THIS ARTICLE IS SPONSORED BY THE
MINNESOTA DAIRY HEALTH CONFERENCE.

UNIVERSITY OF MINNESOTA

College of Veterinary Medicine

VETERINARY CONTINUING EDUCATION

ST. PAUL, MINNESOTA
UNITED STATES OF MINNESOTA

Feed Efficiency—Impact on Economics

Michael F. Hutjens
Professor of Animal Sciences
University of Illinois, Urbana, 61801
hutjensm@uiuc.edu

With the milk to feed ratio at 2.36 in February, 2008, and 2.05 in March, 2008, 2008, dairy managers must carefully reviewing feed inputs relative to milk yield. A milk to feed ratio under 3.0 is a signal to reduce feed inputs. 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. 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 optimizing feed efficiency reflects as cows consume more feed, digestive efficiency decreases 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 consideration 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 $5.50 per cow per day for Holstein cows at 70 pounds of milk. An application of this value is divide the feed components to determine if your costs are optimal for your herd's production and local feed costs (Table 1).

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

Feed	D.M. (lb/day)	Cost/lb DM ($)	Total Cost ($/day)
Forages	28	0.08	2.24
Grain energy	10	0.09	0.90
Protein supplement	5	0.12	0.60
By-product feeds	6	0.10	0.60
Min/vit/additives	1	0.35	0.35
Consultant time			0.10
Totals	50		$4.79

Feed cost per pounds of dry matter is a useful term when comparing similar regions, breeds, and levels of milk production. A target value in Illinois is 10 to 11 cents per pound of dry matter. In the example in Table 1 for Holstein cows at 70 pounds of milk, the cost is $0.96 per pound of dry matter.

Feed cost per 100 pounds (cwt) 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 $7.00 per cwt for Holstein cows (the example in Table 1 is $6.84).

Income over feed costs (IOFC) is a popular value as it provides a benchmark for herd or groups of cows reflecting profitability, current feed prices, and actual milk prices. If dairy managers have calculated fix 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 $11 per cow per day ($18 per cwt). The example in Table 1 is $11.16 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 $18 per cwt and dry matter at 10 cents, the marginal milk profit is 26 cents.

Cost per unit of nutrient allows dairy managers to compare the relative cost of a nutrient. If corn is priced at nine cents per pound (dry matter basis), one unit of net energy is worth $0.099 cents per Mcal of net energy. If corn is the base energy feed resource; forages, by-product feeds, and other cereal grains can be compared on their cost per unit of nutrient.

Milk to feed ratio compares the relationship of milk price to feed costs. In March, 2008, the following prices were used: milk at $18.30 per cwt, $4.83 a bushel for corn, $11.90 a bushel for soybeans, and $143 per ton of alfalfa hay. The formula is based on 16 percent mixed dairy feed with the model using 51 percent corn, 8 percent soybeans, and 41 percent alfalfa. When the ratio is over 3.0, it is considered profitable to feed more dry matter and produce more milk.

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.

Table 2. Benchmarks for feed efficiency comparisons.

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

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.

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.

Pen	Age (group)(no)	Cow (lb)	DMI (lb FCM)	Milk yield (days)	DIM	FE (lb FCM/lb DM)
Pen 1	Cow	390	57.7	116	56	2.10
Pen 2	Cow	399	61.3	111	149	1.87
Pen 3	Cow	393	51.4	82	357	1.30
Pen 4	Cow	402	59.2	103	228	1.70
Pen 5	Heifer	390	51.6	84	218	1.70
Pen 6	Heifer	428	52.7	82	359	1.45
Pen 7	Heifer	386	46.7	80	100	1.77
Pen 8	Mix	56	38.5	93	62 (hospital)	1.17
Pen 9	Mix	32	53.0	103	162 (mastitis)	0.85

Option 3. Estimating and adjusting for FE. Dairy managers and nutritionist 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 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 factors that be causing this to occur). The following factors can be used with estimated impact values on FE. Nutritionists and dairy managers may want to adjusted these values as data are not available for several of these factors (modify as desired).

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

Feed bunk score 0 has no feed remaining
Feed bunk score 1 has 1 lb of dry matter
Feed bunk score 2 has 2 lb of dry matter remaining

Factor 2: Days in milk (DIM). Add 0.15 FE unit for each 50 days starting at 150 DIM.

Factor 3: Somatic cell count. For each linear score change in SCC, add or subtract 2.5 pounds milk to the current production.

Factor 4: Change in body condition. If cows are gaining one half body condition score during lactation, 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 milk yield.

Factor 5: Exercise/pasture. If cow walk 100 feet a day, subtract 0.2 lb of milk (two times a day milking and/or walking to pasture resulting in four trips a day averaging 200 feet per trip can increase maintenance requirements by 1.6 pounds of milk not captured..

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 ratio over 0.9 (3.0 true milk protein and 3.3 milk fat tests
Lose manure (average manure scores under 2.75)
Average lameness scores over 1.6
Dry matter intakes varies over two pounds per cow per day

Factor 7: Protein level and form. Illinois data indicated that level of protein can impact FE. If protein is over 18 percent crude protein or MUN are over 16, shift FE by 0.03 unit.

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

Factor 9: Fiber digestibility. As forage NDF (neutral detergent fiber) digestibility increases one percent point (more digestible), milk yield increases 0.5 pound of milk and dry matter intake increases 0.25 pound.

Factor 10. Heat stress. If cow 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 average 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.

Table 4. Dry matter intake by week after calving and parity (Hutjens, 2005).

Week after calving	1st lactation cows	2nd+ 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

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. Table 5 illustrates that economic savings per cow per day when cows improved in FE while milk remains constant at 70 pounds of milk and feed valued at 10 cent per pound of dry matter.

Table 5. Economic impact of improving FE while maintaining milk yield.

FE (lb of milk/lb DM)	DMI (lb DM/day)	Savings ($/cow/day)
1.20	58.3	
		0.83
1.40	50.0	
		0.62
1.60	43.8	
		0.48
1.80	38.9	

Optimizing feed intake is the "magic" term; not maximizing DMI. Higher nutrient demand for higher milk production led to maximum DMI must be achieved to meet these requirements. The more DMI the cow eats, the more she will milk. 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.

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:

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

Equation 2: 3.5% lb fat and protein corrected milk (lb) =
(12.82 x lb fat) + (7.13 x lb protein) + (0.323 x 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 a 3.9 percent milk fat, the estimated pounds of 3.5% FCM would be 74 pounds instead of 70 pounds.

Field 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 6).

Table 6. Feed efficiencies in a commercial herd in Wisconsin based on age and days in milk.

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

Field Study Two. A herd of 1800 Holstein cows dropped several feed additives replacing it 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 of milk. Dry matter intake became more consistent along with more uniform manure.

Summary

- Feed or 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 1.9 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.

Hutjens, M.F. 2007. Applied Feed Efficiency on Dairy Farms. Penn State Dairy Workshop 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