Feeding to Reduce your Carbon Footprint

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Abstract

Carbon footprint is a new area for dairy managers, veterinarians, environmentalists, and consumers. Government and industry groups have agreed to reduce the dairy carbon footprint by 20%. While controversy surrounds these discussions, it is a win-win situation for dairy producers and the environment. Dairy managers benefit by capturing more carbon as an energy source for their dairy cattle. An important concept is to express carbon footprint as the amount per unit of product (pounds of milk or milk solids). Three areas will be discussed in the presentation. Feed efficiency provides economic and viable comparisons, monitoring pounds of milk produced per pound of dry matter consumed. Feed efficiency can be calculated and evaluated using on-farm measured values to calculate an adjusted feed efficiency. Feeding strategies and rumen modifiers can reduce the level of methane reducing the dairy farm footprint. Dairy heifer feeding programs that reduce dry matter intake while maintaining growth and optimizing age at first calving can reduce their carbon footprint.

Résumé

L'empreinte carbone représente un nouvel enjeu pour les gestionnaires de fermes laitières, les vétérinaires, les environnementalistes et les consommateurs. Le gouvernement et les regroupements industriels se sont entendus pour réduire l'empreinte carbone de l'industrie laitière de 20%. Bien que la controverse entoure souvent ces discussions, cette situation est gagnante aussi bien pour les producteurs laitiers que pour l'environnement. Les gestionnaires de fermes laitières vont bénéficier de la capture accrue de carbone comme source d'énergie pour leurs bovins laitiers. Un concept important consiste à exprimer l'empreinte carbone en tant que quantité par unité de produit (livres de lait ou de solides du lait). On discutera ici de trois éléments. L'efficacité alimentaire est un point d'ancrage économiquement viable par sa mesure des livres de lait produites par livre de matière sèche consommée. L'efficacité alimentaire peut être calculée et évaluée en utilisant des valeurs mesurées à la ferme pour produire une efficacité alimentaire ajustée. Les stratégies d'alimentation et les modificateurs du rumen peuvent réduire le niveau de méthane et donc l'empreinte de la ferme laitière. Les programmes d'alimentation des taures laitières qui réduisent la prise alimentaire de matière sèche tout en maintenant la croissance et en optimisant l'âge au premier vêlage peuvent réduire leur empreinte carbone.

Introduction

Feeding to reduce the carbon footprint on dairy farms can improve feed efficiency (increasing measurable output per unit of input), increase performance (milk yield, milk components, or growth), improve feed digestibility (rumen fermentation and total tract digestion), and use of rumen modifiers. Another key consideration is expressing carbon footprint based on units of output (such as pounds of milk or unit of growth) instead of on an animal basis. This paper focuses on areas that veterinarians can use and implement on their clients' dairy farms.

Measuring Carbon Footprint

Globally, animal agriculture is estimated to contribute approximately 18% of total greenhouse gas emissions. On the dairy farm, methane production is one key aspect when expressing greenhouse gases (GHG) as it is 23 times more potent than carbon dioxide. Cornell workers compared carbon dioxide equivalents in 1944 and 2007 using two comparisons: carbon dioxide per cow and carbon dioxide per unit of milk produced. On a per-cow basis, 66 lb (30 kg) of carbon dioxide equivalents were produced in 1944 and 134 lb (61 kg) were produced in 2007. On a milk production basis, 8.1 lb (3.7 kg) in 1944 and 2.9 lb (1.3 kg) in 2007 of carbon dioxide equivalents per 2.2 lb (1 kg) of milk produced were calculated. Several concepts are apparent:

- High-producing cows that consume more feed than lower-producing cows produce more GHG.
- High-producing cows will have the lower GHG per unit of milk produced.
- Dilution of maintenance in high-producing cows allows for a greater percent of dietary energy for milk production. For example, a cow producing 33 lb (15 kg) of milk captures 51% of consumed energy as milk, while a cow producing 55 lb (29 kg) captures 67% of dietary energy as milk yield.

Feeding and technology applications that increase milk yield will reduce GHG. Milking three times a day, use of rBST (recombinant bovine somatotropin) and/or genomics to select superior animals will reduce GHG. If 1 million dairy cows were supplemented with rBST, some 157,000 fewer milk cows would be needed, 2.4 million metric tons less fertilizer and pesticide would be required, and 540,000 less acres of land would be needed for crop production. The use of rBST technology could reduce GHG by 8.9%. Other aspects of the dairy product carbon footprint include the manufacturing process, transportation of milk and dairy products, and marketing of dairy products.

Ration Considerations and Alternatives

Dairy managers have several tools and alternatives to reduce carbon footprint (methane production) in their feeding program. Several of these applications are outlined below.

- The logical tool available to US and Canadian dairy managers is to add monensin (Rumensin®[a]) to the dairy cattle ration. Monensin (a rumen feed additive) favors gram-negative bacteria growth which reduces methane production, increases propionic acid (rumen volatile fatty acid (VFA)) production, and increases feed efficiency (increased by 6%) as more carbon is available for productive function (such as milk yield or growth). Milk production increases of up to 2.2 lb (1 kg) per cow per day may occur. Levels of monensin range from 250 to 600 mg per cow per day, 300 mg for dry cows, and 200 mg for older dairy heifers in the field. The benefit-to-cost ratio of 14:1 is favorable.
- Feeding essential oils (cinnamon oil, clove oil, and/or garlic oil) can reduce rumen methane production in a role similar to monensin, especially in countries that do not allow monensin supplementation. The level varies from 0.5 to 1.5 grams per cow per day (higher levels can have negative impact). The daily cost varies from 6 to 8 cents per cow. Wisconsin researchers report a benefit to cost ratio of 7:1.
- Increasing grain levels can reduce methane production while increasing propionic acid production in the rumen fermentation, thus shifting the VFA pattern. The feed cost of this application must be considered.
- Increasing forage quality reduces methane production while lowering the amount of total dry matter (DM) required, thereby reducing fecal output.
- Stabilizing the rumen environment using feed additives such as yeast products, buffers, and direct-fed microbial products can reduce GHG levels.
- Feeding oils as PUFA (polyunsaturated fatty acids) can impact rumen fermentation, shifting rumen fermentation VFA pattern and levels. Limit the level of PUFA to less than 500 grams per cow per day, with a total of 5 to 5.5% total fat and oil in the ration.
- Balancing the protein level and sources can reduce nitrogen intake, lowering nitrogen losses which can reduce GHG production related to less-nitrogenous gases.

Limit-Feeding Dairy Heifers

In an attempt to optimize heifer growth and body condition scores while improving feed efficiency, limiting feed intake is an active research area. With feed costs increasing, several approaches have been investigated. Wisconsin researchers have evaluated the impact of limiting DM intake and its impact on growth, manure production, and future milk yield. Older heifers have the greatest opportunity because of their high feed intake potential, reduced need for energy due to confinement housing, and higher excretion of manure. Wisconsin workers formulated a ration by reducing DM intake while maintaining protein, energy, and mineral levels. A control ration (C-100 containing 67.5% total digestible nutrients (TDN)), 90% of control dry matter intake (L-90 with 70.0% TDN), and 80% of control DM intake (L-80 with 73.9% TDN) were fed to 1000 lb (454 kg) Holstein heifers. While DM intake was limited, actual nutrient content consumed remained constant (Table 1). Limit-fed heifers had numerically higher average daily gain, similar body condition scores, 30% increase in feed efficiency (FE), and a reduction in manure excretion (Table 1). Milk production levels were not different with C-100, L-90, and L-80 producing 18,200, 19,000, and 19,800 lb (8,273, 8,636, and 9,000 kg) of milk, respectively.

Penn State workers conducted a series of studies shifting the forage-to-concentrate ratio to measure FE and performance in dairy heifers from 4 to 22 months of age. High-forage (HF) diets were compared to high-concentrate (HC) diets resulting in less DM intake (11.9 lb (5.4 kg) for HC compared to 13.1 lb (6 kg) for HF rations), with similar average daily gain (ADG) and improved FE. No differences in skeletal growth were reported. In a second study, forage levels varied from 75 to 25% forage. No differences in organic dry matter digestibility, neutral detergent fiber digestibility, or total VFA production were observed. Mean rumen pH was lower for HC rations at 6.24 compared to HF pH at 6.51, with 7.1 hours of rumen pH below 6 for HC compared to 3.1 hours for HF rations. Fecal nitrogen excretion was higher for HF, with greater nitrogen retention for HC rations. Researchers concluded that HC diets reduced feed costs by 3 to 16%, improved nitrogen efficiency,

Table 1. Performance, nutrient levels, and behavior response of heifers fed restricted levels of dry matter.

	Control	Restricted	Restricted
Nutrient profile	(100%)	(90%)	(80%)
Dry matter (lb)	21.3	19.9	18.3
TDN (lb)	4.4	13.9	13.0
Crude protein (lb)	2.42	2.54	2.57
NDF (lb)	10.1	8.3	6.5
NFC (lb)	7.26	7.60	7.85
Growth parameters			
ADG (lb/day)	1.66	1.92	1.84
Feed efficiency (lb DM/lb gain)	13.2	10.7	11.1
Total pounds gained	184	213	206
Final weight (lb)	1220	1234	1219
Hip height growth (inches)	1.8	1.7	1.5
Final hip height (inches)	56.8	56.3	56.4
Body condition score	3.2	3.2	3.2
Behavior			
Eating time (hr/day)	2.3	1.9	1.2
Lying time (hr/day)	14.6	14.4	13.6
Vocalization (hr/day)	0.02	0.04	1.10
Milk yield (lb milk)	18,200	19,000	19,800
Manure production (lb/day)	7.7	6.9	5.8

Source: Hoffman PC: Innovations in dairy replacement heifer management. *Proc Western Dairy Management Conf*, Reno, NV, 2007.

reduced manure output by 12 to 40%, and maintained optimal growth (ADG and skeletal measurements).

Management factors to consider when implementing limit-feeding heifers on the dairy farms are listed below.

- Feed bunk space will be critical to insure feed access at feeding time for all heifers.
- Nutrient intake (pounds of protein, units of energy intake, and grams of minerals) must be built into the dry matter consumed.
- Grouping of heifers to insure optimal nutrient intake must be considered.
- Heifers will be vocal initially when DM intake is restricted.
- Feed costs (forages compared to grain) will be important when assessing economic impact.
- Older heifers may provide greater opportunities than younger heifers due to amount of DM consumed.

Feed Efficiency as a Tool

Feed efficiency (also referred to as dairy efficiency) can be defined as pounds of 3.5% FCM (fat corrected milk) produced per pound of DM consumed. Monitoring FE in the dairy industry has not been used as a common benchmark for monitoring profitability and evaluating DM intake relative to milk yield. The "traditional" focus was that as cows consumed more feed to support higher milk production, the proportion of digested nutrients captured as milk was proportionally higher. Accurate feed intake is critical for an accurate FE value. Feed refusals should be removed (subtracted), as this feed has not been consumed. Weekly DM tests should be conducted on the farm to correct for variations in DM intake due to changes in wet feeds or precipitation. Correct for milk component differences, as more nutrients are needed as milk fat and protein content increases. Values reported in this paper are based on 3.5% FCM. The following formulas can be used:

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

Equation 2: 3.5% lb ECM (energy corrected milk) = (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 1 lb (0.45 kg) of milk for every 0.1 percentage point change above or below 3.5% fat test. For example, if a herd or group of cows produced 70 lb (31.8 kg) of milk with a 3.9% milk fat, the estimated pounds of 3.5% FCM would be 74 lb (33.6 kg) instead of 70 lb of milk, correcting for higher milk fat test.

The economic impact of FE is another key factor when shifting FE values. If a herd or group of cows is producing 80 lb (36.3 kg) of milk consuming 57 lb (25.9 kg) of DMI with a FE of 1.4, and the herd or group improves to a FE of 1.6, DMI drops to 50 lb (22.7 kg). When DM is valued at 11 cents per pound, this improvement in FE results in a savings of 77 cents per cow per day or 38 cents per 0.1 point increase in FE.

Guidelines for FE are listed in Table 2 (groups of cows) and Table 3 (herd milk yield). Three options to measure and track FE on dairy farms are listed below.

Option 1. **Computer software program**. FED (Feed Efficiency Determinator) 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. Several detailed measurements and complete herd data are needed to use the computer software.

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

Source: Hutjens MF: Practical approaches to feed efficiency and applications on the farm. *Proc Penn State Univ Dairy Nutrition Workshop*, Grantville, PA, 2007.

Table 3. Target FE based on rolling herd average and milk yield per cow.

Rolling herd average (lb/kg)	FE
18,000 / 8,182	1.24
20,000 / 9,091	1.32
22,000 / 10,000	1.40
24,000 / 10,909	1.47
28,000 / 12,727	1.58
30,000 / 13,636	1.63
Milk yield per cow (lb/kg per day)	
55 / 25.0	1.25
65 / 29.5	1.38
75 / 34.1	1.49
80 / 36.4	1.54
85 / 38.6	1.58
90 / 40.9	1.63

Source: St-Pierre N: Managing measures of feed costs: benchmarking physical and economical feed efficiency. *Proc Tri-State Dairy Nutr Conf*, Fort Wayne, IN, 2008.

Option 2. **On-farm measurements**. This approach collects DM 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.

Option 3. **AFE (adjusted feed efficiency)**. This system can be calculated by dairy managers or veterinarians using on-farm data in a simplified approach, with the following situations or limitations:

- Milk yield is available monthly from Dairy Herd Information (DHI) or daily bulk-tank yields.
- Feed intake by group 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.

The following factors can be used along with bulk-tank milk yields and ration summaries to estimate/correct FE. Veterinarians and dairy managers can adjust these values if data are not available (modify as desired).

Factor 1: **Weigh-backs**. 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% remaining.
- Feed bunk score 4 has 4% remaining.

If a bunk reading was scored 4 with delivered DM of 50 lb (22.7 kg) per cow, the weigh-back could represent 2 lb (0.9 kg) of feed not consumed, reducing DM to 48 lb (21.8 kg).

Factor 2: **Days-in-milk (DIM)**. Reduce 0.11 FE unit for each additional 30 DIM starting at 150 DIM.

Factor 3: **Somatic cell count**. For each SCC linear score decrease, add 2 lb (0.9 kg) of milk to the current herd production. If a herd was linear score 4, reducing linear SCC to 3 could increase milk yield by 2 lb (0.9 kg) of milk.

Factor 4: **Change in body condition**. If cows are gaining one body condition score, this can represent

120 lb (54.5 kg) of milk equivalence. If this occurs over 120 days, this is equivalent to 1 lb (0.45 kg) of additional milk production credit.

Factor 5: **Walking (exercise, milking, and/or pasture)**. If cows walk 800 yards per day (two times a day milking results in four trips a day, averaging 200 yards to the milking parlor per trip), maintenance requirements can be increased by 1.9 Mcal, which is equal to 4.6 lb (2.1 kg) of milk.

Factor 6: **Rumen acidosis**. FE may drop 0.1 unit if cows experience sub-acute rumen acidosis (SARA). Diagnosis could be based on the following indicators:

- Milk protein: fat ratios over 0.90 (such as 3.2% true milk protein test and 3.1% milk fat test).
- Loose manure (average manure scores under 2.5).
- Lameness scores of 3 or higher in over 10% of cows (1 to 5 point scale).
- Dry matter intakes vary over 2 lb (0.91 kg) per cow per day.

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

Factor 8: **Feed additive**. Adding yeast culture/yeast, an ionophore, buffers, and direct-fed microbial may increase FE by 0.05 to 0.10 unit per additive fed.

Factor 9. **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°F (30°C) compared to 68°F (20°C), reduce FE by 0.1 unit.
- Cows exposed to 95°F (35°C) compared to 86°F (30°C), lower FE by 0.3 unit.

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