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TMR digestibility compared using NIRS vs. wet chemistry

Measures of apparent TMRD, calculated using NIRS-predicted parameters, are not well correlated to wet chemistry TMRD for commercial dairies.

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A VARIETY of tools are available to dairy and feedlot consultants to identify bottlenecks in farm profitability and animal performance, including nutrition performance measures available through commercial laboratories.

New and novel laboratory tools are developed every few months. Some of these valuable tools are research backed, being validated against dairy cattle performance or compared against published work, and some do not have supporting research.

Meanwhile, near-infrared spectroscopy (NIRS) measures are continually being advanced and calibrated against these newly developed tools. However, do novel NIRS measures agree with wet chemistry? Do they agree with, represent or accurately predict cattle performance and what is really occurring on the farm?

NIRS has become an invaluable tool for consultants and farms as its technology and accuracy have improved, providing a means to easily, accurately and cost-effectively measure feed and forage nutrition parameters. Within advanced nutritive calculations, however, errors can compound. While potentially valuable, both NIRS measures and calculations from NIRS-derived measures should be validated against wet chemistry before being deemed useful and commercially adopted.

In 2012, Schalla et al. (2012) published an article in the *Journal of Dairy Science* describing how apparent digestion could be assessed for commercial dairy farms and validated this approach by showing a significant relationship with dairy cattle performance. The authors adapted a digestion measurement method used over 100 years of published university research, with recent examples including Voekler and Allen (2008), Lopes et al. (2009) and professor James Ferguson's field work at the University of Pennsylvania (unpublished, personal communication).

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The industry has only recently adopted this approach for assessing dairy and feedlot total mixed ration (TMR) digestion (TMRD). While bringing value to identify nutrition and digestion bottlenecks on commercial farms, the wet chemistry TMRD measure takes time and substantial cost. So, our thoughts turned to calibrating NIRS to this measure to see if it could be a more routine and effective means to assess TMRD.

First, we need to understand how TMRD is determined.

To calculate apparent nutrient digestion, university and commercial laboratories measure nutrient and marker contents in both TMR and fecal samples. In commercial samples, undigestible neutral detergent fiber after 120 hours (uNDF120) is the internal marker. The parameters are then incorporated into an equation to determine TMRD.

In this example, TMR starch digestion is described as: TMR apparent starch digestion = 100 - 100 x (TMR uNDF120 / fecal uNDF120) x (fecal starch / TMR starch).

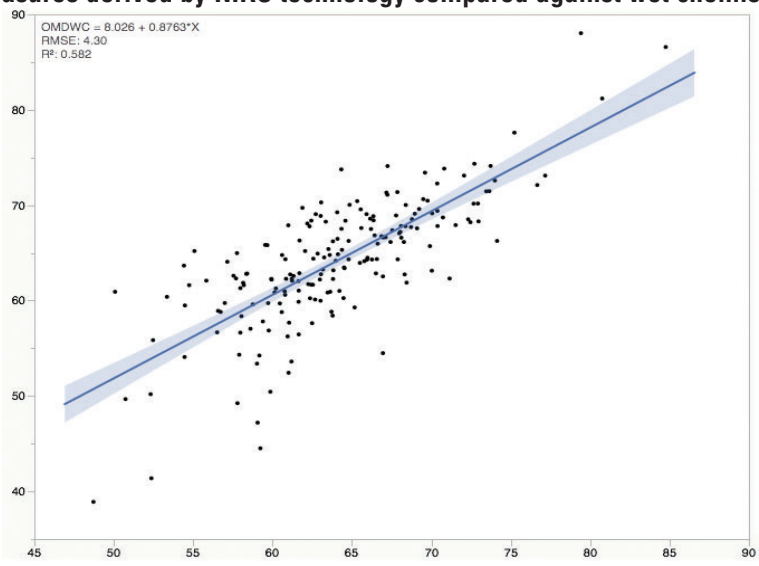
After individual nutrient calibration, NIRS can successfully predict each of the parameters used within this equation with a high degree of accuracy, yielding an R-square value of between 0.85 and 0.95, for example. Hence, NIRS may hold promise to determine TMRD. However, the entire equation results must be validated, not just the individual NIRS-predicted components.

To test the NIRS validity, we compared apparent TMR organic matter (OM), neutral detergent fiber (NDF) and starch digestion results calculated using NIRS or wet chemistry measures for 195 commercial dairy and feedlot TMR and fecal sample pairs. These samples were submitted to Rock River Laboratory for wet chemistry analysis and then were further processed and subjected to NIRS measurement.

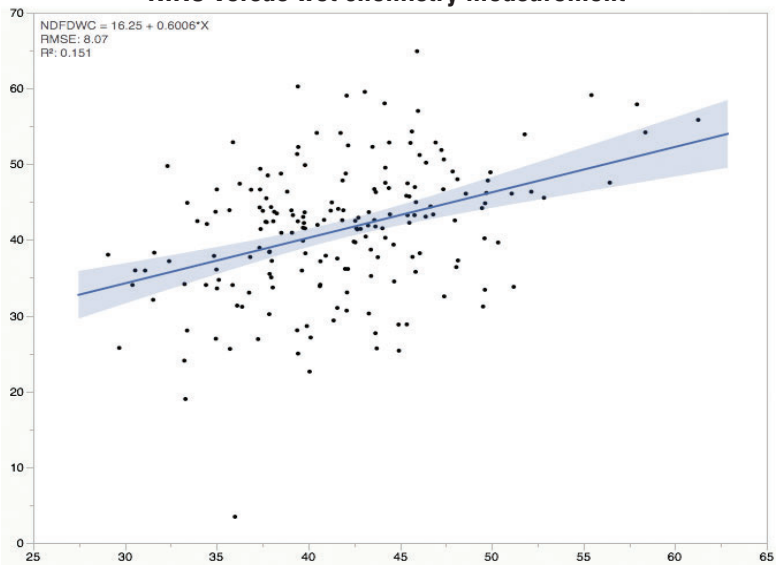
NIRS apparent digestion was determined by using robust NIRS equations to predict OM, NDF and starch on both TMR and fecal measures, and these values then were inserted within the apparent digestion calculation. Wet chemistry apparent digestion was determined using the techniques described by Schalla et al. (2012).

To determine relative NIRS and wet chemistry agreement, TMR OM, NDF and starch apparent digestion measured using NIRS technology were regressed against those analyzed by wet chemistry. The results are presented in the Table and vi-

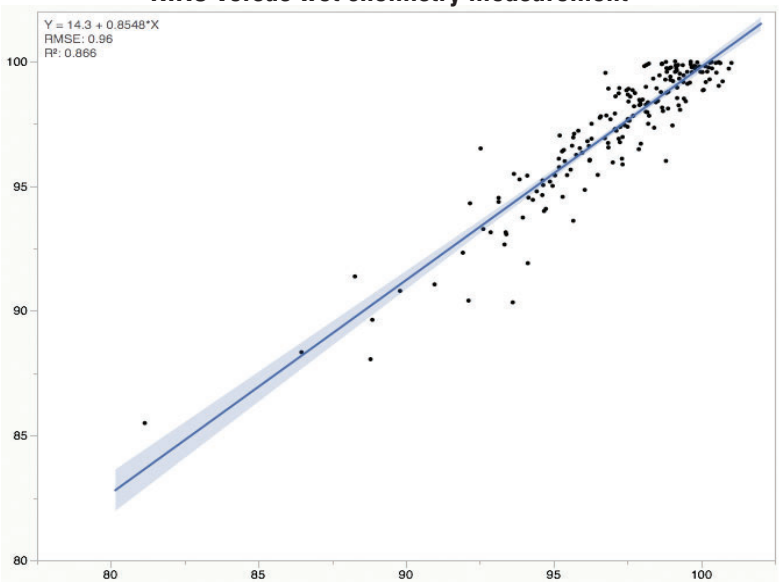
1. Commercial dairy and feedlot apparent TMR organic matter digestion measures derived by NIRS technology compared against wet chemistry



2. Commercial dairy and feedlot apparent TMR NDF digestion: NIRS versus wet chemistry measurement



3. Commercial dairy and feedlot apparent TMR starch digestion: NIRS versus wet chemistry measurement



sually, along with regression equations, in Figures 1-3.

The agreement between NIRS and wet chemistry measurement reached nearly 90% for starch, which is reasonably accurate. However, fecal starch content (percent of dry matter) alone previously has been shown to explain 94% of total tract starch digestion variance (Fredin et al., 2015) and is a simpler and more logical approach. The agreement trailed off substantially for OM and NDF, with less than 60% variance explained by NIRS.

These results suggest that NIRS agreed with wet chemistry less than 60% of the time, and in the case of NDF, which is often a limiting factor on the farm, the agreement was less than 20%, and error was ±8.0 units of NDF digestibility.

Further, as another attempt to derive utility from NIRS for apparent digestion, we used the wet chemistry TMRD measures (e.g., NDF digestibility) as a new data set. We attempted direct NIRS calibrations for each nutrient digestion measure, but calibration equations all exhibited an R-square value of less than 0.5 (results not shown).

Years of research have shown NIRS technology to be accurate for many applications, including predicting forage nutrient profiles (Norris et al., 1975), rumen degradation parameters for corn (de Boever et al., 2002) and even energy available for TMR in beef cattle (de Boever et al., 1995).

Apparent TMR nutrient digestion regression equation error estimates, NIRS versus wet chemistry, commercial dairies and feedlots

Nutrient digestion	R-square	Std. error
OM, % of OM	0.58	4.30
NDF, % of NDF	0.15	8.07
Starch, % of starch	0.87	0.96

So, why has NIRS failed in these circumstances? The answer lies in multiplying errors.

THE calibration performance of NIRS technology is evaluated based on the NIRS versus wet chemistry reference data set calibration statistics, where R-square and error statistics are reviewed. A robust NIRS equation has an R-square value of greater than 0.90, suggesting that NIRS technology is capable of explaining more than 90% of the variance in wet chemistry analysis — or, practically speaking, there is 90% agreement between NIRS calibration predictions and wet chemistry analysis. However, the challenge lies in the fact that there is always unexplained variance, or inherent error, in NIRS calibration equations. In this example, a 90% agreement also equates to 10% error.

While NIRS technology is immensely valuable to determine organic molecule-based nutrition measures (such as starch or NDF digestibility), exercise caution when using NIRS measurement in complex equations. When several measurement parameters are used in an equation, such as apparent TMR digestion, the NIRS measurement errors associated with each parameter multiply together, thus exponentially growing the error.

Consider this theoretical and oversimplified example:

NIRS TMR apparent OM digestion = 100 - 100 * (NIRS TMR uNDF120 (R^2 = 0.90) / NIRS fecal uNDF120 ((R^2 = 0.90)) * (Fecal OM (R^2 = 0.90) / TMR OM (R^2 = 0.90))

NIRS TMR apparent OM digestion resulting R^2? 0.90 x 0.90 x 0.90 x 0.90 = 0.59.

Summary

In summary, on-farm TMRD measures assessed by wet chemistry have proved accurate and reliable, and they agree with performance. The approach is valuable for assessing forage or product performance on commercial herds and could be considered for nutrition programs.

While NIRS-predicted measures are extremely valuable for many ruminant nutritionists, using NIRS measures for TMR apparent digestion appears to prove less

valuable. The lower cost and potentially profitable service for a commercial laboratory, in this case, was outweighed by marginal accuracy.

The industry should strive for research and validation against cattle performance prior to adopting new measures or approaches.

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