



Estimating Dry Matter and Nutrient Digestibility In Vivo with Markers

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Introduction

The purpose of ration formulation is to provide animals with the energy and nutrients they need to meet their physiological requirements. To accurately meet energy and nutrient needs, nutritionists must know the concentration of digestible energy and digestible nutrients from the ration. This information depends on understanding the digestibility of the ration consumed by the animal.

This publication explains how digestibility can be estimated in live animals using markers. The goal is to help farmers and nutritionists interpret scientific publications in animal nutrition, which will assist them in making informed decisions for their nutritional management programs.

What Is Digestibility?

Digestibility is a measure of how much of the feed that an animal eats is actually degraded and absorbed by its digestive system. In simple terms, measuring digestibility reveals how efficient the animal is at utilizing the nutrients from the ration.

The standard practice to measure digestibility in vivo, or in live animals, is not to directly measure the feed that is digested. Instead, the food that is not digested (i.e., what comes out in the feces) is measured. Then the difference between what is consumed and what is not digested is calculated to estimate what was digested.

Measuring Digestibility

The gold standard for measuring digestibility in vivo is the *total collection method*. This involves collecting all the feces an animal produces over a period of time and analyzing them to determine how much of the feed was not digested. While very precise, total collection experiments are labor-intensive and require specific

and expensive facilities, including special housing and equipment, which make them impractical for common use.

To avoid the challenges of total collection, researchers often use markers to estimate digestibility. Markers are substances that pass through the digestive system without being absorbed. Since they are not digested, markers can help track how much of the feed was actually digested.

The two main types of markers are external markers and internal markers. External markers are added to the feed as powders or liquid solutions. For example, the team at the Dairy Forage Research Laboratory at Virginia Tech often sprays a solution of lanthanum chloride, a rare-earth element, that is not digested by the animal. Internal markers, on the other hand, are naturally present in the feed. A common internal marker is undegraded neutral detergent fiber (uNDF), which is a part of plant material that animals cannot digest. Whichever type is used, the methods to measure digestibility are the same.

How Do Markers Measure Digestibility?

This bulletin presents a simplified example using dry matter digestibility, which measures how much of the dry matter (DM) or dry portion of the feed is digested. The key is to start with a known ratio of dry matter to marker in the feed. In figure 1, for example, the ration contains 12 units of dry matter (blue diamonds) for every five units of marker (red circles). After waiting a period of time after feeding, the feces are collected and analyzed, revealing that five units of undigested dry matter are present for every five units of marker. By difference, it is estimated that seven of the original 12 units of dry matter were digested.

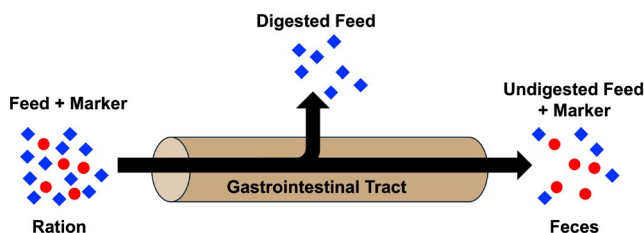


Figure 1. Digestibility can be calculated by comparing the ratio of feed to marker that is consumed with the ratio present in the feces.

This principle can be distilled into a mathematical equation (Equation 1), in which DMD is dry matter digestibility, dDM is the digested dry matter, DM is the total dry matter originally in the feed, and uDM is the undigested dry matter.

$$DMD = \frac{dDM}{DM} = \frac{DM - uDM}{DM} = 1 - \frac{uDM}{DM}$$

Equation 1.

Since the markers are not digested, but the feed and nutrients are, the marker concentration increases as the feed and nutrients are digested and absorbed. Equation 2 illustrates an example when only five units of the original 12 units of feed remained in the feces for every five units of marker.

$$DMD = 1 - \frac{uDM}{DM} = 1 - \frac{\left(\frac{5 \text{ blue}}{5 \text{ red}}\right)}{\left(\frac{12 \text{ blue}}{5 \text{ red}}\right)}$$

Equation 2.

After simplifying the equation, DMD can be estimated when knowing the concentrations of the marker in the feed and the feces (Equations 3 and 4).

$$DMD = 1 - \frac{\left(\frac{5 \text{ red}}{12 \text{ blue}}\right)}{\left(\frac{5 \text{ red}}{5 \text{ blue}}\right)}$$

Equation 3.

$$DMD = 1 - \frac{[Marker]_{Ration}}{[Marker]_{Feces}}$$

Equation 4.

In the example above, the concentration of the marker in the feed is 0.417 units (5 divided by 12), and the concentration of the marker in the feces is 1 (5 divided by 5). Therefore, the resulting digestibility of the feed is 58.3% (equation 5).

$$DMD = 1 - \frac{0.417}{1} = 0.583$$

Equation 5.

To confirm, in figure 1, we can see that 7 of the 12 units of feed (blue diamonds) have been digested, which is 58.3% of the 12 units.

Nutrient Digestibility

In addition to measuring dry matter digestibility, the equation can be used to calculate the digestibility of protein and other nutrients. Equation 6, for example, uses the formula to estimate protein digestibility (ProteinD) by measuring digested protein (dProtein) and undigested protein (uProtein).

$$ProteinD = \frac{dProtein}{Protein} = \frac{Protein - uProtein}{Protein} = 1 - \frac{uProtein}{Protein}$$

Equation 6.

By examining the formula, nutrient digestibility simply adds the concentrations of the nutrient to both feed and feces, as described in Equation 7.

$$ProteinD = 1 - \frac{uDM \times Protein_{Feces}}{DM \times Protein_{Feed}} = 1 - \frac{uDM}{DM} \times \frac{Protein_{Feces}}{Protein_{Feed}}$$

Equation 7.

Rearranging the formula similarly to Equation 4, the final equation for estimating nutrient digestibility (NutrientD) using markers is shown in Equation 8.

$$NutrientD = 1 - \frac{[Marker]_{Ration}}{[Marker]_{Feces}} \times \frac{[Nutrient]_{Feces}}{[Nutrient]_{Feeds}}$$

Equation 8.

Summary

Digestibility of feed and nutrients can be estimated in vivo using internal or external markers. By comparing the concentrations of markers in feed and feces, nutritionists can calculate how much of the feed was digested, without needing to collect all feces. Knowing the underlying formulas for digestibility measurements would likely help farmers and nutritionists understand the conclusions of studies in scientific journals and make better-informed decisions in their nutritional management programs.

Acknowledgment

This publication was supported by Dairy Management Inc. under the project titled, “Reducing Dairy Methane Emissions Through Forage Quality: Solution or Double-edged Sword?”

