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Determining Forage Dry Matter Concentration with a Microwave Oven

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Reliable estimates of forage dry matter (DM) concentration can help managers achieve forage conservation, livestock feeding, and pasture allocation objectives. On-farm and laboratory methods are reviewed by Pitt (1993), and moisture testing devices are advertised in farm periodicals. A common reference method for non-fermented forages is forced-draft oven drying to constant weight at 100-105° C (212-221° F). Oven-drying methods for determination of DM in fermented silage can drive off volatile organic acids containing energy and DM. This can deflate DM and energy, and inflate fiber, values relative to those from less-common methods such as Karl Fischer titration and toluene distillation.

Dry matter concentration can be determined quickly using a microwave oven (preferably with a turntable) with at least 500 watts, and a mechanical or electronic balance with capacity of at least 50 g and precision to 0.1 g, or 100 g and precision to 1 g. Some balances for home use (e.g., dietetic or postal) are suitable, or a balance can be purchased from farm, forestry, or school science supply catalogs for as little as \$100-\$200. Such balances can also be used for weighing clipped plot samples and calibrating seeders and fertilizer spreaders. Microwave-oven drying becomes less accurate at DM contents above 80% (e.g., baled hay). Microwave-oven drying may be inappropriate for preparation of samples for laboratory forage quality analysis, since temperatures above 70° C (160° F) can change sample protein and fiber characteristics and digestibility.

The basic analytical scheme is to gather a representative forage sample, weigh the sample in its 'wet' state, dry the sample to constant oven-dry weight, re-weigh it, and express final dry weight as a proportion of the initial wet weight.



Select a sample that represents the crop, windrow, lot of hay or silage, pasture, or other material you are trying to characterize. Chop and composite multiple subsamples to capture variations in wetness, then homogenize and obtain a subsample for analysis. This process is similar to probing a field to obtain a representative sample for soil testing or coring a hay stack to gather a representative sample for forage quality analysis.

Typical DM sample sizes are approximately 50-100 g wet weight, depending on the precision of the balance and microwave oven wattage. To reduce changes in wetness between sample gathering and initiation of DM determination, minimize transit time between sampling and analysis and use plastic bags and refrigeration or freezing as necessary.

For balances that display only gross weights (e.g., sample plus container), use **Procedure I**. **For balances that can be tared** to display net weight of the sample, **Procedure II** is simpler.

Procedure I. Balances that display gross weights

1. Preheat a microwave-safe container for about 10-20 seconds to remove any residual water. Be cautious with paper plates or bags. Record **empty oven-dry (OD) container weight (A)**.
2. Place a chopped forage sample in uncovered container, spreading material out as much as possible. Record **gross weight of wet sample + container (B)**. For balances with only 1-g precision, wet sample size should ideally be at least 100 g.

To protect oven electronics and minimize sample charring, place a cup with about 6 oz of water in an oven corner to absorb energy as the sample dries; keep water level relatively constant during drying. Newer ovens may not require this cup of water (Pitt, 1993). Find a drying time which is just long enough to remove the water from the sample without burning it. Depending on sample size, water content, and oven wattage, initial drying times may be 6 min or more. Using full power, start with a shorter time (perhaps 3 min), then immediately re-weigh the sample. Stir sample, dry for an additional 1-3 min, and re-weigh. Repeat as necessary until the weight loss from each drying interval is less than 1.0 g. Power levels and drying times may be reduced as the sample approaches constant weight. Dry matter losses due to charring will lower accuracy of DM determination. If charring occurs, use the previous weight. **Samples unattended during drying can cause smoke damage and fire!**

3. Before the OD sample regains water from the atmosphere, record final **gross weight of OD sample + container (C)**.
4. Calculate DM concentration as $(C-A) / (B-A)$ (x 100 for percentage basis)

Example:

empty OD container	(A) = 16.7 g
wet sample + container	(B) = 88.3 g
OD sample + container	(C) = 38.2 g

DM concentration = $(38.2-16.7) / (88.3-16.7)$
= 0.30 of wet wt = 30% of wet wt

Procedure II. Balances that display net weights

Proceed as above, with these exceptions:

1. Re-zero balance with empty OD container. No weight is recorded.
- 2-3. Record only **net weight of wet sample (D)** and **net weight of OD sample (E)**.
4. Calculate DM concentration as E / D (x 100 for percentage basis)

Example:

wet sample	(D) = 71.6 g
OD sample	(E) = 21.5 g

DM concentration = $21.5 / 71.6$
= 0.30 of wet wt = 30% of wet wt

Forage moisture concentration

For both procedures, forage water ('moisture') concentration = 1-DM or 100%-DM%. Example: moisture concentration of sample with 30% DM = 70%. For confirmation of your technique, provide a forage testing lab with a portion of the same sample you used. This sample must be well-packaged and delivered quickly to minimize moisture loss.

Reference

Pitt, R.E., ed. 1993. Forage moisture determination. NRAES-59. Order from Natural Resource, Agriculture, and Engineering Service (NRAES), Ithaca, NY, <http://www.nraes.org/>

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