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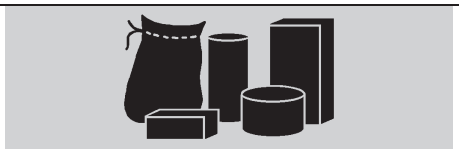

# Comparison of on-farm forage-dry-matter methods to forced-air oven for determining forage dry matter[1]

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## ABSTRACT

*The objective of the study was to compare 3 different on-farm methods of determining DM in forages using traditional forced-air oven (FAO) as a standard for comparison. Silage samples (60 corn silage, 35 grass silage) were analyzed by microwave (MW), Koster Moisture Tester, Q-Dry (a new automatic convection system to measure DM), and FAO using standard or manufacturers' methods for each system. A linear relationship was observed for corn silage between FAO and MW ($\beta = 1.014$; $R^2 = 0.961$), Koster Moisture Tester ($\beta = 1.028$; $R^2 = 0.885$), and Q-Dry ($\beta = 0.982$; $R^2 = 0.921$), where $\beta$ is slope of the regression line and $R^2$ is coefficient of determination. In addition, grass silage showed a significant relationship between FAO and MW ($\beta = 1.021$; $R^2 = 0.961$), Koster Moisture Tester ($\beta = 1.245$; $R^2 = 0.950$), and Q-Dry ($\beta = 0.965$; $R^2 = 0.952$). All methods resulted in similar DM determination, exhibiting a strong, linear relationship with FAO ($P < 0.01$), and all have advantages and disadvantages. Microwave and Q-Dry showed the strongest correlations to FAO. These data suggest that MW and Q-Dry are the best on-farm alternatives to traditional oven drying for DM determination.*

**Key words:** dry matter, silage, microwave, Koster Moisture Tester, Q-Dry

## INTRODUCTION

It is well known that the moisture content of forages is variable (Thiex and Richardson, 2003) and is an important aspect for a farm to maintain a well-balanced as-fed ration on a day-to-day basis. Therefore, it is necessary to assess the DM content of dietary ingredients on an ongoing basis, to obtain the right proportions of each ingredient in a ration. Imbalances in the diet can occur by changes in the moisture content of ingredients, primarily ensiled forages. During the summer season, DM of ingredients can change 5 to 10% weekly depending on the type of storage structure, ingredient surface exposed to the air, and type of silo (i.e., horizontal or tower silos; Holter, 1983; Luchini et al., 1997). The DM in an open, exposed silage bunk can change after a day of rain, often decreasing forage DMI by the animals and altering the forage-to-concentrate ratio in the TMR. This in turn can affect animal performance. An accurate measurement of DM in forages at harvest is important to allow proper silage fermentation (Van Soest, 1994).

One of the most accurate methods to determine DM is the forced-air oven (**FAO**; AOAC International, 2000), and this method is used as a standard to determine DM in the laboratory. This method is not used in the field because of the higher cost for equipment and the lengthy time required for DM determination (i.e., 24 h at 105°C; AOAC International, 2000). There are other easy and inexpensive methods that farmers can use to determine DM. The use of the microwave oven (**MW**) is one of the most frequently used methods to measure DM in feedstuffs on farms (Bouraoui et al., 1993; Pitt et al., 1993). Air-drying systems are also commonly used on farms. Previous studies reported variability and low accuracy of air-drying systems depending on the sample type (Oetzel et al., 1993). A new automatic system being used on some European farms is the Q-Dry system; however, this method has not been validated in the literature. The Q-Dry is a convection-

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heated device that extracts moisture with an automatic air pump and requires no observation while it is working.

In the last decade, studies have focused on improvements related to measuring DM in laboratories (AOAC International, 2000) but not on-farm methods. The objectives of this study were to compare the DM determination of feeds by 4 different methods, to evaluate the relationship between each method and the FAO method, and to characterize variation between and within samples.

## MATERIALS AND METHODS

A total of 95 forage samples (60 corn silage and 35 grass silage) from farms in central Pennsylvania was analyzed as a convenience sample. The samples were collected from the bunk silo or silo bags and immediately stored in airtight bags and kept in a refrigerator until the analysis during the following 2 d. The grass silage samples were principally ryegrass, timothy grass, or mixtures. Samples were analyzed for DM by MW (Daewoo model Kor-600m, 1.1 Kw and 2,450 MHz; Seoul, South Korea), Koster Moisture Tester (**KMT**; Koster Moisture Tester Inc., Brunswick, OH), Q-Dry (Hcs-products, Hofheim, Germany), and FAO (1600 HAFO series, VWR 1690 Scientific Products, Pittsburgh, PA).

According to the specifications of the manufacturers, 50, 50, 40, and 200 g of sample were used for MW, KMT, Q-Dry, and FAO, respectively. Samples were deposited on paper plates and then weighed using a portable electronic balance (Scout Pro 400 g, Ohaus Corporation, Pine Brook, NJ) with an accuracy of ±0.01 g.

Dry matter in the MW was determined by heating the sample sequentially for 1.5 min, 45 s, 30 s, and 20 s at maximum power. Between each period of time, the sample was removed from the MW, cooled 10 s, and mixed to avoid burning. Immediately following, the sample weight was recorded and the sample was heated again for 20 s. This step was repeated until the difference from the previous sample weight was <0.05 g. The MW used was equipped with a rotating plate and digital clock to determine exact timing. Silage DM percentage was calculated from the difference between the initial and final weight of the sample. Approximately 6 sequential periods of 20 s were required for dry grass silages and 8 to 10 periods for corn silages, depending on the moisture of the sample. No water was placed in the MW during DM determination, as doing so prevents the sample from drying completely (Pitt et al., 1993).

The KMT wet samples were placed in the receptacle and then on top of the heating system. Dry matter was measured by heating the sample for 30 min, recording the sample weight, and then heating each sample repeatedly for 10 min until the weight did not change. Silage DM percentage was calculated from the difference between the initial and final weight of the sample.

For Q-Dry, samples were deposited on a plate in the machine. All weights and final DM values were determined automatically as per the Q-Dry system. Determination of DM percentage for FAO was calculated by weighing samples before and after placing in the oven at 65°C for 48 h (Fenner and Barnes, 1965).

In addition, a single corn silage sample was analyzed 10 times per DM method to evaluate variation within methods. All comparison data were analyzed by simple linear regression (Minitab Inc., State College, PA) using the FAO as method of control. An extra set of corn silage samples was analyzed by ANOVA, and *P*-values for pair-wise comparisons were adjusted by the Tukey method (Minitab Inc.).

## RESULTS AND DISCUSSION

The 4 methods in this comparison are different in how they function. The MW is a system that heats through electromagnetic radiation bombarding water molecules, polarizing and producing thermal energy in a process called dielectric heating. On the other hand, KMT dries the sample through a flow of hot air, whereas as was indicated before, the Q-Dry is a convection system with an air pump extracting the moisture of the sample. The FAO is a system with hot air, flowing in a chamber and extracted with fans outside of the oven.

Table 1 shows the means and SD for DM of a single sample of corn silage analyzed 10 times by the 4 different methods. Because of the small variation observed in DM between the methods, there were no significant differences between MW and Q-Dry, and between FAO and Q-Dry (noted by different superscripts). However, DM determined by KMT was lower than with the other methods. These results also confirm previous findings related

**Table 1. Mean and SD for corn silage DM analyzed by 4 different methods**

| Method[1] | n[2] | Mean | SD |
|---|---|---|---|
| Forced-air oven | 10 | 46.925[a] | 1.15 |
| Q-Dry | 10 | 46.260[ab] | 1.35 |
| Microwave | 10 | 45.280[b] | 0.94 |
| Koster Moisture Tester | 10 | 44.660[c] | 1.23 |

[a–c]Means with different superscripts differ at $P < 0.05$.

[1]Forced-air oven (1600 HAFO series, VWR 1690 Scientific Products, Pittsburgh, PA), Q-Dry (Hcs-products, Hofheim, Germany), microwave (Daewoo model Kor-600m, 1.1 Kw and 2,450 MHz; Seoul, South Korea), Koster Moisture Tester (Koster Moisture Tester Inc., Brunswick, OH).

[2]Each corn silage sample was analyzed for DM 10 times using each method.