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Review Article

Advancements in Management Practices from Far-off Dry Period to Initial Lactation Period for Improved Production, Reproduction and Health Performances in Dairy Animals: A Review

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Abstract

There has been a great research interest in the scientific community for managing the dry and initial lactation period of dairy animals in a strategic manner to achieve desired results. Considerable advancement has been achieved in the field of transition management of dairy animals however; a series of innovative studies are being carried out in this field. The scope of achieving improved lactation performances coupled with improved reproduction, health and behavioral activities of dairy animals is the prime reason for such an extensive interest in this field. There is a dramatic change in the physiological and metabolic profile of animals when they enter into a transition period and prepare themselves for a producing state from a non-producing state. This period is exposed to potentially health, production and reproduction related problems as this period is remarked with immuno-supression. Tremendous decrease in the dry matter intake has been found in transition period leading to further health, production and reproduction related issues. Therefore, it is a continuous and challenging task for the herdsman to properly manage the dairy animals during transition period in order to obtain desired results with minimum health and economic loss. Recent studies suggested that nutritional management, improving immune status, increasing comfort to maintain proper energy levels in dairy animals would help in achieving this target. This review focuses on the recent advances in the existing management practices of dairy animals during transition period.

Keywords: Dairy Animals, Health, Management, Production, Reproduction, Transition Period

Introduction

Improved milk yield, milk quality, udder health, and proper body condition and reproductive performances of dairy animals are the key to success for every dairy farm (Kansal *et al.*, 2020; Singh *et al.*, 2020a). Adoption of advanced management practices leads to the improved milk yield and milk quality, udder health, proper body condition and reproductive performances of dairy animals (Kumari *et al.*, 2019; Kumari *et al.*, 2020; Singh *et al.*, 2020b).Transition period management has a far reaching effect on the production, reproduction and health of dairy animals during ensuing lactation performances (McArt *et al.*, 2013; Roche *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020). Therefore, its proper management becomes important for dairy animals. Transition period has been remarked with tremendously reduced dry matter intake thereby the supply of essential nutrients to animal body is compromised and there becomes a gap in demand and supply of nutrient energy to the animals' body. This condition has been named as the state of negative energy balance (nEBL) (Drackley, 1999; Dann *et al.*, 2005; Beever, 2006). nEBL conditions in dairy animals are remarked with a depression in immunity status of dairy animals (McArt *et al.*, 2013; Roche *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020) as a result of which dairy animals become susceptible to several metabolic and physiological health problems (Overton and Waldron, 2004; McArt *et al.*, 2013; Roche *et al.*, 2013; Drackley and Cardoso, 2014; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020).

Recent researches have suggested that proper assessment of energy balance in dairy animals through blood metabolites, body condition scoring, behavioral changes offers a scope to take preventive and curative actions, if needed (Overton and Waldron, 2004; McArt *et al.*, 2013; Roche *et al.*, 2013; Drackley and Cardoso, 2014; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020). Reducing negative energy balance to a minimum stage is the main aim of transition dairy animal management (Overton and Waldron, 2004; Ospina *et al.*, 2010; Chapinal *et al.*, 2011; Chapinal *et al.*, 2012; McArt *et al.*, 2013; Roche *et al.*, 2013; Drackley and Cardoso, 2014; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020). Improvement in nutritional strategies such as feeding ion balanced salts, feed additives, and supplements during transition period with proper fiber and energy density regimes have shown impressive and beneficial consequences in dairy animals for different performances (Ryan *et al.*, 2003; Berry *et al.*, 2007; Drackley and Cardoso, 2014; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020). Moreover, different studies have suggested that increasing comfort level through proper housing, positive handling of dairy animals during peri-partum period enhances their emotional status and reduces their stress levels (Green and Mellor, 2011; Mellor, 2012; Rizvi *et al.*, 2016; Lecorps *et al.*, 2019; Singh et al., 2020c; Singh *et al.*, 2020d). Positive emotional helps them to prepare them for ensuing parturition (Yalcin *et al.*, 2014; Rizvi *et al.*, 2016; Weary *et al.*, 2017; Lecorps *et al.*, 2019). The above-mentioned practices help in improving dry matter intake of animals. However, DARE-ICAR, 2014 (DARE-ICAR, Annual Report, 2013-14) report suggest that there is a huge shortage in the supply of good quality feeds and fodder in India as well as other countries that practice dairy husbandry. In this scenario the rising cost of feeds and fodders becomes a tough task for a herdsman to run his dairy farm economically. In addition to it, disease expenses negatively affect the economics of a dairy farm. Nevertheless, recent management techniques (Ryan *et al.*, 2003; Berry *et al.*, 2007; Roche *et al.*, 2013; Drackley and Cardoso, 2014; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020) have shown that reducing concentrate (i.e., energy dense) feed during far-off dry period improves production, reproduction and health performances of dairy animals which may also improve the economics of large dairy farms as well.

Recent studies have shown remarkable advancement in the field of transition management of dairy animals which needs to be addressed to scientific community of animal science. Therefore, this review has been framed to cover the recent and important studies done in the field of transition dairy animal management for achieving improved production, reproduction and health.

Methodology of Review

This review encompasses important and rich sources of research and review articles published in different reputed journals respectively. Most of the literature findings were done in the National Library in Dairying, Karnal present in the premises of ICAR- National Dairy Research Institute, Karnal, India. Several online platforms such as Google Scholar, Research Gate, ProQuest, EBSCO, etc. were referred to find the related study articles. Reputed journal publishing houses such as Indian Journals, Springer Nature, Elsevier, Willey Online, Sage Publishing, Taylor and Francis, etc. were readily referred to bring out this review article. This review contains important articles from the year 1976 with having a cap on year 2020. Most of the articles were referred in details however, conclusion-based knowledge has been presented in this article for clearer and cohesive understanding for the readers. The aim of this review was not to discuss ailments that occurs during transition period in detail, rather to give a detailed outline of management strategies to combat such losses.

Corporal and Metabolic Changes during the Transition Period

Dry Matter Intake

Dry matter intake (DMI) is highly associated with physiological and metabolic status of dairy animals (Ryan *et al.*, 2003; Beever, 2006; Berry *et al.*, 2007; Drackley and Cardoso, 2014; Singh *et al.*, 2020a). A common pattern of depression in DMI leads to a gap in nutrient energy demanded and supplied to the body of dairy animals and this situation is termed as negative energy balance (Figure 1) in dairy animals (Ryan *et al.*, 2003; Beever, 2006; Berry *et al.*, 2007; Drackley and Cardoso, 2014; Singh *et al.*, 2020a; Soulat *et al.*, 2020). DMI during transition period in dairy animals is strongly associated with production, reproduction, and health performances of dairy animals during initial and overall lactation period (Busato *et al.*, 2002; Ryan *et al.*, 2003; Beever, 2006; Berry *et al.*, 2007; McArt *et al.*, 2013; Drackley and Cardoso, 2014; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020). DMI gets decreasing during close up period and least DMI by dairy animals occurs near calving period (Ingvartsen and Andersen, 2000; Drackley and Cardoso, 2014). Hence, management strategies for transition period of dairy animals should be framed to improve DMI in dairy animals for desired production, reproduction, and health performances of dairy animals during initial and overall lactation period (McArt *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020a).

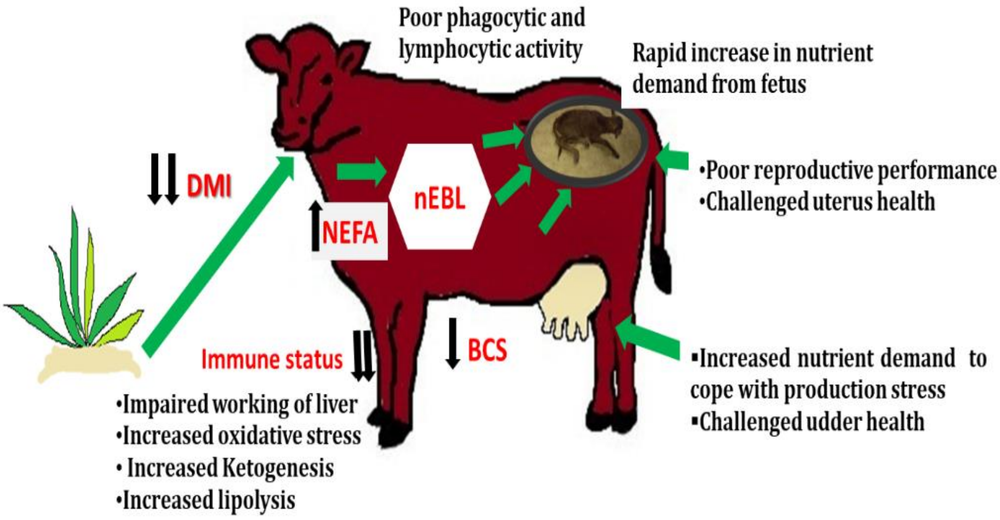

Figure 1: Diagrammatic representation of major changes during transition period in dairy cattle in negative energy balance

Metabolic Status of the Transition Cow

For more than four centuries the strategies for achieving improved metabolic profile in dairy animals had been a centre of focus for most of the dairy owners. In some latest and detailed reviews about the metabolic profile of dairy animals (LeBlanc, 2010; Van Saun, 2016), different blood constituents such NEFA (non-esterified fatty acids), BHBA (beta-Hydroxybutyrate), Aspartate-aminotransferase, Albumin, Calcium, Phosphorus, Potassium, Chloride, Glucose, Cholesterol have been studied in detail to predict metabolic profile of dairy animals (Ospina *et al.*, 2010; LeBlanc, 2010; Chapinal *et al.*, 2011; Chapinal *et al.*, 2012; McArt *et al*., 2013; Van Saun, 2016). Their cut-off and changes in values are given in detail in some remarkable reviews (LeBlanc, 2010; Van Saun, 2016) so, in this review we are not going to discuss here further. Nevertheless, we aim at presenting overall view of changes during transition period and their management solutions. It has been observed in several studies that the changes the value of NEFA and BHBA, in particular, have been studied to represent overall energy status of dairy animals (LeBlanc, 2010; Chapinal *et al.*, 2011; Chapinal *et al.*, 2012; McArt *et al*., 2013; Van Saun, 2016). It has been stated that when NEFA level reaches ≥ 0.3 to 0.5 mEq/L there is depression in DMI and moreover, severe DMI may be observed if NEFA level reaches ≥0.5 mEq/L (LeBlanc, 2010; Van Saun, 2016). Hence, management strategies should focus on elevating DMI in dairy animals when blood NEFA concentrations enter in to the range ≥ 0.3 to 0.5 mEq/L. This elevated NEFA levels gradually decrease after a month of lactation with proper diet but, it may prolong for longer period also. Similar pattern of elevated BHBA concentrations near peripartum period occurs in dairy animals. Normal BHBA concentrations (0.5 to 0.75 mmol/L), generally is not observed with severe negative effects on DMI and health of dairy animals. However, when BHBA concentration escapes 1.0 mmol/L, a remarked loss of DMI and health loss is investigated (Ospina *et al.,* 2010; LeBlanc, 2010; Van Saun, 2016).

Blood Metabolites During Dry Period

The blood metabolites such as non-esterified fatty acids (NEFA and BHBA) have been generally used to reflect energy balance in dairy animals. It is a noticeable trend that NEFA concentrations get elevated during transition period of dairy animals (Ospina *et al.,* 2010). Elevated levels of NEFA during transition period have been corroborated with milk loss (Chapinal *et al.,* 2012). Highly elevated levels of NEFA shows improper management practices to manage negative energy balance in dairy animals (Herdt, 2000). Management practice should aim to reduce the elevated levels of blood NEFA during transition period to minimize the risks for health problems (Janovick *et al.*, 2011). Duffield *et al*. (2009) indicated that severe negative energy balance has been corroborated with milk yield. Recommended dry period for dairy animals is in between 45 to 60 days to allow dairy animals to replenish proper nutrition to the mammary glands to prepare for the ensuing lactation thereby reducing the increase in NEFA levels (Watters *et al.,* 2008). It becomes more important to provide dry period of 45 to 60 days for primiparous dairy animals as their mammary system is under developed at this stage to reduce further physiological and metabolic stress over them. The dairy animals that are overfed during far-off dry period had been associated with an elevated NEFA concentrations, and they lose more body weight during close-up period and initial lactation period (days in milk) (Dann *et al.,* 2005). DMI and blood NEFA concentrations follow an inverse association (Overton and Waldron, 2004). The recommended cut-off value of NEFA is ≥0.5 mEq/L for indicating a reduction in milk yield and more cases of displaced abomasums and other health related problems in dairy animals (Chapinal *et al*., 2011).

Depression in energy intake during transition period has been mentioned to increases NEFA (Douglas *et al*., 2006) moreover, limited feeding also reflected elevated NEFA levels (Busato *et al.,* 2002). In addition to it, an energy dense diet indicated reduced NEFA concentrations than in the case of energy density diet of moderate type fed to the dairy animals in dry period (Rabelo *et al*., 2005). However, few studies also indicated no effect of type of energy diet consumption in prepartum reflected by NEFA levels in overall dry period (Holtenius *et al.,* 2003; Guo *et al.,* 2007). It becomes important to monitor the freshly calved dairy animals carefully with NEFA levels ≥0.3 mEq/L or BCS higher as compared to that of mean BCS of the herd (McArt *et al.,* 2013). Singh *et al*. (2020a) observed that the dairy cows which were over-conditioned showed comparatively elevated NEFA concentration than that in the case of moderate BCS at calving moreover, those over-conditioned cows lost more BCS in early lactation period (Zahrazadeh *et al.,* 2018). Plasma glucose has been found to get reduced during post-partum period as compared to prepartum (3.62 vs. 2.69 mmol/L respectively) (Winkelman *et al.,* 2008). A study suggested that blood glucose remained unchanged with respect to change in NEFA concentrations (Moorby *et al*., 2000). Furthermore, Block *et al*. (2001) reported that plasma leptin content reduces during periparturient and initial lactation period. In addition to that, significantly higher NEFA and growth hormone (GH) levels and lower Insulin and glucose levels were reported. They also observed significantly positive correlations of plasma leptin with Insulin and glucose levels, however; significantly negative correlations of plasma leptin with NEFA and GH were investigated. They indicated that high producing cows may enter into further nEBL. Severe nEBL conditions may lead to production of more oxidative stress which may in turn damage cellular processes resulting in different metabolic diseases (Pedernera *et al*., 2010). More free radicals have been investigated in high producing cows (Pedernera *et al*., 2010).

Calving Related Disorders

Neglected and improper transition cow management invites many ailments and diseases in dairy animals. From management point of view, such health problems include milk fever; retained fetal membranes; abomasal disorder; ketosis and fatty liver; subclincal and clinical mastitis. These problems lead to huge milk, health and overall economic losses (Overton and Waldron, 2004; Ospina *et al.,* 2010; Chapinal *et al.,* 2012; LeBlanc, 2010; McArt *et al*., 2013; Van Saun, 2016). It has been observed that during severe nEBL cases as commonly seen in under or over-conditioned dairy animals these aforementioned health problems become more intense. Therefore, maintaining a normal energy balance in dairy animals become important to avoid such health and economic losses (Chapinal *et* *al.*, 2011; Chapinal *et al.*, 2012; McArt *et al.*, 2013; Van Saun, 2016; Singh *et al.*, 2020a).

Management Strategies During Transition Period for Improved Performances

Supplemental Fat during the Transition

Considerable amount of fat in the milk is produced by dairy animals and hence, the supplementation of fat in the diet of dairy animals in proper amounts may be practiced (Palmquist and Jenkins, 2017). Last two decades witnessed considerable interest in supplementing Conjugated Linoleic Acid (CLA) to dairy animals due to its beneficial effects on milk and other performances in dairy animals. Bernal-Santos *et al.* (2003) performed an experiment on different group animals on supplementation of CLA during transition and initial lactation period and observed that CLA supplementation did not affect DMI, or energy balance of dairy animals (Bernal-Santos *et al.,* 2003; Castaneda-Gutierrez *et al.,* 2005; Moallem *et al.,* 2010; Schlegel *et al.*, 2012). The reason may be that CLA supplementation spares energy towards enhanced milk production than for body gain. The results showed that milk yield, protein content did not change in supplemented group however, short and medium chained fatty acids decreased in milk fat. Hutchinson *et al.* (2012) in an experiment supplemented lipid-protected CLA to the dairy animals and found that milk yield was increased with decreased milk fat%, milk protein and milk lactose content. However, it was indicated that overall, total milk solids remained unchanged in both the groups. In addition to it, there was significantly no difference in reproductive efficiency and somatic cell counts in milk samples of both the groups. Chandler *et al.* (2017) recently conducted a comprehensive experiment on the supplementation of CLA during transition period to assess its impact on production and reproduction performances in multi-parous as well as primi-parous cows. The results of the study showed a increase in milk production with a decrease in milk fat% however, milk fat yield was same. This might had been due to fact that milk yield is inversely associated with milk fat% in case of CLA supplementation (Bernal-Santos *et al.,* 2003; Moallem *et al.,* 2010; Hutchinson *et al.,* 2012; Schlegel *et al.,* 2012). Chandler *et al.* (2017) found that reproductive efficiency was improved in primi-parous cows but, in multi-parous cows the reproductive performance was negatively affected. Lopreiato *et al*. (2020), in their recent review, recommended for n_6: n_3 poly-unsaturated fatty acids ratio to be in between 3.9 to 5.9 for proper immune functions in dairy animals.

Herbal Feed Additives During Transition Period

Impact of antibiotics and hormonal treatments in dairy animals during transition period has been studied in details (Ludri *et al.,* 1989; Singh and Ludri, 1994; Jyotsna and Singh, 2010; Singh *et al.*, 2012; Mullen *et al.*, 2014). However, studies showed that prolonged use of antibiotics and hormonal treatments in dairy animals for improving milk yield may have problems like antibiotic residues and hormonal imbalances thereby resulting in poor well-being of dairy animals (Grosvenor *et al.,* 1993; Singh and Dang, 2006). Hence, herbal feed supplementation came out as an important and useful alternative for antibiotics and hormonal treatments in dairy animals during transition period for improving milk performances, subclinical mastitis cases, with reduced negative energy balance in dairy animals. There are around 300 medicinal spices in the world (Krishna *et al.*, 2005; Pandey *et al.*, 2005; Singh *et al.*, 2012). Kumar *et al.* (2011) supplemented crossbred cows with *Asparagus racemosus* from 60 pre-partum period @ 100mg/kg live body weight and 200 mg/kg live body weight till 3 months postpartum period and observed that overall reproductive performance was improved. Improvement in first oestrus interval postpartum, service period (day) and services per conception, and rate of uterine involution was observed in crossbred cows. Study conducted by Singh *et al.* (2012) on Murrah buffaloes suggested that *Asparagus racemosus,* commonly known as Shatavari, has galactopoietic property (Krishna *et al.*, 2005; Pandey *et al.*, 2005; Singh *et al.*, 2012; Behera *et al.*, 2013; Singh, 2014) and its supplementation to Murrah buffaloes during transition period resulted in significant increase in plasma prolactin and cortisol concentrations along with a increase of milk 0.526 kg/animal/day without altering the total glucose, cholesterol, low-density lipoproteins, and NEFA in blood. Chandra *et al.* (2017) conducted a farm trial on poly-herbal mixture and butyric acid supplementation to Murrah buffaloes during transition period and found that there was a significant increase in the milk yield, fat corrected milk as well as total solids in milk. In addition to it, there was significantly lower somatic cell count (SCC) in the milk samples of supplemented animals. In a recent study (Mendoza *et al.,* 2018), it was found that the supplementation of herbal choline and methionine to dairy cows resulted in improved milk performance, decreased milk protein content without altering milk composition. Koujalagi *et al.* (2018) investigated that herbal biocholine supplementation resulted in improvement of oxidative stress and blood parameters in dairy cows. The results revealed that the supplemented groups showed significantly lower NEFA and BHBA levels suggesting comparatively better energy balance than non-supplemented group. In addition to above, there was significantly higher glutathione (GSH) and superoxidase dismutase (SOD) with reduced lipid per-oxidation levels were observed in the supplemented group. Barjibhe *et al.* (2019) found that on supplementation of mustard oil, poly-herbal mixture and butyric acid, there was similar results as Kumar *et al.* (2011) in which significantly overall improved reproductive efficiency was obtained in the supplemented groups during transition period in Sahiwal cows. In a latest study published in August, 2020 (Koujalagi *et al.*, 2020) it was found that Supplementation of transition dairy cows with herbal vitamin E and organic selenium complex was effective in reducing oxidative stress, SCC with improved quality and quantity of milk produced by supplemented dairy animals. Antioxidant enzymes viz. Glutathione (GSH), and Superoxide Dismutase (SOD) were increased in supplemented dairy animals with improved udder health and immunity.

Inferring the above discussion, it may be pertinent to remark that different types of herbal supplementation to the dairy animals during transition period has got beneficial effects on milk performance, milk quality, udder health, immunity status through reduced oxidative stress in dairy animals. The herbal supplementation during transition period in dairy animals has beneficial effects without the potential of harmful effects than that in the case of antibiotics or hormonal treatments.

Assessment of Body Condition of Dairy Animals

There is dramatic change in the energy status of dairy animals during transition period (Singh *et al.*, 2015; Singh and Kumari, 2019; Singh *et al.*, 2020a; Singh *et al.*, 2020e; Singh *et al.*, 2020b) which may be the potential cause for the alteration of immunity levels of dairy animals thereby altering the physiological and metabolic profile of dairy animals (Drackley, 1999; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Singh *et al.*, 2020e). Hence, assessment of the energy reserves in dairy animals becomes necessary practices in management strategies during transition period of dairy animals (Singh and Kumari, 2019; Singh *et al.*, 2020a; Singh *et al.*, 2020e). Dairy animals generally suffer a negative energy balance condition during transition period (Drackley, 1999; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Ryan *et al.*, 2003; Singh *et al.*, 2020e) where their normal physiological and metabolic activities are negatively affected (Dann *et al.*, 2005; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Ryan *et al.*, 2003; Singh *et al.*, 2020e). Negative energy balance has a drastically negative impact on milk performance, milk quality, oxidative stress, immunity levels, udder health and body condition maintenance of dairy animals (Ryan *et al.*, 2003; Dann *et al.*, 2005; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Roche *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020a). Severe negative energy balance condition in dairy animals may adversely affect the reproductive and health status of dairy animals (Ryan *et al.*, 2003; Overton and Waldron, 2004; Dann *et al.*, 2005; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Roche *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020) and thereby the performance of their progenies may also be affected due to improper fetal nutrition.

Body condition score (BCS) reflects the relative energy status of dairy animals through measuring fat deposition on specific body parts of animals (Drackley *et al.*, 2005; Valde *et al.*, 2007; Reis *et al.*, 2012; Drackley and Cardoso, 2014; Singh *et al.*, 2020a; Singh *et al.*, 2020f). This system of measuring energy status in dairy animals is simple, economic, non-invasive and applicable under field conditions method (Dann *et al.*, 2005; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Roch *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020a; Soulat *et al.*, 2020). It does not require establishment of high installation cost laboratories, sophisticated devices, scientists, and with a considerable experience a farmer may also perform this handy technique at their farms (Singh and Kumari, 2019). BCS measurement may be done on different scales (Reis *et al.*, 2012; Roch *et al.*, 2013; Roche *et al.*, 2016; Singh *et al.*, 2020e; Soulat *et al.*, 2020) to measure energy status of animals. Studies suggested that BCS has strong association with production, reproduction, and health parameters of animals (McNamara *et al.*, 2001; Drackley *et al.*, 2005; Valde *et al.*, 2007; Reis *et al.*, 2012; McArt *et al.*, 2013; Drackley and Cardoso, 2014; Singh *et al.*, 2020a; Singh *et al.*, 2020f). Recent interest of research in last decade seemed in this field to imply the management strategies to obtain optimum BCS during dry period, at calving, and initial lactation period to achieve improved milk performance, milk quality, oxidative stress, immunity levels, udder health and body condition maintenance of dairy animals (McNamara *et al.*, 2001; Drackley *et al.*, 2005; Valde *et al.*, 2007; Reis *et al.*, 2012; McArt *et al.*, 2013; Drackley and Cardoso, 2014; Singh *et al.*, 2020a; Singh *et al.*, 2020f). Recommended BCS range depends upon the scale of BCS utilized. In a recent study (Singh *et al.*, 2020a) it was suggested that BCS range of (3.5-4.5) at calving and dry period for Jersey crossbred cows reflected improved performances in a 1 to 6 scale where BCS 1 reflected emaciated and 6 BCS showed excess fat conditioned animals (Paul *et al.*, 2019; Singh *et al.*, 2020a). In many studies (Ryan *et al.*, 2003; Berry *et al.*, 2007; Drackley and Cardoso, 2014) a scale of 1 to 5 has been used wherein the suggested BCS range is 3 to 3.5 at calving and dry period in dairy animals for improved milk performance, milk quality, oxidative stress, immunity levels, udder health and body condition maintenance of dairy animals (McNamara *et al.,* 2001; Drackley *et al.,* 2005; Valde *et al.,* 2007; Reis *et al.,* 2012; McArt *et al.,* 2013; Drackley and Cardoso, 2014; Singh *et al.*, 2020a; Singh et al., 2020e). Both under and over-conditioning of dairy animals during dry period and at calving should be avoided as they have been corroborated with negative energy balance resulting in impaired milk performance, milk quality, oxidative stress, immunity levels, udder health and body condition maintenance of dairy animals (McNamara *et al.,* 2001; Drackley *et al.,* 2005; Valde *et al.,* 2007; Reis *et al.,* 2012; McArt *et al.,* 2013; Drackley and Cardoso, 2014; Singh *et al.,* 2020a; Singh *et al.*, 2020f; Soulat *et al.*, 2020; Singh *et al*., 2020g; Singh *et al*., 2020h). Special attention should be given to the primiparous animals to bring them in optimum BCS range as their body is not fully grown so there is comparatively more physiological and metabolic stress over them during transition period than that of multiparous animals. Any unwanted change in BCS of animals reflects improper nutritional management practices during different stages of lactation and following which the curative measures in nutritional and health management practices can be followed for desired results (McNamara *et al.*, 2001; Drackley *et al.*, 2005; Dann *et al.*, 2005; Beever, 2006; Butler, 2006; Berry *et al.*, 2007; Butler, 2009; Roch *et al.,* 2013; Roche *et al.,* 2016; Valde *et al.,* 2007; Reis *et al.,* 2012; McArt *et al.,* 2013; Drackley and Cardoso, 2014; Singh *et al.*, 2020a; Singh *et al.*, 2020e).

Supplementation of Essential Vitamins and Anti-oxidants

Vitamin E (Alpha tocopherol) deficiencies are frequently observed during the periparturient period **(**Smith *et al.*, 1997**)** which may be one of the important causes for mastitis (Kafilzadeh *et al.,* 2014; Moosavi *et al.,* 2014; Hoque *et al.*, 2016; Singh *et al*., 2020i; Singh *et al*., 2020j). Vitamin E and Zinc are suggested to be helpful in reducing the mastitis cases which occurs commonly during first week of lactation, through improved antioxidant function and keratinisation of the teat canal (Wilde, 2006). Vitamin E supplementation has been found to reduce the cases of mastitis, retained placenta, and reduced duration of clinical mastitis cases (Spears and Weiss, 2008).

It has been well documented that supplementation of Vitamin E during dry period have found to reduce the chances of mastitis when are supplemented with 1000 to 4000 IU per day during dry period in most of the research findings. Supplementation of Vitamin E at > 1000 IU/ day during the dry period of dairy cow was found to reduce the cases of mastitis (Weiss *et al.,* 1997). Also, it has been stated that doses higher than 9,000 IU of vitamin E per day, in diets may increase the fat content of cow's milk during lactation period (Pottier *et al.,* 2006). However, some studies suggest that Vitamin E supplementation had no significant effect on udder health (LeBlanc *et al.,* 2004). Vitamin E @ 1000 IU/ day/ cow supplemented at least 30 days prepartum to 30 days post-partum was found to reduce the incidence of mastitis and had beneficial effect on milk yield (Chatterjee *et al.,* 2003). Supplementation of Vitamin E positively affects the functioning of neutrophils and milk quality in organized herd (Politis *et al.,* 2004).

Furthermore, literatures show that 4000 IU Vitamin E supplementation during last 14 days of dry period was found to improve udder health (Politis *et al.,* 2004), supplementation of 3,000 IU of vitamin E 8 wk prepartum to 2 wk post- calving reduced oxidative damage to the liver (Bouwstra *et al.*, 2008) also, Politis *et al.* (2012) suggests that 3000 IU should be supplemented during late dry period of dairy cows. Alphatocopherol supplementation with 1000 IU 30 pre and 60 days post-partum period provided better milk performance with better udder health (Singh, 2019). Although some studies state converse results that the supplementation of Vitamin E was found to have no effect on milk yield, reproductive efficiency, or incidence of uterine infections, but, cows were seen to have reduced chances of culling and a reduces cases of mastitis (Bourne *et al.*, 2008).

It is a common note that Vitamin E enhances milk yield and udder health but it may also depends upon the un-availability or shortage of Vitamin E in diet of dairy cow. One study conducted by (Bouwstra *et al.,* 2010) suggests that when supplementation of Vitamin E, during dry period, was done with 3000 IU per day per cow, adverse results were seen leading to increase the udder problems. However, in one study Vitamin E supplementation was not found to alter the fatty acid profile of milk (Monica *et al.,* 2013).

Trace Elements for Dairy Animals During Transition Period

Zinc (Zn), selenium (Se), copper (Cu), iron (Fe), and manganese (Mn) have been considered as important trace elements whose supplementation during transition period may have improved performances in dairy animals (Surai, 2002; Surai and Dvorska, 2002; Surai *et al.,* 2003; Andrieu, 2008). Selenium has been suggested as one of important elements having role as an anti-oxidant (Spears, 2000; Andrieu, 2008). However, toxicity may occur when supplemented in more amounts. Zinc supplementation along with vitamin E during transition period shown positive results by reducing oxidative stress in dairy animals (Sobhanirad *et al.,* 2010; Griffiths *et al.,* 2007; Chandra *et al.,* 2013). Griffiths *et al.* (2007) conducted a detailed study on the supplementation of complexed zinc, manganese, copper and cobalt and found positive effects on lactation performances in dairy animals. Chromium in its one or other form has an important role in electron transport, iron absorption, melanin production and anti-oxidant activities (Surai, 2002; Andrieu, 2008). Iron has essential role in anti-oxidant, protein and energy metabolism, and electron transport (Andrieu, 2008). Copper has an additional role in cardiac functions in addition to metabolism, immune function, keratinization, and bone structuring. Manganese element has been also suggested to have similar effects as copper. It has been suggested that supplementation of zinc, copper, selenium has been found to reduce the cases of mastitis (Chatterjee *et al.,* 2003; Andrieu, 2008; Chandra *et al.,* 2013).

Feeding Regime During Dry Period for Improved Performances

Proper feeding regime for dairy animals offers a practical solution to control BCS of animals into a desired range for improved results consistently (Berry *et al.,* 2007; Butler, 2009; Roch *et al.,* 2013; Roche *et al.,* 2016; Valde *et al.,* 2007; Reis *et al.,* 2012; McArt *et al.,* 2013; Drackley and Cardoso, 2014; Singh *et al.,* 2020a). Free accessible and good quality water should be available all the times to dairy animals for drinking as it an indispensable nutrient and plays role in almost all life supporting body functions (Singh *et al.,* 2020b). Feeding high energy density diet during whole dry period continuously may not be helpful in achieving improved milk performance, milk quality, oxidative stress, immunity levels, udder health and body condition maintenance of dairy animals (Beever, 2006; Roche *et al.,* 2013; Roche *et al.,* 2016; Singh *et al.,* 2020e). Rather, it may negatively affect BCS of dairy animals and they may become over-conditioned resulting in poorer performances (Beever, 2006; Roche *et al.,* 2013; Roche *et al.,* 2016; Singh *et al.,* 2020 a). However, only high forage diet in whole dry period with lower energy density may also give negative impact on performance of dairy animals (Beever, 2006; Roche *et al.,* 2013; Roche *et al.,* 2016; Singh *et al.,* 2020a). Recent and detailed studies on feeding regimes for dairy animals required during dry period for improved resulted indicated that proper use of high forage diet and energy density through concentrates may be considered during different parts of dry period in dairy animals (Beever, 2006; Roche *et al.,* 2013; Roche *et al.,* 2016; Singh *et al.,* 2020a; Soulat *et al.,* 2020). Recent studies (Ryan *et al.,* 2003; Roche *et al.,* 2016; Singh *et al.,* 2020a; Soulat *et al.,* 2020) suggest that *ad libitum* good quality fodders with comparatively less energy density during far-off dry period (First 45 days of dry period) followed by *ad libitum* good quality fodders with comparatively more energy density diet during close-up dry period (last 15 days of dry period) improved milk performance, milk quality, oxidative stress, immunity levels, udder health, reproductive performance, and body condition maintenance of dairy animals (Ryan *et al.,* 2003; Roche *et al.,* 2016; Singh *et al.,* 2020a; Soulat *et al.,* 2020). Better BCS animals' alt calving was found to have better reproductive performances than that of under or over-conditioned dairy animals (Singh *et al.,* 2020a; Soulat *et al.,* 2020; Meier *et al.,* 2020). The results shown that there was improved DMI through above mentioned feeding regime thereby improving all performance parameters in dairy animals. The reason behind this may be explained as the animals' appetite gets satisfied when they consume high energy density diet continuously than consuming high forage diet during far-off period resulting in lower overall DMI. On the other hand, there is tremendous increase in the requirement of energy, and nutrients by the body of animals during close-up dry period to suffice the demand of advanced pregnancy stage close to the parturition stage and hence, comparatively energy dense diet during close-up than far-off dry period is required. The reduction and the increase in the energy density of the ration may be based on the BCS at drying-off stage in dairy animals. Therefore, the combination of high forage diet with low energy diet during far-off period coupled with high energy dense diet with *ad libitum* good quality fodders is recommended for improved milk performance, milk quality, oxidative stress, immunity levels, udder health, reproductive performance, and body condition maintenance of dairy animals (Berry *et al.,* 2007; Butler, 2009; Roch *et al.,* 2013; Roche *et al.,* 2016; Valde *et al.,* 2007; Reis *et al.,* 2012; McArt *et al.,* 2013; Drackley and Cardoso, 2014; Singh *et al.,* 2020a; Soulat *et al.,* 2020; Meier *et al.,* 2020).

Housing Management

Main aim of housing for animals is to provide overall comfort to the animals (Singh *et al.,* 2020 c). Recent studies have suggested that the average mean temperature at the Earth is increasing by more than 1 degree centigrade (IPCC, 2007; IPCC, 2018). In comparison to developed countries who have developed infrastructure to withstand devastating climatic effect as compared to that in the scenario of developing nations such as African and south-east

Asian nations are hugely depended upon climatic conditions for their livelihood will be more on the verge of devastating adverse effects of climate change and so to their dairy production (Singh *et al.*, 2020d). Proper housing management should consider the provision of controlled thermal humidity index (THI), ventilation, microbial load, gaseous concentrations for providing overall comfort to the dairy animals in order to support different physiological and metabolic activities in them (Singh *et al.*, 2020c; Singh *et al.*, 2020d; Mishra *et al.*, 2017). Comfortable range of THI is recommended to be 65 to 72 and beyond that some or other negative impact on different physiological and metabolic activities in dairy animals (Singh *et al.*, 2020d; Das *et al.*, 2016). THI more than 85 imposes a severe negative impact on all performance aspects of dairy animals (Singh *et al.*, 2020d; Das *et al.*, 2016). Different studies have suggested that prolonged high THI also leads to negative energy balance conditions in dairy animals (Singh *et al.*, 2020d; Das *et al.*, 2016; Becker and Stone, 2020) whereby severe reduction in DMI more than 30% may occur (Singh *et al.*, 2020d; Das *et al.*, 2016; Becker and Stone, 2020). This leads to impaired production, reproduction and health performances in dairy animals (Stott and Wiersma, 1976; Bernabucci *et al.*, 2014; Das *et al.*, 2016; Fournel *et al.*, 2017; Singh *et al.*, 2020d; Becker and Stone, 2020). Similarly, improper ventilation facilities would be more potentially causing high unwanted microbial and gaseous concentration inside animal barn may also severely and negative affect the performances in dairy animals (Stott and Wiersma, 1976; Hammami *et al.*, 2013; Bernabucci *et al.*, 2014; Das *et al.*, 2016; Fournel *et al.*, 2017; Tresoldi *et al.*, 2018; Singh *et al.*, 2020d; Becker and Stone, 2020). Housing enrichments such as utilization of shade, mechanical fans, air conditioning, water showers, foggers and misters, wallowing facilities may be helpful in ameliorating negative impact of high THI in dairy animals (Stott and Wiersma, 1976; Hammami *et al.*, 2013; Bernabucci *et al.*, 2014; Das *et al.*, 2016; Fournel *et al.*, 2017; Tresoldi *et al.*, 2018; Singh *et al.*, 2020d; Becker and Stone, 2020). Roof medications may be done to enhance micro-climate of animals such as thatched housing, white painted metallic roofs, insulated roofs, etc as per the economics and suitability of climatic conditions (Lacetera *et al.*, 1996; Aggarwal and Singh, 2008; Aggarwal and Upadhyay, 2013; Hammami *et al.*, 2013; Bernabucci *et al.*, 2014; Silanikove and Koluman, 2015; Das *et al.*, 2016; Fournel *et al.*, 2017; Narwaria *et al.*, 2017; Tresoldi *et al.*, 2018; Singh *et al.*, 2020d; Becker and Stone, 2020).

Furthermore, proper bedding materials become equally important as above-mentioned qualities of a good animal housing (Stott and Wiersma, 1976; Hammami *et al.*, 2013; Bernabucci *et al.*, 2014; Das *et al.*, 2016; Fournel *et al.*, 2017; Tresoldi *et al.*, 2018; Singh *et al.*, 2020d; Becker and Stone, 2020). In a recent and detailed review by Singh et al. (2020) it was indicated that good bedding improves overall performances of dairy animals through enhanced comfort levels. Good bedding may well be helpful in controlling environmental mastitis cases (Singh *et al.*, 2020c; Singh *et al.*, 2020d) thereby improving the quality of milk and udder health of dairy animals. Different bedding materials are suitable for different climatic conditions (Shane *et al.*, 2010; Reich *et al.*, 2010; Hooda and Singh, 2010; Hamzaoui *et al.*, 2012; Rhoads *et al.*, 2013; Rowbotham *et al.*, 2016; Chamberlain, 2018; Singh *et al.*, 2020c; Singh *et al.*, 2020d; Leso et al., 2020). However, the economics of using such bedding materials should also be considered (Chamberlain, 2018; Singh *et al*., 2020d; Singh *et al*., 2020e; Leso *et al.*, 2020). It is recommended that during transition period the advanced pregnant animals should be provided separate comfortable pens with cushioned bedding materials (Chamberlain, 2018; Singh *et al.*, 2020c; Singh *et al.*, 2020d; Leso *et al.*, 2020). Moreover, the bedding should promote proper grip to avoid even the minimum chances of slipping of dairy animals. Proper housing with bedding helps in proper display of their behavioral activities (von Keyserlingk *et al.*, 2013; Singh *et al.*, 2020c).

Handling of Dairy Animals

Handling of dairy animals should be gentle especially during transition period to avoid unwanted stress (von Keyserlingk *et al.*, 2013; Lecorps *et al.*, 2019). Recent studies have focused on studying emotions in dairy animals (von Keyserlingk *et al.*, 2013; Lecorps *et al.*, 2019). Positive handling avoids negative impact on animals' stress and during transition period it becomes more necessary (Denton *et al.*, 2009; Green and Mellor, 2011; Mellor, 2012; Rizvi *et al.*, 2016; Lecorps *et al.*, 2019). Abrupt and forceful negative handling of animals is not recommended and such prolonged conditions may lead to case of Anhedonia (Rizvi *et al.*, 2016; Lecorps *et al.*, 2019) wherein all the performances of the animals may be negatively affected. It becomes necessary for proper handling especially for primiparous dairy animals that do not have previous experience of calving (Yalcin *et al.*, 2014; Weary *et al.*, 2017; Rizvi *et al.*, 2016; Lecorps *et al.*, 2019). A regular, positive and gentle handling intervention of dairy animals is recommended from mid gestation to advanced gestation to make them acquainted with human handling (Yalcin *et al.*, 2014; Weary *et al.*, 2017; Rizvi *et al.*, 2016; Lecorps *et al.*, 2019). This improves the performance and behaviors of dairy animals as well as the performances of their off-springs (Lecorps *et al.*, 2019). Acquainted dairy animals have shown enhanced mothering activities and immunity status of their new nates. Hence, proper handling with gentle attributes towards dairy animals should be given considerable priority during transition period (Denton *et al.*, 2009; Green and Mellor, 2011; Mellor, 2012; Yalcin *et al.,* 2014; Weary *et al.,* 2017; Rizvi *et al.,* 2016; Lecorps *et al.,* 2019).

Conclusion

The transition period is often considered as bridging period in dairy animals where animals' body system undergoes several changes for preparing it towards a producing state from a non- producing state. The transition period imposes an abrupt change in physiological and metabolic profile of dairy animals. Improper management strategies during this period have a far-reaching effect on health, production and reproduction performances of dairy animals. Energy assessment of dairy animals offers a great scope for quantifying the present status of dairy animals which in turn indicates the need for changing or adopting suitable management practices for desired results. Major advancement has been done in the field of nutritional management of transition period dairy animals. Supplementation of feed additives, herbal preparation and ionic salts in the diet of animals has the potential to improve the performances of dairy animals with minimum health and economic losses. In addition to it, comfort management through proper housing and handling to dairy animals during transition period play a pivotal role in lowering stress levels in dairy animals. Altogether, different management strategies focus on attaining improvement in the DMI to enhance the supply of required nutrients, reduce negative energy balance, reduced oxidative stress, and improved immunity status of dairy animals for desired results. Hence, it becomes necessary for a herdsman to properly manage their dairy animals during transition period with advanced transition management practice for improved health, production and reproduction performances of dairy animals.

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Conflict of Interests

There is no conflict of interest.

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