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NDS Dynamics

Starch: how do we handle it?

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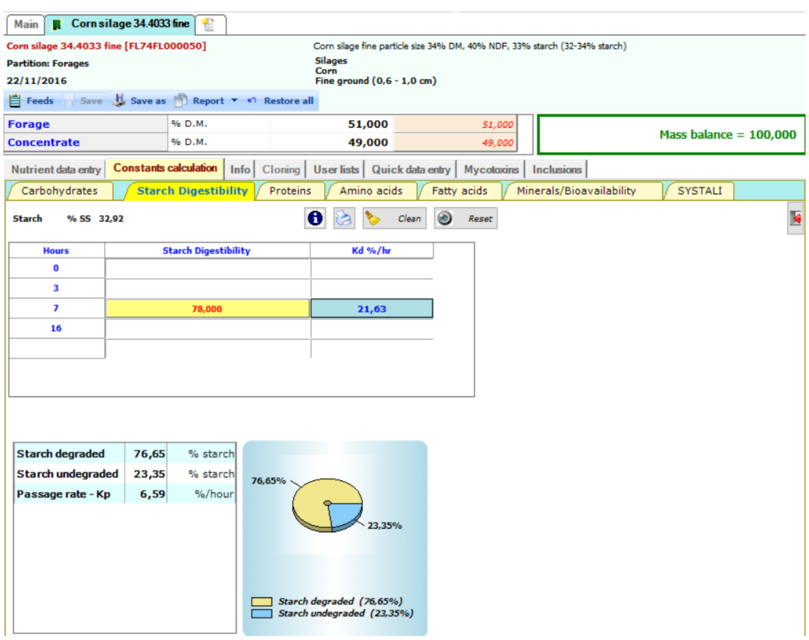
In the last few years there has been a great advancement on the way we handle the first carbohydrate of our dairy cow diets: NDF. We now talk about various time points digestibility values, various pools and how the relationship between NDF and ADL is not a fixed one. At the same time, we have also talked about starch as a hot topic, but without a parallel advancement on how we handle its characterization when formulating diets. Starch is the primary source of energy for dairy cows, and characterizing starch sources properties is of utmost importance to maximize its utilization and overall feed efficiency and reduce the associated risks. The rate and extent of starch digestion is highly variable depending on intrinsic as well as extrinsic factors (Patton et al., 2012; Giuberti et al., 2014; Moharrery et al., 2014), and has greater impacts on the performance and health of dairy cows. Techniques (in vitro, in situ and in vivo) for evaluating digestion of starch have been developed, adopted, criticized and modified, but, for our objectives, in vitro starch digestibility is the most viable option. The in vitro starch digestibility (IVSD) method is based on the anaerobic incubation of samples in rumen fluid with buffered medium. Residual starch is then measured to quantify starch digested after specific time points. By using different mathematical approaches, the rate of starch disappearance is then often estimated either using a single or multiple incubation time points (Sveinbjörnsson et al., 2007; Sniffen et al., 2009; Allen and Piantoni, 2014; Giuberti et al., 2014). A 7-h single incubation time has been adopted by most commercial laboratories, as it is considered the mean rumen retention time of concentrates for lactating dairy cows. As most of you know, the rate calculation for starch (i.e. B1 fraction for the CNCPS 6.55) is embedded in your NDS under the "Constants calculation" tab of each starchy feed.



The formula has been available for few years now and it represents a shortcut to estimate a kd for starch. Obviously, having more time points would result in a more precise and accurate estimation, but at this stage scientists and laboratories are still working to obtain a better starch characterization, while still using less time points. The presence of other time points, from 0 to 48 h, are used for a supposedly more accurate and precise estimation using various non-linear equations but the need for extra time points does not represent the only issue.

Besides the mathematical issues, there is also the need of standardizing both the in vitro procedure and the starch quantification to eliminate any other discordance across laboratories. A standardized in vitro starch digestion method is thus essential to improve intra-lab repeatability, but this seems to be a challenge. So, when obtaining and comparing 7-h starch digestibility values, let's try to stick with the same laboratory, a suggestion that is valid for other fractions as well.

To our knowledge, even if widely used, the mathematical formulation using 7-h IVSD has not been validated against a reference method. Preliminary data (Raffrenato et al., 2018) show how the 7-h kd becomes a weak estimation for extreme values, i.e. for very low or very high rates. It seems that for more fermentable starch sources (e.g. very fine grains, high moisture corn or wheat) the 7-h kd might underestimate the real kd, and vice versa, for less fermentable sources, it might overestimate the true kd. However, differences seem to be small enough to avoid problems. One consequence is that when feeding less fermentable starch sources (coarser grains or corn or sorghum) we might underfeed and provide less energy. A more problematic consequence is that when using highly fermentable starch sources, we might tend to overfeed that source providing extra energy and possibly creating a risky rumen environment. While these are for now only speculations, we always need to have enough peNDF in the system to decrease any risk when feeding highly fermentable starch sources and paying attention to what the cows tell us is always the best way to validate our hypotheses or give us a hint if the recipe we are feeding is the best one for the specific animal inputs.

Possible options that we foresee, to increase accuracy and precision of the B1 kd, are either using multiple time points IVSD (similarly to what is done with NDF) or by using other characteristics of the starch source, such as processing, and adjust the final kd. This might improve estimations especially when dealing with extreme values of starch digestibility.

Another important aspect of starch digestion is relative to the fact that some starch can escape rumen digestion. The amount escaping rumen digestion depends on many factors such as grain (e.g. barley, oat, wheat vs. corn and sorghum), processing (e.g. particle size), amount and possible interactions with other nutrients in the rumen. Starch that escapes rumen fermentation can be enzymatically digested in the small intestine, to provide glucose that is absorbed or metabolized to lactate (Reynolds et al., 2003), or escape enzymatic digestion to be fermented in the hindgut (caecum and colon) to yield volatile fatty acids (VFA) and microbial protein (Huntington et al., 2006). Otherwise, it is excreted in feces. A recent meta-analysis reported an average small intestine starch digestibility of 60%, ranging from 11 to 90% of the starch entering the small intestine (Moharrery et al., 2014). Numerous studies show that although the potential of intestinal starch digestion is considerable, the capacity is still limited (Reynolds, 2006). The overflowing of starch to the small intestine would overwhelm the digestion of starch in the small intestine, resulting in reduced starch digestibility (Matthe et al., 2001; Oba and Allen, 2003b; Huntington et al., 2006; Reynolds, 2006; Ferraretto et al., 2013). Starch digested in the large intestine ranges from 44 to 46% of the starch entering (Huntington et al., 2006), corresponding to an average of 5% of starch intake (Moharrery et al., 2014). Digestion of starch in the large intestine is limited by relatively short residence time, and possibly because the starch particles, having resisted digestion in the rumen and small intestine, are inherently resistant to digestion (Deckardt et al., 2013). Although starch digestion in the large intestine is similar to the digestion in the rumen, the large intestine is regarded as the least efficient site of starch digestion because only VFA are absorbed, but the resulting microbial protein gets excreted in the feces together with undigested starch. Moreover, excessive flow of fermentable carbohydrates to the hindgut can lead to excessive fermentation in the hindgut which can result in hindgut acidosis (Gressley et al., 2011). Total tract digestibility of starch in dairy cows ranges therefore from 70 to 100%, with lower estimates mainly resulting from insufficient starch degradation in the rumen (Theurer et al., 1999; Firkins et al., 2001), as post rumen starch digestion does not completely compensate for ruminal starch escape (Ferraretto et al., 2013). Results have been in any case very diverse and linked to the specific starch source. Nowadays starch characterization does not allow us to have a more dynamic intestinal digestibility so a constant intestinal digestibility is assigned. Of the B1 pool escaping rumen fermentation, 80% is assumed to be intestinally digested. However, it basically seems that there is a logical correlation between quality and quantity of starch leaving the rumen, and the percentage of that starch that can be digested in the intestines.

There are also important physiological consequences on where, in the digestive system, starch is digested. Most studies agree that energy obtained from starch digested in the small intestine is not partitioned to milk, even though small intestine digestion is more energetically efficient than rumen fermentation. On the other hand, according to the hepatic oxidation theory (HOT) of Mike Allen and his collaborators, large amounts of starch digested in the rumen right after calving might contribute to the reduced intake of cows transitioning to higher milk productions. It is apparent then that scientists have a lot of work to decipher the "magical" rumen and the whole cow further. One single nutrient of a recipe like starch might have many consequences and these might vary across physiological stages.

Here at RUM&N we always strive to improve your experience with NDS and you can be sure that we are always in the lookout and will keep you posted of any important updates, as we have done for many years. Also, never forget that your feedbacks are always listened. You are in good hands!

NDS Step Feeding: Optimal Feeding Programs with AMS

By Ermanno Melli
RUM&N Staff

An optimal feeding programs with Automated Milking Systems (AMS) should be an integrated approach involving feeding and management designed to optimize forage utilization, milk production, robot efficiency and herd health. In order to define this optimal feeding program, a basic question should be asked: will increasing the amount of concentrate provided in the AMS improve milk yield/cow/day?

A recent study (S.B. Menajovsky et al. - J. Dairy Sci. 101:1–13, 2018), where diets were formulated based on NDS Professional, was conducted to evaluate the effects of the forage-to-concentrate ratio of the partial mixed ration (PMR) and the quantity of concentrate offered in an AMS, on the behavior and performance of dairy cows.

The results of this study confirm those obtained previously by other authors (Scott et al., 2014; Halachmi et al., 2005; Bach et al., 2007; Tremblay et al., 2016; Paddick et al., unpublished), that is:

- Increasing concentrate provision in the AMS will likely not improve milk yield or milk component yield
- Energy dense PMR may increase DMI without negatively affecting voluntary visits
- Low AMS concentrate provision strategies may allow for more flexibility for the type of feed used in the AMS
- Amount of concentrate targeted ≠ that consumed
- High AMS concentrate provision relies on frequent AMS visits, but increases variability in AMS concentrate intake

And the authors conclude: "….Our results indicate that the quantity of AMS concentrate offered reduces PMR intake with only marginal effects on milk and milk component yield, but feeding a greater amount of concentrate in the AMS increases day-to-day variability in AMS concentrate consumption, challenging the notion of precision feeding when simply increasing the amount of pellets offered in the AMS. In addition, providing a greater proportion of concentrate in the PMR may improve milk yield without increasing variability in PMR or AMS concentrate intake…"

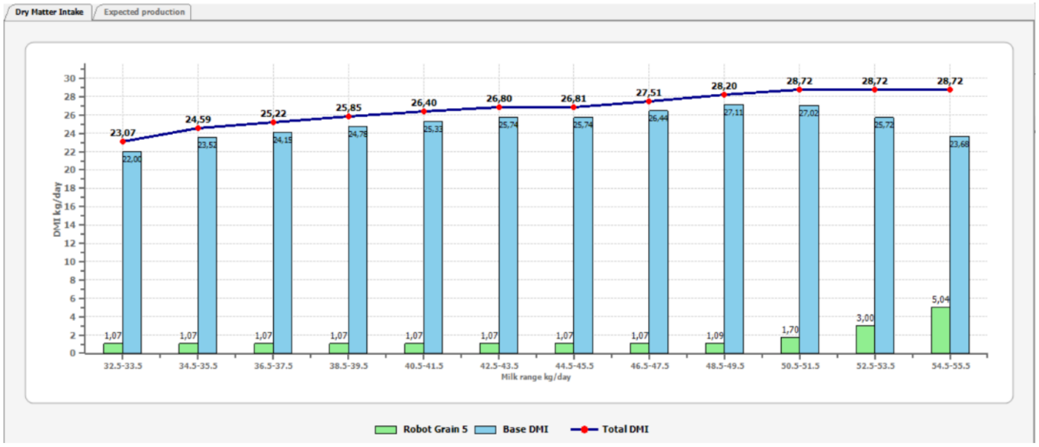
Based on these results and on several field observations, the development group at RUM&N, has implemented some enhancements in the NDS Step Feeding Tool functional to the definition of a suggested formulation strategy with NDS, which can be summarized as follows:

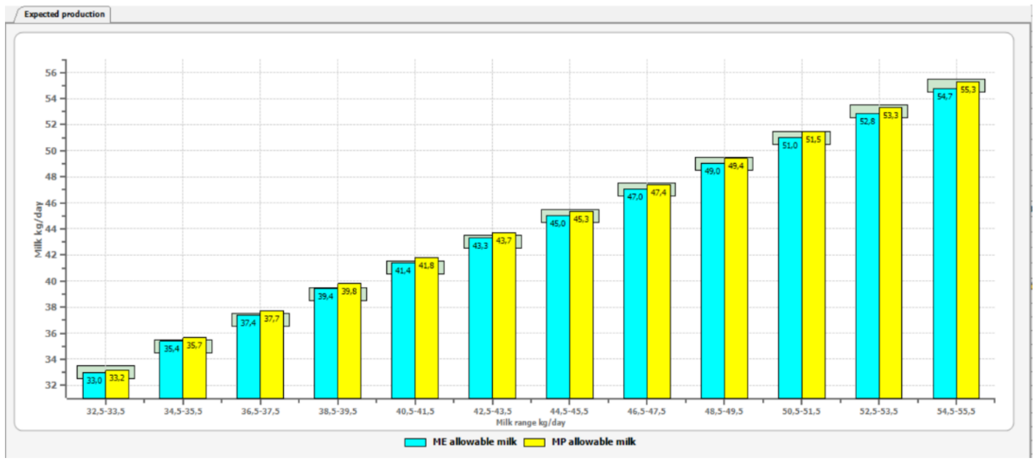
a. Formulate the PMR for the pen average milk yield that includes the minimum amount of the robot pellets able to guarantee the proper number of visit to the robot for the average producing cows.
    - This minimum amount should be around 1-1.2 kg (2-2.5 lbs) delivered through the robot and not included in the PMR.
    - In this way, for the average pen milk yield we should have both for ME and MP allowable milk:
        - PMR without AMS concentrate = 93-95 % of the Requirements
        - PMR with min AMS concentrate = 100 % of the Requirements

b. Set the maximum amount of the robot pellets based on the maximum number of visits observed for high producing cow, considering following constraints:
    - Maximum meal size of 1.50 kg/meal (3.3 lbs)
    - No carry-over

   If we consider that high producing cows at peak can have a milking frequency of 4 to 4.5 (number of visits to the robot), this maximum amount should be around 6.0 to 6.5 kg/day (13.2 to 14.8 lbs).

c. The above constraints should be set for all cows regardless milk yield and number of visits to the robot.





The suggested formulation strategy provides less concentrate in the AMS and should guarantees greater PMR intake, milk and milk component yields, and more stable ruminal fermentation and health.

Send us your comments on this topic! Dave Weber is at rumendvm@gmail.com; RUM&N Staff is at info@rumen.it

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 use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.__*

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