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NDS Dynamics

Welcome to the NDS Dynamics newsletter!

Starting from 2020, our commitment at RUM&N is to devote greater efforts to the publication of the NDS Dynamics Newsletter on a regular basis. We will include wider and in-depth content and informative articles both from the point of view of feeding and nutrition. This will allow users and advisors to obtain indications and tips on how to use the platform and the CNCPS model in the most efficient way and to derive the maximum possible competitive advantage from it. This will be achieved also with the contribution of international experts and technicians and coordinated by the staff of RUM&N.

RUM&N staff is growing

The mission of RUM&N Company is to develop livestock nutrition and management models and decision support tools aimed to apply the correct Precision Feeding Management, improving the accuracy of the predictions and the potential in decision making. To manage these tasks, a lot of skills, as well as passion, commitment and attention to the demands of users of our platforms, are needed.

For us, human capital is the most important resource to consider, therefore we are very pleased to inform you that RUM&N staff has grown thanks to the reorganization of its R&D department now managed by Drs. **Emiliano Raffrenato**, animal nutritionist, and **Giulia Esposito**, veterinarian, who joined us to provide technical support and training as well as to be actively involved in project development.

Emiliano Raffrenato obtained his BSc in Tropical and Subtropical Agriculture *cum laude* in 1998 from Catania's University (Italy). In 2000 he completed an MSc in Animal Breeding at Cornell University (USA) and then started to work for a Dairy Research Centre in Italy, as part of the extension service and the data center analysis. In 2005 he returned to Cornell University where he started his Ph.D. in Ruminant Nutrition, focusing on factors associated with fiber digestibility in dairy cows. During his Ph.D., he also developed new tools to describe how fiber digestion occurs in various feeds, in support of the CNCPS and he also contributed to research in calves and heifers' growth. Since then he has examined the role of carbohydrate digestion and site of digestion on the partitioning of those substrates to milk and other functions in dairy cows. He has also looked at better characterizing various feeds for starch and protein.

Today, he's working with the development of NDS in connection with various institutions in Italy, Denmark, USA, Australia, and South Africa and he is also an extraordinaire senior lecturer at Stellenbosch University (South Africa).

Giulia Esposito obtained her DVM, majoring in production animals *cum laude* in 2006 from the University of Naples Federico II (Italy). After one year as a private practitioner, she started her Ph.D. in animal science at the same university in collaboration with Cornell University (USA). During her Ph.D. she started looking at the link between cow nutrition and dairy products quality focusing on fatty acids profile, later she focused on the effect of polyunsaturated fatty acids on reproductive performance. Since then, she has examined the role of nutrition on metabolic and reproductive performance, especially in transition dairy cows.

Today she's working with the development of NDS in connection with various institutions in Italy, USA, and South Africa and she is also an extraordinaire senior lecturer at Stellenbosch University (South Africa).

With the aim of providing a service increasingly responsive to the needs of the territory, **NDS-North America** has also recently expanded the training and support team with the addition of **Kurt Cotanch**.

Kurt Cotanch obtained a BS in Psychology and a MS in animal science at the University of Vermont (UVM; USA). While at UVM, Kurt managed the Forage and Soils testing lab for nearly 10 years. He spent 2 years as a nutritionist for Cargill. Later, he moved to the WH Miner Research institute where, for 17 years, one of his responsibilities was developing the feed dictionary for the CPM version of the CNCPS ration model. He also guided many research projects aimed at better understanding forage NDF digestibility, particle size, chewing, and rumination. In 2017, Kurt became the director of farm operations for the Jasper Hill Cheese group. There he was responsible for oversight of the production of cheese quality milk, nutrition and production of dry hay.

Today he's working with NDS-North America for the support and training through the Americas. He will also collaborate with the R&D department of RUM&N.

An upgrade of the NDF characterization in NDS

By E. Raffrenato, A. Ferrari and E. Melli
RUM&N R&D Department

Introduction

As fiber is the most important nutritional entity for ruminants, we can expect a continuous evolution in the way we characterize it. It has been in fact defined to affect intake, digestibility, passage and rumen function. NDF has been for many decades known to be slowly degradable but it is also a diverse entity and composed of a digestible and an indigestible fraction. In the CNCPS fractionations system for carbohydrates, the B_3 fraction corresponds to the digestible one (i.e. pdNDF) and the C fraction corresponds to the indigestible one (i.e. iNDF). Thanks to a more precise and accurate measurement of the C fraction through long fermentation (i.e. $uNDF_{240}$) we can nowadays also more reliably quantify and characterize the B_3 fraction.

The 3-pool system

In the '70s, Dr. Mertens (1973 and 1977) had defined NDF degradation as being better described by a 3-pool system, meaning that the B_3 fraction degradation (i.e. fermentation profile) would better fit the contemporary degradation of a fast and slow fraction (with the 3rd pool being the C fraction). The fast pool would, therefore, be degraded more quickly and disappear faster from the rumen than the slow pool, which would be slowly degraded and potentially disappear later. Let's remember that a fraction can disappear from the rumen either by digestion or passage. The main consequence is that the fast pool will probably disappear mostly because of digestion, while the slow pool will mostly disappear because of passage to the lower tract. On the other hand, we know that the C fraction will disappear only because of passage.

In the last years, the C fraction has been estimated in various studies and it seems that it is related to rumen load. Most studies show that at any time the rumen will contain about 50-60% more of the total C fraction ingested in the last 24 h. According to some studies, it also seems that the C fraction passes more quickly than the rest of the cell wall, with the rest of the NDF being selectively retained. Obviously, we can then expect the slow pool having characteristics more similar to the C fraction and therefore contributing more to the load than providing relevant energy to the rumen bugs. On the other end, the fast pool will remain in the rumen depends on the competition between passage and degradation. We can speculate that when being large in amount and possibly higher in kd, its quality will definitely affect feeding behavior, especially meal size and inter-meal time. On the other hand, when the slow pool and C are large, they will affect total intake more. Ultimately the combination of the 3 pools will affect total intake and feeding behavior, but with each having more "weight" according to the respective characteristics. Future studies will probably give us more information. In any case, all the NDF pools need to be evaluated in conjunction with the rest of the diet's components. We then need to start getting to know each of them to better interpret the animal response to each diet and how to possibly improve performance and profitability.

The NDF rates calculator

In 2015 a rate calculator was implemented in NDS. The calculator was based on the work first presented at the CNC in 2011 by Raffrenato et al. (2011), and more recently published in the Journal of Dairy Science (Raffrenato et al., 2019), dealing with the description of the 3-pool system described above.

The calculator used to run on a dynamic non-linear optimization running in the background using Vensim (which is a simulation software). The user was required to input 3 fixed time points of NDF digestibility (30,120 and 240h for forages and 12, 72 and 120h for non-forage feeds). However, both users and our team at RUM&N have realized that the Vensim model has, in many cases, some limitations. The following are some of those limitations.

1) The Vensim tool used to run only at 32 bits, and is, therefore, represented a bottleneck to the improvement of the whole NDS platform.

2) The Vensim calculator resulted at times in negative slow pool amounts and consequently in lower than true aggregated kd values. This happened also when the reported NDFd values were reasonable.
3) The model did not discriminate between reasonable and unreasonable inputted digestibility values and therefore all results were assumed to be reliable independently of the inputted values.
4) When presented with very high-quality forages (e.g. pastures or legume haylages), the Vensim calculator tended to result in lower than real kd. Points earlier than 30h would then be needed. The original Ph.D. work by Raffrenato (2011) had, in fact, showed that the optimal time points needed depended on the specific forage and fiber quality.

Therefore, whatever happened before the 30h was assumed until now of secondary importance and the optimization was independent of that. The model was also built based only on 34 forages, that, even if chosen based on their variability, present some limitations.

An algorithm was therefore developed with the objectives of:

- Characterizing the 3 NDF pools, in terms of amounts and rates;
- Running at 64 bits;
- Internally checking the estimation of the pools to avoid negative pool values;
- Warning the user of time points that are not consistent with the 3-pool system used and the respective equation;
- Allowing the user to utilize extra time points when available.

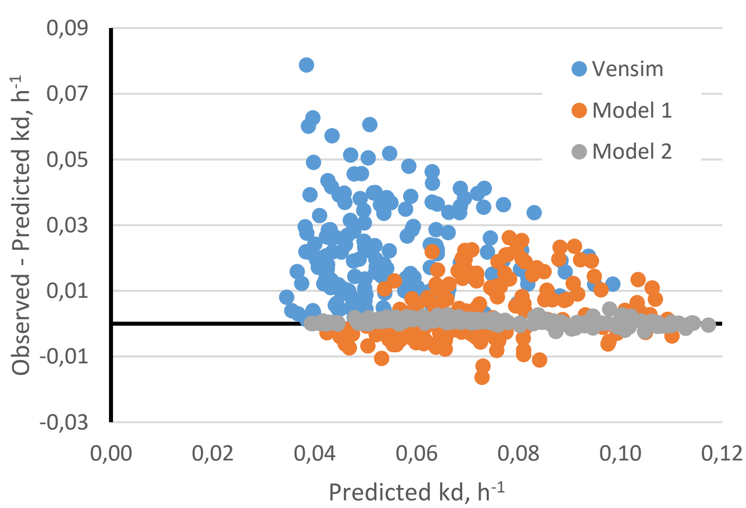
Validation

The updated calculator was validated by generating a set of 500 forages fermentation profiles. Each profile corresponded to a unique combination of the parameters that needed to be estimated (i.e.: k1, k2, fast pool, slow pool, indigestible pool). The main condition was that the pdNDF was exhausted by 240h. The combinations included was based on ranges published in the last 10 years by commercial laboratories and internally available. A fixed lag of 2 h was used in the validation. For each simulated sample, only the uNDF at 30, 120 and 240 were first used to generate the parameters (model 1). The aggregated kd's were compared with the ones generated by both the Vensim model and the updated model, by regressing the simulated aggregated kd on the simulated ones.

Preliminary results showed that with larger aggregated kd, and especially with large k1 (fast degrading pool's rate), a 3-timepoint estimation (i.e. using 30, 120 and 240h) becomes weak. From a mathematical point of view, this means that multiple combinations of k1, k2, pdNDF1, and pdNDF2 will result in a curve passing by those 3-time points and the consequential risk of picking the "wrong" curve and parameters. We, therefore, allowed the addition of extra time points to the model and run another comparison for when using the 12h NDFd as well (model 2). The addition of another time point would obviously reduce the risk of picking a wrong curve or basically parameters very far from the true ones.

The R^2 from all regressions of observed on predicted parameters were not consistently high. The Vensim model showed its limitations with R^2 always lower than 0.60. On the other hand, model 1 and 2 resulted in R^2 always higher than 0.80, when regressing the observed on the predicted parameters. Specifically, the regression of the observed on the predicted values when using model 2 always resulted in R^2 higher or equal to 0.90 with the k_D resulting in R^2 of 0.99.

A better analysis of the residuals was run by plotting the "observed-predicted" against the predicted kd values for each model. The figure shows the difference in model performance according to the size of the kd. The Vensim model always resulted in positive residuals, confirming what previously mentioned. The residuals were higher for the lower predicted values. This means that when the Vensim model predicts a low kd value, the risk of having a falsely low value is higher than when predicting a higher kd forage. Model 1 residuals were instead independent of the size of the kd while model 2 residuals confirmed the drastic improvement of the prediction when including the 12h time point NDFd in the prediction.



Our work clearly showed how relevant is what happens during the fermentation before 30h, especially for extreme cases of either very high or very low-quality forages. Various laboratories are now offering a 12h NDFd value.

Conclusions and Implications

Recently, the characterization of the cell wall has made huge steps forward and we had the urgency of making sure that we were describing the NDF pools in a precise and accurate way. Dealing with modeling also means knowing that what we are using at the moment is not a perfect tool and that can always be improved. We now know that for high quality forages like alfalfas, grass silages and haylages, young pastures and high-quality BMR corn silages, the addition of 12h NDFd to the calculator will drastically improve the NDF characterization and therefore our ration evaluation. When the 12h NDFd is not available, the calculator will tend to be conservative to avoid underfeeding cows.

The NDF characterization: a practical perspective

By K. Cotanch
NDS-North America

A number of commercial forage testing labs have already been including the 12h NDFD value in NIR analyses of corn silage and alfalfa and mix grass silages. This new value is already included in the import of .xml forage analyses. What does this mean to you and how does it affect predictions in NDS?

First of all, the 12h NDFD timepoint is aimed at improving the characterization of the potentially digestible NDF (pdNDF) pool. With high-quality forages, the fast pool can digest very rapidly and thereby affect the kd of NDF to a greater extent than can be described only by the 30h time point. In other words, highly digestible fiber pools and kd will now be better estimated. In some cases, the 12h time point may indicate a more slowly fermenting fast pool than predicted by just the 30h time point. This results in shifts of the rumen NDF degradation curves but does not affect the indigestible fraction of NDF (uNDF240).

The inclusion of the 12h time point will result in a better-aggregated kd value for the entire pdNDF pool. With highly digestible forage, the 12h value will shift the NDF digestion curve to the left resulting in a larger/faster aggregated kd. A lower 12h NDFD value will shift the digestion curve to the right, resulting in a slower aggregated kd. The most obvious change to ration predictions will be either an increased or decreased ME and MP allowable milk.

The first graph (below) shows the original NDF digestibility of corn silage without a 12h NDFD value. The second graph is the same corn silage with a 12h NDFD value of 40%, resulting in a faster fast pool. Note how the digestion curve shifts to the left indicating more rapid fermentation of NDF. The graphs also show the estimated pool sizes of the fast and slow pool of pdNDF. Without the 12h time point, the aggregated pdNDF (CHO B3) kd is 6.56, with the fast pool fermenting at 9.14%/h (k1) and the slow pool degrading at only 1.40%/h. With a 40% NDFD 12h value, the aggregated CHO B3 kd nearly doubles to 10.16 with a k1 rate of 16.01%/h and k2 of 1.56%/h. This change resulted in a 0.54 kg gain in ME milk and 1.13 kg gain in MP milk. These estimated gains in milk are resulting from increased VFA production from the more rapid fiber fraction and also a large increase in microbial protein yield from the fast fiber fermentation. The total effect of the inclusion of the 12h time point will depend on the magnitude and direction of the 12h kd for the forages in the ration along with the amount of forage in the diet.

Nutritional implications with the 12h time point:

1. peNDF will not change. However, if the fast pool of forage is very large and rapid, the functional physical effectiveness of that forage to stimulate chewing upon intake/eating and rumination may be reduced. It ferments faster and is no longer physically effective in the rumen. The cow may have more rumen space available and eat more if a feed is available.
2. Rumen N balance should be monitored as an increase in the NDF fast pool may require more rumen available peptides to support the increased microbial growth.
3. uNDF240 will not change, but the gut fill of NDF may be limited if NDF digestibility is slower than believed with only the 30h NDFD.
4. Predicted rumen pH will not change.

The 12h NDFD value can help improve the evaluation of forages over time. I look to the addition of the 12h time point to be a helpful visual aid in comparing forages in the ration and possibly over years or between fields, lots and, possibly, varieties. The caveat is the accuracy and precision of the NIR predictions.

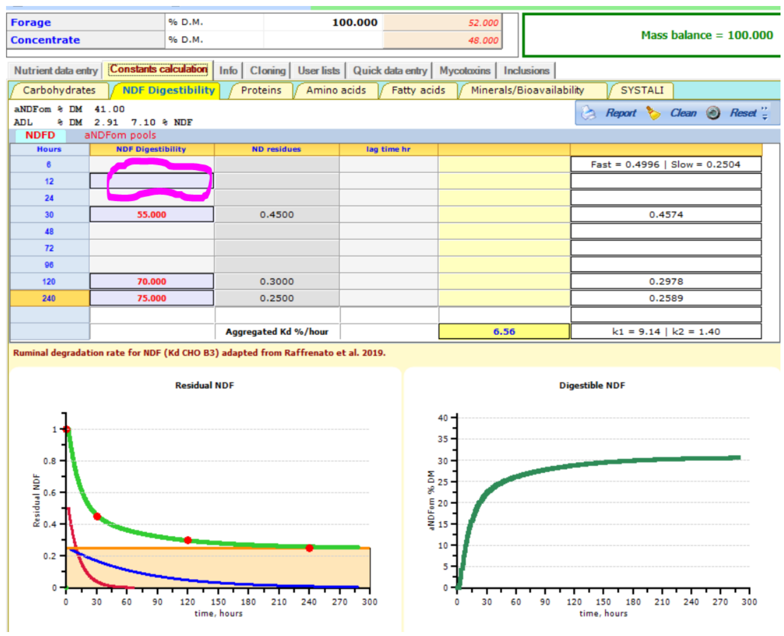


Figure 1. Corn silage NDF digestibility without 12h time point

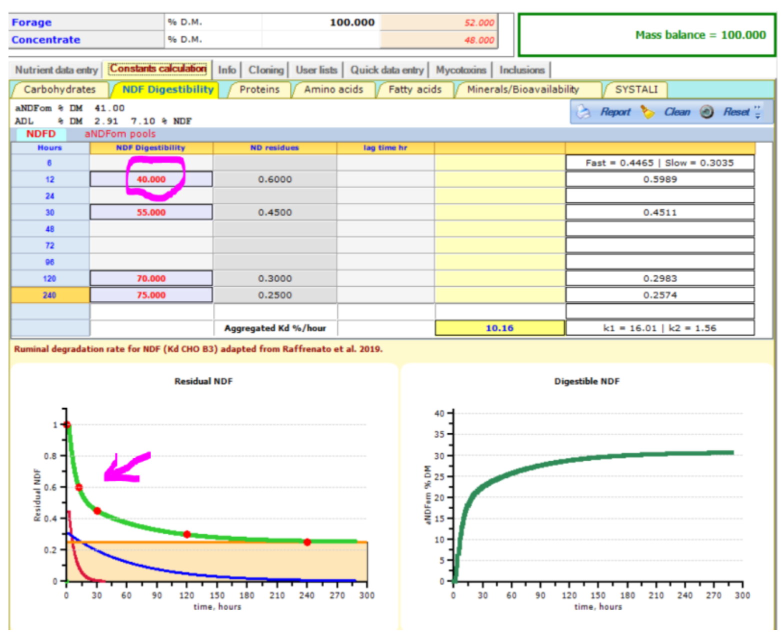


Figure 2. Corn silage NDF digestibility with 12h time point

Send us your comments on this topic! Emiliano Raffrenato is at emiliano.raffrenato@rumen.it; Giulia Esposito is at giulia.esposito@rumen.it; Dave Weber is at rumendvm@gmail.com

Note that the features and utilities developed by the NDS team described above are not components of the underlying CNCPS model, and do not change the CNCPS outputs or results. *Questions about the use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.*

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