Dairy Efficiency and Dry Matter Intake

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Take Home Messages

- Dairy or feed efficiency reflects the level of fat-corrected milk yield produced per unit of dry matter consumed with an optimal range of 1.4 to 1.8 pounds of milk per pound of dry matter.

- Days in milk, age, growth, changes in body condition score, body weight, forage quality, feed additives, and environmental factors will impact feed efficiency values.

- Dairy managers should monitor changes in feed efficiency as feeding and management changes occur on their farms to evaluate the impact of the change. Comparisons between herds must be done carefully.

Dairy efficiency (also referred to as feed efficiency) can be defined as pounds of milk produced per pound of dry matter (DM) consumed. Beef, swine, fish, and poultry industries have used feed efficiency (feed to gain ratio) as a benchmark for profitability. Monitoring dairy efficiency or DE in the dairy industry has not been used as a common benchmark for monitoring profitability and evaluating dry matter intake relative to milk yield. The "new focus" on maximizing efficiency reflects as cows consume more feed, digestive efficiency decreases as the relationship between net energy-lactation intake and milk production is subject to diminishing returns. The "traditional focus" was that as cows consume more feed to support higher milk production, the proportion of digested nutrients captured as milk is proportionally higher.

Economics of Feed Efficiency

With lower milk prices, one way to maintain profitability without sacrificing milk production or herd health is by enhancing feed efficiency. Table 1 is an example of how improving feed efficiency impacts the bottom line. Herd A produced 80 pounds of milk consuming 57 pounds of DMI for a feed efficiency of 1.40. Herd B produced the same amount of milk, but the cows consume only 50 pounds of dry matter, for a feed efficiency of 1.60. Assuming feed costs of $0.07 per pound of dry matter, Herd B has a lower feed cost of $0.49 per cow per day compared to Herd A. In addition, Herd B with the lower feed intake and higher feed efficiency will have lower nutrient excretion as manure. This will be important as manure regulations for whole-farm nutrient management are enforced by local, state, and national government groups.

Table 1. Impact on feed costs in two herds with different feed efficiencies (Agri-King).

Measurement	Herd A	Herd B
Milk, lb/d	80	80
DMI, lb/d	57	50
Feed Efficiency	1.40	1.60
Milk Income @ $12/cwt	$ 9.60	$ 9.60
Feed Costs @ $.07/lb dry matter	$ 3.99	$ 3.50
Income of over feed costs	$ 5.61	$ 6.10
Cost to produce 100 lbs milk	$ 4.99	$ 4.38

Optimizing feed intake is the "magic" term; not maximizing DM intake (DMI). Higher nutrient demand for higher milk production led to maximum DMI to meet higher requirements. The more DM the cow eats, the more she will milk. For Holstein cows, each additional pound of DM consumed could lead to an additional two pounds of milk. If one pound of DM costs seven cents, two pounds of milk can be worth 30 cents added income or 23 cents more income over feed costs. This guideline assumes two points.

- Ration digestibility is constant (but digestibility declines with increased DMI).
- All the nutrients consumed are converted to milk production after maintenance needs have been met (not true as growth and/or weight gain occurs).

Composition of the diet (forage to grain ratio) and dry matter intake (multiples of maintenance) has marked effects on digestibility and subsequent energy values. Diets that do not promote optimal rumen fermentation will result in an over-estimation of energy values and impair health.

Factors Impacting Dairy Efficiency

Dairy efficiency values in the field can vary from 1.1 to 2.0 (Table 2). The following factors will shift DE values.

- Reducing days in milk can lead to higher DE values as cows direct more nutrients to milk production at the expense of growth and weight gain. Cows losing body condition or body reserves will have high DE values as these nutrients can be captured as higher milk yield.
- Age or lactation number (first lactation cows) can lead to lower DE values as young cows divert nutrients to growth in mid and late lactation. Expect DE values for young cows to be 0.1 to 0.2 units lower than mature cows.
- Pregnancy requirements reduce DE values as the fetus requirements increase during late gestation (this impact will be small).
- Fresh cows (less than 21 days in milk) may have DE values below 1.2 if cows achieve higher DMI (desirable) relative to milk yield. If DE values are over 1.4, cows could be mobilizing excessive body condition with high milk fat test (undesirable).

Table 2. Benchmarks for feed efficiency comparisons.

Group	Days in milk	DE (lb milk/lb DM)
One group, all cows	150 to 225	1.4 to 1.6
1st lactation group	< 90	1.5 to 1.6
1st lactation group,	> 200	1.2 to 1.3
2nd + lactation group	< 90	1.6 to 1.8
2nd + lactation group	> 200	1.3 to 1.4
Fresh cow group	< 21	1.1 to 1.2
Problem herds	150 to 200	< 1.3

- Cows gaining body weight will have lower DE values as nutrients are stored as body condition or fat. This decline in DE must occur if cows lose body weight in early lactation. Lower DE values in late lactation can be desirable.

- Higher digestible forage will increase DE values as more nutrients are available for productive functions. NDF digestibility (NDFD) tests will be useful benchmarks that will impact DE.

- As NDF (neutral detergent fiber) percent in the ration dry matter increased, DE declined from 1.8 to 1.4 based on Journal of Dairy Science data from 2002 to 2004. DE values remained constant at 35 percent NDF and above.

- Stimulating rumen fermentation while stabilizing the rumen environment will improve nutrient and fiber digestibility. Rumen acidosis will reduce DE values. When USDA calorimetry data with inverted milk fat to milk protein tests (one potential sign of rumen acidosis) were removed, the R squared value was 0.55 compared to only 0.14 when all data were included comparing DE and DM digestibility. The higher R squared value explains more variation relating dry matter digestibility to higher dairy efficiency values.

- Excessive heat and cold stress will reduce DE values as more nutrients are needed for maintenance requirements.

- Feed additives (such as rumen buffers, ionophores, yeast cultures, and fermentation/digestion aids) and silage inoculants can improve DE values by improving digestion and/or nutrient availability. A summary of 12 yeast culture studies reflected a five percent improvement in DE (control cows averaged 1.26 compared to yeast culture supplemented cows at 1.32).

- Injecting BST can improve DE values as cows divert more nutrients to milk production.

Research on Feed Efficiency

Tennessee workers monitored 13 dairy herds over a 14 month time period evaluating feed efficiencies as environmental and feeds changed. Variables measured included temperature (< 21 degrees C and > 21 degrees C), days in milk, dry matter intake, milk yield, milk fat percentage, acid detergent fiber, neutral detergent fiber, and forage level. Season, days in milk, dry matter intake, percent forage in the ration, neutral detergent fiber, and acid detergent fiber were depressed or lower feed efficiency (negative correlation). Cool weather favored high feed efficiency (1.40) compare to warm weather conditions (1.31). Dairy efficiency and milk yield were positively correlated (more milk resulted in higher efficiency). Fiber intake and level reduced feed efficiency. The variation in these rations was limited reducing the impact on feed efficiency.

Genetics may also play a role in dairy efficiency. Daughters from high genetic merit bulls produced more milk than low genetic merit bulls even though feed intake was not different. The F1 Holstein-Jersey crosses demonstrated greater net efficiency than did the purebred Holstein or Jersey. It might be possible to select for more economic efficiency by focusing on dry matter intake, live animal weight, and/or other variables.

Fine Tuning Feed Efficiency

Management factors listed below can be used to evaluate and refine DE values measured on dairy farms.

- Actual feed intake is critical for an accurate DE value. Feed refusals should be removed (subtracted) as this feed has not been consumed. If a dairy manager targets four percent feed refusal with 50 pounds of dry matter offered, the correct value to use in the calculation is 48 pounds instead of 50 pounds. Weekly dry matter tests should be conducted on the farm to correct for variation in dry matter intake due to changes in wet feeds or precipitation.

- Correct for milk components as more nutrients are needed as milk fat and protein content increases. Values reported in this paper are based on 3.5 percent fat corrected milk (3.5%FCM). The following formulas can be used:

  Equation 1: 3.5% FCM = (0.4324 x lb of milk) + (16.216 x lb of milk fat)

  Equation 2: 3.5% fat and protein corrected milk (lb) =
  (12.82 x lb fat) + (7.13 x lb protein) + (0.323 x lb of milk)

  In 476 treatment observations in a data set compiled by Agri-King in journal articles, the difference between 3.5% FCM corrected and uncorrected milk for fat ranged from -0.28 to +0.41 units reflecting the need to adjust for milk fat.

- Field data from a high producing herd in Wisconsin reflects herd trends based on parity and days in milk (Table 3).

Table 3. Feed efficiencies in a commercial herd in Wisconsin based on age and days in milk.

Group	DIM (days)	Milk (lb)	DMI (lb)	DE (lb/lb)
1st fresh	27	42	44	0.95
1st high	124	79	50	1.58
1st preg	225	64	53	1.21
2nd fresh	20	60	52	1.15
2nd high	80	101	58	1.74
2nd preg	276	67	51	1.31

- On the Holstein farms, use the thumb rule of adding or subtracting one pound of milk for every one-tenth percentage point change above or below 3.5 percent fat test. For example, if a herd averages 70 pounds of milk with a 3.9 percent milk fat, the estimated pounds of 3.5% FCM would be 74 pounds instead of 70 pounds.

- Small body weight favors higher feed efficiency due to lower nutrients for maintenance will be needed. Adjusting for differences in body weight within breed may be a useful correction.

- Another comparison is using the "13 pound tax" for Holsteins (adjustment for maintenance). The "13 pound tax for Holsteins reflects that 10 megacalories (Mcal) of net energy is needed for maintenance functions (higher for cows on walking to pasture and/or experiencing heat/cool stress).

  Milk yield: (DMI consumed - 13 pounds of DM) x 2

  For example, a herd consuming 50 pounds of dry matter could support 74 pounds of milk (50-13 equals 37 times 2 equals 74 pounds of milk). For Jersey cows, use 10 pounds of dry matter for maintenance.

- Factors increasing maintenance (such as heat stress, extended walking to pasture and the milking parlor, and/or cold stress) will reduce feed efficiency as more nutrients are needed for non-productive functions.

Impact of Monensin on Dairy Efficiency

With the FDA clearance to use monensin for dry and lactating dairy cow, dairy managers have a new tool to improve feed efficiency and herd health. Table 4 is a summary nine studies in the U.S. and Canada including 357 first lactation cows (primiparous) and 609 second and great lactation cows (multiparous) starting 21 days prepartum through the entire lactation. The following points should be considered...

- Efficiency of milk production increased 2 to 4 percent with recommended level of 11 grams to 22 grams per ton of total ration dry matter (TMR) on a dry matter basis.

- Higher milk yield with lower milk components resulted in similar levels of solids-corrected milk.

- Dry matter intake did not change in early lactation and dropped in the later stages of lactation.

- Body weight was not different between controls and supplemented cows.

- The benefit to cost ratio for monensin for lactating cows was 5 to 1 while DE was 1.50 (control) compared to 1.54 to 1.56 for supplemented cows.

Lactating cows should receive monensin to increase feed efficiency, reduce methane losses, improve protein status, and reduce bloat for cows on pasture.

Table 4. Summary of effectiveness of monensin by level (nine studies).

Level of monensin (g/ton)	Control	11g/t	15g/t	22g/t
Dry matter intake (lb/day)	43.9	43.4	42.8	42.3
Milk yield (lb/day)	65.0	66.7	66.8	67.5
Milk fat (%)	3.65	3.53	3.49	3.38
Milk protein (%)	3.15	3.13	3.13	3.10
Solids corrected milk (lb)	58.2	58.6	58.0	58.0
3.5% FC milk (lb)	66.1	66.8	66.7	66.0
Dairy eff (lb 3.5/lb DM)	1.50	1.54	1.56	1.56
Imp milk efficiency (%)	control	+ 2.0	+2.5	+4.0

Future Opportunities

New software programs will be developed to allow on-farm data to standardize DE values (similar to management level milk or 150 day milk). Using spreadsheets, managers could enter days in milk, body weight, milk yield, milk fat test, milk protein test, changes in body condition score, temperature, walking distances, and lactation number allowing equations to adjust values from week to week or month to month.

Selected References

Britt, J.S., R.C. Thomas, N.C. Speer, and M.B Hall. 2003. Efficiency of converting nutrient dry matter to milk in Holstein Herds. J. Dairy Sci. 86:3796-3801.

Casper, D, L Whitlock, D. Schauff, and D. Jones. 2003. Feed efficiency boosts profitability. Hoard's Dairyman Magazine. Sept 25.

Casper, D.P., L. Whitlock, D. Schauff, D. Jones, and D. Spangler. 2004. Feed efficiency is driven by dry matter intake. J. Dairy Sci. 87 (Suppl. 1):462, Abstract 933.

Hutjens, M.F. 2001. Where are you on feed costs? Hoard's Dairyman. Jan 20

Linn, J, T.Trulla, D.L. Casper, and M. Raeth-Knight. 2004. Feed Efficiency of lactating dairy cows. Minnesota Nutr. Conf. Proc.

Veerkamp. R.F. 1998. Selection for economic efficiency of dairy cattle using information on live weight and feed intake: A review. J. Dairy Sci. 81-1109-1119

Wang, S, G.L. Roy, A.J. Lee, A.J McAlliser, T.R. Batra, and C.Y. Lin. 1992. Evaluation of various measurements of and factors influencing feed efficiency in dairy cattle. J. Dairy Sci. 75:1273-1280