New Trends in Transition Cow Management: Separating Facts from Fiction

Ric R. Grummer, Ph.D.
Professor Emeritus
University of Wisconsin-Madison
Email: rgrummer@wisc.edu

INTRODUCTION

Management of transition cows (generally regarded as cows between 3 wk prior to calving and 3 wk postcalving) continues to be intensely studied. A review of the literature for the past 2 y indicates the following areas being actively researched:

- Factors affecting immune function and oxidative stress,
- Interrelationships between environment and animal behavior or welfare,
- The effects of subclinical hypocalcemia on animal performance and effects of oral calcium supplements on blood calcium,
- Nutritional effects on gene expression in a variety of tissues,
- Benefits of cooling dry cows,
- Implications of reducing dry period length,
- The effects of hyperketonemia on animal performance, and
- Electronic monitoring (e.g., rumination time) for predicting animal health and well-being.

The quantity of research is overwhelming and beyond the scope of this presentation as well as beyond my area of expertise. Therefore, for this presentation I will discuss some of the recent trends in managing energy status of transition cows that are fast becoming dogma and provide some cautionary notes for you to think about. Hence the title includes the wordage *fact or fiction*.

CONTROLLING DRY PERIOD ENERGY STATUS

Numerous studies have indicated that there is no need to *steam up* cows being fed a totally mixed ration, i.e., feed a separate pre-fresh diet for the final few weeks before calving that has increased grain content (Grummer, 2008). If that is the case, then a dairy producer should be able to feed a diet with a consistent energy density for the entire dry period. Doing so would save money as feed costs would be lower and there would be less labor required for mixing diets if only 1 dry cow diet (rather than 2) needed to be mixed.

Many studies (e.g., Janovick and Drakley, 2010; Silva-del-Rio et al., 2010; Mann et al., 2015; Zenobi et al., 2018) have compared the feeding of a controlled energy diet (**CED**; also known as the Goldilocks diet) versus overfeeding for the dry period. The concept behind the CED is to formulate a diet, that when consumed *ad libitum*, would meet but not exceed the cow's energy requirement. These diets are high in fiber, low in nonstructural carbohydrate, and contain considerable amounts of low quality forage, often wheat or oat straw. Most of the studies have compared feeding the CED to one that provides 40 to 50 % more than the cow's requirement. That may seem high, but often in experiments treatments are exaggerated to increase the likelihood of seeing treatment differences. However, historically, dairy producers commonly have over fed energy to dry cows because of forages being higher quality than necessary.

In theory, cows fed above their maintenance energy requirement during the entire dry period become similar to human type II diabetics; they become more insulin resistant. Since insulin suppresses fat mobilization, a more insulin resistant cow will have higher rates of fat mobilization. Consequently, the cow becomes more susceptible to fatty liver, ketosis, and other health problems. When conducting research to evaluate CED, there have been 2 ways to achieve the controlled energy intake treatment. In a few studies, the approach has been to limit feed a diet relatively rich in energy that would normally lead to body weight gain if consumed *ad libitum*. While feasible with cows fed in stanchion barns, it is not practical for cows housed in groups. Most studies have included low energy feeds, such as straw, so that energy requirements are met when cows consume the diet *ad libitum*.

The effects of overfeeding cows on blood nonesterified fatty acids (**NEFA**, an indicator of fat mobilization), beta-hydroxybutyrate (**BHBA**, a ketone body), and liver fat are very consistent across trials (Dann et al., 2005, 2006; Douglas et al., 2006; Grum et al., 1996; Janovick and Drackley, 2010; Janovick et al., 2011; Richards, 2011; Mann et al., 2015; Zenobi et

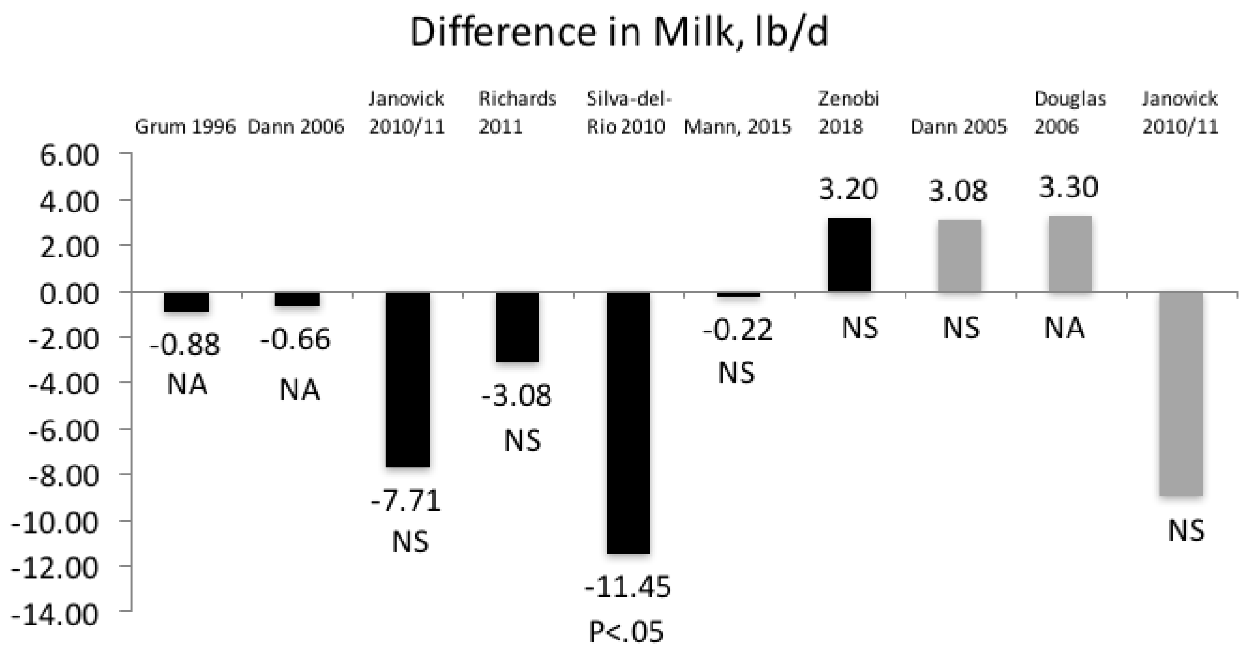

Figure 1. Differences in milk yield between dry cows fed a controlled energy diet (80 - 100 % of energy requirements) vs. a diet that provides in excess of requirements (typically 140 – 150 % of requirements). Black bars represent trials in which energy intake was controlled by feeding a high fiber (straw) diet; grey bars represent trials in which energy intake was controlled by limiting feed intake (cows receiving the high energy treatment and controlled energy treatment were the same diet but fed at different amounts. NA = there were other treatments in the experiment and the statistical analysis did not allow a direct contrast between these 2 treatments), NS = a statistical contrast between controlled energy and excess energy intake was available, but differences between treatment were not significant.

al., 2018); consequently, there is no controversy on these effects and, therefore, they will not be discussed here. Higher NEFA, BHBA and liver fat in cows that are overfed energy are consistent with the hypothesis that these cows are diabetic-like. Typically, there may be a transient increase in feed intake postcalving when feeding CED compared to higher energy diets, but it is only for a few days and may be related to CED treated cows relishing a diet that finally has more grain! One other benefit of feeding CED may be lower incidence of displaced abomasum (Cordoso, 2013). Unquestionably, these trials indicate that cows fed a CED have an improved *metabolic profile* and consequently there has been wide spread adoption of this feeding practice.

However, what I consider to be controversial is the milk production response of cows that are fed CED. Figures 1, 2, and 3 contain a summary of milk yield, fat %, and fat- or energy-corrected milk yield. Some of the trials have observed reductions in milk yield, although this has not been a consistent response. Much more consistent is the reduction in milk fat percentage and fat- or energy-corrected milk yield.

The reduction in milk fat percent, and potentially milk yield, makes biological sense. If cows fed CED precalving are mobilizing less body fat postcalving, compared to those overfed energy during the dry period, then there is less NEFA available

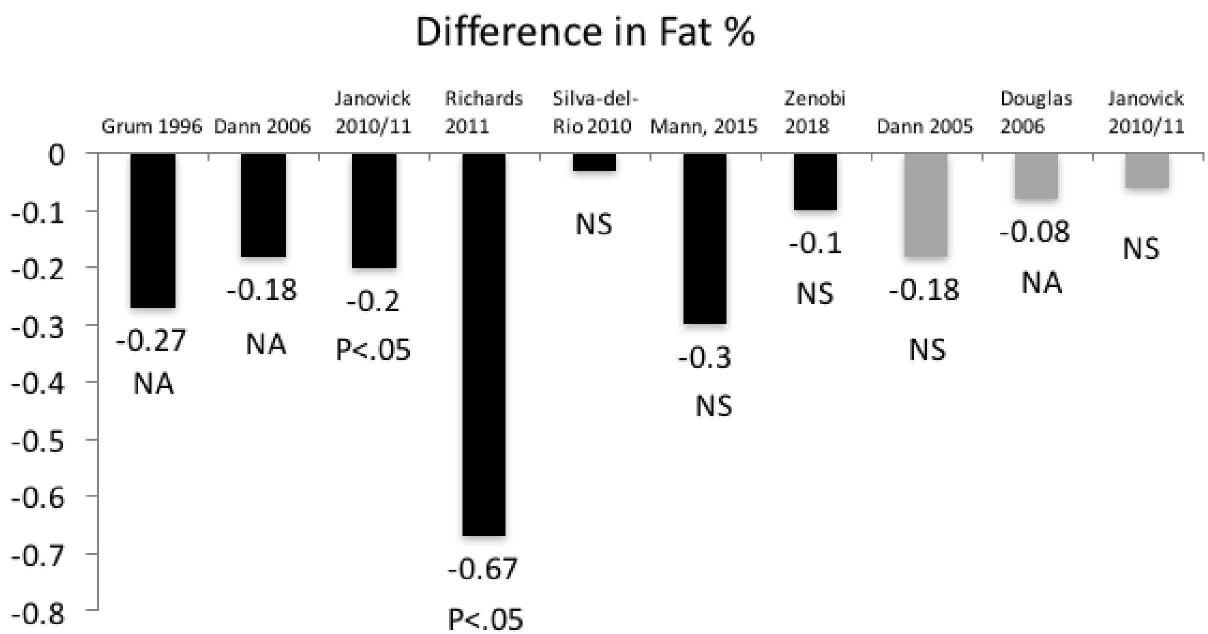

Figure 2. Differences in milk fat percentage units between dry cows fed a controlled energy diet (80 - 100 % of energy requirements) vs. a diet that provides in excess of requirements (typically 140 - 150 % of requirements). Black bars represent trials in which energy intake was controlled by feeding a high fiber (straw) diet; grey bars represent trials in which energy intake was controlled by limiting feed intake (cows receiving the high energy treatment and controlled energy treatment were the same diet but fed at different amounts). NA = there were other treatments in the experiment and the statistical analysis did not allow a direct contrast between these 2 treatments, NS = a statistical contrast between controlled energy and excess energy intake was available, but differences between treatment were not significant.

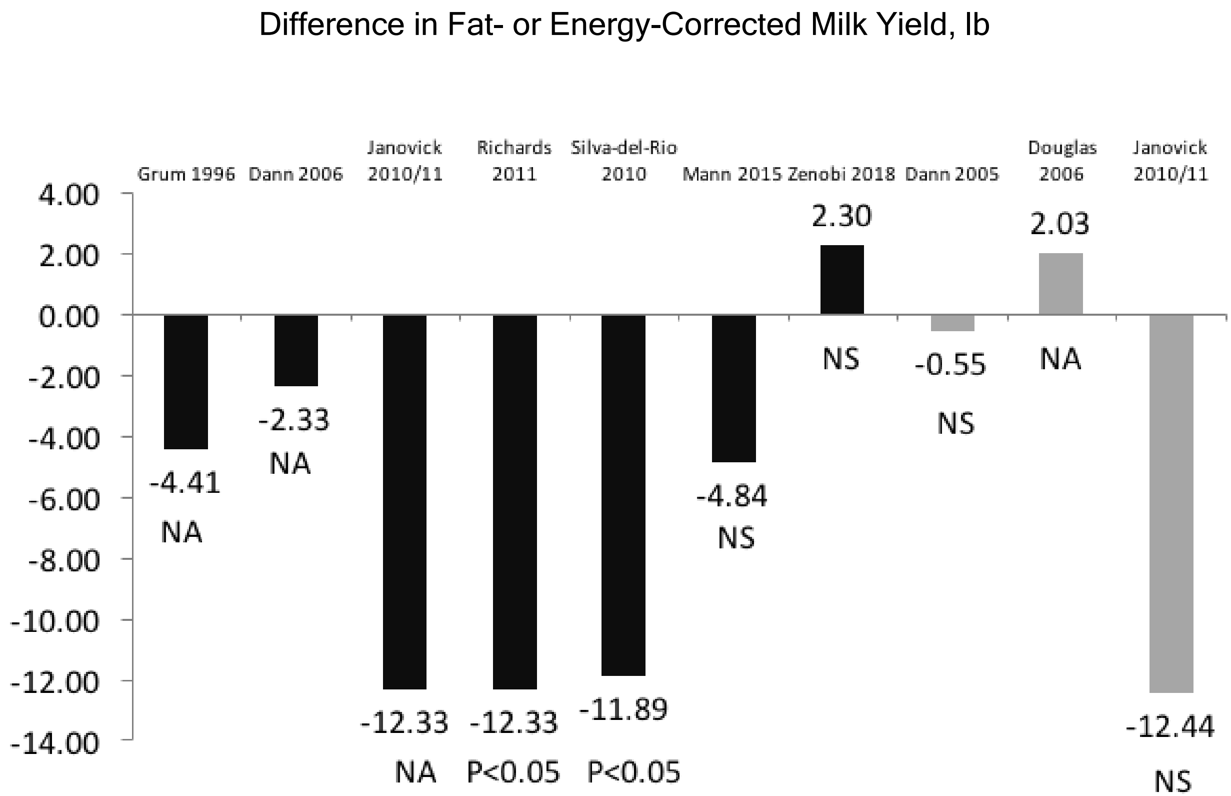

Figure 3. Differences in fat- or energy-corrected milk yield between dry cows fed a controlled energy diet (80 – 100 % of energy requirements) vs. a diet that provides in excess of requirements (typically 150 % of requirements). Black bars represent trials in which energy intake was controlled by feeding a high fiber (straw) diet; grey bars represent trials in which energy intake was controlled by limiting feed intake (cows receiving the high energy treatment and controlled energy treatment were the same diet but fed at different amounts). NA = there were other treatments in the experiment and the statistical analysis did not allow a direct contrast between these two treatments, NS = a statistical contrast between controlled energy and excess energy intake was available, but differences between treatment were not significant.

to the mammary gland for an energy source or for a precursor for milk fat synthesis. Unfortunately, most of the trials have implemented a very high level of energy intake for the overfed cows (140-150 % of requirement). Further research is needed to determine the optimal energy density for producers that elect to feed diets with a consistent energy density throughout the dry period. In other words, is there a dry cow diet energy density that provides some protection against excessive fat mobilization while not sacrificing energy output by the mammary gland? In the meantime, caution should be exercised when employing CED. I would recommend feeding slightly above energy requirements, perhaps target .65 - 67 Mcal/lb of dry matter (**DM**). I would also avoid feeding more than 25 – 30 % straw. Lastly, feeding a CED should not preclude the inclusion of a close-up transition diet. Even though this may not be needed from an energy density perspective, there are numerous diet supplements that can be incorporated into a close-up diet to assist the cow through the transition period (e.g., monensin, choline, yeast, anionic salts).

MAXIMIZING DRY MATTER AND ENERGY INTAKE IMMEDIATELY POSTPARTUM

Surprisingly, there is very little research to identify optimal starch or fiber feeding in cows during the first 3 wk postpartum. Most early lactation research in this area has commenced when cows are beyond 3 wk postpartum. Consequently, there are many questions on this topic, but few answers. For example,

- Should cows be fed straw or other low quality forage right after calving?
- Does this help acclimate them to higher starch diets (avoid acidosis) or help maintain a rumen mat and reduce the incidence of displaced abomasum?
- Does it promote greater feed intake?
- Or, can fresh cows be fed the same diet formulated for the highest producing cows?

From a management standpoint, it begs the question: "Do I need to mix a separate diet for cows during the first few weeks postpartum?" All these questions have intensified since Dr. Mike Allen proposed the *hepatic oxidation theory*, also known as **HOT** (Allen et al., 2009). His theory states that if too much fermentable carbohydrate (e.g. starch) is fed immediately after calving, feed intake will be depressed. The hypothesized mechanism of action is through propionate production in the rumen. If too much propionate is delivered to the liver, end products of hepatic propionate oxidation signal to the brain to decrease feed intake. There is excellent evidence in support of the theory that has come through a model employing propionate infusion into the rumen of dairy cows. Some have refuted this theory in the belief that very little propionate gets oxidized by the liver during the first few weeks after calving due to the tremendous demand for hepatic conversion of propionate to glucose (McCarthy et al., 2013). Applied feeding trials testing the theory with transition dairy cows are limited.

From the limited amount of research available, it appears that early lactation cows often respond with more milk production when energy density of the diet is increased by increasing non-fiber carbohydrate (**NFC**) and decreasing neutral detergent fiber (**NDF**) (Anderson et al., 2003; Rabelo et al., 2003, 2005). In general, other strategies to increase energy availability to the early postpartum cow (e.g. increase starch content, increase starch fermentability, increase NDF digestibility, supplement monensin) have not had negative effects on intake or lactation performance and in some cases have had positive effects (Dann et al., 1999; Adin et al., 2009; Rockwell and Allen, 2016; McCarthy et al., 2015).

There are some feeding trials supporting the HOT. Nelson et al. (2011) lowered starch content for the first 21 d postcalving (while maintaining NE_l/lb DM) and improved feed intake and milk yield. They fed controlled (low starch) energy diets pre-fresh, while higher starch levels were fed pre-fresh in other trials (Rabelo et al., 2003, 2005; McCarthy et al., 2015). Perhaps acclimation to high starch diets needs to occur immediately post-fresh if dietary starch content is extremely low in pre-fresh diets? After an initial trial showed no effects of starch fermentability on dry matter intake (**DMI**) (Rockwell and Allen, 2016), a second trial was conducted to determine if starch fermentability may be more crucial at higher dietary starch levels (Albornoz and Allen, 2016). Indeed, feeding high moisture corn decreased DMI compared to dry corn (lower fermentability of starch) and the effect was more dramatic when diets contained 28 % starch as compared to 22 % starch.

Clearly, more research is needed to determine factors that influence optimum starch content in fresh cow diets. Based on the limited data available, fresh cows should be able to be fed diets containing 25 – 26 % starch without incurring any problems. Higher starch diets may be tolerated by fresh cows and could be explored to promote greater energy intake. However, doing so should be done judiciously with careful observation for signs of subclinical acidosis or effects of HOT. This can probably best be monitored by closely following fresh pen feed intakes. Additionally, all the research trials cited above employed a totally mixed ration. Conclusions from these studies may not apply when feeding management deviates from that, e.g., feeding concentrates separate from forage, grazing systems, etc.

NEFA AND BHBA TESTING TO MONITOR ENERGY STATUS

When body fat is mobilized during the transition period, NEFA enters into the blood stream and approximately 25 – 30 % of the NEFA are taken up by the liver. If the capacity to oxidize NEFA or export NEFA from the liver as a constituent of lipoprotein triglyceride is exceeded, partial oxidation to ketone bodies may occur. One of those is BHBA. Consequently, blood NEFA and BHBA are used to monitor energy status of transition dairy cows. Indeed, there is considerable research describing the negative effects that excessive blood NEFA or BHBA may have on cellular, tissue, and whole animal function (Grummer, 2016). On farm, blood BHBA is most commonly measured because it is very easy to do so in a quantitative fashion using hand held meters. Over the past several years, BHBA testing has become common place on commercial dairies. Several excellent large epidemiological studies have been conducted to determine *cut-off* blood concentrations, that when exceeded, signal potential losses in subsequent milk yield, poorer health, and decreases in reproductive efficiency (for a review see Overton et al., 2017). Rather consistently, these studies report BHBA values above 1.2 - 1.4 mmol/L are detrimental to the cow and hence should be classified as hyperketonemic. Protocols usually recommend sampling 12 - 15 cows between 4 and 14 d postpartum and if 10 – 15 % of cows test above 1.2 or 1.4 mmol/L, an *alarm level* has been reached. On many farms, all fresh cows are tested and treated (propylene glycol drench is most common) if BHBA concentrations exceeds the cut point.

As the popularity of BHBA testing has increased, I regularly receive questions that go something like this: “I am testing BHBA and my herd is above the alarm level, but my cows are milking like crazy. What should I do?” As with most blood tests, we tend to oversimplify and make black and white interpretation of the results. Unfortunately, this can be problematic. Consider the results of a multi-state university study (Harrison et al., 1990) in which herds were subdivided so that for several decades, cows and subsequent offspring were bred with semen from bulls with superior genetic merit or semen from bulls with average genetic merit. For the first 75 d postpartum, cows with superior genetic merit produced 11.6 lb/d more milk than cows with average genetic merit and yield differences started immediately after calving. However, during the first 3 - 5 wk postpartum, genetically superior cows did not consume more feed. Consequently, they were in a more severe negative energy balance (**NEB**) and had higher blood NEFA and BHBA. A recent study (n = 570) from the University of Wisconsin-Madison (Rathbun et al., 2017) indicated that cows testing above 1.2 mmol BHBA/L produced 6-10 lb more milk per day for the first 30 d postpartum. The hyperketonemic cows were treated with 300 ml propylene glycol/d for 3 d, but clearly there was insufficient energy from propylene glycol to account for the increase in milk yield. A recent study from the Netherlands (Vanholder et al., 2015) surveyed 23 herds (1,149 cows) and found that first test day milk was 7.3 lb/d higher for cows testing between 1.2 to 2.9 mmol BHBA/L than those testing less than 1.2 mmol/L. How can one reconcile results from large epidemiological studies suggesting milk production is reduced when BHBA exceeds 1.2 mmol/L with studies cited above in which high BHBA was associated with higher milk yield? Realize that the inference from the epidemiological studies is to a very large population of cows and the *cut-off* value of 1.2 or 1.4 mmol/L is really a *one size fits all* recommendation. However, there is herd-to-herd variation and cows in high producing herds will likely test higher for BHBA and may need a different cut point. This needs to be researched.

For the record, I am not against BHBA testing! However, interpretation of results may be complicated and must be done with caution. BHBA testing allows producers to monitor relative changes in energy balance and can be helpful for early detection and troubleshooting of energy-related problems within the herd. That said, I tell producers whose herds are above the alarm level, are achieving high levels of milk production, and are not having problematic issues related to NEB: R-E-L-A-X!

MANAGING FAT STORES

Body fat stores are a valuable resource. During early lactation, energy from one point of body condition loss is approximately equivalent to energy in 550 lb of diet DM and can support approximately 1300 lb of fat-corrected milk production. As previously mentioned, there are potential drawbacks when fat mobilization becomes excessive, e.g., fatty liver, ketosis, impaired immune system, and reduced reproductive efficiency. On the flip side, NEFA (and BHBA) are an extremely important source of energy and are precursors for milk fat synthesis during the time of NEB. Hence a balance must be struck between supporting lactation and avoiding health and reproductive problems.

Historically, managing fat mobilization has been restricted to strategies that reduce fatty acid mobilization (e.g, niacin, CED). As previously discussed, this approach may potentially reduce fat test and milk yield, especially fat or energy-corrected milk yield. Dr. John Newbold (2005) stated it very well: “Nutritional restriction to adipose tissue mobilisation might be necessary, but there is a philosophical problem. We have selected cows that have increased reliance on mobilised body reserves as a source of nutrients for milk production. The farmer has paid the geneticist for this - are we now going to ask him to pay the nutritionist to work in the opposite direction? We have our priorities wrong. We should explore what can be done to help the liver deal with mobilised fatty acids before considering whether we need to try to reduce the amount of fatty acid supplied to the liver.” Choline is the only compound that has been shown to help the liver *deal* with mobilized fatty acids (Goselink et al., 2013; Chandler and White, 2017). Choline helps the liver export fatty acids as a constituent of lipoprotein triglyceride. Once exported from the liver, the fatty acids can become available to the mammary gland to support milk synthesis. Dietary choline is degraded, so if supplemented, it must be encapsulated to protect it from ruminal degradation. A meta-analysis of trials in which choline has been supplemented to transition cows beginning prior to calving shows that it supports lactation (+ 4.9 lb milk/d; Grummer, 2012) and the benefits of feeding choline during the 6-wk transition period carry over for the entire lactation (Zenobi et al., 2017). If compounds such as niacin are fed to suppress fat mobilization, I generally recommend that use occurs prepartum and ceases when lactation begins.

FINAL COMMENTS

Sometimes good concepts catch on and become dogma. This presentation was not intended to discourage you from implementing CED during the dry period, reducing fermentable starch feeding in post-fresh diets, or testing for BHBA. The purpose was to point out that often times management recommendations and guidelines become overly simplistic and are presented as *one size fits all*. That is rarely the case! In reality, novel management concepts and resulting recommendations are seldom completely fact or completely fiction.

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