Samples dried with commercial dry matter techniques differ in volatile compound contents

Donald Meyer[2], Lynn Nagengast[2], Dustin Sawyer[2] and John P. Goeser[1,2]

[1]Department of Dairy Science, University of Wisconsin-Madison, Madison, WI, [2]Rock River Laboratory, Inc., Watertown, WI

2015 ADSA-ASAS JAM
Poster #M416

Introduction:

- Dairy and beef cattle nutrition hinges on delivering both accurate and precise nutrition to the feed bunk
- Great strides have been made toward improving precision in nutrition; implementing tools such as TMR management software
  - These tools depend upon both precise and accurate routine dry matter (DM) measures being made on-farm
- On-farm, oven-based feed dry matter techniques determine DM by difference measuring between original feed weight and a dried weight
  - This approach can prove inaccurate when particles or compounds other than water disappear from the sample
  - This approach should more appropriately be described as loss upon drying (Thiex and Richardson, 2003)
- Despite being held as a reference procedure in many refereed journal articles, oven-based DM techniques have been documented to volatilize more than water
  - Volatilizes compounds such as fermentation acids, alcohols, and ammonia-N (Porter and Murray, 2011)
- Drying/removing compounds other than H_2O leads to inaccurate and underestimated true feed DM measures and further results in substantial forage inventory errors (Ed DePeters and Bill Weiss, 2015 Personal communication) or nutrition errors

Objective:

The objective of our work was to evaluate if feeds, dried using commercially adopted DM techniques, differ in total volatile compound contents; with the assumption that differing total volatile content from undried samples represents a dry matter technique flaw/error.

Materials and Methods:

- Corn (n=14), grass (n=5), legume (n=15), and small grain silages (n=14) were collected, divided into equal subsamples using a riffle-splitter, then vacuum-sealed, and frozen until analyzed
- Subsamples were thawed and then handled according to 5 different drying treatments;
  1. Undried as-is (CTL)
  2. On-farm type forced-air oven dry, 60 min. (Koster Moisture Tester, KOS)
  3. 50°C for 48h forced-air oven dry (OV)
  4. Freeze-dry (FD)
  5. Sequential microwave dry – followed by NIR assessment of remaining water (LAB).
- Following drying treatment, to assess DM technique non-water losses, samples were analyzed for volatile fermentation products by HPLC
  - Measured constituents included: lactic, acetic, propionic, butyric, succinic, and formic acids, and ethanol
- Each constituent was expressed as a % of DM
  - "Standard Dry Matter" was determined on a percent of each treated sample using sequential microwave-3h 105° C oven dry to achieve uniformity across samples
- Fermentation products were then summed to determine total volatile compounds (TV, % of DM)
- The resulting data were not normally distributed and were log-transformed prior to being evaluated using the Fit Model procedure in SAS JMPv11.0
  - Log transformation satisfied the normality assumption
- Feed, drying treatment, and their interaction were then treated as fixed effects and assessed using backward-elimination model selection
- Significance was declared at P<0.05.
- Final model (LM1) analysis included fixed effects for:
  - Feed type
  - Drying technique
- <u>Drying technique differences from CTL were then assumed to represent significant non-water loss and a DM measure error.</u>
- **Further, an expanded linear model analysis (LM2) was conducted including standard dry matter as a fixed effect**
  - After submitting abstract, time permitted further data analysis, including standard dry matter as a fixed effect
    - Linear and quadratic responses were assessed using a backward elimination approach
    - Six outliers were manually identified and removed prior to analyses
      - Small grain silage; unfermented feed samples with low respective dry matter contents and little or no measured total volatiles content
- Model parameters were retained when p<0.05
- Model fit was assessed using mixed model AIC and BIC, where smaller values suggest best model fit
- The final model included fixed effects for:
  - Feed
  - Drying technique
  - Standard dry matter
  - Drying technique x standard dry matter
  - Feed type x standard dry matter
  - Standard dry matter x standard dry matter (quadratic effect)

Results and Discussion:

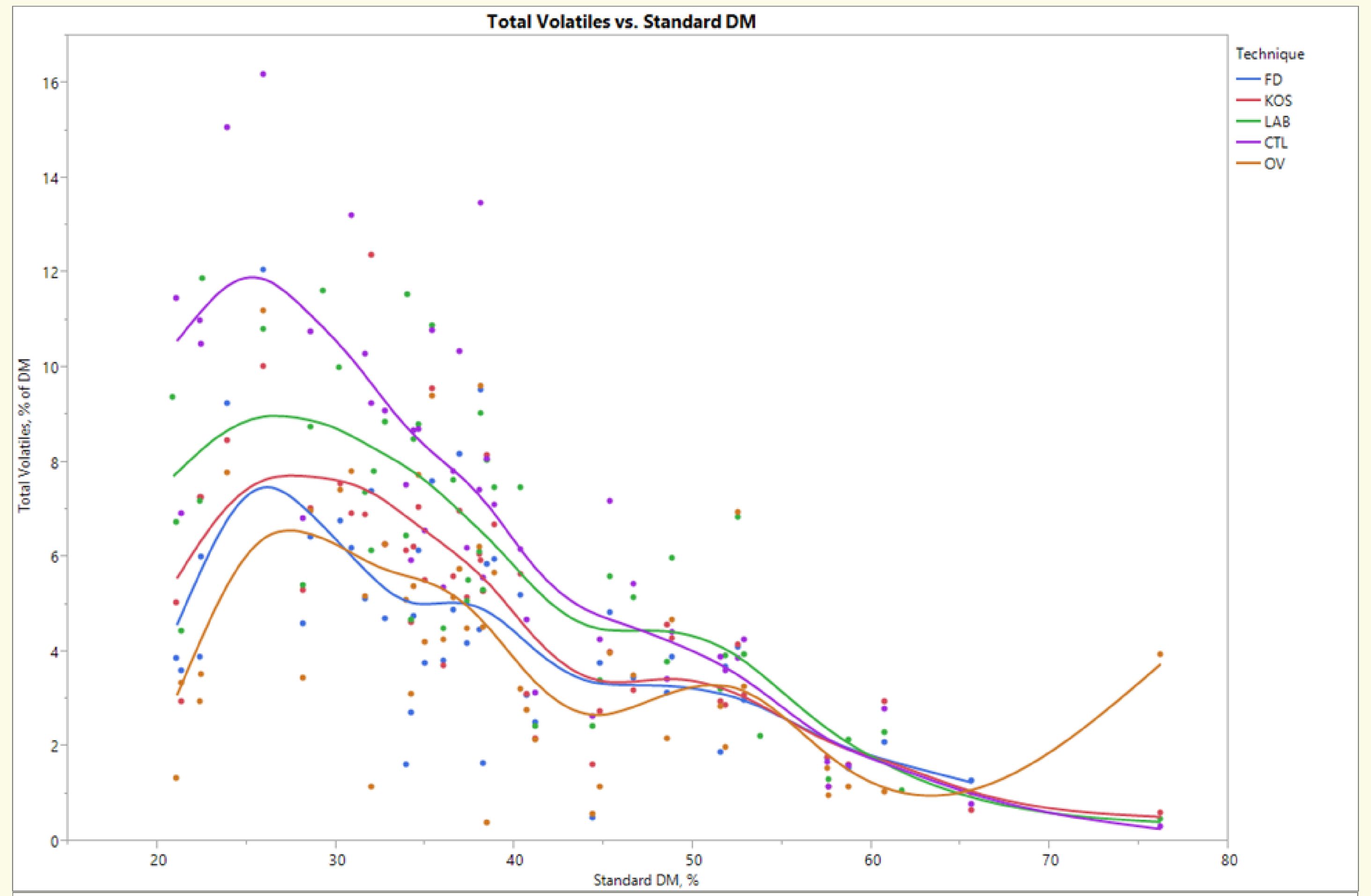

Figure A. Total Volatiles (% of standard DM, sum of measured fermentation products; lactic, acetic, propionic, butyric, succinic and formic acids, and ethanol) remaining after 5 different drying techniques plotted against respective standard DM (partial microwave drying followed by a 3h 105C forced air oven dry).

Following LM1 analysis:

- Feed type and drying treatment were significantly related to TV
  - Results presented here are converted back to % of DM (Tables A, B, and C)
- The total volatile content (% of standard DM) means were compared using Tukey's test,
- Legume and corn silage differed from small grain, which differed grass silage (Table A)
  - The TV was the greatest for CTL (4.43) and was not significantly different from LAB, KOS, or FD (4.18, 3.67, and 3.13, respectively).
  - The CTL differed (P<0.05) from OV (2.7) while KOS and FD did not differ from OV.

Following LM2 analysis:

- Feed type, drying technique, and standard dry matter were all related (p<0.0001) to total volatiles content (% of standard DM)
  - Adding the standard dry matter to the linear model improved model power and variance explanation
    - Improved model R-square from 0.19 to 0.67 and reducing root mean square error from 0.74 to 0.43 for LM1 relative to LM2, respectively
- Following improved model, FD, KOS, and OV were all significantly different than CTL
  - <u>This observation suggests FD, KOS and OV underestimate true feed DM content</u>
- Our results differ from Oetzel et al. (1993) who found the KOS approach similar to microwave based drying however the authors noted poor precision for KOS
  - Differences in drying time may explain the discrepancy in results
  - We utilized a standard 60 min drying time, which is similar to on-farm implementation, compared to a variable time to stable weight for different feeds as reported by Oetzel et al. (1993)

Table A: Linear model 1 least square means (LSM) for feed total volatile compound content (% of DM). Means with differing superscripts differ at p<0.05.

Feed	LSM, Natural Log. Total Volatiles	Total Volatiles, % of Standard DM
Legume Silage	1.62	5.06^{a}
Corn Silage	1.59	4.93^{a}
Small Grain Silage	1.28	3.58^{b}
Grass Silage	0.59	1.80^{c}

Table B: Linear model 1 least square means (LSM) for drying technique total volatile compound content (% of DM). Means with differing superscript differ at p<0.05.

Drying Technique	LSM, Natural Log. Total Volatiles	Total Volatiles, % of standard DM
CTL	1.50	4.47^{a}
LAB	1.43	4.18^{a}
KOS	1.30	3.67^{ab}
FD	1.14	3.12^{ab}
OV	0.99	2.68^{b}

Table C: Linear model 2 least square means (LSM) for total volatile compound content (% of DM) remaining after each drying technique. Means with differing superscript differ at p<0.05. Significant differences from CTL signify technique errors in determining true feed DM content.

DM Technique	LSM, Natural Log. Total Volatiles	Total Volatiles, % of standard DM
CTL	1.68	5.39^{a}
LAB	1.60	4.95^{ab}
KOS	1.43	4.16^{bc}
FD	1.28	3.60^{cd}
OV	1.16	3.20^{d}

Conclusions:

- Results of the simple linear model suggest forced-air drying at 50°C for 48 h underestimates feed DM.
  - This technique has been widely reported as a reference technique in referred journal articles however is likely inaccurate in expressing true feed DM content and associated calculations
- Following an expanded model and statistical analysis, freeze drying and Koster Moisture Tester drying techniques, in addition to oven drying, were different from control undried samples and hence underestimate true feed DM
  - Sequential microwave oven drying followed by NIR water content assessment appears to be more reliable and accurate
- On-farm, oven-based routine dry matter analysis techniques should be interpreted with caution
  - While conceivably precise, results appear inaccurate
- Farm- and forage-specific correction factors could be generated by determining TV on fresh as well as on-farm, oven-dried samples
  - Correction factor could be applied to KOS results to improve feed program accuracy

References:

Oetzel, G.R., F.P. Villalba, W.J. Goodger and K.V. Nordlund. 1993. A comparison of on-farm methods for estimating dry matter content of feed ingredients. J Dairy Sci. 76:293-299.

Porter, M.G. and R.S. Murray. 2011. The volatility of components of grass silage on oven drying and the inter-relationship between dry-matter content estimated by different analytical methods. Grass Forage Sci. 56:405–411.

Thiex, N. and C.R. Richardson. 2003. Challenges in measuring moisture content of feeds. J Anim Sci 81:3255-3266.