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From guesswork to precision: Mastering feed intake prediction in dairy cows

Accurately estimating feed intake allows for the formulation of precise diets, prevents underfeeding or overfeeding, and enhances feed efficiency

By Alvaro Garcia

Predicting feed intake in dairy cows plays a crucial role in optimizing their nutritional management and overall productivity. Accurately estimating feed intake allows dairy farmers to formulate precise diets, prevent underfeeding or overfeeding, and enhance feed efficiency. However, predicting feed intake in dairy cows is a complex task influenced by various factors, including animal characteristics, diet composition, and environmental conditions.

In recent years, significant advancements have been made in developing prediction models that provide more accurate estimations of feed intake in dairy cows. These models incorporate a range of factors, such as milk production, body weight, body condition score, days in milk, and parity, among others. By harnessing the power of predictive models, dairy farmers can make informed decisions to optimize feeding strategies, improve animal health, and maximize profitability. In this article, we will explore the importance of predicting feed intake in dairy cows, discuss key factors influencing intake, and highlight emerging technologies and techniques for more accurate feed intake prediction.

The Nutrient Requirements of Dairy Cattle (NRC, 2001) provides an equation [1] for estimating DMI in Holstein cows, that incorporates factors like 4% fat-corrected milk (FCM), BW, and week of lactation (WOL).

[1] DMI (kg/d) = (0.372 × FCM + 0.0968 × BW^0.75) × {1 − e^[-0.192 × (WOL + 3.67)]}

To elevate BW (body weight) to the power of 0.75, you can use a mathematical operation known as exponentiation. In most programming languages and calculators, the caret symbol (^) or the double asterisk (**) is used to represent exponentiation.

To calculate BW raised to the power of 0.75, you can use the following formula: BW^0.75. For example, if the body weight is 500 kg, the calculation would be: 500^0.75 = 117.692. The term "e" represents the mathematical constant known as Euler's number or the base of the natural logarithm. It is approximately equal to 2.71828. In the context of the equation, the term "e" is used as the base of the exponential function.

The purpose of using the exponential function in this equation is to model the decrease in dry matter intake (DMI) as the value of "-0.192 × (WOL + 3.67)" increases. It allows for a non-linear relationship between the week of lactation (WOL) and DMI, capturing the decreasing trend of DMI as cows progress further into lactation.

A recent study published equation [2] to predict DMI based on animal factors such as follows:

***[2] DMI (kg/d) = [(3.7 + parity × 5.7) + 0.305 × MilkE (Mcal/d) + 0.022 × BW (kg) + (−0.689 + parity × −1.87) × BCS] × [1 – (0.212 + parity × 0.136) × exp(−0.053 × DIM)]*, where parity equals 1 for multiparous animals and 0 otherwise.**

"MilkE" represents milk energy in Mcal/d, "BW" or body weight of the cow in kg, "BCS" is body condition score, and "DIM" days in milk. The term "exp (-0.053 × DIM)" represents the exponential function of the product of -0.053 and DIM. The purpose of including this term is to incorporate a nonlinear adjustment for the effect of DIM on DMI. By using this exponential function, the equation considers the changing relationship between DIM and DMI, allowing for a more accurate prediction of DMI based on the cow's stage of lactation.

To estimate the energy content of milk in Mcal per kilogram based on the percentages of fat, protein, lactose, and total solids in the milk one can use formulas like the following:

Mcal of Milk Energy (MilkE) = (0.158 × fat %) + (0.086 × protein %) + (0.075 × lactose %) + (0.37 × total solids %)

Compared to the NRC (2001) model this equation showed smaller mean bias, indicating its potential to enhance diet formulation for lactating dairy cows. When evaluated using an independent dataset, both models performed similarly in predicting DMI during early lactation (1-75 DIM). However, equation [2] outperformed equation [1] in predicting DMI during mid and late lactation (76-368 DIM). Regarding the estimated coefficients for milk and BW, equation [2] suggests that changes in milk production have less impact on DMI compared to changes in BW.

Feed factors can further be used to adjust predicted DMI in ration formulation (Allen et al. 2019). These factors can be incorporated into a prediction equation for dry matter intake (DMI) in lactating cows after peak lactation as follows:

[3] DMI (kg/d) = 12.0 − 0.107 × FNDF + 8.17 × ADF/NDF + 0.0253 × FNDFD – 0.328 × (ADF/NDF – 0.602) × (FNDFD − 48.3) + 0.225 × MY + 0.00390 × (FNDFD − 48.3) × (MY – 33.1)

Dry matter intake was positively associated with milk yield (MY) and ADF/NDF (% ratio of ADF to NDF), while negatively associated with NDF digestibility (FNDFD). The FNDFD showed a positive relationship with DMI in cows with high MY but a negative relationship in cows with low MY. Additionally, DMI was positively related to FNDFD for low ADF/NDF but negatively related to FNDFD for high ADF/NDF. The inclusion of the ADF/

NDF captures the variations in forage fragility between grasses and legumes. The digestibility of the NDF and the concentration of ADF and NDF can be obtained from any nutrition lab where samples of TMR are sent for analysis.

The NRC equation without the correction for diet factors over-predicted DMI at high levels of intake and under-predicted DMI at low levels. The feed factors equation is considered useful to predict DMI response to factors related to the filling effects of rations during ration formulation thus improving the prediction of the NRC equation.

Predicting feed intake in dairy cows is crucial for optimizing their nutritional management and productivity. Recent advancements in prediction models have improved accuracy by considering factors like milk production, body weight, body condition score (BCS), days in milk (DIM), and parity.

The Nutrient Requirements of Dairy Cattle (NRC, 2001) equation and a recent study's equation were compared, with the latter showing smaller bias and better performance during mid and late lactation. Additional feed factors, such as acid detergent fiber (ADF), neutral detergent fiber (NDF), and NDF digestibility (FNDFD), can be incorporated for more precise predictions.

Emerging technologies like 3D cameras have shown promise in determining BCS and estimating body weight, providing more accurate input variables for feed intake prediction models. By utilizing 3D cameras, dairy farmers can assess BCS and monitor changes in body weight, contributing to more reliable feed intake estimations. These advancements in technology further enhance diet formulation and overall feed efficiency in dairy farming, enabling more precise and effective nutritional management.