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## *The New NDS Fiber Adequacy Tab: Troubleshooting & Avoiding Sub-Acute Acidosis*

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In the previous NDS-Dynamics newsletter we addressed the importance of accurately knowing ration *physically effective NDF* (**peNDF**), which is important because ration peNDF intake is closely linked to rumen pH. We also described the use of the NDS P-Size tab to improve estimates of peNDF. Rumen pH affects diet digestibility and is also strongly connected to health disorders such as displaced abomasum, laminitis, and "bloody gut" (hemorrhagic bowel syndrome) for example. Rumen pH is also an important factor in butterfat depression, and can contribute to decreased milk protein yield when pH is low enough to decrease microbial yield. These are all reasons that regular screening of rations and adjustment of calculated peNDF to match observed peNDF are important. But, once evaluated, there is another critical piece of managing ration peNDF – deciding how much peNDF is necessary for optimum performance.

Frequently nutritionists use proxies for peNDF and fiber to decide how much peNDF is necessary, for instance based on the percentage of forage NDF in a ration, or forage : concentrate ratio, or the ratio of forage NDF to fermentable starch. However, forage content of a diet is not as closely related to rumen pH as is often presumed ($r^2$=0.148, Pitt et al., 1996). Sometimes a nutritionist will target a benchmark amount of peNDF gleaned from published research, or knowledge of CNCPS, and might expect there to be a universally optimum level of peNDF that rations for high producing cows should contain. *<u>However, there is not a one size fits all peNDF level that fits all diets.</u>* Often, we nutritionists decide intuitively how much peNDF is needed, and in doing so intuitively take into account our experience with different types of feeds, different levels of concentrate or types of starch, and different feeding management issues such as ration sortability, overcrowding, and feeding frequency.

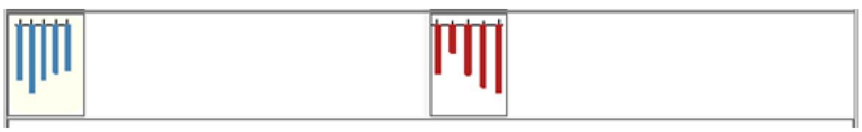
One limitation of relying too heavily on our intuition and experience is that many of us usually work with the same diet type almost all of the time. Eastern and Midwestern US nutritionists typically feed mostly ensiled feeds, and fairly high levels of corn silage and starch, i.e. "Eastern" diets. Many Western US nutritionists typically feed rations that contain predominantly alfalfa hay and include much less corn silage and less ensiled forage than "Eastern" diets. Typically such "Western" rations are likely to be routinely lower in both peNDF and starch. Nutritionists become adept at intuiting what the peNDF content should probably be when formulating diets similar to what they routinely formulate. Sometimes however, nutritionists need to formulate "hybrid" diets containing intermediate levels of starch and peNDF. This occurs commonly when there is a need to formulate with less forage and an increased amount of byproducts containing nonforage fiber, perhaps for cost reasons, or sometimes because of poor forage quality. Another frequent reason for "hybrid" formulations is forage inventory constraints, which can change traditional inclusion levels of corn silage or alfalfa hay and put the nutritionist out of their historical experience-based "comfort zone". In these "hybrid" formulation situations it can be difficult to decide how much peNDF to include in a ration to avoid *sub-acute acidosis* (**SARA**) and other deleterious effects of low rumen pH.

Interestingly, daily average rumen pH is not highly correlated to peNDF alone (Beauchemin et al., 2003). However, taken together, peNDF and *rumen degradable starch* (**RDS**) are two primary factors affecting rumen pH. Research by Zebeli et al. (2008) and Beauchemin & Yang (2005) clearly shows that to optimize the rumen pH environment, we need to consider both peNDF and RDS, as well as the amount of dry matter intake. Furthermore, ruminal pH is highly variable during the day, typically varying more than a full pH unit over a day (Zebeli et al., 2008). Thus, defining an optimum rumen pH can be considered relative to several characteristics of diurnal rumen acidity fluctuations. One might focus on the daily average pH for instance, or the daily pH nadir, but neither is the best index of rumen function or SARA. A more important parameter is the duration of time that the rumen pH is under 5.8 (Zebeli et al., 2008; Rustomo et al., 2006). Below pH 5.8 ruminal fiber digestion is impaired; being below pH 5.8 is also a threshold for SARA. The duration of time under ruminal pH 5.8 is negatively correlated with mean ruminal pH ($r^2$=.88, Zebeli et al., 2008). Change in the duration of time below pH 5.8 appears to plateau above a mean daily pH of about 6.25, at which pH the length of time under pH 5.8 is approximately 1 hour/day. SARA is unlikely to be present if mean ruminal pH is greater than 6.16, or when the duration of ruminal pH under 5.8 is less than 5.24 hours/day (Zebeli et al., 2008).

But for field nutritionists, the daily rumen pH profile of our herds is mostly unknown and unknowable. Fortunately for NDS users though, there is a new NDS feature that can help guide decisions about formulating lactating rations to avoid SARA or compromised fiber digestion and microbial yield. This new feature, the "Fiber Adequacy" tab, can guide us on how much peNDF is needed, and also provides useful guidance for identifying an appropriate level of fermentable starch to avoid SARA. The fiber adequacy tab is located in the center of the main recipe tab.

NCPS | Milk quality | Well-being risks | Fiber adequacy

| Current rumen pH | mean 6.01 | minimum 5.44 | |
|---|---|---|---|
| | | peNDF % DM | RD Starch % DM |
| Low/No SARA risk | target pH 6.15 | 32.30 | 14.50 |
| | Time pH <5.8 hours/day | | |
| Current values | 5.96 | 20.80 | 16.55 |
| Safe values (<5 h) | target 4.5 | 25.30 | 14.50 |
| Borderline values (5-6 h | target 5.5 | 22.03 | 14.50 |
| Critical values (>6 h) | target 6.0 | 20.71 | 16.80 |



The tab provides information derived from the current ration, and shows parameters for pH, peNDF, and rumen degradable starch. The top line (red text) provides the estimated current mean daily pH, and the expected daily pH minimum. The line below that with a bright yellow background suggests the "target" pH we would need to be at or above in order to avoid SARA. Note though that it is usually not possible to formulate rations for high producing cows and still meet the suggestions on this line. The right hand side columns labeled "**peNDF % DM**" and "**RD Starch % DM**" provide either the current levels (green row) or suggested guidance (yellow rows) for the levels of peNDF and RDS needed to be at the risk levels defined at the left – ranging from "Low/No SARA risk" through "Safe", "Borderline", and "Critical" risk levels. <u>*The suggested peNDF and RDS levels should be considered independently, and should NOT be considered as a pair of values which taken together will result in the risk level for the row!*</u> Rather, they are suggestions of what the <u>minimum</u> level of peNDF would likely be for that risk category ***if the current diet RDS value was held constant***. Similarly, the RDS column suggests <u>maximum</u> RDS levels for each risk category ***assuming the current diet peNDF value was held constant***. Clicking on the graphics at the bottom of the tab shows similar information graphically for peNDF and RDS respectively.

These values are intended to guide iterative ration reformulation such that it results in a revised ration with the expected level of risk of SARA. The algorithm used is an adaptation of equations that predict rumen pH which are published in peer reviewed papers. Users should appreciate that while the data available for developing these equations is the best available at this time, the data used has a considerable amount of unexplained variance in observed rumen pH. Statistics assessing the equations in the original papers suggested they explained much (~66% to ~88%) of the variation in rumen pH observed in the assembled data, but certainly not all of it. In addition, while the Fiber Adequacy suggestions in NDS are based on peer reviewed papers, there was considerable variation in how peNDF was measured in those papers. <u>Users are therefore cautioned to use the values suggested as just that: ***suggestions***, based on the best available information. They are not a definitive quantification of amounts of either peNDF or RDS that will</u>

absolutely restrict risk of SARA to the specified risk category. Furthermore, the predicted levels of peNDF or RDS for specific risk scenarios are constrained in the NDS implementation to be consistent with the central range of data in the original papers in order to avoid extrapolating suggestions that might be outside the data range used in their development. The red icons in the cells in the example above indicate that the value in that cell is not generated by the algorithm, but represents the constraint to a limit that can be reasonably used as the prediction based on the original data. Some diets that perform well do exceed those limits, but usually that occurs limited to cases where exceptional feeding management and related factors provide an optimum situation; users should be cautious if they are formulating to values outside the constrained limits. The tab is intended as a guide for troubleshooting and reformulation, and values should not be interpreted as absolute requirements or precise recommendations.

Additional factors such as feeding management that are not invoked in the NDS fiber adequacy algorithms should also be considered when choosing the level of risk one might find acceptable among the suggested peNDF / RDS levels on the fiber adequacy tab. Such other factors might include:

Grain fermentability – work by Krause et al. (2002) reported that time under pH 5.8 could increase by nearly two hours to as much as 5 hours per day longer when highly fermentable corn grain replaced a less fermentable corn grain. Both mean and minimum daily pH also decreased with increasing grain fermentability.

Sortability of the ration - The algorithms used to generate the NDS suggestions for peNDF and RDS rely on peNDF values, but such values by themselves do not account for differences in consumed peNDF if the ration is sorted. Research by Gao and Oba (2014) reported that when fed the exact same ration, cows that had the lowest rumen pH and most severe SARA were cows that sorted extensively. The potential for sorting should be a consideration in formulating rations.

Stage of lactation of cows consuming the ration - Penner et al. (2007) reported that the incidence and severity of ruminal acidosis is increased in cows during the immediate post calving period. Also, after the immediate postpartum period, early lactation cows near peak milk have high dry matter intakes, and increased dry matter intake is associated with reductions in ruminal pH (Zebeli et al., 2008).

Overcrowding – In a trial at Miner Institute, overcrowding (stocking density of 142% vs. 100%) increased the number of hours rumen pH was under pH 5.8, and decreased mean daily ruminal pH (Cotanch, 2015).

Observed peNDF – As described in the last NDS newsletter, for the mixed TMR it is important to reconcile the actual observed *physical effectiveness factor* (**pef**) based on either the Penn State Particle Separator results or the Z-Box results with the calculated pef by empirically adjusting the pef for individual ingredients contained in the mixed ration.

**Bottom line:** In the original paper defining the peNDF concept, Dr. David Mertens stated that there is “difficulty in defining an absolute requirement for fiber” (Mertens, 1997). While that remains true, The NDS Fiber Adequacy tab incorporates recent research on establishing peNDF needs in dairy rations, and can be very useful in making formulation decisions regarding peNDF and RDS, or troubleshooting SARA related health or performance problems.

Note that the Fiber Adequacy tab is a utility developed by the NDS team, and is not a component of the CNCPS model. *Questions about use of this feature should be directed to the NDS support team, and not to the CNCPS group at Cornell.*

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