Economics of Supplemental Feeding with Pasture-Based Systems

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A common question of dairy managers relates to the optimum amount of concentrate supplement and/or supplemental forages to feed to achieve the most profitable milk production response by lactating cows. Some of our producers think about adopting the "New Zealand" system where little to no concentrates are fed. However, this may not be the most profitable system in the Untied States, and feeding some level of supplements will usually yield higher income and profit. The decision on how much supplemental concentrate to feed depends on the following:

- Substitution rate of concentrate for pasture.
- Expected milk yield response to supplementation.
- Price of milk and the price of supplemental concentrate (milk:feed price ratio M:F)
- Production of milk components (fat and protein).
- Long-term effects on body condition, herd health, and reproductive performance

Pasture as the only feedstuff (the New Zealand "system")

Studies from New Zealand, Ireland, and the USA indicate that when high quality pasture is the only feedstuff and offered in adequate amounts, lactating cows (Holsteins) can be expected to consume 35 to 40 lb. of dry matter (DM)/cow/day. This amount of intake may support 45 to 55 lb. of milk in early lactation based on the estimated energy intake. However, body condition loss should be monitored. In studies that conducted at Penn State, high genetic Holstein cows fed only high quality ryegrass pasture consumed 42 lb. DMI/day and produced 64 lb. milk/day. However, cows were still mobilizing body reserves to produce this amount of milk. We believe that 39-42 lb. of DMI/day is about the maximum DMI that a Holstein cow can consume from pasture with excellent pasture management.

Why do cows continue to lose body condition and weight? Basically, the high genetic merit cow has the “drive” to produce milk, and when she does not consume adequate energy compared to energy output in milk, she uses body reserves to supplement energy intakes. The energy required for the activity to walk to and from pastures is often not considered when feeding supplements and in the body condition loss with pastured cows. The energy required for walking and eating activity associated with grazing may be 12 to 15% above the maintenance requirement for non-grazing cattle. For example, a grazing cow that walks 1.5 miles/day requires about 2 to 3 lb. supplement to provide energy for activity. If she walked 3 miles, then about 4 to 5 lb. supplement is needed per day.

Substitution Rate

When supplemental grain is fed, pasture DMI decreases as concentrate substitutes for pasture. This is defined as substitution rate, a term used to describe the relationship between concentrate allowance and total DMI. For example, if a cow reduces pasture DMI by 1 lb. for each 1 lb. of concentrate DM fed, the substitution rate is 1.0. If a cow maintains full pasture DMI, the substitution is 0 which seldom occurs. A summary of published research from around the world indicates a substitution rate of 0.4 to 0.6 is expected with high producing cows grazing good quality pasture. Feeding 1 lb. of concentrate will reduce pasture intake by 0.5 lb., however total intake is increased. The increased energy intake with a 0.5 substitution rate is about 0.50 Mcal/day, an amount that could support about 1 to 1.5 lb. more milk per day. A summary of several of our studies indicated that when adequate high quality pasture is available and when concentrate is fed in amounts “typical” for these milk production levels, total DMI approaches the DMI expected with non-grazing cows.

Milk Response to Supplement

The marginal response of milk per unit of concentrate fed follows the law of diminishing returns. The first units of concentrate fed are most profitable, and each extra unit yeilds a lower return. Expected milk responses of high producing cows in early lactation with increasing increments of concentrate feeding is summarized in Table 1. As concentrate feeding increases from 0 to 20 lb. of concentrate, the milk yield per unit of grain fed tends to decrease from about 1.2 to 0.6 lb. Recent studies with U.S. genetics have reported milk responses of about 1.3 lb. per 1.0 lb. concentrate fed, which is nearly the amount expected based on higher energy intake. Overall, the average milk response to feeding 20 lb. of concentrate is about 20 lb. of milk, or 1 lb. of milk per 1 lb. of concentrate fed. Even more important is the marginal response and profitability of supplement feeding.

Marginal Profitability

The expected marginal profit response to increasing concentrate feeding with the substitution rate and milk yield response discussed is in Table 2. The milk:feed price ration (M:F), is the ratio of the price of one lb of milk and one lb of concentrate supplement. In Table 2, the milk price is $0.13 per pound and supplement price is $0.08 per pound giving a ratio of 1.65:1. As more concentrate is fed, pasture DMI decreases and total DMI and total feed costs increase. Also, marginal milk yield decreases as concentrate feeding increases, and the marginal response to each 4 lb of supplement decreases from $0.39 to $0.00 when supplement is increased from 0 to 20/lb/cow/day (Table 2). When 20 lb of concentrate is fed, the marginal return to concentrate was zero, indicating that the additional concentrate did not yield any higher income over feed costs compared to when 16 lb of concentrate was fed. In this case, the profit maximizing level of supplement is 16 to 20 lb of concentrate per cow per day. However, when milk prices are lower, (around $11 to $12/cwt), the profit maximizing level of supplementation will fall also, to about 16 lb. per cow per day.

With the milk:feed price ratio close to 2.0:1 in the USA, (1.65 was used in this example), it makes economic sense to feed up to 16 to 20 lb. of supplement daily to high genetic merit Holstein cows. When the M:F ratio approaches 1.0 or less, which it does in New Zealand and other countries, then concentrate feeding is not profitable, except perhaps when targeted for early lactation, high genetic cows. In our example, if the milk:feed price ratio decreased to below 1.5:1, then we may want to reduce the maximum of concentrate to 12 to 16 lb, with targeted feeding of early lactation cows. Guidelines of expected profit responses with changing milk:feed price ratios are in Table 3.

The “bottom line” is that concentrate feeding of high producing cows on pasture results in higher total DMI, which translates into higher milk production and improved body condition, and a higher income over feed cost, compared to no supplementation. The greatest benefit to concentrate (energy) supplementation may be long-term benefits of improvement in body condition, and, in turn, reproductive performance. Feeding up to 18 to 20 lb of concentrate per day will not likely lead to acidotic conditions in the rumen if pasture and supplemental forage intake is adequate. Table 4 contains suggested concentrate feeding guidelines for a grass-based pasture system for Holsteins. These guidelines and some other points discussed in this article need to be modified for smaller breeds and crossbreds.

One concern that arises with feeding concentrate supplements is that the milk fat percentage tends to decrease as the amount of supplement increases. However, it is most important to look at what happens to yields of components not percentages. When supplemental concentrate is fed, milk yield increases and concurrently fat yield increases. Feeding supplemental concentrates increases milk protein percent and protein yield.

Table 1. Expected milk yield response of high producing cows to increasing increments of concentrate feeding.

Supplemental concentrate fed (lb)	Expected lb. milk/lb each additional lb. of concentrate
0-4	1.2 to 1.3
4-8	1.0 to 1.2
8-12	0.8 to 1.0
12-16	0.65 to 0.8
16-20	0.4 to 0.65

Table 2. Expected economic response (early lactation) to supplemental concentrate feeding.

Pasture[a]		Concentrate[b]		Total		Milk[d]		INC-FC[e]	Marginal[f] Response
DMI	Cost	DMI	Cost	DMI[c]	Feed Cost	(lb)	($)	($)	($)
(lb)	($)	(lb)	($)	(lb)	($)				
38	1.14	0	0	38	1.14	45	5.85	4.71	
36	1.08	4	.32	40	1.40	50	6.50	5.10	0.39
34	1.02	8	.64	42	1.66	54.5	7.08	5.42	0.32
32	0.96	12	0.96	44	1.92	58	7.54	5.62	0.20
30	0.90	16	1.28	46	2.18	61	7.93	5.75	0.13
28	0.84	20	1.60	48	2.44	63	8.19	5.75	0.00

[a]Pasture cost – 0.03¢/lb. DM
[c]Concentrate cost - 8¢/ lb. DM
[c]Assume substitution rate of 0.5 (1 lb. concentrate fed with 0.5 lb. decrease in pasture DMI)
[d]Milk price – 13¢/lb. of 3.5% fat milk. Milk:feed price ratio of 1.65:1
[e]Income minus feed cost
[f]Does not consider long-term benefits on body condition and reproductive performance

Table 3. Guidelines for a milk and profit response to concentrate supplementation of pastures[a].

Item	Early Lactation	Mid Lactation
Expected lb. milk response/lb. concentrate	1.0	.6 to .8
Milk:feed supplement price ratio		
>1.50:1	Profit	Profit
1.25:1	Profit	Break even
1.00:1	Break even	Loss

Table 4. Concentrate (DM) feeding guidelines for a grass based pasture system [ab].

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	22-24	1:3	20	1:4 to 1:5
70	15-18	1:4 to 1:5	19-21	1:3.5	16-18	1:4 to 1:5
60	11-13	1:5	15-18	1:4	12-14	1:5
50	8-10	1:5 to1:6	10-12	1:4.5	8-10	1:4 to 1:5
>40	6-8	1:6 to 1:7	8-10	1:5	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 forages may require more grain. Maximum grain DM fed should be equivalent to about 20 lb per day. Some adjustment should be made based on body condition scores and stage of lactation. Lower amounts of concentrates can likely be fed when pasture contains legumes.
[c]Grainfed (G) (DM basis) to milk yield (M) on a lb to lb basis (i.e. 1 lb of supplement mix per 4 lbs of milk gives a G:M of 1:4).