SIGNIFICANCE OF VITAMIN A AND E DURING PERIPARTURIENT PERIOD IN DAIRY COWS AND BUFFALOES - A REVIEW

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Abstract

Nutrition has a primary role for optimum expression of genetic potential, and most of the dairy farmers have limited resources of green fodder. Hence, a fat-soluble vitamin, especially vitamin A and E remained most critical in the dairy animal's ration and affects their productive and reproductive performance adversely. Animals cannot be able to produce these vitamins in their bodies; hence, an exogenous regular supply is needed to fulfil the physiological needs and to maintain high production performance. Dairy animals undergo intense changes in mammary gland during the periparturient period and become ready for the production of colostrum and milk. Since the concentration of both vitamins A and E are very high in colostrum, so the circulating levels of these vitamins drop during the time of calving causing many health problems and thus reduced the feed intake during the periparturient period. The precursor of vitamin A, and β -carotene is responsible for normal vision, cell growth, maintaining epithelial cells, healthy teeth, skeletal function and, therefore, protect the mucosal surface integrity. The β -carotene also acts as an antioxidant against free radicals. An intracellular antioxidant like vitamin E maintains cell membrane integrity by the protective effect against oxidation of polyunsaturated fatty acids which are enriched in the membranes of immune cells; especially lymphocyte membrane has high free fatty acids, making them prone to oxidative damage. It also increases the production of immunoglobulins in the body and increased the killing of intracellular microorganisms by neutrophils during calving. Vitamin E supplementation improves reproductive efficiency in farm animals by reducing the number of free radicals in tissues of the ovaries.

Key words: Antioxidant, Periparturient period, Vitamin A, Vitamin E

Introduction

An imbalance between oxidants-antioxidants in the body lead to oxidative damage, is known as 'oxidative stress' (Whaley-Connell *et al.*, 2011). Oxidants have been formed due to aerobic metabolism in the body and under normal pathophysiological conditions. Supplementation of vitamin A and E helps to neutralize the high number of oxidants (free radicals) generated under parturition, lactation

stress and pathophysiological conditions, also maintained a quasi-steady state of oxidants in the body because of both vitamin A and E as a powerful antioxidant, lowers oxidative stress and influences the health of dairy cows. Vitamin E increases both cellular and humoral immunity of the dairy animals and maintains the blood tocopherol levels. Addition of vitamin E also increases the killing ability of neutrophils and thus improves macrophage function in cattle

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(Baldi *et al.*, 2018). Milk secreted from these animals is rich in this antioxidant vitamin, thereby reducing the spontaneous oxidation of milk. Vitamin A and E also help in reducing the reproductive problems after parturition in farm animals. A meta-analysis of the effects of vitamin E supplementation on cows reveals a positive effect on serum and colostrum enrichment, milk yield (MY) and somatic cell counts (SCC), as well as on different reproductive disorders of transitional cows (Moghimi-Kandelousi *et al.*, 2020).

Vitamin A and E status during periparturient period

Fat-soluble vitamins are decreased at the time of parturition, may be due to various factors such as udder engorgement, transfer of vitamins into colostrum and milk, alteration in vitamin intake, hormonal change and so on. For the health and efficiency of periparturient animals, role of vitamin A and E are crucial. They prevent cell membranes from peroxidative damage, and are necessary for a well-functioning immune system to combat diseases. The concentrations of vitamin A, β -carotene and α -tocopherol, the most active form of vitamin E (Kumagai and Chaipan, 2004) in the blood start to decline nearly 15 days before calving, reaching its lowest value at the time of parturition (Oldham *et al.*, 1991). This drop is mainly due to reduce dry matter intake and transfer to colostrum (Weiss, 1998). Deficiency of β -carotene and vitamin A around calving can lead to low reproductive performance and higher incidence of intramammary infections (Michal *et al.*, 1994; Dey *et al.*, 2019). The plasma α -tocopherol, β -carotene and retinol concentration was recorded 3.62-4.10 $\mu\text{g/mL}$, 7.78-8.69 $\mu\text{g/mL}$ and 1.05-1.21 $\mu\text{g/mL}$, respectively in cows (Chawla and Kaur, 2004). Goff and Stabel (1990) reported that plasma retinol concentration between 14 to 7 days before parturition remained 0.54 $\mu\text{g/mL}$ in cows. Rajiv (2001) reported that a decrease in

plasma vitamin A from 0.19 $\mu\text{g/mL}$ to 0.13 $\mu\text{g/mL}$, 10 days prepartum to parturition in crossbred cows had been observed. Milk pool does not exist in dry animals, so fat-soluble vitamins stay in plasma for a longer time, resulting in a higher concentration of these vitamins during the non-lactating stage than at calving (Hidioglou *et al.*, 1997). Goff and Stabel (1990) hypothesized that udder engorgement between 7 to 14 days prepartum was also responsible for the decrease in plasma vitamin levels. Plasma levels of the vitamin A were 0.42, 0.38 and 0.45 $\mu\text{g/mL}$ at seven days before calving, at calving and after calving respectively, reported by Daniel *et al.* (1991). Most of the fat-soluble antioxidant vitamins such as retinol, α -tocopherol and β -carotene decrease at the time of parturition and are associated with severe health problems (Batra *et al.*, 1992; Rajiv, 2001; Bach, 2019). Low concentration of α -tocopherol in the plasma at the time of calving had been documented with a significant risk of intramammary infection (IMI) that causes the mastitis during the first seven days of lactation (Kaur *et al.*, 2002; Omid *et al.*, 2017). The plasma level of α -tocopherol reduces nearly one week before calving and remains low for 14-21 days of lactation, even after orally vitamin E supplementation to cows in a constant rate throughout this period (Hogan *et al.*, 1993; Kandli *et al.*, 2019). The blood concentration of α -tocopherol on parturition decreased from 2.1 to 1.3 $\mu\text{g/mL}$ and remained as same until 14-21 days after parturition (Hogan *et al.*, 1993). Decrease the level of α -tocopherol (3.5 to 1.8 $\mu\text{g/mL}$) from the dry period to calving in cows was also reported by Weiss *et al.* (1990). Goff and Stabel (1990) reported that decrease in plasma α -tocopherol in cattle was 1.8 $\mu\text{g/mL}$ to 0.7 $\mu\text{g/mL}$ in the last 14 days of parturition. During the transition period when there is a significant decrease in α -tocopherol, the cows' immunity and activity of neutrophils are depressed (Hogan *et al.*, 1993; Ghaffari *et al.*, 2019), that's why 30 to

50% of clinical mastitis occurs during the first month of lactation (Weiss *et al.*, 1990). Jukola *et al.* (1996) confirmed that 3.0 µg/mL of β-carotene is necessary at parturition for proper immunity in the dairy animals. Supplementation of optimum/higher vitamin E and β-carotene to periparturient cows may be required to maintain the desired vitamins levels around parturition. When plasma level of α-tocopherol was more than 3 µg/mL during calving, the clinical mastitis did not occur in cows (Weiss *et al.*, 1997). Panda and Kaur (2005) and Pinotti *et al.* (2020) indicated that the decreasing of α-tocopherol and total antioxidant activity at parturition could be minimized by prepartum supplementation of vitamin E.

Immunity status during periparturient period

Animals go extreme metabolic changes during the periparturient period and undergone reduced immune response around the calving. Indeed, decreased immunity has been associated with various metabolic disorders. β-carotene, vitamin A and E are supplemented to animals with aims to minimize the harmful effect of excessive production of free radicals and these improve the immunity status of animals by enhancing cellular and humoral immunity. The role of these vitamins in phagocytosis, increasing lymphocyte proliferation, increased intracellular killing activity of polymorpho nuclear neutrophils (PMN) and antibody production are well established (Weiss, 1998). The immunoglobulin concentration increases until the eighth month of pregnancy and then it starts to decrease due to the accumulation in the mammary gland (Mc Guire and Adams, 1982; Lopez Cabas, 2019); it suddenly decreases before calving, and increases again during the first week after calving (Dixon *et al.*, 1961). Herr *et al.* (2011) reported physiological evidence of reduced IgG1 and IgM concentrations in serum during the periparturient period. Impaired functioning of

several immunological parameters has been observed in peripartum dairy cows (Kehrli *et al.* 1989). The lymphocyte and neutrophil functions decrease about a week before calving, reach their lowest levels at calving and return to initial periparturient levels one to three weeks after calving (Lee and Kehrli, 1998). LeBlanc *et al.* (2004) established relationship among the concentrations of α-tocopherol, β-carotene, and retinol before parturition and their significance with disease risk factor. An increase in α-tocopherol level (1 µg/mL) in the last seven days before parturition minimizes the risk of the retention of placenta by 20 per cent whereas reduced serum esterified fatty acid concentration ≥ 0.5 mEq/L associated with increased risk of retention of placenta by 80 per cent. About 60 per cent minimize the risk of mastitis in early lactation was associated with 100 ng/mL elevation of serum retinol in last seven days before parturition. Weiss (2005) reported that the body as a defense mechanism produces several endogenous antioxidants those are responsible for scavenging the harmful reactive oxygen species and to maintain an optimal oxidant: antioxidant balance in the body during the periparturient period. He *et al.* (2007) showed that supplemental β-carotene (control diet plus 150,000 IU vitamin A/cow/day or 300 or 600 mg β-carotene/ cow/day) increased the vitamin A and β-carotene concentration in the plasma and lymphocyte proliferation with sufficient vitamin A in the diet during periparturient period.

Effect of vitamin A and E supplementation on oxidative status and antioxidant enzymes

Oxidative stress and reactive oxygen metabolites (ROM): Oxidative stress resulting from the increased generation of free radicals and reactive oxygen metabolites lead to damage of biological macromolecules and disruption of the normal metabolism of body and physiology. These free radicals can harm and/or lead to

various health problems in cows (Miller *et al.*, 1993). Vitamin E is a powerful intracellular antioxidant, reduces oxidative stress and improves the health of cattle. The vitamin E levels in the blood and oxidative metabolite products changes during the periparturient period. For example, the plasma concentration of α -tocopherol reduces during the last 3-4 weeks of prepartum (LeBlanc *et al.*, 2004), so oxidative stress highly increases near to parturition (Castillo *et al.*, 2005). Lohrke *et al.* (2005) reported that during periparturient period the metabolic activity of body increases, especially in the mammary gland and hepatic cells, the increased metabolic activity is associated with higher production of reactive oxygen species that causes higher oxidative damage of the cell if antioxidant enzymes are insufficient in the cells. The ROM is an oxidative stress indicator, which involves free radical oxygen-centred species such as O_2^- and hydroxyl (OH $\cdot$), as well as various non-radical O_2 derivatives. ROM is unavoidable products of normal body metabolic and physiological processes and is not always harmful. The plasma levels of ROM are an indicator of the generation of free radicals (Miller *et al.*, 1993). Free radicals, especially superoxide dismutase and hydrogen peroxide are produced. Miller *et al.* (1993) reported that reduction of reactive oxygen metabolites before parturition is associated with an increase of antioxidant status of the body.

Effect of vitamin A and E supplementation on metabolic status: Dairy cows undergo metabolic and physiological changes around parturition to support the lactation. The periparturient period that includes both pre and post-parturition, is the most important stage of a dairy animal, as the animal is under a lot of stress. Stress harms the immune response and can make both adults and young animals less resistant to infectious diseases. Powerful antioxidant property of β -carotene and vitamin

E helps animal to alleviate the harmful effect of ROS and improve health and immunity status of dairy animals. The dairy cow is more susceptible to infection and clinical diseases (mastitis and metritis) during two weeks before and two weeks after parturition than during the rest lactation period.

Stress during this period is due to parturition, the starting of lactation, negative energy, protein and calcium balance and increased level of steroid hormones. Glucose concentration is highest during the calving and lower after parturition than prepartum (Dann *et al.*, 2005). The peak level of glucose at time of parturition is due to release of glucocorticoids just before calving that stimulates the process of glycogenolysis and gluconeogenesis but the decreased level of glucose concentrations after calving is probably due to low DM intake. Vitamin E supplemented buffaloes have significantly higher levels of glucose and albumin whereas low DMI was reported by Mili *et al.* (2014), but no effect on supplementation of vitamin E was observed on body weight. Cho *et al.* (2014) reported that the body weight in heifer's with vitamin A supplementation in the feed starting from 9 months until 15 months @15000 IU/350 kg body wt were higher than control group (without vitamin A supplementation). Vitamin A treated pregnant heifers maintain higher body weights as compared to control group and serum cholesterol in the treatment group is higher than control group from the beginning of pregnancy up to the parturition in pregnant cattle. Mudron *et al.* (1997) reported that cows with increased liver triglyceride had low plasma α -tocopherol levels. Significantl higher protein concentration in normal cyclic animals than postpartum anestrous (PPA) buffaloes has been reported by Amanullah *et al.* (1997) and Kumar *et al.* (2010). Omur *et al.* (2016) observed a significant variation in the high-density lipoprotein levels, low-density lipoprotein, total

protein, glucose, total cholesterol, triglycerides in the control group. In the treatment group, significant changes observed in levels of cholesterol, high-density lipoprotein, low-density lipoprotein, triglycerides and glucose level.

Influence of vitamin A and E supplementation on milk quality and quantity: An increase of 13.8 per cent milk yield in dairy animals was observed when administered vitamin E @ 9000 IU/kg as reported by Sinek *et al.* (2000). The increase in milk yield was assumed to be due to the mammary tissue protection from harmful reactive oxygen species. Kaur *et al.* (2001) found an increase of 20% in milk production in cows supplemented with vitamin E 1000 IU/cow/day during the dry period. The increase in supplemented cow's milk production was suggested to be due to reduced incidence of clinical as well as sub-clinical mastitis. Chatterjee (2002) recommended that vitamin E supplementation @ 1000 IU/day should be started at least 30 days before parturition to minimize the cases of mastitis upon parturition and therefore increase in milk yield. Kandil *et al.* (2019) reported significant ($P < 0.05$) increase in milk yield on supplementation of vitamin E (3000 IU/head/day and 6000 IU/head/day) in varying levels. Oldham *et al.* (1991) proved that supplement with vitamin A (170,000 IU) produced significantly more fat corrected milk (FCM) than those receiving only 50,000 IU. The average value of somatic cell count (SCC) over the first 6 weeks of lactation did not differ between groups. Politis *et al.* (2004) given oral administration of vitamin E @ 3000 IU/cow/day, from 4 weeks prepartum and then reduced the dose to 1000 IU/cow/day postpartum, and reported a reduction SCC/mL of milk for the first 4 weeks of lactation. Panda and Kaur (2008) reported that the average somatic cell (SCC) of the vitamin E supplemented groups was lower. It was inferred that supplementation of vitamin E @ 1500 IU/

d to buffaloes benefitted the postpartum udder health besides milk quality. de Ondarza *et al.* (2009) found the beneficial effect of orally supplementing β -carotene (425 mg/day /cow) in the lactating multiparous cows with the normally low level of β -carotene ($< 3 \mu\text{g/mL}$) in serum. Overall milk and fat corrected milk (3.5%) yield, milk protein% and SCC remained comparable between groups. Mature cows (3+ lactation), as well as cows during the early lactation period (first Hundred days), tended to produce higher FCM (3.5%) and milk fat when supplemented with β -carotene. Kuczynska *et al.* (2015) established a correlation between milk β -carotene concentration and cytological quality of milk of high yielding cows with the same stage of lactation (15 ± 14 days). They established the inverse correlation between SCC and concentration of β -carotene. The supplementation of antioxidant vitamin A and E and β -carotene in dairy cows having high somatic cell count is very effective in decreasing their somatic cell count and maintaining milk composition (Santoshi *et al.*, 2018).

Effect of vitamin A and E on reproduction: Overproduction of reactive oxygen species (ROS) contributes to oxidative stress, so these free radicals can disturb the embryonic development and steroids synthesis. During the periparturient period, dairy cows are particularly susceptible to reproductive disorders. Vitamin A and E supplementation aim to protect the cell from the toxic effect of free radicals and act as membrane antioxidants to maintain the integrity of phospholipids against oxidative damage and peroxidation, thus improve the reproductive health status of animals. The primary reproductive problem that has been linked to vitamin E deficiency is the retention of fetal membranes (RFM). Reduction in RFM cases up to 50% has been recorded due to supplementation of selenium (Se) with vitamin E in various experiments (Brzezinska *et al.*, 1994), whereas no reduction in RFM was

observed when vitamin E was given alone (Batra *et al.*, 1992; Campbell and Miller, 1998). Plasma α -tocopherol concentration and unsaturated iron-binding capacity were significantly lower in cows that retained fetal membranes (Campbell and Miller, 1998). Measures of reproductive performance of experimental animals studied in most of the reports were days to first observed estrus, days to first breeding, days of conception and services per conception. Panda *et al.* (2006) administered α -tocopheryl acetate orally from prepartum (+60 days) to postpartum (30 days). There was a 17% reduction in the retained placenta and metritis in treatments groups than the control and minimize in days open (127 vs. 146). Treated with vitamin E @ 1,500 IU/day from 60-days prepartum to 30 days postpartum to buffaloes showed a beneficial effect on the α -tocopherol level and total antioxidant activity near parturition and continuation with 1,000 IU/day starting 30-60 days of lactation improved reproductive efficiency of buffaloes after calving. Bourne *et al.* (2008) reported that vitamin E @ 680 IU supplementation during prepartum in dairy cow decreased the incidence of retained fetal membrane and they also concluded that synthetic vitamin E is more effective as compared to the natural compound. Bian *et al.* (2007) reported that in deficient (mean 1.2 μ g / mL) plasma β -carotene status of nonlactating Holstein-Friesian cows, vitamin A supplements 120000-200000 mg/ day/cow from 21 prepartum to 70 days postpartum significantly decreased the incidence of retention of placenta, mastitis and reduced the days from calving to heat. de Ondarza *et al.* (2009) reported the importance of supplementing β -carotene (425 mg/day/cow) in the diet of lactating multiparous Holstein cattle with normally low β -carotene (<3 μ g/mL) in serum. They also reported that the overall conception rate was unaffected by treatment, but after 105 days of supplementation, the pregnancy rate was 22 per

cent (treatments groups) compared to 11 per cent in control groups. Trojancanec *et al.* (2012) reported supplementation of β -carotene and vitamin A combination (Group1 received both 200 mg β -carotene and 50,000 IU vitamin A while group 2 received 200 mg β -carotene only) significantly increased the size of corpora lutea and progesterone level in serum as compared to the supplementation of β -carotene only. A significant positive correlation was found between the progesterone concentrations and the β -carotene levels at ovulation in the luteal phase. Khan *et al.* (2016) reported that progesterone concentration increased and the number of the follicles decreased, indicating quality of graffian follicles with the supplementation of vitamin E @ 3000 IU/head/day. The progesterone concentration and antioxidant markers were positively related to each other. Ahmed *et al.* (2017) added vitamin A @ 2,50,000 IU, vitamin E @ 100 IU and vitamin D @ 50 IU daily in water from 4 weeks prepartum to seven weeks postpartum. He revealed that the prevalence of subclinical endometritis minimized significantly on supplementation of AD₃E in treatment as compared to control group at 5 weeks (23.15 per cent and 38.46 per cent) and 7 weeks (9.8 per cent and 32.34 per cent), respectively. The AD₃E supplemented buffaloes had shorter days open (97.5 vs. 152.1) and higher pregnancy rate at 120th (50 vs. 44%) and 150th (75 vs. 56.33) days postpartum than the control ones. Khatti *et al.* (2017) recorded early first postpartum estrus ($P < 0.001$) and higher pregnancy rate ($P < 0.05$) in crossbred cows when supplemented with vitamin E (80 IU/kg DM) with Se and along with increased energy diets. Modi *et al.* (2018) supplemented vitamin E with Se and noticed higher mean serum progesterone in the treatment group than control before parturition.

Effect of supplementation of vitamin A and E on immunity: Supplementation of vitamin A

and E to animals are very important in maintaining the host defense mechanism, including antibody production, cell proliferation, cytokine production, prostaglandin metabolism and neutrophil functions. Vitamin E also modulates the prostaglandin synthesis because increase production of prostaglandin PGE₂, suppresses the T cell function. The killing ability of blood neutrophils has been associated with the concentration of α -tocopherol (Weiss *et al.*, 1994). Michal *et al.* (1994) reported that on daily supplementing 120,000 IU of vitamin A enhanced intracellular killing activity of neutrophils. LeBlanc *et al.* (2004) established a correlation between peripartum concentrations of α -tocopherol, β -carotene and retinol in the serum and their relation with disease exposure. He *et al.* (2007) showed that supplemental β -carotene (control diet plus 150,000 IU vitamin A/cow/day), or a control diet plus 300 or 600 mg β -carotene/ cow/day) increased vitamin A concentration and β -carotene in plasma, and also enhanced the proliferation of lymphocyte. Jin *et al.* (2014) supplemented vitamin A to Holstein cows during mid-lactation (control: 110 IU/kg body weight or vitamin A: 220 IU per kg of body weight) and indicated that supplementation with 220 IU of vitamin A/kg of body weight significantly increased the concentrations of IgA, IgM, IgG, interleukin-1(IL-1), tumor necrosis factor- α (TNF- α) and soluble CD4; selenoprotein phosphorus content; the activities of glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase; total antioxidant (TA) capacity. Khan *et al.* (2016) reported that on supplementing vitamin E @3000 IU/head/day to cows the stress markers (serum cortisol, plasma malonaldehyde) and heat shock protein (HSP-70) reduced significantly. Ahmed *et al.* (2017) added vitamin A @2,50,000 IU, vitamin E @100IU and vitamin D @ 50 IU to 24 pluriparous pregnant 4 weeks' prepartum Egyptian

buffaloes and revealed that serum SOD and NO significantly increased and then decreased, respectively at 7 weeks in the supplemented group. The PMN per cent was significantly correlated with the stress markers enzymes at 5 weeks and 7 weeks. The vaginal score, percentage of polymorphonuclear cells and the neutrophils number were significantly increased in the control group than the AD₃E supplemented group. The prevalence of subclinical endometritis significantly reduced in supplemented group than to control group at 5 weeks (23.2 per cent and 38.5 per cent) and 7 weeks (9.8 per cent and 32.3 per cent), respectively. Increasing dietary energy along with vitamin E (80 IU/Kg DM) and Se, increases the immunity function in dairy crossbred cows (Khatti *et al.*, 2017). Modi *et al.* (2020) reported the overall pooled mean of cortisol level was significantly ($P<0.05$) lower in the pregnant group as compared to non-pregnant groups of buffaloes when supplemented vitamin E with Se. Cortisol level considered as a stress indicator and influence the immunity.

Supplementation of vitamin A and E and immunity status of neonatal calves: The main antioxidant vitamins are vitamins A and E. Since calves are born with the inadequate status of β -carotene, retinol and α -tocopherol, supplementation of these vitamins improve calves' immunity by protecting membrane integrity from free radicals and also improve immunity by influencing cell-mediated immune response and humoral immune response because lymphocytes are more susceptible to oxidative damage due to high free fatty acids in their membrane. Jukola *et al.* (1996) confirmed that 3.0 μ g/mL of β -carotene is necessary at parturition for immunity in the dairy animals. Supplementation of optimum/ higher vitamin E and β -carotene to periparturient cows may be required to maintain the desired vitamins levels around parturition.

Supplementation of vitamins in the pregnant animals will not only enhance the udder health and immunity of animals but will also increase the vitamins carryover in colostrum and milk which will be beneficial for the neonatal calves. Rajeesh *et al.* (2008) had taken five Murrah buffalo calves in each group and fed either control or supplemented with 300 IU and 600 IU of DL- α -tocopheryl acetate/day, respectively. Retinol concentration ($\mu\text{g/mL}$) in the serum of 3 groups of calves was statistically similar whereas the cumulative means of groups serum of α -tocopherol concentration ($\mu\text{g/dL}$) was significantly increased in vitamin E supplemented groups as compared to control group. Weiss *et al.* (2009) used cows from 14 days before the calving date and started supplementing vitamin E @2500 IU/cow/day until 14 days after parturition. The concentrations of plasma α -tocopherol in colostrum, in milk, and neutrophils numbers were highest in the treatment group and lowest in the control group. On supplementing the β -carotene with diet (1 g /cow/day) in the dry period in dairy cows did not influence the

concentrations of various metabolic hormone and different enzyme activities in newly born calves with increased β -carotene concentrations in mother blood and colostrum but was unable to increase colostrum IgG was reported by Kaewlamun *et al.* (2012).

Conclusion

From the recent studies, it is proved that supplementation of the vitamin A and E at different levels during the periparturient period is helpful to increase the total solids and immunoglobulin concentrations of colostrum with the improvement of milk fat and total solids percentage, with the increase in FCM production. Higher β -carotene and vitamin E concentrations are not only in calves but also in dams are helpful to increase the reproductive performance in animals with lower incidences of different reproductive disorders. Vitamin A and vitamin E supplementation also increase the immunity in dams as well as in calves, but more research should be conducted on the immunity and reproductive performance of cattle and buffaloes.

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