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Mini Review

Promotion of Early Embryonic Development in Dairy Cows with Dietary Polyunsaturated Fatty Acids

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Abstract

Polyunsaturated fatty acids (PUFAs) have multiple functions: as precursors to eicosanoids, steroid biosynthesis regulators, inflammatory mediators, and supply energy (especially oocytes). PUFAs affect signaling pathways and susceptibility to oxidative damage and affect reproduction. The PUFAs diet reduces the ability of the endometrium to produce prostaglandin F2α (PGF2α) and thus affects the control of other PG-mediated events such as luteal lysis and ovulation. Increased egg cleavage and blastocyst development in PUFA-fed cows after insemination reduces early embryo mortality and increases pregnancy rates.

Keywords: *Embryonic Losses; Polyunsaturated Fatty Acids (PUFAs); Postpartum Dairy Cows; Prostaglandin F2α (PGF2α); Negative Energy Balance (NEB)*

The transition period for dairy cows is 3 weeks before and after calving. Negative postpartum energy balance (NEB) not only affects milk yield, but also significantly affects reproductive performance. High yielding cows are in NEB state because the amount of energy required to maintain both metabolic function and milk production exceeds the amount of energy consumed by the cow. NEB increases or decreases the concentration of circulating metabolites; (decreased: levels of glucose, insulin, IGF-I), (increased: levels of non-esterified fatty acids, ketone bodies). NEB acts in combination with metabolic signaling of low blood glucose and insulin levels with elevated non esterified fatty acids (NEFA) and ketones, delays increases in LH pulses required to stimulate follicles. Low blood insulin levels and low IGF-I production from the liver together reduce the responsiveness of ovarian gonadotrophin. Decreased or delayed production of ovarian steroids, estradiol and progesterone, slows the rate of involution and recovery of normal uterine function.

Embryo loss occurs on the 8^{th} to 17^{th} day of gestation and is a major cause of reduced fertility in cattle [1]. Maternal pregnancy recognition (MRP) in cattle is based on interferon-tau (IFNT), which acts on the endometrium in a paracrine manner to prevent luteolysis and maintain corpus luteum (CL) and progesterone production [2]. Short-term nutritional changes directly affect bovine follicular kinetics without altering circulating levels of gonadotropins. It causes follicle growth, predominant follicle selection, growth to maturity, ovulation, and subsequent luteolysis, resulting in low conception rates and a high rate of embryonic losses [3]. The high circulating FFA concentration in postpartum dairy cows affects the amount of oocyte triglyceride (TG) [4]. In cystic cattle, glucose levels in both follicular fluid and serum are low, and concentrations of all fatty acids in the cystic fluid (especially palmitic acid and stearic acid) are significantly higher than those in normal estrus follicles [5].

Fatty acids from plants and oil seeds have a significant impact on reproductive performance. The most common sources include sunflower, flaxseed, cottonseed, rapeseed, soybeans, and fish by-products, which are high in polyunsaturated fatty acids (PUFAs). PUFAs include n-3 and n-6 fatty acids. N-3 fatty acids are represented by linoleic acid and arachidonic acid (AA), α-linolenic acid and eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). N-6 fatty acids are typified by linoleic acid and arachidonic acid. These are essential fatty acids that cannot be synthesized by the body. PUFAs are a rich source of energy and play an important role in the structure and function of biological membranes, affecting reproductive function. Dietary n-6 PUFA increases endometrial linoleic acid and arachidonic acid (AA), PGF2α synthesis and metabolism, enhancing uterine health and immunity in cattle [6].

In lactating cows, the type and content of PUFAs have different effects on reproductive performance. Dietary n-3 fatty acid supplementation in dairy cows has a direct impact on postpartum pituitary-gonadal activity. N-3 fatty acid intake accelerates follicle growth and shortens early postpartum ovulation time [7]. And, it increases the amplitude and frequency of luteinizing hormone (LH) secretion and increases progesterone levels. PUFAs supplementation increases postpartum pregnancy rates [8]. N-3 fatty acid reduces PGF2α secretion and induces luteolysis, which reduces endometrial PGF2α secretion in favor of establishing and maintaining pregnancy [9]. Feeding the n-6 fatty acid reduces follicle diameter and luteal size, reduces plasma progesterone and conception rates, and increases embryo mortality compared to cattle fed the n-3 fatty acid [10]. Therefore, PUFA-added uterine PGF2α synthesis depends on the ratio of supplemented n-3 to n-6 fatty acids. Feeding with an n-6: n-3 fatty acid ratio of 4 (rich in n-3 FA) maximizes PGF2α levels and is effective in establishing and maintaining pregnancy [11].

Changes in the metabolism of dairy cows during the transition period lead to a rapid decrease in antioxidants, immunosuppression and the development of metabolism (milk fever, ketosis, etc.) and infectious diseases (uteritis, etc). Postpartum cows are more likely to develop through normal physiological processes of uterine regression, such as endometritis (MET), clinical endometritis (CE), and cytological endometritis (CYTO). Linoleic acid supplementation had antioxidant effects on lactating dairy cow lipid peroxidation. Increasing n-6FA or decreasing the proportion of n-3 fatty acid will increase milk yield and increase immunity [12].

PUFA activates gene peroxisome proliferator-activated receptors (PPARα, PPARγ, and PPARδ) [13]. PPARs are transcription factors that regulate gene expression following ligand activation. PPARα increases cellular fatty acid uptake, esterification, and transport, and regulates lipoprotein metabolism genes. PPARδ increases mitochondrial function and fatty acid unsaturated pathways, stimulating the utilization of lipids and glucose. In contrast, PPARγ promotes fatty acid uptake, triglyceride formation, and storage in lipid droplets, thereby increasing insulin sensitivity and glucose metabolism [14]. PPARs are expressed in immune cells and plays a new important role in immune cell differentiation and fate commitment [15].

Postpartum cattle supplementation with n-6 and n-3 fatty acids has a positive effect on reproductive hormones, immune function, and physiological processes.

Conclusion

Minimizing the duration and level of NEB is important in the management of dairy cows during the transition period. N-3 PUFA supplementation improves postpartum by affecting follicular growth and ovulation. It also improves fertility in dairy cows by lowering embryo mortality and increased conception rates.

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