

Reproductive activity of dairy cattle in the postpartum anestrus period

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ABSTRACT

Objective: To review the metabolic and hormonal processes that regulate reproductive activity in dairy cattle during the postpartum anestrus period.

Design/methodology/approach: Analysis of scientific documents and systematization of information related to the reproductive physiology and management of dairy cattle in postpartum anestrus.

Results: Postpartum anestrus is an event that occurs naturally and is necessary for restoration of the homeostasis of the cow's body following calving. However, failure to reestablish this homeostasis actually increases its duration and negatively affects the subsequent reproductive performance of the individual cow.

Limitations on study/implications: Reproductive management decisions must be based on scientific knowledge.

Findings/conclusions: Management of dairy cattle in the postpartum anestrus period should focus on reestablishment of the state of homeostasis and the subsequent reproductive activity, with nutritional and hormonal strategies implemented to induce cyclicity, ovulation and formation of the first corpus luteum in that period, through application of exogenous hormones after day ten postpartum.

Key words: reproductive reestablishment, follicular development, ovulation.



INTRODUCTION

Cows can live for more than 15 years, but their life expectancy is significantly reduced (by 3-4 years) within specialized dairy production units (DPU), with reproductive failure one of the main causes (De Vries, 2020).

The predisposing factors for poor reproductive performance in cows after calving include poor corporal condition, caloric stress and postpartum diseases. This can represent an annual economic loss of approximately \$622.00 dollars per cow (Kim & Jeong, 2019) peri- and postpartum disorders, body condition score (BCS). This is added to the historic decline in cattle fertility caused by genetic selection towards greater milk production, although reproductive characteristics are now included within the genetic improvement programs (Kgari *et al.*, 2020).

Postpartum anestrus is one of the most dynamic periods in the reproductive life of the dairy cow. It is of natural occurrence, and is characterized by the absence of estrus (Ambrose, 2021). The postpartum normalization of reproductive activity is certainly of vital importance to achieve early gestation, but it is necessary to understand the main events that trigger postpartum anestrus in order to implement management strategies that can contribute to reducing its duration. The objective of this study is therefore to review the metabolic and hormonal processes that regulate the reproductive activity of the dairy cow during the period of postpartum anestrus.

Hormonal and metabolic profile of the postpartum cow

During postpartum, cows present a period of negative energetic balance that can last up to 140 days (Beever *et al.*, 1998). The lag between the rapid increase in the production of milk and the gradual increase in the consumption capacity of the cow is its main trigger. In turn, this causes a mobilization of corporal reserves, and loss of corporal condition (Figure 1). The energy provided by the corporal reserves is used to maintain vital physiological functions, since the loss of sensitivity to insulin on the part of peripheral tissues during postpartum favors consumption of glucose by the udder (Habel & Sundrum, 2020).



Figure 1. Dairy cow presenting poor corporal condition.

The cow presents a state of hypoinsulinemia in postpartum (Weber *et al.*, 2016), associated with a reduction in the hepatic expression of receptors of growth hormones (GH, Rhoads *et al.*, 2004) and causing an increase in the blood concentrations of the GH and a reduction in those of the factor analogous to insulin (IGF-I, Fenwick *et al.*, 2008). The GH, through lack of linkage with their hepatic receptors, promote lipolysis (Silva *et al.*, 2017) causing increased blood concentrations of non-esterified fatty acids (NEFA), such as palmitic and stearic acid (Contreras *et al.*, 2010), which can be used as energy sources and in the formation of ketone bodies.

Secretion of ghrelin increases during fasting, dietary restriction and postpartum (Nowroozi-Asl *et al.*, 2016). It is likely that this hormone promotes postpartum lipolysis, since it can stimulate the secretion of GH (Itoh *et al.*, 2005). On the other hand, the concentrations of leptin, produced by the adipocytes, decrease as a result of the loss of corporal condition (Liefers *et al.*, 2003). The concentration patterns of both hormones, and those of insulin, are used as signals to stimulate the appetite, through the release of neuropeptide Y (NPY, Nowroozi-Asl *et al.*, 2016), since an increase in its concentration is associated with greater consumption of food by the cow during postpartum (Gaowa *et al.*, 2021). For this reason, following calving, the cow presents a hormonal and metabolic response directed towards developing a state of homeostasis between the quantity of nutrients available and the production of milk.

Ovarian activity of the cow during postpartum

The effects of the events that occur during postpartum, in terms of the reproductive functions of the cow, depend to a large extent on the quantity of milk that is being produced and the severity of the loss of corporal condition. The first dominant follicle can be observed from the seventh day after calving (Tanaka *et al.*, 2008), but the first ovulation is not produced until 18 to 57 days after calving in cows of high milk production (Sakaguchi *et al.*, 2004). In cows of low milk production, however, this takes place at 17 to 35 days after calving (Kawashima *et al.*, 2007). The delayed appearance of the first postpartum ovulation, or indeed the lack of ovulation, has been related to reduced steroidogenic follicular capacity, low frequency of luteinizing hormone (LH) and low consumption of food (Cheong *et al.*, 2016). Moreover, cows that present a rapid loss of corporal condition during postpartum present a reduced follicular population (Walters *et al.*, 2002), which is associated with a delay of up to 20 days in the appearance of the first ovulation (Furukawa *et al.*, 2020).

The state of hypoinsulinemia during postpartum is undoubtedly prejudicial to ovarian activity. The insulin promotes the proliferation of granulosa cells and the production of estradiol (Gutiérrez *et al.*, 1997). It has also been reported that the preovulatory follicles contain greater concentrations of this hormone than the subordinate follicles (Landau *et al.*, 2000), probably due to the fact that this is important for completion of the cascade of events that lead to ovulation (Sekulovski *et al.*, 2020). This helps to explain the lack of ovulation or its delay in cows in the postpartum. For its part, the IGF-I is necessary for follicular development and promotes cellular proliferation, the expression of gonadotropin receptors and the production of estradiol (Zhou *et al.*, 1997; Mani *et al.*, 2010). This suggests

that the low concentrations of IGF-I observed during the postpartum are undesirable in terms of follicular activity.

The maturation, culture and fertilization of oocytes, in the presence of concentrations of palmitic and stearic acid similar to those found in the follicles of cows of high milk production during postpartum, increases the apoptosis of the cells of the clusters and reduces the level of competition of the oocyte (Leroy *et al.*, 2005). In contrast, in cows that are not in a negative energetic balance, intra-follicular injection of these acids temporarily reduces the follicular size, but not the steroidogenic activity (Ferst *et al.*, 2020). This suggests that the effect of the NEFA is dependent on the energetic balance of the cow.

Uterine health of postpartum cows and its effect on reproductive function

Uterine infections are common during postpartum. However, the probability that a cow becomes pregnant following its first insemination postpartum is four times lower in cows that suffered an infection than it is in healthy individuals (Gobikrushanth *et al.*, 2016). This is possibly due to the presence of high intra-follicular concentrations of endotoxins (Cheong *et al.*, 2017), since the intra-follicular injection of bacterial products (lipopolysaccharides) reduces the number of ovulations (Gindri *et al.*, 2019).

The addition of follicular liquid of cows with subclinical uterine infection in the middle of the culture acts to diminish the competition of the oocyte, because of a high concentration of lipopolysaccharides (Heidari *et al.*, 2019). This could be due to the fact that these induce an inflammatory response and an oxidative stress (Zhao *et al.*, 2019), as well as altering the nuclear and cytoplasmic maturation in the oocyte (Magata & Shimizu, 2017).

Nutritional and hormonal strategies to break postpartum anestrus

Nutritional and hormonal strategies to shorten or to break postpartum anestrus are directed towards reestablishing the hormonal and metabolic balance of the cow. Restoration of the blood concentrations of insulin is perhaps one of the main objectives. Supplementation with propylene glycol in postpartum is effective in terms of increasing the blood concentration of insulin, while reducing those of NEFA and ketone bodies (Rizos *et al.*, 2008). In addition, to improve fertility, it is recommended to establish a pattern of feeding that allows an increase in the blood concentrations of this hormone in the first days postpartum, with the subsequent provision of a diet that allows the reduction of these concentrations (Garnsworthy *et al.*, 2009).

There is a large quantity of scientific information that addresses the application of hormones to induce postpartum cyclicity (Rhodes *et al.*, 2003). Hormonal strategies to induce this generally include the use of progestogens, estradiol and GnRH. The progestogens are used to sensitize the hypothalamus to the effect of the estradiol following calving, such that the female can exhibit the behavior of estrus (Figure 2; Nagai *et al.*, 2013).

On the other hand, the LH content in the pituitary remains low between days one and 15 compared to that of day 30 postpartum, while the quantity of GnRH receptors increases at 15 days after calving (Nett *et al.*, 1988). This explains the absence of a peak in LH in response to the injection of GnRH within the first eight days postpartum (Peters *et al.*, 1985), although it has been observed that the response tends to normalize after day ten

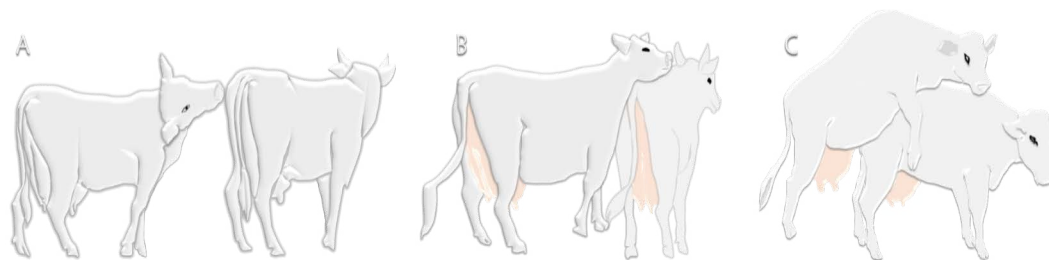


Figure 2. Secondary signs of estrus. A: the cow sniffs its companions. B: the cow rests its head on the back of another. C: primary sign of estrus; the cow accepts being mounted by another and is then considered to be in estrus.

(Fernandes *et al.*, 1978), for which reason it is recommended to begin the treatments after day ten postpartum.

CONCLUSIONS

Management of dairy cattle in postpartum should be focused on reestablishing the state of homeostasis, and then reproductive activity, for which reason the nutrition, health, well being and reproduction should be coordinated into a single management strategy; mainly featuring nutritional and hormonal strategies designed to induce cyclicity with ovulation and formation of the first corpus luteum in the postpartum period, through the use of progesterone, estradiol and GnRH after day ten postpartum.

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