Nutritional modelling – the next frontier for Irish pasture-based systems

A TEAGASC project is addressing how we can utilise nutritional modelling to gain a greater understanding of nutrient supply and requirements of pasture-based animals.

Introduction

Nutritional models quantify an animal's nutrient demands, which change across physiological stages, while also quantifying the supply of nutrients, which is highly variable from pasture-based diets. The use of nutritional models in pasture-based systems is limited, with conflicting reports surrounding constraints to more efficient milk production in these systems. The Cornell Net Carbohydrate and Protein System (CNCPS) is a mathematical model designed to evaluate the nutrient requirements of cattle over a wide range of environmental, dietary, management and production situations. The model also uses estimations of carbohydrate and protein degradation and passage rates to predict the extent of ruminal fermentation, microbial growth, and the absorption of metabolisable energy (ME) and metabolisable protein (MP) throughout the gastrointestinal tract. Therefore, application of the CNCPS has the potential to help quantify the nutrient(s) first limiting milk production output and feed conversion efficiency in pasture-based systems.

Dairy cow nutrition research programme

The overall objective of this research is to develop and implement a dairy cow nutrition programme that increases the competitiveness of the Irish dairy industry. In order to achieve this, it is necessary to build a solid foundation comprising three main pillars in dairy cow nutrition.

Pillar 1: The feed

Measuring forage composition is an integral part of understanding nutrient supply to livestock. An example of this can be seen in the neutral detergent fibre (NDF) estimate. Currently, NDF is reported on feed analysis output as an indicator of feed quality and plant maturity. However, NDF is not a uniform fraction and requires further analysis to understand its nutrient supply to the animal. Numerous animal studies have shown that when forages of different *in vitro* digestibility but similar NDF concentration are fed, significant increases in dry matter intake (DMI) and milk production can be achieved. NDF can be fractionated into two pools, one that is unavailable to microbial digestion (uNDF) and a potentially digestible pool (pdNDF), which is calculated as NDF minus uNDF. Further fractionation can occur, with a three-pool system approach, assigning fast, slow and undigested pools to the total NDF (**Figure 1**). These fractionation schemes can provide nutritionists with better information about the heterogeneity and digestibility of NDF, and the dynamic nature of the pool sizes that may influence feed intake and energy supply. This novel feed chemistry analysis was performed on spring and autumn Irish pastures at Cornell University. The rate at which the pdNDF pool degraded was faster for spring compared to autumn pasture (9.53 versus 7.76% $hour^{-1}$, respectively). Furthermore, the extent to which NDF was digested was greater for spring compared to autumn (9.75 versus 15.50% uNDF, respectively). Predictions of the ME per kg of dry matter of the swards showed that spring pasture had a greater energy density and also supplied a greater quantity of MP to the animal. By

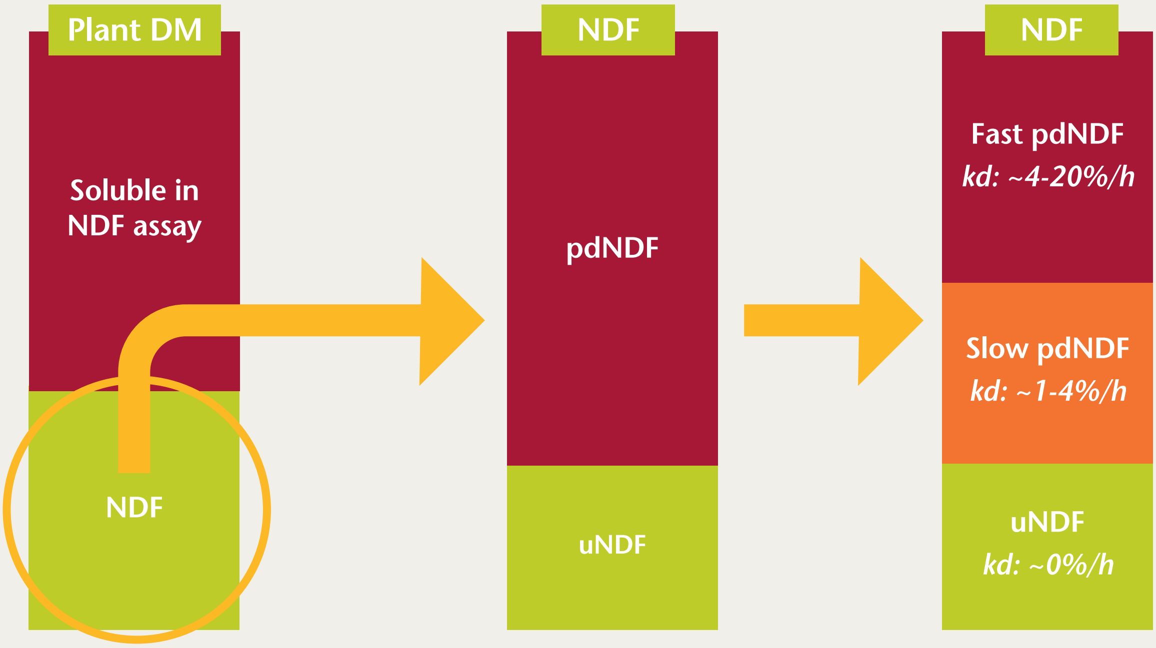

FIGURE 1: Fractionation of feed NDF according to the three-pool system.

implementing new feed chemistry analysis, as described above, a more accurate prediction of the nutrient supply to the animal can be achieved for pasture-based systems.

Pillar 2: The cow

In combination with an accurate description of the feed, *in vivo* animal variables and their potential impact on the nutritional value of the feed requires quantification. These variables include passage rate, rumen degradative ability, rumen pH and ammonia dynamics, and microbial growth rates. To mechanistically describe this biology of the grazing dairy cow, new experimental techniques need to be implemented. In the summer of 2017, 10 ruminally cannulated cows participated in an omasal flow experiment, which allows the digesta leaving the rumen to be sampled periodically across the 24-hour day. The animals were fed fresh pasture or pasture plus 3kg DM of a starch supplement. To complement this procedure, rumen evacuations and faecal sampling were also carried out to help quantify amino acid flows and total tract digestibility. Laboratory analysis of the samples collected in this study is still ongoing, with results of the experiment to be published by summer 2019. These types of mechanistic experimental procedures will provide greater knowledge of how pasture swards impact outcomes such as intake, digestibility, milk solids production and feed conversion efficiency.

Pillar 3: The nutritional model

The third challenge is to incorporate this new knowledge of feed and animal physiology into a functional model to predict animal requirements and performance potential at pasture. Currently, evaluation and refinement of the CNCPS is being undertaken to assess its potential application in pasture-based systems. An initial evaluation demonstrated a moderate capability of the CNCPS to predict the first-limiting nutrient (MP or ME) with coefficient of determination (R^2) = 0.67. This evaluation was conducted before new knowledge on the feed and *in vivo* variables was generated, and it is expected that incorporation of these data will improve the predictive capability of the model when simulating high-quality pasture diets.

Future application

Teagasc is building both a robust decision support tool and a multi-year Irish feed library that can be utilised to support the Irish farmer and the wider industry. Using this approach, Teagasc will be better equipped to support producers in terms of nutritional advice and intervention practices.

Authors

Michael Dineen
Ruminant Nutrition Scientist, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork
Correspondence: michael.dineen@teagasc.ie

Brian McCarthy
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Michael Van Amburgh
Cornell University, Ithaca, New York, USA.