Fermentrics: A new ration evaluation tool

Bill Mahanna for *Progressive Dairyman*

Jay Johnston, CEO of RFS Technologies and Ritchie Feed and Seed in Ottawa, Canada, demonstrates gas-fermentation feedstuff anaylsis.

Courtesy photo by Bill Mahanna.

Fermentrics is a nutritional diagnostic report unique in that it contains data generated from a novel, gas-fermentation method popular among European academic researchers. There are only a few university and corporate product development research labs in North America with gas-fermentation systems and they are not capable of processing and handling the sample volume needed in a commercial offering. The desire to provide a more dynamic and diagnostic nutritional tool led to an August 2010 joint initiative between Dairyland Laboratories, Inc. and RFS Technologies to commercialize Fermentrics and make this cutting-edge analysis more widely available to commercial dairymen and their nutritionists.

Jay Johnston, CEO of RFS Technologies and Ritchie Feed and Seed in Ottawa, Canada, is the developer of Fermentrics. He became intrigued with the gas-fermentation system as a tool for quantifying the variability among feed ingredients his mills were purchasing and for evaluating on-farm rations. He has spent the past 15 years developing, refining and field testing an automated system to provide a unique perspective on the dynamics of nutrient digestion not available from current laboratory analyses. A gas-fermentation analysis report (See **Figure 1**) provides traditional nutritional parameters (e.g., NDF, starch, CP etc.) along with carbohydrate pool digestion rates (e.g., C:B1, C:B2 and C:B3). It also provides other unique analytes, such as direct measurement of microbial biomass production (MBP) and a microbial approach to measuring soluble protein.

In vitro (test tube) and in situ (fistulated cattle) methods are currently being used at commercial laboratories to characterize the digestion kinetics of starch and fiber by analyzing the feed before and after incubation. However, due to the labor and expense, these methods typically provide a very limited number of data points (e.g., seven-hour starch digestibility or 24-hour NDF digestibility). Fermentrics is a tremendous step forward by utilizing a highly automated system where individual feed or TMR samples are combined with rumen fluid in a closed vessel, from which 5,000 data points are collected over a 48-hour incubation. The system monitors gaseous fermentation products (carbon dioxide [CO_2] and methane) of microbial metabolism, in addition to CO_2 produced by the buffering of short-chained fatty acids produced by the rumen bacteria.

The use of sophisticated curve-peeling software then makes it possible to estimate carbohydrate digestion rates (Kd) by separating the gas production into a "fast pool" (primarily C:B1-starch and C:B2-soluble fiber) and a "slow pool" (primarily C:B3-insoluble available fiber, NDF). It should be noted that these pools are not homogeneous because there can be both slow and fast pools within each carbohydrate type – in other words, the slow pool, typically comprised mostly of NDF, may also contain some slowly digested starch. However, by using equations gleaned from the European literature, it is possible to estimate the digestion rates of the B1, B2 and B3 pools commonly defined in more sophisticated ration-balancing software, such as the Cornell Model. This allows nutritionists who are using these software packages the ability to more accurately populate their feed libraries with measured

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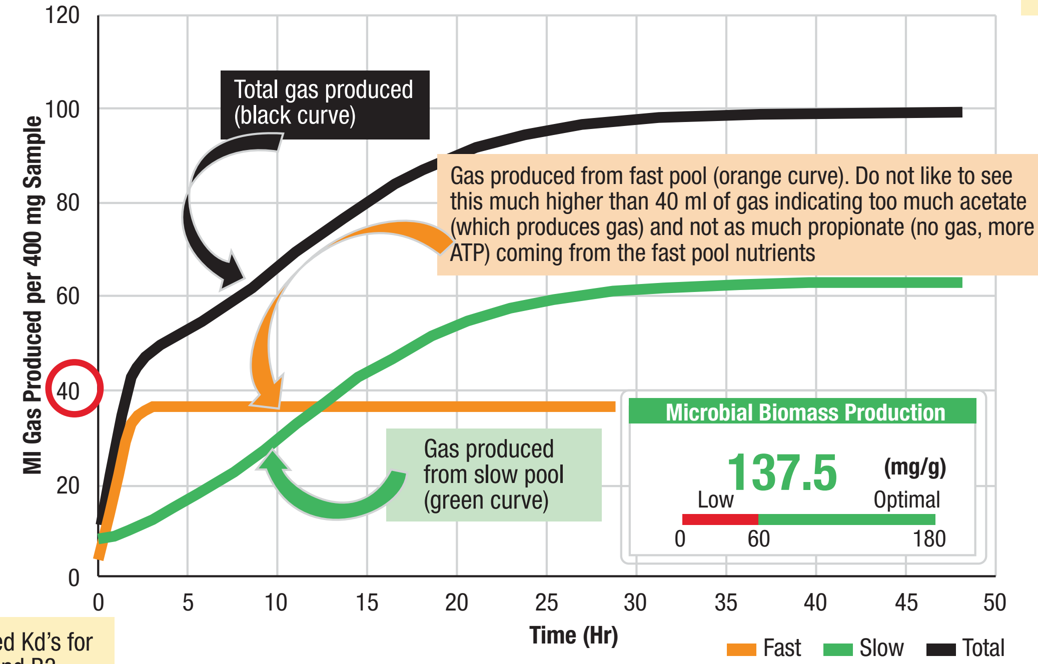
Figure 1

Description: pen 88 TMR
Sample #: 75354

aPartitioning Factor: larger number (>4) means more efficient fermentation with less gas (acetate) and propionate driving more energy (ATP) and microbial biomass yield. PF is calculated as: (VFA + microbial protein)/gas production
More gas = less efficient with less ATP



	DM
Moisture, %	53.4
Dry Matter, %	46.6
Crude Protein, %	18.4
AD-ICP, %CP	1.0
ND-ICP, %CP	2.95
SP (BB), %CP	41.21
SP (Microbial), %CP	30.15
Lignin %	2.87
ADF %	17.54
aNDF %	26.7
peNDF	22.80
EE %	4.94
Sugar %	6.7
Starch %	25.91
NFC %	42.47
aPartitioning Factor	2.85
aOMD (%DM)	67.59
TDN (Est.)	73.16
NE/Lact, Mcal/lb	0.76
NE/Maint, Mcal/lb	0.82
NE/Gain, Mcal/lb	0.54
Ash %	8.35
Calcium (Ca), %	1.22
Phosphorus (P), %	0.53
Potassium (K), %	1.85
Magnesium (Mg), %	0.42
Sodium (Na), %	0.54

Estimated Kd's for B1, B2 and B3 pools. Fast pool rates should be greater than B1 rates as the fast pool also contains soluble fibers, pectins etc. Prefer the B1 rate ~18-20%/hr and B3 rate ~ 5-6%/hr

Digestion Rates

Fast Pool (Kd/hr)	50.99
Slow Pool (Kd/hr)	4.68
C:B1 (Kd/hr)	20.12
C:B2 (Kd/hr)	50.99
C:B3 (Kd/hr)	4.68

Relative Pool Contributions

	ml gas	% of total
Fast Pool	36.54	36.74%
Slow Pool	62.90	63.26%
2-Pool Total	99.43	

Relative Times to Max Rate

	Max (hr)
Fast Pool	1
Slow Pool	11

Amount of gas from the fast pool vs. slow pool. Over 40ml gas from fast pool indicates considerable acetate production and less propionate production as propionate produces minimal gas.

More than a 10-hour difference in "Time to Max" between fast vs. slow pools can lead to asynchrony of digestion causing production problems.

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carbohydrate digestion rates rather than relying on book values or rates estimated from single, time-point measurements, like 24-hour NDF digestion.

Fermentrics also reports a microbial biomass production (MBP) value measured directly by analyzing the substrate that remains after a 48-hour incubation with a NDF analysis. The difference between the weight of the substrate before and after NDF analysis is the microbial biomass (e.g., the entire organism, not just the microbial protein). Current ranges in MBP for TMRs are from 60 to 160 mg per g, with higher MBP values associated with higher milk production.

One of the limitations of a gas fermentation system is that, without knowing which VFAs are being produced, you can not accurately predict the energy (adenosine triphosphate. ATP) coming from the feed to support microbial growth. For example, apparent organic matter digestibility (aOMD) is a value on the report and is defined as the percent of organic matter that disappeared in the system. However, a high or low aOMD does not explain which VFAs were produced from the digested organic matter. If acetate is produced, more gas is generated, yielding less ATP for microbial growth compared to when propionate is produced.

Several researchers have employed gas chromatography to detail VFA production in an attempt to predict ATP generation. A recent enhancement by the RFS Technologies lab is the ability to quantify, in real time, the level of methane and CO_2 produced in the system. This will aid in the understanding of which VFAs are being produced at what time in the incubation and allow further insight as to how this impacts the growth of the rumen microbial population.

The data on a Fermentrics report can help guide nutritionists as to the direction of corrective action when animals are not performing to expectations or can be used as a way to benchmark rations when animals are exhibiting superior performance. The author and his colleagues have four years of applied experience using Fermentrics data generated on over 525 forage, grain and TMR samples.

Fermentrics is an integrative approach, so multiple analytes must be considered in relationship to each other. One of our first lesson in interpreting Fermentrics reports was that differences among feedstuffs or rations does not reside only in the total amount of gas produced but in the relative gas pool sizes, rates, time for each pool to reach maximum rates and the total microbial biomass produced during the incubation. A helpful approach that Jay Johnston implemented with his nutritionists was to group TMRs into one of four major quadrants (**Figure 3**).

Quadrant I is typical of a herd with good production, components and feed efficiency and is opposed to Quadrant III, which is prone to acidosis from a too fast "fast pool" and a too slow "slow pool." Interestingly, over 75 percent of the TMR rations we have diagnosed with Fermentrics fall in Quadrant III, showing how prevalent acidosis is in the dairy industry. The Dairyland website (http://www.dairylandlabs.com) contains a document showing the target value and distribution statistics for the key Fermentrics metrics on 275 TMRs analyzed in 2011.

A recent example of the applied use of Fermentrics data involved a herd transitioning to new-crop corn silage and experiencing low intakes, stiff manure and reduced milk production. Fermentrics analysis of the TMR showed an extremely fast "fast pool" along with very high gas production. The elevated gas production suggested that the cause of the excessively fast "fast pool" was due to the B2 (soluble fiber) pool producing lots of methane and CO_2 (along with acetate) rather than from fermentable starch (B1).

Supplementing this TMR with additional soluble fiber sources would only result in the production of more gas. In this situation, more energy from propionate (whose pathway does not directly produce gas) was needed to drive energy for increasing microbial biomass and improving milk production. The herd did respond to the addition of starch and the removal of some mature, high dry matter alfalfa silage. Without the knowledge provided by the Fermentrics report, the nutritionist may have chosen a different approach and lost valuable production waiting

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Figure 3 Four quadrants for benchmarking TMRs

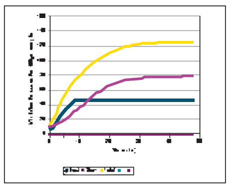
QUADRANT I

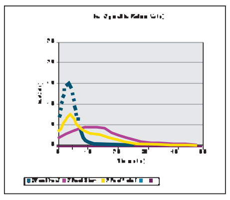
Quadrant (and Kd's) where cows are typically milking well, but watch for any sudden changes in feed delivery or consistency.

Symptoms
- Good manure consistency
- High dry matter intakes (DMI)
- Excellent milk yield
- Exceptional feed conversion ~ 1.7

TMR Rates
CB1 Kd: 18 - 20%/hr
CB3 Kd: 5 - 6/hr

Consider
- Ensure enough NPN and peptides to feed rumen bacteria.





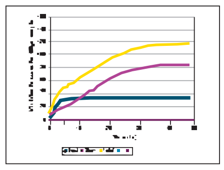
QUADRANT II

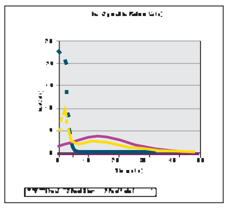
Not enough energy.

Symptoms
- Grain in manure
- Low milk protein
- Milk yield lower than expected
- Rough hair coats
- Poor reproduction

TMR Rates
Small pool of CB1 that disappears quickly
CB3 Kd: 5 - 6%/hr

Consider
- Increasing supply of rumen available starch and sugar (get B1 rates closer to 20-22%)
- Grinding grains finer
- Ensure adequate supply of peptide & NPN protein





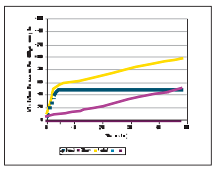
QUADRANT III

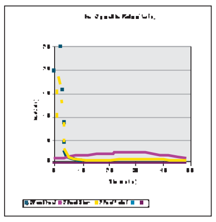
Where the majority of "problem" herds reside. High acidosis potential due to a fast "fast pool" and a slow "slow pool."

Symptoms
- Sore Feet - Repro problems - Poor DMI
- Ketosis in early lactation cows
- Fiber in Manure - Low rumen pH
- Variability in body condition score
- Fat/Protein Inversion in >10% of the herd

TMR Rates
CB1 Kd: >25%/hr
CB3 Kd: <5%/hr

Consider
- Increase NDFD by adding non-forage fiber
- Beet Pulp, Brewers Grains, Soyhulls
- Slow B1 to <21%





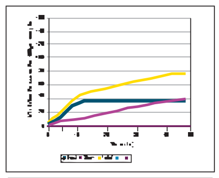
QUADRANT IV

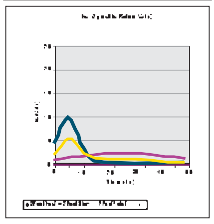
Slow "fast pool" and Slow "slow pool."

Symptoms
- Poor milk production
- Early peak/poor peak milk
- Cows "look" OK
- Diet CP is OK - but manure is stiff
- Average milk components
- Very expensive ration per CWT
- Reproduction - delayed, but not bad

TMR Rates
CB1 Kd: >15%/hr
CB3 Kd: <5%/hr

Consider
- Increasing rumen available starch and sugar
- Grind grains finer
- Increase NDFD by adding non forage fiber
- Add beet pulp, brewers, soyhulls, more digestible forages





for the cows to show a response.

The Fermentrics report can be a powerful diagnostic tool to assist nutritionists in making data-driven ration adjustments. Now that gas-fermentation has exited the research lab and is available to consulting nutritionists, interpreting the data and relating it to practical on-farm solutions will require time and experience no different than that required following the introduction of other analysis, such as peNDF, NDFD or kernel processing scores.

Dairyland and RFS technologies have also recently instituted a "Fermentrics Advisory Board" consisting of eight highly respected academic, feed company and independent dairy nutritionists to further guide the future development of Fermentrics. For more detailed information on pricing and interpretation guides, see either the Dairyland (http://www.dairylandlabs.com) or Fermentrics (http://www.fermentrics.com/) websites. **PD**

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