 1; Mother Nature is good. However, with corn supplementation, dietary supplementation of calcium and phosphorus is needed. Our studies have depended on free-choice mixes with salt supplied by the marketplace, but depending on mineral intakes, phosphorus intake may be excessive. When intake of salt is known, this can be regulated by custom mix. But, some excess of phosphorus may not be a problem in grazing because of the timely distribution on the soil with adherence to the soil. Many of the by-product feed sources probably will supply all the phosphorus needed, maybe even in excess.

Conclusions

Lactating grazing dairy cows are limited in milk yield by inadequate energy yielding sources due to insufficient feed intake. Intake can be increased by supplementation of grain sources. The amount of grain supplementation desired depends on many factors, most important of these are quality and availability of pasture and milk production potential of the cows. Amounts of grain to feed would usually be between 8 and 20 lbs. daily. One pound of grain per 4 lb milk provides a rule of thumb recommendation. Excessive grain will lower milk fat content and possibly create ruminal and metabolic problems. Grain offered may provide needed minerals, should not exceed 12% crude protein and should be readily fermentable in the rumen. Such supplementation should capture excess ruminal ammonia produced from pasturage protein and convert it into useful microbial protein.

References

Bach, A., I. K. Yoon, M. D. Stern, H. G. Jung, and H. Chester-Jones. 1999. J. Dairy Sci. 82:153.

Bargo, F., D. H. Rearte, F. J. Santini, and L. D. Muller. 2001. J. Dairy Sci. 84:2260.

Bargo, F., L.D. Muller, J. F. Delahoy, and T. W. Cassidy. 2002. J. Dairy Sci. 85:1777.

Jones, Endsley, J. M., M. J. Cecava, and T. R. Johnson. 1997. J. Dairy Sci. 80:3283.

Kolver, E. S. 1997. Supplemental feeding strategies to increase the utilization of positive nitrogen by high producing cows. Ph.D. Thesis. The Pennsylvania State University, University Park, PA.

Kolver, E. S., and L. D. Muller. 1998. J. Dairy Sci. 81:1403.

Loor, J. J., W. H. Hoover, T. K. Miller-Webster, C. E. Polan, and W. A. Wark. 2000. J. Dairy Sci., 83 (Supplement #1):276.

Mayne, C. S., D. McGilloway, A. Cushnahan, and A. S. Laidlow. 1997. The effect of sward height and bulk density on herbage intake and grazing behavior in dairy cows. In Proc. XVIII Grassland Congress. Paper 2.15-2.16.

McCormick, M. E., J. D. Ward, D. D. Redfearn, D. D. French, D. C. Blouin, A. M. Chapa, and J. M. Fernandez. 2001. J. Dairy Sci 84:896.

Muller, L. D. 1998. Proc. 1998 Great Lakes Grazing Conf., State College, PA.

Muller, L. D., and S. L. Fales. 1998. Grass for Dairy Cattle. CABI Publishing. Cherney and Cherney (Ed).

Muller, L. D., K. Hoffman, L. A. Holden, L. E. Chase, and D. G. Fox. 1998. Nutrition of grazing dairy cattle. In Grazing in the Northeast, NRAES 113. C. R. Krueger, and H. B. Pionke ed. Northeast Regional Agricultural Engineering Service, Ithaca, NY.

Rayburn, E. D. 1991. Animal Sci Mimeo 151. Department of Animal Science, Cornell Univ., Ithaca, NY.

Reis, R. B., and D. K. Combs. 2000. J. Dairy Sci. 83:2888.

Schroeder, G. F., and G. A. Gagliostro. 2000. J. Dairy Sci. 83:2899.

Vaughan, J. M., J. A. Bertrand, T. C. Jenkins, and B. W. Pinkerton. 2002. J. Dairy Sci. 85:1267.

Voisin, André. Grass productivity. 1998. Island Press, Washington, D.C. (A reprint of a 1959 classic by Philosophical Library, New York).