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Welcome to the NDS Dynamics newsletter!

Nutritional strategies to optimize growth and performance of calves and heifers

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Summary

- The pre-weaning period is a period of life in which the calf is undergoing significant developmental changes and this development is directly linked to its future productivity in first and subsequent lactations.
- Pre-weaning growth rate, and primarily protein accretion, seems to be a key factor in signaling/communicating with the tissues that enhance lifetime milk yield.
- Anything that detracts from feed intake and subsequent pre-weaning growth rate reduces the opportunity for enhanced milk yield as an adult.
- Nutrient supply, both energy, and protein are important, and protein quality and digestibility are essential.
- There are no substitutes for a liquid feed before weaning that will enhance the effect on long-term productivity.
- Factors other than immunoglobulins in colostrum modify feed intake, feed efficiency and growth of calves and can enhance the effect of early life nutrient status.
- As an industry and as nutritionists we need to talk about metabolizable energy and protein intake and status relative to maintenance and stop talking about cups, quarts, gallons, buckets, and bottles of dry matter, milk, milk replacer, etc. The calf has discrete nutrient requirements not related to dry matter and liquid volume measurements.
- The effect of nurture is many times greater than nature and the pre-weaning period is a phase of development in which the productivity of the calf can be modified to enhance the animal's genetic potential.
- Within the management system available, adhering to specific growth targets throughout the rearing period and calving as early as feasible is essential to ensure optimum economic returns during the first lactation.

Consideration for the overall development of the calf has become a reality with the refinement of nutrient requirement and supply data for pre-weaned calves and the realization that the long-term productivity of the calf is enhanced with increasing nutrient intake above maintenance nutrient requirements. The energy and protein requirements of the calf should be considered on the first day of post-natal life and a proactive growth objective should be established to ensure proper nutrition and management are in place. The current growth objective for a pre-weaned calf is to double the birthweight by approximately 60 days. Colostrum is important not only for immunoglobulins, but also to stimulate the development of the gastrointestinal tract and enhance the uptake and utilization of energy from the diet. Thus, adequate colostrum intake is important not only for the immune system but also to set the calf up for energy and protein utilization and this is part of the continuing process of the dam to reinforce anabolic behavior in the calf. Also, the nutrient content of colostrum should be recognized along with the immunoglobulins and other non-nutritive factors. Meeting and exceeding the maintenance requirement is the first step in ensuring adequate health and growth of the calf and adjusting the feeding and management to account for the effect of the environment is necessary to achieve the growth objectives. The nutrient requirements for growth have been refined and new data are available that describe the energy and protein requirements for dairy calves. These data clearly point to the need for greater intakes of milk or milk replacer to achieve greater growth before weaning and the nutrient profile needs to reflect the growth objective (e.g. greater protein intake for higher gain) and this will be discussed. The long-term productivity of calves has been strongly linked to pre-weaning nutrient intake and this has implications for the calf and the industry and provides opportunities and challenges for the nutritional and management strategies needed to ensure a proper transition to a functional and healthy ruminant.

To achieve optimum milk yield during the first lactation, there are benchmarks for growth post-weaning. Those benchmarks are a function of the desired age at first calving (AFC) and the mature size of the herd you are working with. These benchmarks have been described in the 2001 Dairy NRC but are difficult to implement because of the lack of existing data for BW and

ADG in most herds. As an industry, we simply don't weigh enough heifers or cattle on a regular basis to provide feedback to make good nutrition and management decisions. It is analogous to asking a nutritionist to increase milk yield, without any understanding of the current level of production and what factor might be first limiting. This lack of data puts the nutritionist and heifer manager in a situation in which they are attempting to make decisions in the absence of any real quantifiable data. The most important input in any diet formulation software is body weight and this also happens to be the most important information for managing heifer growth and AFC. It is important that if we are going to invest so much effort into the pre-weaned calf, that post-weaning, a similar amount of effort be applied to ensure that the benchmarks are met to achieve a BW at calving that allows the potential increase in milk yield to be realized.

Rumen Fill assessment in NDS

By K. Cotanch
NDS-North America

Short answer

The Rumen Fill tab allows for improved estimation of DMI based on NDF digestibility. Generally, as forage quality improves, NDFd increases and fiber ferments faster and is more quickly reduced in particle size and buoyancy, allowing faster passage out of the rumen. Through faster digestion and passage, more space in the rumen is available for another meal. As forage quality decreases, NDFd decreases, fiber stays in the rumen longer, a slower digestion and slower size reduction, taking up space for a longer time thereby limiting DMI.

Recent research indicates potential rumen fill maximums and minimums that should be considered to maintain sufficient gut fill and motility. In consideration with peNDF, rumen fill allows us to consider NDFd along with particle size when monitoring rumen healthy rations.

Rumen Fill and DMI, More than just NDF

For years, DMI estimates have been based on average NDF intake 1.10% of BW with a range of 0.9-1.4%. Forage NDF (fNDF) was then considered since most long, slower digesting fiber was from forage. The forage fiber particles being the primary stimulus of rumination, physical chewing resulting in saliva production to buffer rumen acids. We now understand that rumen acidosis and milk fat depression are largely affected by CLA fatty acids, which are not biohydrogenated, with conditions of rumen acidosis. The range of NDF as % BW does not account for varying "qualities" or digestibility and sources of NDF. As forage harvest techniques have improved, along with genetic improvements such as low lignin crop varieties, intake of NDF up towards 1.6-1.8% of BW have been observed. Even if NDF amount is a very secure reference value, NDF alone is not sufficient for estimating and adjusting for total DMI, especially when the contribution of non-forage fiber sources, such as beet and citrus pulp, soy hulls, wheat-midds, almond hulls and a variety of other human food industry waste products, becomes relevant.

Focusing on forage fiber, improved characterization of NDF digestibility with the 30, 120, 240, and more recently 12 h time points, allows us to more accurately predict how fast fiber will digest and the pool size of undigested fiber that will remain in the rumen at any given time. This undigested fiber (uNDF) takes up space and both the rate at which NDF ferments (kd) and the rate at which it is physically reduced in size (kr) determine how long it will stay in the rumen taking up space.

Research conducted at WH Miner Institute involving rumen evacuations produced data regarding potential rumen fill limits on DMI and milk production. Rumen fill data was obtained by emptying the rumen digesta on 2 separate days, one 2 h before feeding and another 2 h after feeding to average rumen max and minimum fill level. The digesta were analyzed separately for chemical composition, including NDF and uNDFom 240 (indigestible NDF). Over 2 different studies involving 8 different diets of high and low NDFd and non-forage fiber sources it was found that the ratio of uNDF240 in the rumen/uNDF240 consumed was consistently 1.63 for 7 of the 8 rations. Furthermore, as a % of BW, uNDF240 ranged between 0.30-0.40 and at 0.40% of BW, cows DMI was significantly less with resulting decreased milk production. In other words, cows were trying to eat to meet their energy demands but rumens were full, and they could not consume more than 0.40% of BW of uNDF. Diets were predominantly corn silage or grass species-based. A similar trial was conducted in Italy using various qualities and grind sizes of alfalfa hays and the upper limits in that case corresponded to uNDF intakes of 0.45% of BW.NDF is composed of potentially digestible fiber (pdNDF) and indigestible fiber (uNDF240 or uNDF). Not all potentially digestible NDF is digested, much ends up in feces. How much pdNDF is digested in the rumen depends on several factors (NDFd, DMI, DIM, lactating or non-lactating, other ration ingredients and possibly most importantly, Cow Comfort).

How to interpret and use the Rumen Fill Table

This table allows comparison of an initial recipe to the current (or proposed) recipe and calculates the differences between the 2 as well as a new expected DMI and resulting change in milk for each of the uNDF parameters listed.

In Figure 1 below are the NDFd profiles of a barley and alfalfa silage, respectively. To note is that the barley is highly digestible with a very low uNDF240, i.e. very little indigestible fiber. The alfalfa has instead a very large pool of uNDF240. As stated above, the more uNDF in the ration, the longer it stays in the rumen requiring digestion or particle size reduction, taking up space and possibly limiting DMI. Substituting 12 lbs. DM of barley silage with the same amount of alfalfa has large effects on predicted DMI.

Barley and alfalfa silages NDF digestion profiles. Barley silage (Figure 1) has a large and fast, fast pool of NDF indicated by the red line, a small slowly digested NDF pool, noted in blue, and a very small uNDF pool. For barley, approximately 22% of NDF remains undigested at 120h, indicated by the light brown area. Highly digestible NDF compared to the alfalfa silage digestion profile just below. The alfalfa profile (Figure 2) shows a small fast NDF pool indicated by the short red line, similar slow NDF pool to the barley and a very large uNDF pool, approximately 58% of the NDF. The slow and indigestible NDF pools take up space in the rumen as the only way of exiting is through slow digestion or particle size reduction and passage of the indigestible uNDF fraction. For visual reference, the outline of a cow has been drawn around the graph to indicate the rumen fill effect of uNDF.

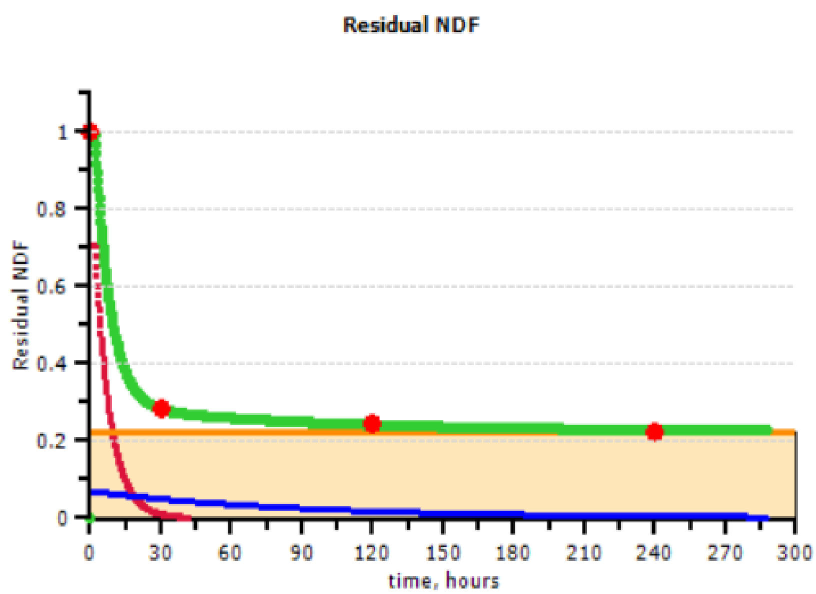

Fig. 1: Barley Silage
NDF digestion curve. NDF remaining at given time point

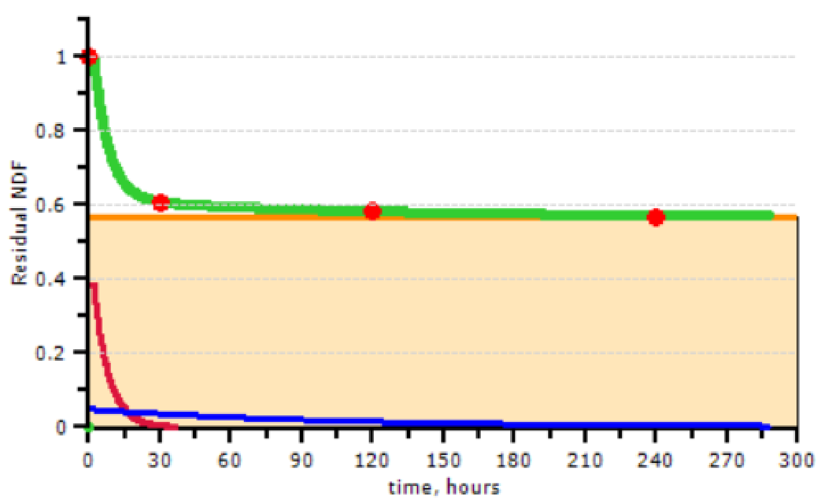

Figure 2: Alfalfa Silage
NDF digestion curve. NDF remaining at given time point

Below are the results of replacing 12 lbs DM (5.45 kg) of the barley silage with 12 lbs DM (5.45 kg) of the alfalfa silage. The initial recipe, with the barley silage, 15.55 lbs of NDF ingested (7.06 kg), 4.587 lbs of uNDF (u240) (2.08 kg), 7.157 lbs of uNDF in the rumen (3.25 kg) (accounting for uNDF from previous days DMI waiting to clear the rumen), the ratio of uNDF in the rumen to intake, the peuNDF (physically effective uNDF consumed) and the uNDF30 consumed.
By assuming a constant DMI, NDF consumed on the alfalfa silage diet would drop to 13.62 lbs (6.34 kg) (from 15.55 lbs – 7.06 kg), suggesting cows could increase DMI by 1.01 lbs (0.46 kg) and gain 2.14 lbs of milk (0.97 kg). However, looking at uNDF intake (highlighted in yellow) and uNDF in the rumen, rumen fill is nearly maximized and possibly exceeded, resulting in an estimated decrease in DMI of 1.69 lbs (0.76 kg) or 1.19lbs (0.54 kg) (if considering rumen uNDF) and associated loss of milk. Not shown here are the peNDF values of the rations of 17% with the alfalfa and 20% with the barley silage. Both values would indicate sufficient effective fiber to maintain rumen health. Though not indicating possible limiting effects on Rumen Fill and DMI.

Intake | Check DMI | Forages/Concentrates | Rumen fill | Other items

	Initial recipe			Current recipe			DMI lb/day		Milk Production lb	
	lb/day	%DM	%BW	lb/day	%DM	%BW	Δ	Expected	Δ	Expected
DMI	54.385			54.385						
NDF Intake	15.550	28.59	1.04	13.618	25.04	0.91	+1.01	55.40	+2.14	94.93
uNDF Intake	4.587	8.43	0.31	5.332	9.80	0.36	-1.69	52.69	-3.58	89.20
uNDF Rumen	7.157		0.48	8.217		0.55	-1.19	53.19	-2.52	90.26
uNDF Ratio Rumen/Intak	1.56			1.54						
peuNDF Intake	3.300	6.07		3.472	6.38		-0.84	53.54	-1.78	91.01
uNDF30 Intake	4.252	7.82	0.28	4.832	8.88	0.32	-6.52	47.87	-14.26	78.53

We have differing indicators in this instance and on-farm observations are needed. The value of the Rumen Fill table is to provide estimations of DMI and gut fill using NDFd. Simply tracking NDF and peNDF is helpful, yet incomplete.

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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