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Invited review: Cessation of lactation: Effects on animal welfare

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ABSTRACT

The forced cessation of milk production, or dry-off, is a routine management practice in dairy cattle, sheep, and goats. This practice initiates a dry period, during which the animal is not milked. Milking begins again after parturition. Most of the literature on the dry period has focused on how various drying-off strategies affect milk production and disease; little work to date has addressed how dry-off affects the overall welfare of the dairy animal. The first aim of this review was to present an overview of the importance of dry-off and how it is commonly achieved. Our review shows that much scientific progress has been made in improving health status between lactations. The second aim was to identify important gaps in the literature, of which 2 key research disparities have been identified. We find that much of the work to date has focused on cattle and very little research has examined dry-off in dairy sheep and goats. We also find a lack of research addressing how common dry-off methodologies affect animal welfare on more than just a biological level, regardless of species.

Key words: natural behavior, dry-off, intramammary infection, dairy cow, dairy goat

INTRODUCTION

Female ruminants, including cows, ewes, and does, initiate lactation immediately following birth. Under natural conditions, offspring will be nursed for 5 to 12 mo, depending on the species. Milk production increases rapidly, peaks, and then slowly declines until the offspring become nutritionally independent. At this point, milk production ceases, and the birth of the next offspring begins the cycle again. Conversely, in most commercial dairy systems, the offspring are separated from the mother within hours of birth, and milk is redirected for collection and human consumption. The resulting lactation cycle is different from what would occur in a natural setting. Dams are encouraged to produce large amounts of milk, and eventually milk production is abruptly ceased for a short period before the birth of new offspring.

The benefit of a rest from lactation, or dry period, has been acknowledged since the early 1800s (reviewed by Dix Arnold and Becker, 1936) in dairy cows. A dry period is now standard on most dairy farms. In the case of the cow, most farmers aim for one calf per cow per year, allowing for approximately 305 d of lactation and 60 d when it is not lactating (dry). Much research has focused on the physiological effects of the dry period. Progress has been made in understanding mammary physiology at the cellular level (e.g., Wilde et al., 1999) and how this ties into milk production during the next lactation (e.g., Bachman and Schairer, 2003). Also, the effects of dry period management on IMI have received a great deal of attention (e.g., Dufour et al., 2011). Even though knowledge of dry period mammary health has expanded, our knowledge of how the individual animal is affected by the way we manage the dry period remains minimal.

Few working in the dairy industry today would disagree with the fact that poor health and reproduction are bad for the animal and farm profitability. Nonetheless, a health-only focus is not sufficient. Concerns regarding animal welfare go beyond health, with proponents arguing that assurances for good welfare are only achieved when 3 key components are balanced: (1) the biological functioning (including health) of the animal, (2) the affective states the animal is experiencing, and (3) the naturalness of its life (Fraser et al., 1997). It follows that when seeking to understand how welfare is affected by cessation of lactation, it is vital to identify how the associated management practices affect productivity and health, prevent states such as pain and hunger, and affect the natural adaptations of the animal.

The first part of this review summarizes the abundance of dry-off and dry period related research that

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has focused on milk production, metabolic status, and udder health (i.e., IMI). Next, an argument is presented that this narrow focus on biological functioning has ignored how dairy animals actually experience the cessation of milking (e.g., Do they experience pain when milking is stopped?). Last, a brief overview is given of how standard management practices used in today's dairy industry have resulted in a lactation cycle that strongly deviates from a natural one. Exploring this deviation and how it affects dairy animals could provide insight into finding solutions for welfare concerns facing the dairy industry. Given the available literature, the majority of this review focuses on the dairy cow. Where applicable, evidence from other mammalian species, in particular dairy sheep and dairy goats, is discussed.

BIOLOGICAL FUNCTIONING AND HEALTH

Mammary Involution and Apoptosis

A major area of focus within the dry-off literature is that of cellular processes occurring at dry-off. Mammary involution, or the process where a gland moves from a lactating state to a nonlactating state, occurs in all lactating mammals and can be categorized into 3 main types: gradual, senile, and acute involution.

Gradual involution occurs early in lactation and results in the slow decline of milk production observed in the natural lactation cycle (Wilde et al., 1999). The point at which gradual involution occurs is dependent on peak milk yield and is therefore highly species specific (e.g., rats, 12 d: DeSantiago et al., 1998; humans, 40 d: Butte et al., 2002; cows, 45 to 90 d: Stanton et al., 1992; Khorshidie et al., 2012; sheep, 35 to 40 d: Pollott and Gootwine, 2000; Ruiz et al., 2000; goats, 50 to 124 d: Gipson and Grossman, 1990) and is also variable by breed within species.

Senile involution refers to an age-related decline in the mammary gland's ability to produce milk. The high culling rate (or turnover rate of individual animals within a herd) frequently observed in many intensive commercial milk production systems (Oltenacu and Algers, 2005) has resulted in a reduced average age at removal from the herd; thus, this aspect of involution has received little focus within the dairy science literature. Senile involution is largely only considered in human literature (Neville, 1983; Silanikove, 2014).

Acute involution occurs when milk removal from the mammary gland is ceased. This can occur naturally (e.g., death of an offspring) or, as is common in the modern dairy industry, when lactation is abruptly halted in preparation for the dry period before the birth of the offspring. When milking is ceased abruptly, the cisternal ducts and alveoli of the udder become engorged, raising intramammary pressure (Oliver and Sordillo, 1989). This local physical change triggers the involution process (Wilde et al., 1997). Rodent work has shown that apoptosis, or programmed cell death, has a negative relationship with the presence of galactopoietic hormones (i.e., hormones that stimulate milk production; e.g., prolactin; Wilde et al., 1997). When milk is no longer removed from the gland, prolactin production ceases, triggering apoptosis. Apoptosis occurs with all 3 types of involution, but the highest rate of apoptosis is associated with acute involution. A major difference between apoptosis and trauma-related cell death (i.e., necrosis) is that the former does not elicit an immune response, thus generating no inflammatory response. Because no inflammation is triggered by apoptosis itself (Wilde et al., 1997), it has been suggested that any inflammation that does occur is therefore a result of excessive milk engorgement caused by acute involution. Hence, monitoring for an inflammatory response could be a useful indicator of any tissue damage caused by abrupt cessation of milking, which is pertinent because this practice has been receiving increasing criticism (e.g., Bertulat et al., 2013). This hypothesis is supported by work showing that although mammary glands with low engorgement do exhibit some inflammatory response (likely due to a backlog of clearing of dead cells), the cell types involved in the inflammatory response are different when engorgement is high (Silanikove et al., 2013). This difference led the authors to conclude that abrupt mammary involution associated with sudden cessation of milking causes distress in high-producing cows.

The level of net cell death due to apoptosis of milk epithelial cells (**MEC**), and regression of surrounding mammary tissue, is species dependent. Rodents appear to have the most significant losses of MEC (Paape and Tucker, 1969) and collapse of alveoli (Li et al., 1999). Conversely, much less tissue degeneration occurs in cows (Capuco et al., 1997), sheep (Tatarczuch et al., 1997), and goats (Sordillo et al., 1984). It has been shown that the alveoli decrease in size corresponding to the reduced milk secretory activities within them, but the surrounding stromal (i.e., connective) cells increase in size, resulting in many of the alveoli staying intact (cows: Li et al., 1999; sheep: Tatarczuch et al., 1997). Although a rudimentary indicator of potential changes in alveoli structure in dairy goats, it has been noted that lactating and nonlactating glands on the same animal remained similar in size (Fowler et al., 1991).

It follows that with species contrasts (e.g., between cows, sheep, and goats) in tissue degeneration and apoptosis during involution, the necessity of the dry period across species would also be questioned. Omitting the dry period entirely does not result in a net loss