Review Article

Haryana Vet. (April, 2019) 58 (S.I.), 25-30

# ROLE OF NUTRITIONAL MANAGEMENT ON REPRODUCTIVE EFFICIENCY IN DAIRY ANIMALS

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Received : 26.02.2019; Accepted : 26.03.2019

## ABSTRACT

The key to getting dairy animals to milk to their genetic potential and to getting them bred back is to provide them with a well balanced diet composed of quality forages, supplement, and a mineral and vitamin mix. There should be a well-planned feeding and management schedule, specially for the transition period (last phase of gestation and ensuing lactation) because improper feeding (under or over) during this phase could lead to low birth weight of newborn calf, postpartum estrus and obviously low productive performance of dairy animals. Low intake of energy and protein during late lactation and early dry periods adversely affects feto-placental development, leading to low birth weight, neonatal weakness and retention of foetal membranes. Strong evidence suggests that management of cows during the pre-partum period affects uterine health. Strategic nutritional management during transition period may improve ovulation and during pregnancy may improve calving performance and improve postpartum reproductive efficiency of the dam. Improving energy balance by increasing energy intake through additional non-fiber carbohydrates or supplemental fat in the diet reduces days to first ovulation and improves conception postpartum.

**Key words:** Animals, Dairy, Efficiency, Management, Nutritional, Reproductive

Reproductive efficiency in dairy animals is measured mostly in terms of early attainment of sexual maturity and number of calves delivered during her entire life span. Under ideal management and feeding conditions the heifers should reach sexual maturity at an early age of 2.5- 3.0 years. The first calf should be produced early and subsequently at every 12 to 14 months interval. The productive and reproductive performances of the dairy animals are much lower than the desired optimal level. Feeding on poor quality roughages with imbalanced supplementation is the major reason for poor reproductive and production performance of dairy animals (Qureshi *et al.,* 2002). Requirements for pregnancy represent nutrients necessary to support both growth and maintenance of foetus, placenta, uterus and mammary gland. It was reported that due to decreased feed intake around parturition there is increased risk for uterine diseases in dairy cattle as animal receives less nutrients (Hammon *et al.,* 2006; Huzzey *et al.,* 2007). During early lactation, the demand for nutrients to support maintenance and milk production is given the highest priority. Thus, reproduction takes a "back seat" until these demands for nutrients are met. The key to getting cows to milk to their genetic potential and to getting them bred back is to provide them with a well balanced diet composed of quality forages, supplement, and a mineral and vitamin mix. In rural areas most of animals are reared under grazing, cereal straws (wheat/paddy) supplemented with unbalanced supplements, some time green fodder and occasionally balanced concentrate are feed. Rather, there should be a well-planned feeding and management schedule, for the transition period (last phase of gestation and ensuing lactation). Improper feeding (under or over) during this phase could lead to low birth weight of newborn calf, postpartum estrus and obviously low productive performance of dairy animals (Qureshi, 1995).

## ROLE OF NUTRIENTS ON REPRODUCTION

### *Energy*

Energy is the most common nutrient limiting reproduction. During early lactation, the peak in feed intake lags behind the peak in milk production. Milk production usually peaks approximately six weeks into lactation, whereas feed intake peaks four weeks later at ten weeks after calving. During this ten-week period, the cow is in a negative energy balance. To meet their energy needs, cows rely on their body stores of fat. Dairy animals gaining weight during early lactation have a higher conception rate and need less service per conception compared to those losing weight. Dairy animals that lose an excessive amount of body condition or fat stores during early lactation have longer intervals to first ovulation and first estrus (heat period), lower first service conception rates and more days open (Ojha *et al.,* 2017). There was a tendency for high energy dense diets to decrease non-esterified fatty acids (NEFA) concentration which suggests a reduction in body fat mobilization (Rabelo *et al*., 2005). Ojha *et al.* (2013) reported that feeding high energy dense diets pre-partum increases total pre-partum dry matter intake (DMI). Improvements in a cow's energy balance may be an important signal to the ovaries to start cycling. Cows may start cycling when they are still in negative energy balance but are starting to return to a positive value. When cows experience negative balance, the blood concentrations of NEFA increase, at the same time that insulin-like growth factor-I (IGF-I), glucose and insulin are low. These shifts in blood metabolites and hormones might compromise ovarian function and fertility. It has also been reported that

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energy balance and DMI might affect plasma concentrations of progesterone (Vasconcelos *et al.*, 2003; Villa-Godoy *et al*., 1988), which may interfere with follicle development and maintenance of pregnancy. Preliminary results from research trials indicate that energy balance may also influence developing ova .

Heifers that are not fed adequate amounts of energy reach sexual maturity later. Dairy heifers reach sexual maturity when they are 30-40% of their adult weight. Heifers which are overfed will reach adequate weight at an early age but will lack sufficient bone growth, especially in the pelvic area, which increases calving difficulty. Excessive weight gain is more harmful to heifers before they reach puberty than after they are bred. Overfeeding heifers before puberty (before nine months of age) can cause heifers to store excessive fat tissue in the developing udder and decrease the amount of milk-producing tissue. So, during the last trimester adequate energy and protein should be provided whilst avoiding overfeeding in heifers to prevent foetal oversize, excess adipose deposition in the birth canal and resultant dystocia (Dimitrov *et al.,* 2000).

***Protein***

Protein deficiencies in lactating cows may increase the incidence of silent heats (cow releases the egg but she is not seen in heat) and lower conception rates while at the same time decreasing feed intake and milk production. Cows which are deficient in protein increase milk production within a couple of days when additional protein is added to the diet. Heifers that are raised on a protein-deficient diet lack the skeletal growth in relation to their size, especially in the pelvic area. These heifers are older when they start cycling, have more difficulty calving, and may not milk as well once they enter the milking herd. Sasser *et al*. (1988) found that a deficiency of crude protein reduces pre- and post-partum weight gains, decreased the percentage of heifers showing estrus by 110 days after calving (89 vs 63%), decreased the first service conception rate (71% vs 25%), and increased the post-partum estrus interval (75 vs 86 days) in beef heifers. Excesses of protein (CP 17-20% of diet) have been implicated in lowering conception rates with increases seen in the number of services per conception and days open (Thatcher *et al.,* 2001).

When an excess of degradable protein and/or a deficiency of energy is fed, ammonia not incorporated into microbial protein is absorbed into the blood stream. In turn, this excess ammonia and urea in the blood stream may decrease fertility at the same time energy is diverted away from milk production and/or reproduction. The excess degradable protein acts through some undefined mechanism to decrease uterine pH during the luteal phase, which may play a role in the observed reduction of fertility (Elrod and Butler, 1993). Some studies have indicated that blood urea nitrogen (BUN) above 20 mg/ 100 ml may decrease the chances of pregnancy (Raboisson *et al.,* 2017). Zhang *et al.* (2002) reported that low intake of energy and protein during late lactation and early dry periods adversely affects feto-placental development, leading to neonatal weakness and retention of foetal membranes (RFM). RFM delay uterine involution, predispose cows to endometritis or metritis and decrease fertility (Maizon *et al.,* 2004). Thus, maintenance of normal uterine physiology by good nutritional management during the dry and transition periods is important to reduce the incidence of RFM, which is an important risk factor for endometritis.

***Calcium***

Low calcium level has been reported in anoestrus heifers. It is stated that GnRH stimulation of LH released from pituitary cells is calcium dependent and the LH is not released in absence of certain level of circulatory calcium or in the presence of calcium blocking agent (Stojilković *et al.* 1989). Reduced blood Ca may delay uterine involution and increases the incidence of dystocia, retained placenta and prolapsed uterus. Excess Ca may impair reproductive function by causing secondary deficiency of P, Mg, Zn, Cu and other trace elements. Cows diagnosed with clinical hypocalcemia were 3.2 times more likely to experience retained placenta than cows that did not have clinical hypocalcemia (Curtis *et al.,* 1983). Whiteford and Sheldon (2005) also found that hypocalcemia was associated with occurrence of uterine disease in lactating dairy cows. Both retained placenta and metritis can have devastating effects on reproductive efficiency in lactating dairy cows, with reduced conception rates and extended intervals to pregnancy (Goshen and Shpiegel, 2006).

***Phosphorus***

Phosphorus deficiencies decrease fertility, feed intake, and milk production. Most of the effect of phosphorus on reproduction is secondary to enzyme deficiency as it plays an important role in energy metabolism. However, even a marginal deficiency of Phosphorus has a direct adverse effect on pituitary ovarian axis causing failure of onset of estrus.

## STRATEGIES FOR IMPROVING REPRODUCTIVE EFFICIENCY

***Effect of concentrate supplementation***

Supplementation through balanced concentrate mixture has been proven to be one of the easiest and economic ways to increase intake, digestion and performance of animals fed cereal crop residue/poor quality roughage based diet. Ojha *et al.* (2017) observed significantly improved lactation performance in strategically concentrate supplemented buffaloes during pre-partum than non-supplemented buffaloes.

The effect of supplementary feeding on animal performance has been reviewed earlier by many authors. However, most of them did not include any reproduction parameter. Supplementary feeding also increases the plane

of nutrition which favorably influences reproductive function. In case of supplementary feeding a practical feeding situation is considered as standard. The response of supplementation is measured in terms of improvement in performance over the control. Supplementary concentrates may manifest their influence either through:

a) Increase in general nutritional status and improved body condition scores (BCS), which may shorten the onset of puberty and post-partum anoestrus.

b) Strategic supplementation before mating (flushing) may improve ovulation and during pregnancy may improve calving performance and improve post partum reproductive efficiency of the dam.

Ojha *et al.* (2013) reported that BCS of buffaloes appreciably increased by strategic supplementation of concentrate during prepartum period. Supplementation of paddy straw based diet with as low as 1 kg of homemade concentrate mixture reduced the anoestrus problem from 52 to 26 % (Ramakrishna, 1997). In a similar study conducted in other tropical developing country (Kanjonpruthipong and Buatong, 2002) indicated that 100 % of the cows become cyclic in response to supplementation in comparison to only 54 % of a control un-supplemented group. Ojha *et al.* (2015) also reported higher birth weight in calves of strategically concentrate supplemented buffaloes during 2 month before calving (pre-partum). These studies clearly imply that reproductive disorders as observed in cattle fed on poor quality roughages can be ameliorated by supplementation.

***Effect of oil seed cakes/meals***

Oilseed meals are probably the most widely used supplement for straw based ration. These supplements may be divided into 2 categories (highly degradable and low degradable) depending upon their degradation characteristics and they may act differently to influence reproductive performance. Providing soybean meal for 14 days before and 2 days after mating increased the fecundity by 0.5 lambs/ewe. Excess of dietary rumen degradable protein (RDP) was reported to impair conception rate, when RDP was given in the form of soybean meal or urea (Bishonga *et al.,* 1994). Dietary fishmeal improved pregnancy rate from 32 to 41 % (Burke *et al.,* 1997), however, other studies conducted on similar line showed no advantage of adding fishmeal over soybean meal in dairy cows (Carroll *et al.,* 1994). Similarly, liberal provision of RDP in the form of soybean meal was found to stimulate follicle recruitment, resulting in earlier ovulation, when compared with a less degradable source of protein, corn gluten meal.

***Supplementation with fat***

Feeding of supplementary fat is being practiced by farmers, particularly for high yielding cows/buffaloes to maintain milk production and body condition. However, this may have some positive bearing on the reproductive performance of the cow. Fat supplemented cows had shorter interval between calvings (McNamara *et al,* 2003). An improvement of conception rate at first service to the tune of 13 to 17 % was observed when the cows were fed with supplemental fat (Garcia-Bojallil *et al.,* 1998; McNamara *et al.,* 2003). Supplementary feeding of fat has been associated with shortening of anovulatory period post partum (Beam and Butler, 1997). If the supplementation of fat fails to increase the DMI along with the increased milk production, then the cows are likely to be more prone to negative energy balance. In such situation, the response to supplementary fat on reproductive performance may not be observed (Erickson *et al.,* 1992), the effective way is to fed fat in ruminally inert form usually as Ca-salt of long chain fatty acids (Moallem *et al.,* 1997; Spicer *et al.,*, 1993), usually maximum response has been observed with those supplements like rice bran (Fries et al, 1998) or rice bran oil (Sajipaul *et al.,* 2001) containing higher proportion of oleic acid or linoleic acid (Thomas *et al.,* 1997).

Supplemental fat fed during the early postpartum period enhanced induced luteal function by reducing the incidence of short cycles. Mechanisms associated with the enhancement of mean serum progesterone concentrations in cyclic cattle, and the prolongation of corpora lutea destined to be short-lived, have not been definitively determined. However, the enhancement of luteal lifespan may be related to the ability of fat supplementation to modify growth and physiology of the preovulatory follicle before ovulation (Wehrman *et al.,* 1991; Ryan *et al.,* 1992). This phenomenon could also be related to the effects of linoleic acid on uterine prostaglandin synthesis. Effects observed on serum progesterone during normal cycles may involve a decrease in metabolic half-life of progesterone in plasma or increased availability of cholesteryl esters in luteal cells (Hawkins *et al.,* 1995). Based on dose-response studies of luteal cells to nonesterified cholesterol (Carrol *et al.,* 1992), it is possible that the supply of HDL-cholesterol within the ovary can be marginally limiting under conditions of extreme nutritional restriction (Ryan *et al.,* 1994). Fat supplementation affects follicular growth dynamics in cattle by increasing the number of follicles in the medium-sized classification by 1.5 to 5 fold. Shelke *et al.* (2011) reported that rumen protected fat (@ 2.5% of DMI) and protein (formaldehyde treated cakes) supplementation 60 days pre-partum, increased the calf birth weight and decreased the incidence of RFM and premature births due to higher TDN intake.

***Strategic supplementation***

Ojha *et al.* (2013) reported decreased incidence of RFM in strategically supplemented buffalo during prepartum. Ojha *et al.* (2017) reported that overall reproductive performance of buffaloes was better in supplemented group during pre- and post-partum than non-supplemented buffaloes. Strategic supplementation of pregnancy allowance during the last month of gestation may be adopted to economize goat production and to minimize reproductive wastage (Rastogi *et al.,* 2006).

They further reported that optimum period for pregnancy allowance supplementation may depend on intrauterine growth pattern of goat breed; the last month of pregnancy appears to be the most nutritionally sensitive period of gestation for non-descriptive goats found in northern plains of India. Supplementation of 150 g of groundnut cake 3 days during mating and through 45 days pre-partum decreased the weight change (-3.4 kg vs -0.7 kg), increased lambing rate (41.7 vs 91.7%) and lamb birth weight (3.5 vs 3.9 kg) of ewes grazing on tropical pasture (El-Hag *et al.,* 1998).

Strategic feeding of urea treated straw (TS) to buffaloes during late pregnancy significantly increased the birth weight of their calves (Sharma *et al*., 2004). Feeding of TS during lactation significantly ($P<0.05$) improved total dry matter intake. The buffaloes given TS consumed 24% more straw as compared to their counterparts in the control group. The buffaloes fed TS produced 57% more milk than these fed untreated straw without any apparent loss in body condition. Improvement of straw intake after urea treatment has been well established and may vary widely depending on straw quality and treatment conditions, and it would be mainly induced by the reduction in rumen load caused by increasing both rumen degradability and rate of passage (Castrillo *et al.,* 1994) due to better availability and utilization of nutrients (nitrogen, cellulose and hemicellulose) by rumen.

**Effect of green fodder supplementation**

Green fodder supplementation is one of the most efficient economic and farmers' friendly mean to increase intake, digestion and performance of ruminants fed poor quality roughages. Nevertheless most of such experiments did not include any reproductive parameters. Supplementation of rice straw plus Napier based diet with a mixture of legumes at the rate of 20 % of total diet DM decreased the post-partum anoestrus of Ongole cows from 115 to 67 days. Supplying 20% of DCP through berseem increased the cyclicity from 25 to 50%. Similarly supplementation of oat chaff based ration with lapin increased both proportion of animals ovulated and multiple ovulation (Pearse *et al.,* 1994). Increasing the proportion of *Dolicbos lablab* from 30 to 50% increased the kid birth weight (1.9 to 2.4 kg) and kid growth rate (21.9 to 49.0 g/d) in goats fed maize stover based diet (Makembe and Ndlovu, 1996). Supplementation with as low as 2-3 kg green grass to cows fed on paddy straw and grazing reduced incidence of anoestrus from 52 to 31%.

***Supplementation of area specific mineral mixture (ASMM)***

The efficacy of a supplemental mineral mixture on reproductive efficiency was assessed by Selvaraju *et al.* (2009) and they found that supplementation of the ASMM improved reproductive performance in crossbred dairy cattle. Out of the 110 crossbred dairy cattle examined, 73 were had reproductive problems such as postpartum anestrous and repeat breeding (28% each), followed by delayed puberty (21%), silent heat (10%), infectious endometritis of mild to moderate degree (10%) and cystic ovary (3%). Among the postpartum anestrous animals, 84.21 and 85.71% exhibited estrus and conceived, respectively, within 2 months of ASMM supplementation. Among the repeat breeders, which received the ASMM, 78.6% conceived within 2 inseminations. Onset of estrus occurred in 66.7% of the delayed pubertal animals, which received the ASMM supplementation. Among the silent heat animals, 66.7% conceived within 3 months of the ASMM supplementation. Similarly, effect of supplementation of deficient minerals (Ca, P, Cu, Zn and Mn) through area specific mineral mixture (ASMM) was studied in Chittoor district of Andhra Pradesh (Devasenat *et al.,* 2010). They reported that among the animals under study, 60% of anoestrous cows, 62% of repeat breeders' cows and 59% of anoestrous heifers responded to supplementation, indicating the beneficial effect of mineral supplementation on their reproductive performance. Supplementation of wheat straw based diets either with mineral supplement (@ 40-50 g/d) or both protein and area specific mineral supplement improved the reproductive performance of anoestrus buffaloes (AICRP, 2010).

## CONCLUSION

Inadequate intake of nutrients and inadequate body reserves during early lactation are the major factors affecting reproductive performance of dairy animals. Improving energy balance by increasing energy intake through additional non-fiber carbohydrates or supplemental fat in the diet reduces days to first ovulation and improves conception postpartum. Prepartum strategic feeding may ensure postpartum production and health of the dairy animals. So for proper reproductive efficiency of the dairy animal the balance feeding of critical nutrients during the transition period is an important key.

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