September 2021
Volume 9 Issue 5

NDS Dynamics

Welcome to the NDS Dynamics newsletter!

Dear readers,

The RUM&N team has just attended the NASEM (National Academies of Sciences, Engineering, and Medicine; previously known as NRC)- "Nutrient Requirements of Dairy Cattle conference" during which updates about dairy cattle nutrient requirements have been presented. Therefore, for the column "NDS updates", Dr. Emiliano Raffrenato (R&D at RUM&N) will give you a quick overview of the major advancements presented at the conference. Following, Dr. Mike Van Amburgh (Cornell University, Ithaca, NY) describes differences in first lactation milk yield by integrating concepts of pre-pubertal mammary development and rates of body growth.

Please continue to follow us on our channels to receive updates on what is new and what is happening at RUM&N and NDS North America.

The Editor
Ermanno Melli

NDS UPDATES

Revised Nutrient requirements for Dairy Cattle

*By E. Raffrenato**
**R&D RUM&N*

Many of you know that the long-awaited revised Nutrient Requirements of Dairy Cattle was finally introduced a few weeks ago, after 20 years from its previous edition (Dairy NRC, 2001). From August 30 to September 2, dairy cattle experts gathered, both in person and virtually, at the 40th ADSA Discover Conference, to learn about the updated requirements. Professors Erdman and Weiss headed up the committee for the eighth revised edition of the Nutrient Requirements of Dairy Cattle. All the work behind was overseen by the National Academies of Sciences, Engineering, and Medicine, hence the new name "NASEM 2021".
Even if the revised edition will be officially released in December 2021, we, at RUM&N, virtually attended the conference to learn about the latest advancements. The original publication dates back to 1945 when the dairy section consisted of just 21 pages. The eighth revision will cover all aspects of dairy cattle feeding, in more than 300 pages and 21 chapters and will include downloadable software, as in the previous edition.

Most of the topics exposed started from the NRC 2001 framework, attempting to improve it. Among the updates, the following are some that we believe are important to underline. It is important to emphasize that the main reference for the revision was indeed the previous 2001 edition, so all the comparisons were done to the NRC 2001 estimations but with more recently available data.
Professor Erdman emphasized how in the previous editions the term "nutrient requirement" was not defined. The nutrient requirement was now defined as the daily amount of a nutrient necessary to meet a healthy animal's needs for maintenance, activity, growth, reproduction, and lactation without any change in body reserves or status. This implies that the requirement for each nutrient is based on physiological factors and environmental conditions.
New intake predictions were introduced by professor Mike Allen and those are now available in NDS Professional as well. The predictions include either only animal factors or

both animal and diet factors. The term "adequate intake" was also introduced, which is used when only "limited experimental data" are available to define an "actual requirement".

Of all the topics that we listened to, the followings are the ones we believe are the most important ones: energy requirements for maintenance, the metabolizable protein supply, and the calf model. Energy requirements for maintenance were increased by about 20%. Smaller refinements were made to energy needs for pregnancy, growth, and lactation. Digestibility coefficients for feeds and common fat supplements were recalculated based on newer data. The component NFC made popular by the NRC 2001, was now partitioned into starch and residual organic matter (ROM).

Estimation of amino acids and metabolizable protein supply and requirements presented innovative aspects and had the largest update. The new recommendations are now calculated for all EAA, using a factorial approach, and emphasizing the component of protein secretions and accretions, EAA composition of each protein, and efficiency of use of these EAA to cover secretions and accretions. Professor Firkins also shared the limitations of the in-situ approach, previously used by the NRC 2001 when characterizing feeds for protein. However, in NASEM 2021 protein sources will still use the kinetic approach. Relative to protein, milk protein prediction is now computed using 5 EAA and non-protein digestible energy.

The nutrient requirements for calves were completely overhauled with equations for metabolizable protein, metabolizable energy, and minerals all derived from newer data. Maintenance requirements were adjusted for environmental temperatures outside the thermoneutral zone for the calf. With much larger databases now available, more accurate estimates for energy and protein for growth could be derived by the committee.

Relative to carbohydrates, even if recommendations are presented for minimum forage NDF, minimum total NDF, peNDF, and maximum starch, the new concept of physically adjusted NDF (paNDF) was introduced. This latter system aims at using diet characteristic inputs, animal body weight, and the percentages of diet dry matter retained on the screens of the Penn State Particle Separator to determine the proportion of the total mixed ration dry matter that needs to be retained on the 8 mm sieve to achieve dietary targets for physical form relative to the rest of the diet.

For minerals, a factorial system for expressing macro-mineral requirements on an absorbed basis was used except for dietary S. Absorption coefficients diets were introduced and based on either feed ingredients (Ca, P, Mg) or diet basis (Na, K, Cl). For the first time, absorption coefficients for some minerals (Mg, P, Cu) can be adjusted based on user inputs rather than using ingredient-specific constants. Maintenance requirements for most macro-minerals were primarily based on dry matter intake rather than a body weight basis reflecting the fact that metabolic fecal excretion is the major component of maintenance requirements. This resulted in significant increases in the overall maintenance requirement for Na and Cl. Adequate intakes for vitamin D and vitamin A both were adjusted.

As in NRC (2001), the NASEM (2021) will include a detailed literature review on metabolic disorders that commonly occur during parturition. A discussion on recommendations to reduce the prevalence of those disorders is also included.

Our job at RUM&N in the months following the publication will be to carefully monitor the applied use in the field of the new NASEM 2021, which is the ultimate objective of the model and where the true validation will come from.

Integrating concepts of pre-pubertal mammary development and rates of body growth to describe differences in first lactation milk yield

By M.E. Van Amburgh[1], F. Soberon[1], M.J.Meyer[1] and R.A. Molano[1]

[1]Department of Animal Science, Cornell University

[2]Nutreco USA, 115 Executive Drive, Highland, IL 62249

The growth of dairy replacement animals has several objectives: low cost and a low number of days of non-productive life, adequate body size, appropriate body composition, and capacity for optimum milk yield over their lifetimes associated with a long productive life. The actual growth objectives are a function of several factors such as mature body weight (MBW), the body weight (BW) at calving, and calving age that optimizes raising cost and nutrients partitioned to growth during lactation, thus allowing for optimum milk yield and a prospective decision concerning the age at first calving (Hoffman, 1996; Fox et al., 1999).

The integration of those factors provides the target growth rate necessary to meet the BW goal for the first parturition within the stated amount of time and this then determines the nutrient supply required daily to meet the objectives.

The goals for raising replacement heifers go beyond achieving a specific weight gain. Given that they are future dairy cows, the final goal of heifer rearing should be to optimize their future milk production potential. Body composition is directly related to growth rate, diet composition, and stage of maturity at the time the growth occurred. With this in mind, it is vital to remember the effects of body condition or body composition at calving on milk yield. The effect of greater body condition on the performance of dairy cattle was reported as a linear decrease in milk yield (Garnsworthy and Topps, 1982). More contemporary data has refined this observation and associated it with reduced dry matter intake and further, this is the focus of much research into transition cow metabolism, insulin resistance, and the interaction between obesity and milk yield (Ingvartsen and Andersen, 2000; Douglas et al. 2006; Allen et al., 2009; Overton, 2011). Thus, when evaluating the data integrating pre-pubertal growth rates, mammary development and milk yield, the composition of growth, and therefore the final body composition of the heifer at calving are essential when comparing studies related to milk production.

Traditionally, body composition has been overlooked when analyzing the effects of pre-pubertal growth rates on first lactation performance. However, just as body composition and obesity influence the performance of mature dairy cattle, those factors are also a crucial determinant of first lactation heifer performance. The work by Sejrsen et al. (1982; 1983) describing the effect of high energy intake on mammary development and the relationship with circulating growth hormone linked the relationship between pre-pubertal growth, mammary development, and future milk yield. The primary outcome of this work was to provide an intuitive mechanism to explain why rapid growth during the pre-pubertal phase resulted in reduced milk production in the first lactation. The observation of reduced mammary development could be repeated in almost every experiment (Pritchard et al., 1972; Petitclerc et al., 1984; Mäntysaari et al., 1995; Capuco et al., 1995; Meyer et al., 2006ab). These repeatable observations lead to the conclusion that high energy intakes reduced mammary development through altered hormone status or signaling processes. However, Meyer et al. (2006ab) were the first to recognize that mammary development was not reduced by high energy intake, and instead was the time to reach puberty and the associated signals to change allometric mammary growth that were altered. The mammary gland, like all other reproductive organs, grows in proportion to the size of the body and not in proportion to nutrient intake during the post-weaning, pre-pubertal phase. In the studies by Radcliff et al. (1997; 2000), bST was administered from 125 to 336 kg (276 to 740 lbs) of body weight to enhance pre- pubertal mammary development. In the tissue harvest study, mammary development was enhanced approximately 48% by the use of growth hormone (Radcliff et al. 1997). Milk yield from the heifers treated pre- pubertally with growth hormone did increase by approximately 5.9%, but that was not significant and not highly correlated with the increase in mammary parenchyma development (Radcliff et al. 2000). Thus, mammary development, measured as DNA content of the parenchyma at puberty, varied by about 100% (+48 to -60%) with no significant difference in milk yield. This strongly suggests that mammary development when measured as DNA content at puberty is not a good indicator of future milk yield. This is not to dismiss the concept that mammary development is important, but rather to provide the opportunity to consider specific cell types instead of gross measurements using DNA as a proxy for cell number (Sinha and Tucker, 1969; Ballagh et al., 2008).

One aspect that is harder to quantify is the difference in body composition among heifers at calving in studies investigating the effect of age at first calving on milk yield. Again, for example, Swanson (1960) compared the milk yield of fat versus moderately conditioned heifers and observed that the fatter heifers did not perform as well. Based on data describing the productivity of dairy cattle calving at higher than desired body condition scores, dry matter intake, milk yield and post-partum health are usually at greater risk of being compromised (Grummer et al. 2004; Allen et al 2005; Douglas et al., 2006; Ospina et al. 2010). Thus, body composition at calving as it relates to energy balance is as important for first lactation cattle as multiparous cattle. Further, any difference in body composition of heifers at puberty or pregnancy will most likely be maintained or enhanced since under most conditions the animals remain in a positive energy balance from puberty to calving. Thus, experiments evaluating rapid growth prior to puberty are potentially measuring the long-term effect of altered body composition at calving. One of the most crucial and overlooked variables in the effects of growth rate on future performance is mature size. As previously mentioned, the composition of the gain is dependent on the stage of maturity, therefore, when evaluating growth rates pre-puberty, it is important to characterize the growth rates within the stage of physiological maturity. This concept was described for dairy cattle by Fox et al. (1999), where they described the percent of mature BW at pregnancy (55%) and post-calving BW (minimum 82%) necessary to optimize first lactation milk yield. The key factor in this approach is utilizing the mature BW of the herd to adjust for the stage of maturity for nutrient requirements instead of using a population value. In all of the studies conducted on heifers prior to the publication of the Dairy NRC (NRC, 2001), no consideration was given to the mature size of the cattle, thus most data were not adjusted for stage of growth and under those conditions, energy intake is almost always greater than required for dairy replacements (Van Amburgh and Meyer, 2005).

The overall goal of heifer rearing is to provide the management and nutrition that allows for optimum milk yield in the first and subsequent lactations. Research has evaluated many aspects of heifer rearing. However, most of the focus has been on pre-pubertal growth rate and its effects on mammary development. Little to no attention has been placed on the effects of such growth rates on body composition at calving. Transition cow research has unequivocally shown the negative effects of over-conditioned cattle at the time of calving on DMI, metabolic problems, and milk yield. These findings also apply to first lactation heifers. When accounting for predicted body composition at calving, we are able to explain most of the variation in milk production observed in different studies. Body composition explains both the lack of differences in production observed in some studies (Valentine et al., 1987; Waldo et al., 1998) as well as the differences in milk production observed in others (Swanson, 1978; Foldager and Sejrsen, 1987; Hohenboken et al., 1995). Thus, in many studies evaluating mammary development and milk yield, directly or indirectly, the outcome was most likely better predicted by body composition at calving and not mammary development.

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 are not components of the underlying CNCPS model. None of the original CNCPS structures or equations have been changed in the NDS platform. NDS does provide sub-models and utilities to provide enhanced predictions based on the original CNCPS model. *Questions about the use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.*