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Understanding the Transition Period of Dairy Cows: Review on Recent Developments

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Abstract — **Transition period of dairy cows has been one of the major physiological stages which decided the success of productivity and productive life of a dairy cow. Since early 19's until up-to-date researchers had struggled to unveil the underline phenomenon of this particular phase of life to establish precise management practices to overcome its negative consequences. However, still the dairy farmers face numerous complications during the transition period of their animals. Hence, this review has focused on the most recent developments on understanding and overcoming the challenges of transition period of dairy cows. The recent developments are discussed under two major themes; developments in understanding the physiological changes occur during transition stage of dairy cows and molecular aspects of transition stage. As a conclusion, a holistic approach combining molecular, nutritional and management practices is recommended to overcome the problems faced during transition stage.**

Keywords — **Transition Period, Dairy Cow, Negative Energy Balance.**

I. Introduction

Transition period of dairy cattle is considered as the most important time period which determines the further success of the entire lactation [1]. This period can be divided in to two major parts as the late pregnancy period which fall three weeks pre-partum and early lactation period which covers three weeks post-partum. Even though, the length of the transition period is debatable, many authors had referred this period as three weeks pre-partum and three weeks post-partum [2]. During the transition period of dairy cows, the animal undergoes a tremendous transformation from non-lactating pregnancy period to lactating non-pregnant period. This transformation is associated with most of the metabolic diseases such as, ketosis, displaced abomasum, milk fever and retained placenta which governs the persistency of lactation and wellbeing of the dairy cattle [3].

Even though a remarkable number of research has been conducted on success of transition period, still problems persists in farms making this period a time of utter importance. The negative economic impact made by the downfall of this period still affects most of the large scale dairy cattle farms [4]. Understanding the underlying concepts of this most delicate period is important to avoid the negative consequences it conveys to dairy farmers. Plenty of research had been conducted regarding this matter on the basis of nutritional management, disease identification and management practices during dry period. However, with the persistence of problems during transition period the research work will continue to develop [4].

During the past few decades, many excellent reviews had been written based on this theme. These reviews had clearly discussed about the physiological changes, relationship of metabolic disorders, adaptations to metabolic changes, nutritional management, relationships with reproductive success and possible future developments to alleviate the negative outcomes of transition period [4]-[6]. Hence, discussing about the facts existing on these reviews will be in vain. Thus, the objective of this review will be to capture few of the most recent developments regarding the transition period of dairy cows.

II. Physiological Changes during Transition Period

The rumen adaptations during the transition period are one of the major changes that can be observed. At parturition, the dry period diet is replaced with high energy lactation diet. This causes changes in rumen fermentation including rumen pH, volatile fatty acid concentration (VFA) and osmotic pressure. The adaptation of rumen for early lactation is depending on these variables [7]-[8]. The rumen papillae size will be increased and mild acidosis conditions will be observed with more energy dense diets fed during whole dry period until sixty days post-partum [9]. However, more recent studies regarding this issue did not conclude such pronounced changes in papillae size or surface area [10]. An acceptable reason for this might be the duration of high energy ration provided. The study done by [10] had been conducted for small duration, hence the changes with papillae were less pronounced. Proving this phenomenon, in a study done by [11] showed that the papillae size was significantly different in a high energy transition cow ration provided during the whole dry period until 82 days in to lactation. Furthermore, in the two treatments provided during the experiment, the rate of concentrate provision did not affect the papillae size significantly. However rumen epithelial thickness was significantly low with higher rates of concentrate supplement. The production performances were also significantly higher with higher rates of concentrate supplement and no acidosis conditions were observed. With these observations, it defines that the papillae and their surface area increase more rapidly than the growth of the epithelial tissue mass and this causes a thin layer of epithelial tissue and allowing rapid absorption of molecules through rumen wall. The molecular mechanisms of these adaptations were not observed in this study, hence there is still space to expand our knowledge on rumen adaptations during transition period.

The functions of the liver are vital in transition period of dairy cow. Sufficient adaptations in liver metabolic pathways decide the success of the transition period energy metabolism [1]. However the negative energy balance is combined with the body lipid mobilization and this condition simultaneously causes fat accumulation in hepatocytes [12]. With the hepatolipidosis condition, it may reduce the liver gluconeogenesis causing reduction in glycaemia. Further, the hepatolipidosos condition had shown significant relationship with reduced uraemia, proteinemia and albuminemia [13]. Due to these reasons the malfunctioning of hepatocytes could be observed through blood metabolites such as, albumin, glucose and total protein content. The disruption of hepatocytes could be identified using Aspartate Transaminase (AST) and Gamma-Glutamyl Transpeptidase (GGT) enzymes. These enzymes are present abundantly in cytoplasm and mitochondria and microsomal of liver hepatocytes respectively. The disruption of these cells release these intracellular materials in to blood flow making them indicators of hepatocyte damages [13]-[14]. Further developing the concept of identification of liver variables relating with inflammation conditions, a more recent study has been conducted by [15]. In this study the authors had found a significant relationship between acute phase responses (APR) and inflammation conditions in early lactating dairy cows. Further they had related the identified positive acute phase reactants and negative acute phase reactants with liver variables (AST, GGT and Bilirubin). They had concluded that with the relationship of APR and liver variables, a pronounced APR may alter hepatic bilirubin clearance and cause negative changes in liver hepatocytes. However they had recommended further studies on this conclusion. These studies indicate that there are interrelationships and missing parts of our knowledge on liver physiological status during transition period.

Another physiological challenge met by the transition dairy cow is the oxidative stress which may cause transition disorders [16]. With the lipid mobilization during the transition period, the lipid peroxidation becomes one of the major factors of oxidative stress [17]. Further, Sharma et al. (2011) have found that increasing of oxidative stress due to lipid peroxidation products is negatively correlated with the level of antioxidant species. Due to this fact they have concluded that, the increasing oxidative stress and reduction of antioxidant species during the parturition could be a possible reason for increased vulnerability to production diseases. Further research regarding methods of depressing the oxidative stress and identification of mechanisms generation reactive oxygen species will be valuable.

The relationship between negative energy balance and reproductive performances of transition dairy cattle are controversial and yet to be determined. [18] State that cows with endometritis had lower dry matter intake at the post-partum period and their blood Non-esterified fatty acids (NEFA) and Betahydroxy butyric acid (BHBA) levels were also significantly high in pre-partum. The possible explanation for this fact was that, the pre-partum DMI and NEFA level was negatively correlated with peripheral blood neutrophils, which indicated a predisposal of periparturient immune suppression [18]-[19]. However these results are challenged by the study done by [20]. Through this study [20] had indicated that energy status was not a risk factor for endometritis condition. However they have indicated that depressed albumin concentrations, indicting liver impairment may have a significant relationship with endometritis condition. Even though these studies paves the way to the indication that nutrient deficiencies at transition are related with reproductive performances, further research are needed to confirm the metabolic pathways which affect the success of reproductive performances in transition dairy cows. Furthermore, the controversial conclusions on relationships between negative energy balance and reproductive performances indicate a whole novel research area to be considered by future researchers.

III. Genomic Aspects of Transition Period

A comprehensive study had been conducted by [21] to observe the expression of genes regulating liver metabolic pathways under severe negative energy balance (SNEB) conditions in post-partum dairy cows. The study had shown that SNEB influences the expression of genes favoring the lipid catabolism and they exhibit inhibitory impact on cell repair and growth. Abnormal gene expressions were indicted suggesting the negative impacts of poor energy balance. A summary of few important genes studied through this research work is shown in table 1.

Going beyond the expression of genes, through a study done by Graber et al. (2010), had suggested that the gene expression of liver during transition period could be potentially utilized in “expression assisted selection” in animal selection for breeding. They had suggested that identifying the diversity in gene expression of individual animals may provide a useful tool in selecting most adaptable individuals. The gene expressions were similar with the previous study.

Table 1: Few important genes studied by [21]

Gene	function
DDO	Catalyzes oxidation of D-aspartate, NH_3 and H_2O_2
FADS2	Encode enzyme for synthesis of polyunsaturated fatty acids
CPT1B	Involve in transferring long-chain FA from cytosol to mitochondrial matrix
PNLP	Encode a protein having TAG lipase activity
HSD17B2	Involve in estrogen metabolism

Apart from the gene expression in liver, [23] had conducted a study regarding molecular basis of glucose uptake in mammary gland during transition period. Glucose transporters (GLUT) in bovine mammary tissues are responsible for the transportation of glucose from blood in to the mammary tissues. Increased metabolic demands during the transition period combined with hypoxia stimulate the GLUT expression in bovine endothelial cells. Further they have found that hypoxia associated genes exert control over expression of GLUT mRNA facilitation increased glucose uptake during higher demands for glucose during lactation.

IV. Nutritional Strategies to Alleviate Negative impacts of Transition Period

During the past few decades several nutritional studies had been conducted to diminish the negative energy balance condition in transition dairy cows. However, the studies are still continuing due to poor effectiveness of previous studies.

[24] Had conducted a trial by providing higher energy diets for dairy cattle during the dry period. The results showed that due to over-nutrition syndrome the cows indicated metabolic dysfunctions during the post-partum period. Overfeeding during pre-partum had caused hyperglycemia, hyperinsulinemia and higher leptin level during pre-partum and this had caused higher lipid mobilization during post-partum period. Controlling energy intake during pre-partum is suggested as a precaution for avoiding pronounced negative effects during post-partum.

Monensin is an ionophore that regulate the bacteria population in rumen promoting ruminal production of glucogenic precursors [25]. This function of Monensin had been utilized to treat transition dairy cows to favor more glucogenic precursor production during ruminal digestion. The Monensin supplementation had decreased the triglyceride accumulation in liver and had increased CPT1 activity in mitochondria favoring higher fatty acid oxidation. It had also reduced the plasma (BHBA) concentration [26]. Even though positive indications of Monensin supplementation had been shown in experimental basis, a commercial application was recommended to confirm its effect.

High energy containing cereal based concentrates have shown increased intakes and milk production [27]. However, non-fiber carbohydrates in cereals are rapidly digested in the rumen resulting acidic conditions, if fed more than recommended levels. Hence, feeding non-fiber carbohydrates has limitations in dairy cattle ration formulation.

[28] Had reported that, propionate and calcium salts of long chain fatty acids supplement diets had minimal effects on lactation performance and blood metabolites in transition dairy cows. However, [27] stated that negative energy balance can be avoided if grazing crossbred cows are supplemented with starch-based concentrates but not with calcium salts of fatty acids during early lactation. Theoretically, metabolism of fatty acids, which are supplied by the diet, may increase the Ketosis condition due to lack of Oxaloacetate in liver during a negative energy balance condition [29]. Therefore, in one point of view it can be postulated that supplementing a rumen inert fat during transition period may have ill effects on productivity of dairy cows.

However, [30] had concluded that feeding palmitic acid for lactating dairy cows increased the milk yield, milk fat percentage and had no effect on milk lactose and protein composition. Furthermore, [31] had shown, feeding non-fermentable energy in the form of saturated fat had increased milk yield in early lactation cows and it did not caused body weight loss. Hence, these studies indicate the positive effects of fat supplementations for early lactating dairy cattle.

Apart from these strategies, feeding of rumen protected niacin and n-3 fatty acids had also shown beneficial effects during transition period of dairy cattle [32]-[33]. Rumen protected niacin had inhibited lipolysis and improved postpartum energy balance. But further research was recommended by the authors [33].

Even though several feeding strategies were implemented, most of them have controversial conclusions and most research studies recommend further research on confirming the results.

V. Conclusion

The transition period of dairy cattle has been identified as one of the most important time periods which decide the further success of a lactation cycle. The negative energy balance created during the transition period and its impact on physiological conditions of dairy cow had implemented negative consequences such as, metabolic disorders, reproductive failures and lower productive performances. Even after decades of experimental trials, the impact of negative energy balance has not being completely eradicated or none of the clear solutions were developed.

However with the development of novel research areas, a holistic approach will be beneficial to create a sustainable solution to fulfill this gap. Hence nutritional aspects were almost clearly identified and most of the metabolic pathways have been discovered, combining these with genomics and creating a full image of a treatment or experiment will be beneficial rather considering factors individually. Most of the studies done so far regarding negative energy balance had been conducted considering only one subject area. In future research, a multidisciplinary approach will be beneficial to create an effective solution to fulfill this gap.

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