Successfully Transitioning the Dry Cow From the End to the Beginning of Lactation

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About 30 to 50% of dairy cows are affected by some form of metabolic or infectious disease around the time of calving (LeBlanc, 2010). In addition, virtually, all early-lactation cows experience a period of reduced immune function for 1 to 2 weeks before, and 2 to 3 weeks after calving low feed intake, negative energy balance, lipolysis, insulin resistance, and weight loss, and some may suffer hypocalcemia (clinical or subclinical); uterine infections, ketosis (also clinical or subclinical), and displaced abomasum.

The importance of the dry period in the epidemiology of mastitis at calving has been studied for years. Some studies in the eighties evidenced that new infection rates by environmental organisms can be 10 times greater during the dry period than during lactation (Smith et al., 1985) and more recent studies confirmed that over 50% of all environmental mastitis occurring in early lactation (first 100 days in milk) result from infections acquired during the dry period (Green et al., 2002). Furthermore, it has been proposed that for every 5-kg increase in milk production at dry-off above 12.5 kg, the odds of a cow suffering an intra-mammary infection at calving increases by 77% (Rajala-Schultz et al., 2005). Throughout the years, as a result of bold improvements in genetics, nutrition, health, and management, the amount of milk that cows produce at dry-off has doubled (Bradley et al., 2015). And thus, the risk of intra-mammary infections at dry-off has also increased.

Antibiotic resistance has progressively become a global concern for human health. The extensive use of antimicrobials in human and veterinary medicine in recent decades has been implicated in the acceleration of the emergence and spread of resistant microorganisms. In an effort to control this concern, the European Commission launched in 2015 a set of guidelines for the practical use of antimicrobials in veterinary medicine, which included the avoidance of the prophylactic use of antibiotics (OJEU, 2015). To prevent the udder from new intra-mammary infections during the dry period, the use of blanket dry cow treatment on all cows (**BDCT**) has a dual role: the cure of existing intra-mammary infections and the prevention of new intra-mammary infections. The use of selective dry cow therapy (**SDCT**) vs BDCT resulted in a reduction in the number of intra-mammary antimicrobials used on dairy herds and SDCT was found to be economically beneficial over BDCT in herds with a lower incidence rate of clinical mastitis and a lower bulk tank SCC level (Scherpenzeel et al., 2018). However, quarters from cows with a low SCC with no antibiotic treatment at dry-off had a 1.7-times greater incidence rate of clinical mastitis during the dry period and the first 100 days in the subsequent lactation than quarters dried-off with antimicrobials (Scherpenzeel et al., 2014). The dairy industry has attempted to reduce milk at dry-off by decreasing feed availability, increase milking intervals, or both. Advantages include: decreased risk of udder engorgement and decreased risk of milk leakage (potentially resulting in less new intra-mammary infections). However, there are some disadvantages, including: decreased milk production prior until dry-off (which entails an economic loss), increased labor to manage individual cows differently from the milking herd, and welfare concerns due to decreased availability of feed. Furthermore, cows on restricted feed before dry-off experience greater blood non-esterified fatty acids and cortisol concentrations compared with cows with no restriction (Odensten et al., 2005, 2007) which may lead to metabolic problems and impaired immune function (Ster et al., 2012), and thus, ironically, increased risk of contracting intra-mammary infections.

Since the early 90's (and especially after the release of the NRC model in 2001, which recommends energy densities around 1.60 Mcal of NEl/kg during this period) late pregnant cows have been fed high-energy rations in the immediate pre-calving weeks to 1) compensate for the assumed decrease feed intake as calving approaches, 2) minimize body fat mobilization, ketosis, and fatty liver after calving, 3) adapting the rumen microflora towards a high nutrient dense ration (that will be fed post-calving), and 4) foster the growth of rumen papillae to minimize the risk of rumen acidosis during lactation through an improved absorption (and removal) of volatile fatty acids from the rumen. The first two objectives (compensate reduction of feed intake and minimize body fat mobilization) do not seem to be attained by feeding high-energy diets before calving. Several studies have shown that high-energy density diets fed prepartum do not physically limit intake of cows (VandeHaar et al., 1999; Mashek and Beede, 2000; Rabelo et al., 2003) resulting in over-consumption of energy. Over-consumption of energy prepartum has been linked to decreases in feed intake prepartum compared with cows that are fed to meet their energy requirements (Agenäs et al., 2003; Dann et al., 2006; Douglas et al., 2006; Guo et al., 2007). Furthermore, Janovick et al. (2011) described that a bulky diet with a low energy density fed prepartum improved metabolic status postpartum, and reduced the incidence of health problems. Interestingly, overfeeding energy to cows during the last 21 days before parturition triggered a robust upregulation of lipogenic gene expression in adipose tissue (Ji et al., 2012), suggesting that insulin sensitivity may not be impaired by the hyperinsulinemic response to overfeeding energy (Janovick et al., 2011; Ji et al., 2012). This situation may increase the odds for cows to accumulate fat pre-calving when feed high-energy density diets. In fact, Drackley et al. (2014) have shown that overfeeding energy to nonpregnant-nonlactating cows drastically increases omental, mesenteric, and perirenal adipose tissue of dairy cows, without translating in detectable changes in body condition of the animals. Furthermore, Graugnard et al. (2013) reported that cows that were moderately over-fed during the prepartum period have an altered immune response and more prone to sustain liver lipidosis than those fed low energy diets. Thus, the current view is that recommended high-energy feeding during the dry period, especially as calving approaches, may be detrimental to cow health, or at least unnecessary, as a much lower energy density is sufficient to meet the energy requirements of the late pregnant cow. An average pre-partum cow requires about 15 Mcal of NEl/d, and feeding a ration with an energy density of 1.60 Mcal of NEl/kg ration would readily provide more than 19 Mcal of NEl/d. Consequently, lower energy rations (approx. 1.32 Mcal/kg of NEl) should be sufficient to meet the energy requirements of dry cows. Cereal straw provides an excellent source of fiber in such rations as well as an important energy diluent provided the ration is well mixed to avoid ingredient selection by the cows. With respect to dietary protein, feeding rations of approximately 13% crude protein are recommended, possibly marginally greater when a significant number of first-calving heifers are being fed.

The third objective (adapting the rumen microflora to a high-starch diet) is also debatable. In ruminant nutrition it has typically be assumed that at least 3 week are needed for the rumen microflora to adapt to a dietary change. However, the vast majority of organisms in the rumen are bacteria and they can double their population in as fast as 600 min in the absence of oxygen (under areobic conditions this figure could be as low as 20 min). Thus, 3 weeks seems like an extremely long time to consolidate a change in term of bacteria lifespan. In fact, Fernando et al. (2014) have recently evaluated changes in the rumen microbial population when shifting steers from a prairie-based diet to a high-grain ration. Within a week of each step-up (animals were gradually moved to a high-grain diet), the authors already reported drastic changes in the rumen microbial population.

Lastly, the fourth objective (fostering growth of rumen papillae) could also be argued. The NRC (2001) made this recommendation based on the study by Diksen et al. (1985) that compared the characteristics of rumen papillae between cows fed a straw-based gestation ration to a high concentrate lactation ration. However, studies substituting barley for forage in the diets of late-gestation dairy cows, in an attempt to increasing rumen acid load and alter rumen volatile fatty acid concentrations, had no effect on rumen papillae characteristics (Andersen et al., 1999) or subsequent lactation performance (Ingvartsen et al., 2001). Furthermore, a more recent study (Reynolds et al., 2004) that compared a high fiber diet vs the same diet plus additional 800 g/d of barley precalving reported that total mass of rumen papillae excised from the floor of the cranial sac was not affected by transition diets, but the number tended to be greater when barley was fed, and this was associated with a marked reduction in average width, which resulted in a reduced average surface area. Thus, it would seem that there would be no need to 'adapt' rumen papillae before calving by providing high-starch diets.

Therefore, keeping the dry cows in one single group and feeding a low energy diet throughout the period could be recommended. There are, however, other reasons for feeding special diets pre-calving. These reasons include minimizing the incidence of hypocalcemia and udder edema. Dairy cows have between 2 and 4 g of calcium in blood, half of which is in the ionized form. On the first day of lactation, synthesis and secretion of colostrum impose major losses of calcium equivalent to 7 to 10 times the amount of calcium present in blood (Horst et al., 2005). Clinical hypocalcemia, nowadays has a relatively low prevalence (< 2%); however, subclinical hypocalcemia (i.e. cows with calcemia ≤ 8.2 mg/dl) has a staggering prevalence (>50%; Goff, 2008; Rodriguez et al., 2017; Venkajob et al., 2018). Cows with clinical hypocalcemia are at increased risk of developing other periparturient problems, including dystocia and ketosis (Curtis et al., 1983), displaced abomasum (Massey et al., 1993), uterine prolapse (Risco et al., 1984), and retained placenta (Melendez et al., 2004). Furthermore, hypocalcemic cows have increased plasma concentrations of cortisol (Horst and Jorgensen, 1982), reduced proportion of neutrophils with phagocytic activity (Ducusin et al., 2003; Martinez et al., 2012), and impaired mononuclear cell response to an antigen-activating stimulus (Kimura et al., 2006; Martinez et al., 2014). This reduction of immune response has linked hypocalcemia to metritis (Martinez et al., 2012) and mastitis (Curtis et al., 1983).

Strategies to minimize hypocalcemia may require separating dry cows in 2 groups. One strategy, that does not require separate groups of dry cows, for preventing hypocalcemia is feeding low calcium diets throughout the dry period. If low-calcium diets are not an option, other alternatives include 1) feeding anionic salts, 2) supplementing vitamin D, and 3) supplementing calcium right at calving. The latter strategy would also allow to keep a single group of dry cows. Dry cow diets that are high in potassium, sodium, or both, alkalinize the cow's blood and increase the susceptibility for milk fever (NRC, 2001). For many years, it has been known (Ender et al., 1971; Ender and Dishington, 1967; Block, 1984) that addition of dietary anions before calving could prevent hypocalcemia. An acidogenic diet ameliorates parturient hypocalcemia by enhancing calcium mobilization before parturition by increasing calcium absorption and bone resorption. When supplementing pre-calving rations with anions, urine pH should be monitored. In Holstein cows, effective anion addition should reduce urine pH to 6.8 (Oetzel and Goff, 1998). Nevertheless, although acidogenic rations are effective in reducing clinical hypocalcemia (Lean et al, 2006), evidence of positive responses to acidogenic diets in terms of reducing the incidence of subliminal hypocalcemia is scarce.

Supplementing vitamin D3 is important because parathyroid hormone does not stimulate fibroblast growth factor 23 (responsible for inhibiting calcitriol production) under situations of hypocalcemia (Rodriguez-Ortiz et al, 2012) to prevent further aggravation of calcemia. In this regard, supplementing 3 mg of calcidiol per day during 2 weeks before calving has been shown to improve peripartum Ca metabolism (Wilkens et al., 2012), but feeding 5.4 mg/d of calcidiol for the last 13 d prepartum seemed to cause more detrimental than beneficial effects (Weiss et al., 2015).

Lastly, supplementing calcium subcutaneously at calving and 12 h after calving has also been shown to greatly improve (more than feeding it orally) calcium homeostasis in dairy cows (Domino et al, 2017).

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