

Practical Approaches to Feed Efficiency and Applications on the Farm

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Feed efficiency (also referred to as milk performance efficiency and dairy efficiency) can be defined as pounds of 3.5% FCM (fat corrected 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 feed efficiency (FE) 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 focus on maximizing feed efficiency reflects that 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 Feeding Programs

A key measure when evaluating feeding changes is the impact on profitability. Several measurements are listed below for consideration. Each value can have advantages and disadvantages.

Feed cost per cow per day does not reflect milk yield, stage of lactation, or nutrient requirements. A target value in Illinois is less than \$3.50 per cow per day for Holstein cows at 70 pounds of milk. A better application of this value is to divide the components to determine if your costs are optimal for your herd’s production and local feed costs (Table 1).

Feed cost per pound of dry matter is a useful term when comparing similar regions, breeds, and

levels of milk production. A target value in Illinois is less than seven cents per pound of dry matter. In the example in Table 1 for Holstein cows at 70 pounds of milk, the cost is 7.5 cents per pound of dry matter.

Feed cost per 100 pounds (cwt) or 45 kg of milk has the advantage of standardizing milk yield allowing for comparisons between groups and farms within a region. Milk yield per cow and feed costs will impact this value. A target value in Illinois is less than \$5.50 per cwt for Holstein cows (the example in Table 1 is \$5.39).

Income over feed costs (IOFC) is a popular value as it provides a benchmark for a herd or groups of cows reflecting profitability, current feed prices, and actual milk prices. If dairy managers have calculated fixed costs and other variable costs, IOFC can be used to determine breakeven prices, optimal dry off time, and culling strategies. A target value in Illinois is over \$9.50 per cow per day (\$15 per cwt). The example in Table 1 is \$9.61 per cow per day.

Marginal milk response reflects the profit if additional pounds of milk can be achieved. Generally, this approach is profitable if cows respond to the feeding change because maintenance costs and fixed costs have been covered by previous production. For example if adding one pound of dry matter increases milk yield by two pounds with milk valued at \$15 per cwt and dry matter at 7.5 cents, the marginal milk profit is 22.5 cents.

Cost per unit of nutrient allows dairy managers to compare the relative cost of a nutrient. If corn

is priced at seven cents per pound (dry matter basis), one unit of net energy is worth \$0.065 cents per Mcal of net energy. If corn is the base energy feed resource; then forages, by-product feeds, and other cereal grains can be compared on their cost per unit of target nutrient.

Feed efficiency can be defined as pounds of milk produced per pound of dry matter intake (DMI) consumed. Guidelines for FE are listed in Table 2. In the example in Table 1, the value was 1.4 pounds of milk per pound of feed dry matter.

Practical Approaches to Measuring FE on Farms

Option 1: Computer software program. FeedAd was developed by Zinpro Corporation and is available for field application. The software program allows on-farm data that will standardize FE 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, environmental temperature, walking distances, and lactation number using research-based and NRC 2001 equations to adjust values.

Option 2: On-farm measurement of FE. This approach collects dry matter intake by group or herd using actual feed amount delivered with automated computer tracking systems (such as Feed Tracker), subtracting feed refusals, and collecting daily milk yield using a group total (such as in-line milk meters) or individual cow production summaries. An Illinois herd is listed in Table 3.

Option 3: Estimating and adjusting for FE. Many dairy managers and nutritionists are faced with some form of this option due to the following situations or limitations.

- Milk yield is available monthly from DHI or daily bulk tank yields.
- Feed intake by groups or herd is not recorded daily. A feed sheet or ration may be available.
- Weigh backs may or may not be measured.

- No group or pen milk components are available.

Using this approach to estimate FE, the following factors can be used along with bulk tank milk yields and ration summaries. For example, the herd of 100 cows averaged 6800 pounds of milk and consumed 4800 pounds of dry matter a day based on feed ration sheets. The FE is 1.42 for this herd (a low value that requires review of potential factors that may be causing this to occur). The following factors can be used with estimated impact values on FE. Nutritionists and dairy managers can adjust these values as data are not available for several of these factors (modify as desired).

Factor 1: Weigh back. Estimations of feed refusals can use a bunk scoring system based on a subjective estimate.

Feed bunk score 1 has no feed remaining

Feed bunk score 2 has 2 to 4% remaining

Feed bunk score 3 may have over 5% remaining

If a bunk reading was bunk score 3 in our example herd, the weigh back could represent 2.4 pounds. Adjusting for this amount of feed not consumed, the adjusted FE could be 1.49.

Factor 2: Days in milk (DIM). Add 0.15 FE unit for each 50 days starting at 150 DIM. In our example herd, if days in milk were 200 days, add 0.15 unit or adjusted FE of 1.57.

Factor 3: Somatic cell count. For each linear score decrease in SCC, add 2.5 pounds more milk to the current production. If our example herd was linear score 4, reducing linear SCC to 3 could add 2.5 pounds to 68 or 70.5 pounds leading to an adjusted FE of 1.47.

Factor 4: Change in body condition. If cows are gaining one half body condition score, this milk equivalent can represent 138 pounds of milk (60 pounds of body condition equals 2.3 pounds of milk per pound). If this occurs over 100 days,

adding 1.4 pounds of milk to the base results in an adjusted FE of 1.45.

Factor 5: Exercise/pasture. If cows walk 800 meters per day (two times a day milking and/or walking to pasture resulting in four trips a day averaging 200 meters per trip can increase maintenance requirements by 1.9 Mcal which is equal to 5 pounds of 3.5 lb FCM). Adding this amount to the example herd could raise FE to 1.52 units.

Factor 6: Rumen acidosis. Field reports estimate that FE may drop 0.1 unit if cows experience sub-acute rumen acidosis (SARA). Diagnosis could be based on several field indicators.

- Milk protein: milk fat ratios over 0.9 (3.0 true milk protein test and 3.3 milk fat test)
- Loose manure (average manure scores under 2.75)
- Average lameness scores over 1.6
- Dry matter intake varies over two pounds per cow per day using TMR values

Factor 7: Protein level and form. Illinois data indicated that the level of protein can impact FE as diets from 16.8 to 18.7 decreased FE by 0.03 unit while an animal protein blend increased FE by 0.07 unit compared to soybean meal control source.

Factor 8: Feed additive. Adding yeast culture/yeast, ionophores, buffers, and direct-fed microbials may increase FE by 0.05 to 0.10 unit.

Factor 9: Fiber level. As NDF (neutral detergent fiber) percent in the ration dry matter increased, FE declined from 1.8 to 1.4 based on Journal of Dairy Science data from 2002 to 2004. FE values remained constant at 35 percent NDF and above.

Factor 10. Heat stress. If cows are exposed to heat stress with no heat abatement intervention, the following declines in FE can occur due to higher maintenance requirements, lower milk yield, and lower feed intake.

Cows exposed to 86 degrees F compared to 68 degrees F, reduce FE by 0.1 unit.

Cows exposed to 95 degrees F compared to 86 degrees F, lower FE by 0.3 unit.

Fresh Cow Monitoring of FE

For dairy managers and nutritionists that have a fresh cow pen with daily milk yields, group feed intakes, and days in milk recalculated daily, FE is a useful tool to monitor dry matter intake after calving, comparison of heifer and mature cow fresh pens, and the success of the transition program. A California field study of 50 herds reported the FE for the following groups of cows (days in milk was not reported).

- Heifer fresh cow group averaged 1.47 with a range of 1.19 to 1.87
- Cow fresh cow pen averaged 1.75 with a range of 1.26 to 2.26

A low FE can be plus if dry matter intake after calving is optimal. A low FE after calving can reflect low milk production in early lactation, a potential problem. A high FE can indicate cows are achieving high milk after calving (good), low dry matter intake after calving (bad), and/or excess weight losses leading to ketosis and fatty liver development. Table 4 lists dry matter intake guidelines by week after calving and parity.

Economics of Feed Efficiency

With shifting milk prices, one way to maintain profitability without sacrificing milk production or herd health is by enhancing feed efficiency. A herd or group of cows producing 80 pounds of milk consuming 57 pounds of DMI has a feed efficiency of 1.40. Another herd or group produced the same amount of milk, but the cows consumed only 50 pounds of dry matter, for a feed efficiency of 1.60. Assuming feed costs of \$0.07 per pound of dry matter, the second herd has a lower feed cost of \$0.49 per cow per day compared to the first herd. In addition, with the lower feed intake and higher feed efficiency, cows will have lower nutrients in fecal material. As a guideline, for each

improvement of 0.1 unit in FE (from 1.4 to 1.5 for example), the increased income can vary from 15 to 22 cents per cow per day.

Optimizing feed intake is the “new approach,” not maximizing DMI. Higher nutrient demand for higher milk production leading to maximum DMI must be achieved to meet these requirements. The more DMI the cow eats, the more she will milk. For Holstein cows, each additional pound of DMI consumed could lead to an additional two pounds of milk. If one pound of dry matter costs seven cents, two pounds of milk can be worth 30 to 36 cents more income or 23 to 29 cents more income over feed costs. This guideline assumes two points.

- Ration digestibility is constant (digestibility declines with increased DMI).
- All the nutrients consumed are converted to milk production after maintenance needs have been met (no growth or weight gain for example).

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

Fine Tuning Feed Efficiency

Actual and accurate feed intake is critical for an accurate FE value. Feed refusals should be removed (subtracted) as this feed has not been consumed. 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:

$$\text{Equation 1: lb 3.5\% FCM} = (0.4324 \times \text{lb of milk}) + (16.216 \times \text{lb of milk fat})$$

$$\text{Equation 2: lb 3.5\% fat and protein corrected milk} = (12.82 \times \text{lb fat}) + (7.13 \times \text{lb protein}) + (0.323 \times \text{lb of milk})$$

On 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 3.9 percent milk fat, the estimated pounds of 3.5% FCM would be 74 pounds instead of 70 pounds.

Examples of Feed Efficiency

Field Study One. A herd of 1200 high producing Holstein cows illustrate herd trends based on parity and days in milk (Table 5).

Field Study Two. A herd of 1800 Holstein cows dropped several feed additives, replacing them with a new commercial product. Changes (monitored using Feed Watch and Dairy Comp 305) included an increase in milk yield from 76 pounds to 80 pounds of milk per cow. A drop in dry matter intake from 53 pounds to 51.7 pounds per cow increased feed efficiency from 1.43 to 1.55, and a decline from \$5.44 to \$4.58 per 100 pounds (45 kg) of milk. Dry matter intake became more consistent along with more uniform manure.

Summary

- 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 1.9 pounds of milk per pound of dry matter.
- Days in milk, age, growth, changes in body condition score, walking distances, 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.

- Several approaches can be used in the field to measure or estimate FE in groups, herds, and feeding / management changes.

Selected References

- 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.
- Hutjens, M.F. 2005. Feed efficiency and its impact in large dairy herd. Southwest Nutritional Conf. Proc.
- 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.



Table 1. Illinois feed costs for a group of cows averaging 70 pounds of milk

Feed	DMI (lb/day)	Cost (\$/lb DM)	Total cost (\$/day)
Forages	30	0.06	1.80
Grain energy	10	0.07	0.70
Protein supplement	5	0.10	0.50
By-product feed	4	0.08	0.32
Min/vit feed	1		0.25
Feed additives			0.10
Feed consultant			0.10
Totals	50		\$3.77

Table 2. Benchmarks for feed efficiency (FE) comparisons

Group	Days in milk	FE (lb milk/lb DM)
One group, all cows	150 to 225	1.4 to 1.6
1 st lactation group	< 90	1.5 to 1.7
1 st lactation group	> 200	1.2 to 1.4
2 nd + lactation group	< 90	1.6 to 1.8
2 nd + lactation group	> 200	1.3 to 1.5
Fresh cow group	< 21	1.3 to 1.6
Problem herds/groups	150 to 200	< 1.3

Table 3. Daily data from various groups in a herd of Holstein cows using computer summaries from feed truck and in-line milk meter results (May, 2007)

Pen	Age (group)	Cow (no)	DMI (lb)	Milk yield (lb FCM)	DIM (days)	FE (lb FCM/lb DM)
Pen 1	Cow	390	57.7	121	56	2.10
Pen 2	Cow	399	61.3	115	149	1.87
Pen 3	Cow	393	51.4	67	357	1.30
Pen 4	Cow	402	59.2	100	228	1.69
Pen 5	Heifer	390	51.6	88	218	1.70
Pen 6	Heifer	428	52.7	76	359	1.44
Pen 7	Heifer	386	46.7	83	100	1.78
Pen 8	Hospital	56	38.5	45	62	1.17
Pen 9	Mix	32	45.0	45	162	1.00

Table 4. Dry matter intake by week after calving and parity

Week after calving	1 st lactation cows	2 nd + lactation cows
	-----lb per cow per day-----	
1	31.0	36.5
2	35.0	42.5
3	38.0	45.5
4	40.0	49.0
5	41.5	52.5

Table 5. Feed efficiencies (FE) in a commercial herd in Wisconsin based on age and days in milk

Group	DIM (days)	Milk (lb)	DMI (lb)	FE (lb/lb)
1 st fresh	27	42	48.4	0.95
1 st high	124	79	49.9	1.58
1 st preg	225	64	53.0	1.21
2 nd fresh	20	60	51.9	1.15
2 nd high	80	101	58.1	1.74
2 nd preg	276	67	51.0	1.31