March 2019
Volume 7 Issue 2

NDS Dynamics

Transition cows: NEFA or ketone bodies?

By Giulia Esposito, DVM, PhD
Department of Animal Sciences, Faculty of AgriSciences - Stellenbosch University - South Africa

Herd profitability is determined by constant cycles of milk production and reproduction. Thus, the transition from pregnancy to lactation must progress unperturbed. The main challenge during this phase is the sudden increase in nutrient demand for milk production at a time when dry matter intake (DMI) lags behind. A certain degree of negative energy balance (NEB) is then inevitable and considered physiological (Dänicke et al.,2018; Turner et al., 2016; Ingvarsten et al., 2003). During NEB, gluconeogenesis is enhanced and a large portion of non-esterified fatty acids (NEFA) is released into the blood stream and converted into ketone bodies in the liver hepatocyte as a different form of energy (Gordon et al.,2013). Only when the liver is overloaded with NEFA, their partial oxidation by the liver increases, thus causing accumulation of β-hydroxybutyrate (BHB) and other ketone bodies (Herdt et al., 2000). The major consequence of this excessive lipid mobilization is clinical ketosis characterized by exacerbated reduction of intake, loss of body weight, altered rumen motility and, eventually, drop in milk production. Although, especially in large herd size, the average herd prevalence of clinical ketosis is 1.6% (Berg and Vertenten 2014), the signs of subclinical ketosis (diagnosed only through milk or blood tests) are often subtle and missed by farmers. In fact, the prevalence of subclinical ketosis can be as high as 50% (Berg and Vertenten 2014) resulting in increased incidence of periparturient diseases such as metritis, endometritis and retained fetal membranes, displaced abomasum and poor reproductive performance.

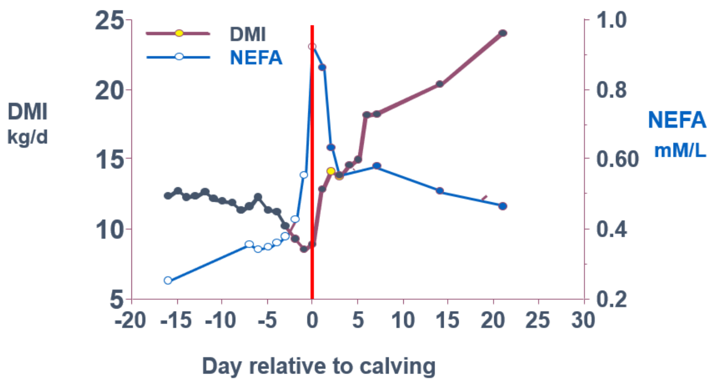
Therefore, investigation of changes in blood concentration of NEFA and BHB during the transition period has been of interest for many researchers due to their potential to be used as indicators of risk factor for several diseases. It has been reported (Roche et al., 2015; Carter et al., 2008), in fact, that their concentration during the early post-partum period is associated with intake, BCS at calving and losses in BCS after calving. For example, high BCS at calving or a rapid loss in BCS after calving, or both, have been associated with poor cow health, and high postpartum circulating NEFA and BHB concentrations (Pires et al.,2013; Adrien et al.,2012). The high relation between these metabolites and the increased risk of diseases seems to be explained by a strong correlation between elevated NEFA and BHB levels and immunosuppression (Hammon et al., 2008; Scalia et al., 2006).

According to recent studies (Ospina et al.,2010; Herdt et al., 2000), in the early post-partum, NEFA concentration above 0.6 mmol/L is indicative of risk for subclinical ketosis, whereas NEFA level above 1.0 mmol/L is indicative of risk for clinical ketosis. Even though we have these suggested NEFA thresholds, the development of ketosis (clinical or subclinical) is not entirely due to the NEB itself, but mainly to inadequate metabolic adaptation to it, resulting in an increased production of BHB. So, to be exact, blood NEFA levels are not indicator of risk of ketosis, but of the degree of lipid mobilization the animal is going through. Thus, although blood NEFA levels can give us a very good indication of possible risk of ketosis, being directly correlated to blood levels of BHB, we have to keep in mind the individual variability.

The prediction of blood concentrations of NEFA based on diet characteristics is quite complex task and still not well established.
However, it is well established that decreased DM intake (Grummer, 1993) and high glucose requirements of the fetus and mammary gland (Bell, 1995) often result in hypoglycemia and lipolysis in the periparturient dairy cow.

Dry Matter Intake and Plasma NEFA

Grummer, 1993



Based on the recognized high correlation between DMI and NEFA concentration, NDS provide an opportunity to estimate the expected blood NEFA (Vallimont et al 2001; Grummer et al., 1993)during the Close-up:

[Na + K] - [Cl + S]	-10,5	Urine pH		7,0
[Na + K + 0.15Ca + 0.15Mg] - [Cl + 0.6S + 0.5P]	-7,2	Hypocalcemia	%	0,8
[Na + K] - [Cl + 0.6S]	-0,1	Plasma Ca	mg/dl	9,0
		Plasma Ca	mmol/l	2,2
		NEFA	mEq/l	0,36

as well as during the post-partum:

[Na + K] - [Cl + S]	+26,6	NEFA	mEq/l	0,56
[Na + K + 0.15Ca + 0.15Mg] - [Cl + 0.6S + 0.5P]	+21,8			
[Na + K] - [Cl + 0.6S]	+32,4			

The objective of the functionality is not to provide a diagnostic tool for estimating the “exact” level of blood NEFA, but to indicate the correct directionality towards a possible alarm situations in specific feeding conditions, such as to make possible corrections in order to minimize negative effects.

Although this estimated value can certainly give the user a good indication of possible periparturient diseases, it is important to remember that the model does not take into account BCS at calving, a value that, from more recent research (Reist et al., 2003), has been considered to play an important role in controlling lipid mobilization. In fact, regardless of the cows’ intake, animals with high BCS at calving have a more intensive mobilization of NEFA from adipose tissue compared to thinner cows (Reist et al., 2003). Thus, especially when formulating diets with estimated NEFA levels close to the threshold of risk for diseases, it is highly suggested to verify what the diet is actually doing on the animals.So which test should we use? In the recent past, a very common tool to identify cows with subclinical ketosis was to look at the milk fat percentage and the fat to protein ratio. In fact, as observed by Jenkins and collaborators (2015), fat to protein ratio has been positively correlated with degree of NEB, therefore it has been proposed as a diagnostic tool for subclinical ketosis in dairy cattle. However, this tool can only identify cows that are already experiencing the disease, but it doesn’t help preventing it. Therefore, blood NEFA level has been considered a better indicator for risk of cows incurring in diseases based on the degree of lipid mobilization. However, it is not a rapid test and blood handling and storage can easily alter the values (Morris et al., 2002). Thus, more recently, testing blood ketone bodies using ketones strips, has proved to be a much more rapid and accurate diagnostic method compared to the measurement of blood NEFA levels (Oetzel, 2007). When considering BHB blood concentration, levels above 1.0 mmol/L are considered to be indicators of risk of subclinical ketosis, and above 1.2 mmol/L are considered to be indicators of risk of subclinical ketosis (Zhang et al., 2016). Both NEFA and BHB levels start rising from 48 hours after parturition, therefore early testing of fresh cows will be the ideal strategy to limit the incidence of periparturient diseases.

So, what is NDS aiming at? The next objective is to develop a more accurate model to predict NEFA and, eventually, BHB, by including also BCS at calving and degree of loss of body condition soon after parturition. Stay tuned!

NDS Calf Model

NDS Calf Model has been recently updated. The changes made consist mainly in new estimates focused on a more accurate evaluation of the energy content of calf starter. Based on this new approach, energy content of calf starter it is not constant but increases with increasing NFC intake supplied by dry feeds.
It is well established that intake of calf starter is critical to ensure adequate rumen development and growth during the first few months of life.
Even though prediction of starter intake on an individual farm will probably differ from another, due to many factors that can influence calf starter intake, this prediction can give us an indication of the potential for intake of dry feeds in calves. Given that the fermentation of carbohydrates early in life initiates rumen development, the intake of starter accelerates the time at which calves are prepared for weaning.
However, based on recent research (Quigley et. al., 2019), equations to calculate dietary energy in current models of nutrient requirements for calves (NRC, 2001) do not reflect changing digestibility in young calves and, therefore, may overestimate the contribution of calf starter and other dry feeds to total nutrient supply in the first months of life. As these observations are in agreement with clear field evidence, we decided to partially modify the Calf Growth Model, specifically in the section concerning the nutritional evaluations of the dry feed associated with milk replacers.
The approach proposed by Quigley et. al., 2019 was then followed. It suggests that cumulative exposure to fermentable carbohydrate may be an important criterion for determining maturation of the gastrointestinal tract in general and the rumen in particular and is consistent with current theories regarding the importance of fermentable carbohydrate to initiate rumen development (Baldwin et al., 2004; Khan et al., 2016).
While nothing has changed for milk replacer evaluation, the changes made consist mainly in new estimates focused on a more accurate evaluation of the energy content of calf starter. Based on this new approach, energy content of calf starter it is not constant but increases with increasing NFC intake supplied by dry feeds.

Calf Feeding Program

Early weaning requires that a specific feeding program be adopted in order to get a rapid development of the young animals, minimizing health problems. The Feeding Program tab within NDS Calf Model is designed to provide a feeding plan, consistent with the goals above, from birth to weaning.

Meals 2 | Weaning (days) 56 | Milk replacer Solid contents % 13,0 | Milk supply plan: (•) Flat ( ) Weekly | Report

Period (days)	Milk replacer			Starter kg		Expected gain kg/day		Costs €	
	Powder (kg)	Water (L)	Milk (L)	DM	As Fed	ME	ADP	per head	per kg ADG
4 - 7	0,92	6,2	7,1 (3,5)			0,732	0,632	1,471	2,009
8 - 14	0,92	6,2	7,1 (3,5)	0,100	0,112	0,732	0,612	1,471	2,010
15 - 21	0,92	6,2	7,1 (3,5)	0,242	0,272	0,732	0,622	1,471	2,009
22 - 28	0,92	6,2	7,1 (3,5)	0,411	0,461	0,732	0,646	1,471	2,009
29 - 35	0,92	6,2	7,1 (3,5)	0,604	0,678	0,732	0,678	1,471	2,010
36 - 42	0,92	6,2	7,1 (3,5)	0,823	0,924	0,731	0,716	1,471	2,013
43 - 49	0,92	6,2	7,1 (3,5)	1,067	1,198	0,733	0,761	1,471	2,008
50 - 56	0,92	6,2	7,1 (3,5)	1,337	1,501	0,731	0,849	1,471	2,014

Based on current animal inputs, feeds included in the diet and some additional inputs, the feature propose a weekly plan for feed delivering from post-colostrum time to the weaning.

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.*

E-mail: ndsrumen@gmail.com
rumendvm@gmail.com
Phone: (316) 841-3270

RUM&N Sas
Via Sant'Ambrogio, 4/A
42123 Reggio Emilia - ITALY