Journal of American Science

Websites:
http://www.jofamericanscience.org
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

A Review on Negative Energy Balance in Transition Dairy Cows, and Management Options

[1*]Kebadu Endeg and [2]Negesse Welde

[1*]Doctor of Veterinary Medicine, Assosa University College of Agriculture and Natural Resources, Department of Veterinary Science, Assosa, Ethiopia, Tel: +251-928-582-965, E-mail: kebadu2006@gmail.com
[2]Doctor of Veterinary Medicine, Assosa University College of Agriculture and Natural Resources, Department of Veterinary Science, Assosa, Ethiopia, Tel: +251-925-503-497, E-mail: negessewelde@gmail.com

Abstract: Negative energy balance refers to deficits in energy requirements that are estimated. Increased energy requirements and decrease dry matter intake during periparturient period cause dairy cows to enter a negative energy balance. It is a common problem of dairy cows during the transition period which is the time around three weeks before calving and three weeks after calving. Cows respond to negative energy balance, which is associated with lowered blood glucose and insulin concentrations, by increasing mobilization of body energy stores, mainly glycogen, fat, and protein to compensate for their energy requirements. Increased fat mobilization (lipolysis) causes an elevation of non-esterified fatty acids in the blood. In the liver, these non-esterified fatty acids are re-esterified to triacylglycerols or are oxidized to form energy or ketone bodies. Although these changes are normal adaptive process in high yielding cows, when a cow fails to adapt to this metabolic challenge, several metabolic and infectious disorders occur and affect the productive and reproductive efficiency beyond the transition period. The combined effects of all these challenges are reduced fertility and milk production resulting in diminishing profits beyond the transition period. For evaluation of energy balance we can estimate glucose and non-esterified fatty acids concentration of serum. Intravenous administration of 50% dextrose solution, which must be repeated for 2-4 days, can be used as a treatment of negative energy balance. For its proper management diets should always be properly formulated to meet energy and protein requirements for high levels of milk production. Attention also should be given to comfortable design of pens or stalls, provision of adequate dry bedding, and good footing. Thus, the objective of this seminar paper is to review the effect of negative energy balance on transition dairy cows and to forward some management options to reduce the effects.

[Kebadu Endeg and Negesse Welde. **A Review on Negative Energy Balance in Transition Dairy Cows, and Management Options.** *J Am Sci* 2021;17(2):1-11]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 1. doi:10.7537/marsjas170221.01.

Key words: Cows, Dry matter intake, Negative energy balance, Non-esterified fatty acids, Transition period

1. Introduction

Transition cow biology and management has become a focal point for research during the last two decades. Dairy farmers as well as scientists world over are looking for significant breaking through which could ensure successful transition cow management. The transition period in dairy cows is defined as the last three week prepartum until three week postpartum. It is characterized by marked changes in metabolism to support late gestation and the onset of milk synthesis. It is regarded as one of the most challenging periods of the production cycle, which entails profound physiologic changes that often disrupt the homeostatic mechanisms of the cow. This is because at this stage the liver adapts from a minimal glucose demand to an overwhelming demand for glucose (Drackley, 1999).

Along with a gradual decline in dry matter intake (DMI) that starts 2-3 week prepartum, an abrupt increase in nutrient demand with initiation of lactation results in negative energy balance (NEB) and extensive mobilization of body fat reserves as non-esterified fatty acids (NEFA) (Grummer *et al*., 2004). It is an important characteristic of transition cow particularly in high yielding animals, due to the integrative outcome of reduced intake and higher demand for maintenance and production. NEFA and beta-hydroxybutyric acid (BHBA) are important energy metabolites that are traditionally used as indicators of NEB during transition period (Duffield *et al.,* 2009). Although these changes are normal adaptive process in high yielding cows, when a cow fails to adapt to this metabolic challenge, several metabolic and infectious disorders occur and affect the productive and reproductive efficiency beyond the transition period (Pratik *et al.,* 2017).

Therefore, a smooth transition is important for minimizing health problems and optimizing productivity and profitability for the forthcoming lactation. One possible intervention is manipulation of energy intake (Grummer *et al*., 2004**).** The increase in fat and protein content is not sufficient to compensate for the decrease in milk volume. However, it may provide a tool to manage the metabolism and energy balance of cows during early lactation better (Stelwagen *et al*., 2013). Measures to minimize effects of heat stress such as; shade, fans, and cooling systems, likely will pay large benefits for transition cows (Cook and Nordlund, 2004).

Selective breeding of dairy cattle today has led to a dramatic increase in milk yield per cow but this increase in yield has been accompanied by declining ability to reproduce, increasing incidence of health problems and declining longevity in modern dairy cows which is mainly as a result of negative energy balance during the transition period.

Therefore, the objectives of this seminar paper were:

- To review the effects of negative energy balance in transition dairy cows, and
- To forward some management measures to reverse the effect of negative energy balance in transition period and subsequent effects.

2. Negative Energy Balance

2.1. Transition Physiology

The period comprising the last three weeks of gestation and first three weeks of lactation is often referred to as the transition period, because the cow 'transits' from the dry period to lactation (Drackley, 1999). During the transition period the final growth of the fetus and calving occur and milk production starts. The cow is also challenged by other stressors such as separation from her calf, immune challenges when the uterus is cleared (Salasel *et al*., 2010), increased demands for energy, nutrients and minerals (LeBlanc, 2010), and most often also exposure to a new feeding regime and regrouping (Schirmann *et al*., 2011). Thus, it is not surprising that there is an over-all increased risk of health disturbances during the transition period (Ingvartsen, 2006).

Previous work has shown that 75% of all health disorders occur during the transition period. From 30 to 50% of dairy cows are affected by some form of metabolic or infectious disease during this time (LeBlanc *et al*., 2006). More than half of all culling events are associated with health disorders occurring within the first 60 days in milk (DIM) regardless of parity or production level (Grohn *et al*., 2003). Further consequences in the early lactation period include, lowered milk production, immune-depression and compromised reproductive performance. Therefore, it is important for the animal's productivity and welfare so that, it do not succumb to production diseases (Ravi *et al*., 2016).

Higher demand of energy and nutrients for the synthesis of colostrum and milk coupled with decreased feed intake force the transition cows to undergo NEB and micronutrient deficiencies. This down regulation of the appetite is reported to be caused by an increased concentration of sex hormones, an incipient mobilization of lipid from body deposits and reduced rumen capacity as a result of the growing fetus (Ingvartsen and Andersen, 2000).

Negative energy balance occurs when a cow's metabolic output, in the forms of tissue maintenance, activity, and lactation, exceed the caloric intake from its feed (Shanna, 2012). The NEB stimulates cows to mobilize body fat in the form of NEFA and subsequent accumulation of BHBA in the blood. Negative energy balance in dairy cows after calving is characterised by low blood glucose, low blood insulin, high blood NEFA, high blood BHBA and low blood insulin-like growth factor I (IGF-1) (Ingvartsen and Andersen, 2000).

Although these changes are normal adaptive process in high yielding cows, when a cow fails to adapt to this metabolic challenge, and the physiological conditions associated with insufficient energy supply predispose dairy cows to metabolic and microbial diseases such as milk fever, endometritis, ketosis, displaced abomasum and retained placenta. The combined effects of all these challenges are reduced fertility and milk production resulting in diminishing profits beyond the transition period (Duffield and Herdt, 2000).

2.2. Etiology and Pathogenesis

The cow's glucose requirements spike from 1 kg/day during late gestation to over 2.5 kg/ day during the postpartum transition period (Reynolds *et al*., 2003). There is significant decrease in DMI by over 30 percent in the last 3 weeks of gestation, limiting the availability of energy sources during the time of increased energy demand (Hayirli *et al.,* 2002). During this time, glucose is directed from normal bodily functions to the nutrition of the developing calf. As lactation starts, glucose is essential for the formation of lactose (milk sugar) and milk fat. If the amount of suitable carbohydrate in the diet is not enough to meet the glucose needs of the cow in full milk, the liver starts to manufacture glucose from other basic compounds in the body, usually from fat reserves (Bruss, 2008).

Negative energy balance also results in a high ratio of growth hormone to insulin in blood of cows, which promotes mobilization of long chain fatty acids from adipose tissue (body fat). Fatty acids released from adipose tissue circulate NEFA, which are a major source of energy to the cow during this period. The release of NEFA from body fat overwhelms the capacity of the liver to use the fatty acids as fuel. They are instead converted to ketone bodies such as acetone, aceto-acetic acid, and BHBA (Hayirli, 2006; Ospina *et al*., 2010). The NEB and high plasma NEFA contribute to the development of fatty liver syndrome which in turn is a contributing factor to other health concerns and periparturient immunosuppression in the postpartum period (Lacetera *et al*., 2005; Kehrli Jr *et al.,* 2006).

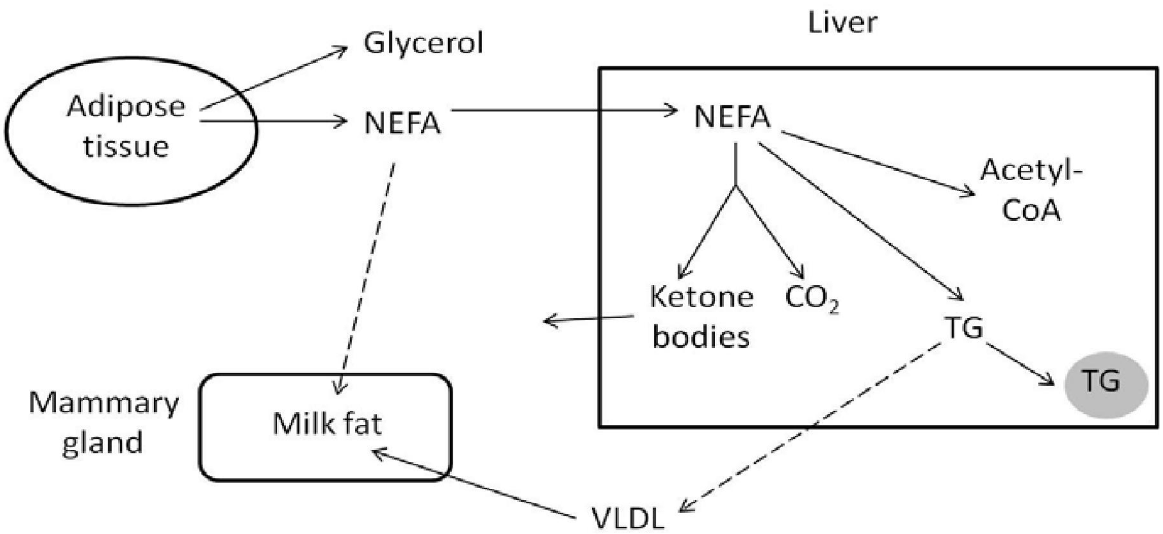

Figure 1: Lipid metabolism in adipose tissue, liver and mammary gland (Drackley, 1999).

2.3. Risk Factors

2.3.1. Lactation number

In primiparous cows NEFA was elevated one week before calving, thus primiparous cows had higher NEFA concentrations at calving in comparison with multiparous cows. After calving, the concentration of NEFA did not increase further and started to decrease two weeks postpartum. Multiparous cows on the other hand, had the peak NEFA concentration at three weeks postpartum. So, primiparous cows were in worse energy status before calving. On the other hand, multiparous cows will suffer from energy status after calving (Wathes *et al*., 2007a).

2.3.2. Body condition score

The recommended body condition score (BCS) at calving lies between 3.0 and 3.25. It is generally assumed that over-conditioned cows at calving have a greater decrease in feed intake in comparison with cows with a lower BCS. The over-conditioned cows therefore will have a more severe NEB, because their energy intake is lower. Thus mobilisation of fat in the early lactation period will be higher, which results in a higher risk of developing fatty liver (Roche *et al*., 2009; Šamanc *et al*., 2010).

2.3.3. Heat stress

Heat stress is an important factor contributing to different metabolic and reproductive disorders of lactating dairy cows in a tropical climate. It leads to reduction in feed intake that results negative energy balance (Rukkwamsuk *et al*., 2004).

2.3.4. Milk fever

Milk fever is defined as a blood calcium concentration lower than 2.0mmol/L. It occurs within 72 hours after calving and is caused, just as NEB, by the onset of lactation. Milk fever leads to a greater decline in feed intake after calving. This increases the severity of NEB, the mobilisation of fat and the risk of fatty liver and ketosis (Melendez, 2009).

2.4. Clinical Signs

Clinically ill cows experience reduced dry matter intake, a loss in milk yield, and the coat is described as having a "woody" appearance, presumably due to the loss of fat reserves under the skin. Ill cows are also weak and sluggish to move. Temperature, pulse, and respiration rates of the cow remain fairly normal as the animal loses weight. If ketosis develop the cow in this disease have a characteristic sweet "sickly" smell, which may be detected on the cow's breath and less commonly in milk samples and demonstrate symptoms of nervous system involvement such as staggering, and lack of coordination (Adewuyi *et al*., 2005).

2.5. Diagnosis

Negative energy balance results in a decrease of the serum glucose concentration, measuring the glucose concentration are used to evaluate the energy balance. The decrease in serum glucose concentration leads to an increased lipolysis of adipose tissue, which leads to an increase in serum NEFA concentrations (Rukkwamsuk, 2010). The change in NEFA concentration four weeks before calving and 0 to 3 days after calving is an indicator for the severity of NEB; a higher rise in serum NEFA concentration means a more severe NEB. The NEFA concentration four weeks before expected calving could be served as a control value, because at that moment, cows are raised on their maintenance requirement. Animals whose blood levels with NEFA>0.5 mmol/L were declared positive (Le Blanc, 2010).

We can also use body condition scoring system, which is a subjective assessment of the cow's fat reserves through visual assessment of its lipid stores relative to its body frame. Over conditioning at calving is associated with a more severe NEB and higher BCS loss is associated with fatty liver, ketosis and more severe NEB (Hoekstra, 2011).

A final approach is the use of diagnostic ultrasound in screening the back fat thickness of these cows, which can serve as an objective test of the degree of adipose tissue mobilization at the level of herd screening (Schröder and Staufenbiel, 2006).

2.6. Treatment

The goal of treating cows for negative energy balance is to meet the glucose need, and reverse the ketogenic process in the liver. This is achieved with an intravenous, 50% dextrose solution, which must be repeated for 2-4 days (Duffield, 2000). The daily administration of 1000ml propylene glycol or glycerol, starting from the last days of gestation and for 2 or 3 weeks after calving, is used to decrease the plasma concentration of ketone bodies and NEFA, increase concentration of glucose and insulin, and decrease triglyceride accumulation in the liver (Hoedemaker *et al.*, 2004; Lomander *et al.*, 2012).

Slow release insulin has also been used for therapy of negative energy balance, and has resulted in increased DMI and milk yield. In addition, there were reduced liver triglyceride and non-esterified fatty acid levels (Hayirli *et al.*, 2002). Other treatments for NEB include vitamin Bl2, monensin, and anabolic steroids (Duffield *et al.*, 2002).

3. Adverse Effects and Consequences of Negative Energy Balance

3.1. Effects on Milk Production

Generally, milk production and energy balance slopes are in opposite direction immediately post-calving but parallel to each other in later lactation. During early lactation, the relationship between energy supply and milk production appears to be uncoupled where milk yield is increasing toward peak while intake or energy balance is simultaneously decreasing toward its lowest point particularly during the immediate postpartum period (1-10 DIM) and then increases toward positive energy balance. This uncoupling continues for at least 6-8 weeks (Lance *et al.*, 2006). Although fat mobilization is important reason for compensation of energy requirement during early lactation, the same phenomenon does not continue during mid or later stage of lactation (Baumgard *et al.*, 2007), where milk yield itself is the main determining factor of feed intake (Collier *et al.*, 2005).

In other words, whenever, an animal is in NEB, additional metabolizable energy (ME) would increase the milk production, while under positive energy balance, providing additional ME will improve efficiency without increasing of milk yield. These findings suggest that milk synthesis is the single most factors deciding the energy balance of individual cow (Baumgard *et al.*, 2007). Thus, the poor transition from pregnant to lactation stage often results in the loss of 10-20 pounds (4.54-9.07 kg) of peak milk yield, which could equal to 2000-4000 pounds (907.18-1814.37 kg) of untapped milk yield (Wallace *et al.*, 1996).

3.2. Effects on Reproductive Performance

A high negative energy balance in the transition period decreases luteinizing hormone (LH) pulse frequency, growth rate and diameter of the dominant follicle, IGF-I, glucose and insulin concentrations and increases growth hormone (GH) and certain blood metabolites. The decreased insulin and IGF-I concentrations in high yielding dairy cows can not sufficiently stimulate follicular growth. If there are decreased insulin and glucose concentrations, structures and messengers of the central nervous system signal metabolic stress to the hypothalamus. The result is reduced synthesis and secretion of gonadotropin releasing hormone (GnRH), and subsequently the synthesis and secretion of follicle stimulating hormone (FSH) and LH (Opsomer *et al.,* 2000).

A follicle developed under such conditions is more likely to become non-ovulatory and hence delay cyclicity than a follicle developed during normal conditions, indicating that cows simply postpone their reproductive functions up to the energy balance compromise survival of the embryo or fetus (Wathes *et al.*, 2007b). These effects result in greater loss of BCS and a higher percent of anestrus cows in the herd (Kadokawa and Martin, 2006). Furthermore, NEB is related to reduce serum progesterone concentrations during the breeding period which results lower pregnancy rates (Butler, 2012).

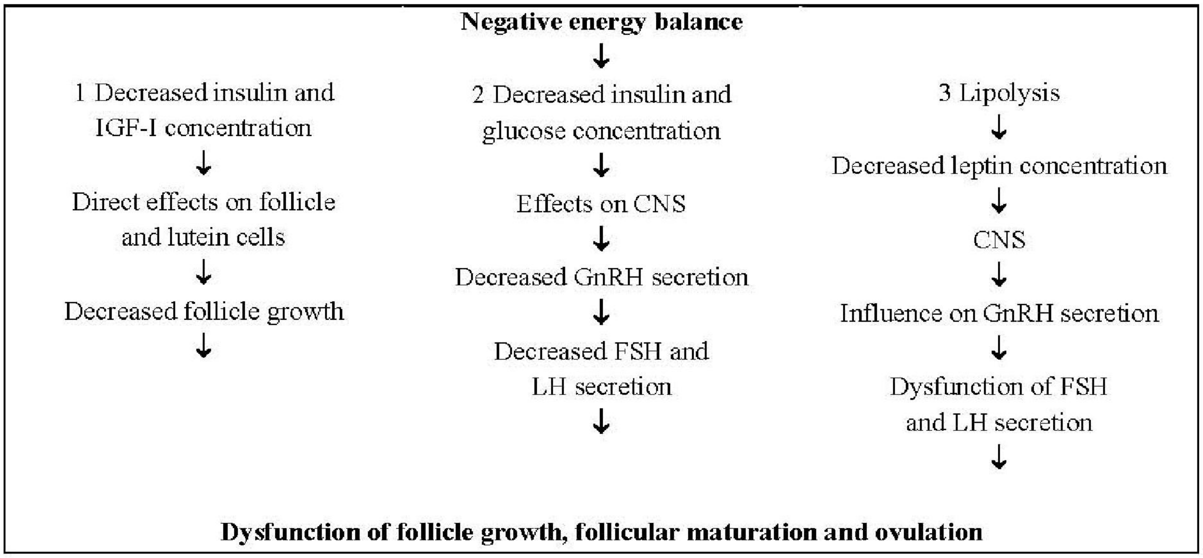

Figure 2: Relationships between energy deficiency and ovarian functions (Remppis *et al.,* 2011).

3.3. Effects on Immune Function

Immune responses require resources such as energy, nutrients and time (Adelman and Martin, 2013). In late gestation cows, adaptive immune responses are dampened and metabolic processes are stressed to preserve the pregnancy and milk production. Negative energy balance negatively impacts the immune system through several pathways; impaired leukocyte response to chemical factors released by microorganisms, a decrease in specific cytokines including interferon and tumor necrosis factor-α, and depressed lymphocyte production (Amber, 2014).

Recent studies show that inflammatory immune genes are up-regulated in cows suffering severe NEB (Wathes *et al*., 2009), whereas genes involved in the acquired immune responses are down-regulated in NEB cows (Moyes *et al*., 2010). Furthermore, Leukocytes from naturally occurring cows with NEB have lower chemotactic differentials than those from without NEB cows, and chemotactic capacity is impaired when leukocytes migrate in an environment with ketone bodies (Holtenius *et al*., 2004). Elevated plasma NEFA mimic intense lipomobilization and alter the ability of lymphocytes to proliferate or secrete immunoglobulin M and interferon-γ in response to polyclonal stimulation (Lacetera *et al*., 2004) as well as the viability and oxidative burst of polymorphonuclear cells (Scalia *et al*., 2006).

Moreover, β-oxidation of body fat reserves terminates with the production of β-hydroxybutyrate, and other ketone bodies as end products which have negative effect on immune function of animals, thus enhancing the susceptibility of animals to infections in and around parturition such as mastitis and metritis (Ingvartsen and Moyes, 2013; Sordillo and Mavangira, 2014).

3.4. Other Metabolic and Immune Related Effects

The negative energy balance stimulates cows to mobilize body fat in the form of NEFA and subsequent accumulation of BHBA in the blood. After parturition, extreme negative energy balance and high level of NEFA and BHBA in the blood predisposes the cow to the occurrence of several periparturient diseases and health problems that can impact on milk production and profitability of the cow during the entire lactation (Mulligan and Doherty, 2008).

The incidence of metabolic disorders (such as milk fever, displacement of abomasum, fatty liver syndrome, and ketosis), mammary gland infections (mastitis and udder edema), and reproductive disorders (such as dystocia, retained placenta, and uterine infections) have been reported from 7.8 to 16.8, 2.8 to 12.6, and 6.7 to 19.2%, respectively, in high-producing herds (Correa *et al*., 1990; Jordan and Fourdraine, 1993).

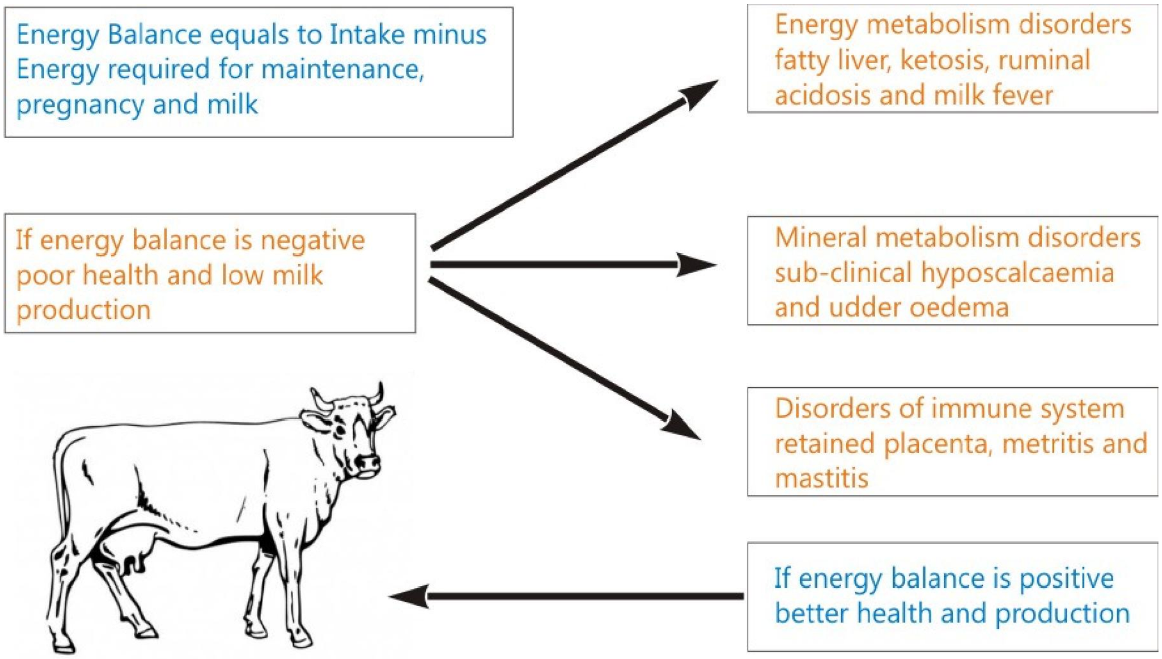

Figure 3: Negative energy balance and related health disorders *(*Ashwani *et al.,* 2017*)*.

4. Management Options

Dairy cattle health management is evolving from a focus on treatment to prevention (LeBlanc *et al*., 2006). During cow management in transition period we should consider dry matter intake (Grummer, 1995), dry period length (Sorensen and Enevoldsen, 1991), feeding behavior, hormonal and metabolic changes, rumen mucosa and immune system of the dairy cow (Bell, 1995).

4.1. Feeding Management

4.1.1. Dietary energy and protein intake

The primary goal of nutritional management strategies during the transition period should be to support the various physiological changes, including those for glucose metabolism. The optimum DMI during prepartum and postpartum should be 1.7% and 2-3% of body weight, respectively. The balance between structural carbohydrates (fiber) and nonstructural carbohydrates (grains or concentrate by-product feeds) in diets fed before and after calving is probably the most important dietary factor for maximizing feed intake. Adequate fiber of sufficient particle size is needed to maintain rumen function, prevent acidosis and displaced abomasums, and achieve high DMI (Lean *et al*., 2013).

Sufficient non fiber carbohydrates (sugars and starch provided by grain) must be present to provide adequate energy in the form of propionic acid for glucose synthesis and to suppress synthesis of ketone bodies. Diets higher in non-fiber carbohydrates content than traditional dry cow diets must be fed prior to calving to promote development of ruminal papillae for adequate absorption of volatile fatty acids produced during ruminal fermentation. There are also likely to be benefits associated with the prepartum adaptation of the rumen microflora to postpartum diets high in concentrates (Rabelo *et al*., 2003).

The Dairy NRC committee (2001) suggest that approximately 1.25 Mcal/kg of net energy for lactation (NEL) has to be fed from dry off until approximately 21 d before calving, and that a diet containing 1.54 to 1.62 Mcal/kg of NEL has to be fed during the last 3 week preceding parturition. The NRC guidelines (NRC, 1989) specify a crude protein content of 12% for dry cows and increase to 14% protein during the transition. For fresh cows the NRC (1989) recommends that dietary protein should be 19%, compared with 18% for the period of peak milk production.

The primary rationale for feeding a lower energy diet during the early dry period is to minimize body condition score gain during the dry period. Furthermore, recent data support managing cows to achieve a body condition score of approximately 3.0 at dry off rather than the traditional 3.5 to 3.75 BSC (Contreras *et al*., 2002).

4.1.2. Fats

Linoleic and linolenic fatty acids are classified as essential fatty acids and must be supplied in the diet, because the double bonds between the D-9-carbon and the terminal methyl group of the fatty acids cannot be produced by cattle. Roles for fatty acids include precursors for reproductive hormones (prostaglandins), in membrane structures as phospholipids, and in immune function (Jones *et al*., 2008). Feeding conjugated linoleic acids (CLA) in a rumen protected form to transition dairy cows reduces negative energy balance, NEFA and BHBA levels in blood. CLA supplementation also increases DMI and some of the negative acute phase proteins such as albumin and cholesterol (Trevisi and Bertoni, 2008; Esposito *et al*., 2013).

On a molecular level, these fatty acids also decrease the production of classical inflammatory cytokines, TNF and IL6. They also decrease the expression of adhesion molecules involved in inflammatory interactions between leukocytes and endothelial cells (Calder, 2006).

The optimal requirement for 15% to 25% of energy being supplied as lipogenic precursors (or about 8% long-chain fatty acids in the diet) for efficient milk production is required (DeVeth *et al.*, 2009).

4.1.3. Minerals

Hypocalcemia can be prevented through manipulation of dietary cation-anion difference that has important implication for transition success. Hypocalcemic cows have decreased motility in the digestive tract, which decreases DMI that finally results negative energy balance (Goof and Horst, 1997). Controlling cation-anion difference of the transition diet should not only decrease incidence of milk fever, but lead to decreased incidence of other metabolic disorders (Horst *et al*., 1997).

Other trace elements such as copper, zinc, and selenium play important roles in immune function and regulation of metabolism, and deficiencies may decrease DMI. Nutritionists should insure that all trace nutrients are provided in adequate amounts and in highly bioavailable forms in the diets for transition and fresh cows (Beede, 1992).

4.1.4. Vitamins

Vitamin E has been proven to be beneficial in enhancing the ability of cows to protect from infections such as mastitis and to help prevent retained placenta. Supplementation of close-up and fresh cow rations with at least 1000 IU of vitamin E daily is recommended. Current NRC recommendations for vitamin A also are too low, and supplementation with 100,000 IU of vitamin A daily is recommended (Weiss *et al*., 1990).

4.1.5. Feed additives

Moreover, feed additives such as propionate production promoters; propionate enhancers like fumarate and malate; antioxidants; ketosis controlling agents; methyl donors like Methionine and Choline; monensin; rumen inert fats; rumen bypass protein; direct fed microbials; niacin; folic acid and vitamin B12; Pantothenic acid and riboflavin are very much effective in managing the transition stress in dairy animals (Ravi *et al*., 2016).

4.2. Cow Comfort and Housing Management

Cow comfort probably is more important to transition success than many nutritionists would care to admit. Stress results in increased breakdown of body fat, with resultant increases in liver fat and suppression of the immune system. Cows that are protected from extreme environmental stresses and that have comfortable, spacious surroundings and housing will have greater DMI (Nordlund, 2009). Measures to minimize effects of heat stress, such as shade, fans, and cooling systems, likely will pay large benefits for transition cows (Cook and Nordlund, 2004). Transition cows exposed to heat stress shows a number of significant alterations in blood metabolite parameters indicative of lowered DMI, metabolic acidosis and negative energy balance (Van Saun and Davidek, 2008).

Attention also should be given to comfortable design of pens or stalls, provision of adequate dry bedding, and good footing (Cook and Nordlund, 2004). Traditional free stall design has 122cm wide stalls, which balances well with barn structural design. However, transition cows are typically wider and would benefit from wider stalls (127 cm recommended). Additionally, stalls should be designed to facilitate normal cow lying, resting and raising behaviors (Nordlund, 2009). Stall surface cushion is recommended to be deep sand as this provides the best footing anchor for the cow when attempting to stand. For housing bedded pack barns or pasture housing systems, close-up, calving and immediately fresh cows should be provided 11meter square of lying space per cow, not including feeding or walking alleys (Cook *et al*., 2004).

Handling fresh cows separately or as a separate group minimizes competition between fresh cows and more aggressive herd mates (Nordlund, 2009). These cow groups seem more sensitive to behavioral competition and intimidation that results in altered feeding behaviors (Huzzey *et al*., 2005; Proudfoot *et al*., 2009). Bunk space is most critical in farms where feed availability is limited or where overcrowding occurs. At least 76 cm of bunk space is recommended per cow in these groups (Cook and Nordlund, 2004).

Animals should also be given a sufficient time to rest and regenerate mammary tissue, which can be attained by providing a dry period of 45 to 60 days duration. In case of high yielders, incomplete milking or alternate day milking for 1-2 weeks followed by complete cessation is an effective method to dry off the animals. The method of complete cessation of milking is a common practice in the low producing cows (<6 kg) (Rastani and Grummer, 2005).

Furthermore we can apply dry cow therapy which is the treatment of cows at the end of lactation with a long acting antibiotic preparation with or without a teat sealant. This is to treat for any intra-mammary infections contracted during lactation and provides protection against new infections during the dry period. It is practiced via two different techniques i.e. use of intra mammary and systemic administration of antibiotics prior to calving (Ahmad *et al*., 2015).

5. Conclusion and Recommendations

Generally, the way cows get through the transition period directly and indirectly influences production, fertility and survival in subsequent lactation. As a consequence of the high energy requirements involved in producing milk, many cows suffer from negative energy balance after calving at different times and for varying durations (up to 60 days). Negative energy balance is an important characteristic of transition cows, and it is a normal adaptive mechanism in high yielding dairy animals. Loss of profits caused by negative energy balance stems from three main elements: reduction in milk production, poor fertility performance and increased involuntary culling of cows. Good management during the transition period is essential for maximizing dairy profitability. Different available information suggests that feeding higher energy diets promotes higher energy intake and milk yield along with better metabolic status during the postpartum period. Apart from the nutritional aspects, housing is also very important for effective management of transition cows especially to reduce the incidence of the probable complications arising out of metabolic disturbances. At present, several association studies between energy balance during transition period and subsequent postpartum performance are available; however, further studies are required for effective postpartum management.

Based on the above concluding remarks the following recommendations are forwarded:

- ➢ Care should be taken to provide the best management possible for close-up and fresh cows to avoid depressions in intake and to reduce disease incidence and reproductive problems.
- ➢ Daily monitoring and evaluating of detailed records during the high risk period (to about 60 DIM) is required to efficiently treat and reduce damages.
- ➢ Future research should be done on the status and effect of negative energy balance in Ethiopian dairy production.
- ➢ Further research should also be done to improve transition cow health and reproductive performance without compromising milk production.

References

1. Adelman, J. and Martin, L. (2013): Vertebrate sickness: Adaptive and integrated neuroendocrine immune responses. *Integ. Comp. Biol*., 49: 202-214.
2. Adewuyi, A., Gruys, E. and Van Eerdenburg, F. (2005): Non esterified fatty acids (NEFA) in dairy cattle. *Vet. Quarterly,* 27: 117-126.
3. Ahmad, T., Nadeem, A., Saleem, M., Nadeem, M. and Saqib, M. (2015): Control of mastitis through dry cow therapy. *Sch. Adv. Anim. Vet. Res.,* 2:128-135.
4. Amber, J. (2014): Clinical ketosis and standing behaviour in transition dairy cows at two commercial dairy farms in Washington State. M.sc. Thesis, The faculty of graduate and postdoctoral studies, The University of British Columbia, Vancouver, Pp 1-42.
5. Ashwani, K., Mahendra, S. and Meeti, P. (2017): Impact of bypass fat feeding on dairy animals. National Reaserch Institute, Kamala (Haryana), Pp 1-2.
6. Baumgard, L., Schwartz, G., Kay, J. and Rhoads M. (2007): Does negative energy balance (NEB) limit milk synthesis in early lactation. In: Proceedings of Western Canadian Dairy Seminar, Advances in Dairy Technology, Pp 77-86.
7. Beede, D. (1992): The DCAD concept: Transition rations for dry pregnant cows. *Feed stuff.,* 64:12.
8. Bell, A. (1995): Regulation of organic nutrient metabolism during transition from late pregnancy to early lactation. *J. Anim. Sci.,* 73: 2804.
9. Bruss, M. (2008): Lipids and Ketones. Clinical biochemistry of domestic animals. 6th ed. Elsevier Inc., Pp 81-115.
10. Butler, W. (2012): The role of energy balance and metabolism on reproduction of dairy cows, Department of Animal Science, Cornell University, Ithaca, NY., Pp 767-783.
11. Calder, P. (2006): n-3 polyunsaturated fatty acids, inflammation, and inflammatory diseases. *Am. J. Clin. Nutr*., 83: 1505-1519.
12. Collier, R., Baumgard, L., Lock, A. and Bauman, D. (2005): Physiological limitations, nutrient partitioning. In: Sylvester-Bradley, R., Wiseman, J., ed. Yield of farmed species, constraints and opportunities in the 21st Century, Pp 351-377.

13. Contreras, L., Ryan, C. and Overton, T. (2002): Effects of dry cow grouping strategy and body condition score at dry off performance of dairy cows during lactation. *J. Dairy sci*., 85: 185.
14. Cook, N. and Nordlund, K. (2004): Behavioral needs of the transition cow and considerations for special needs facility design. *Vet. Clin. North Am. Food Anim. Pract.,* 20: 495-520.
15. Cook, N., Bennett, T. and Nordlund, K. (2004): Effect of free stall surface on daily activity patterns in dairy cows with relevance to lameness prevalence. *J. Dairy Sci.,* 87: 2912-2922.
16. Correa, M., Curtis, C., Erb, H., Scarlett, J. and Smith, R. (1990): An ecological analysis of risk factors for postpartum disorders of Holstein-Friesian cows from thirty-two New York farms. *J. Dairy Sci*., 73: 1515-1524.
17. DeVeth, M., Bauman, D. and Koch, W. (2009): Efficacy of conjugated linoleic acid for improving reproduction: a multi-study analysis in early-lactation dairy cows. *J Dairy Sci*., 92: 2662-9.
18. Drackley, J. (1999): Biology of dairy cows during the transition period: The final frontier? *J. Dairy Sci*., 82: 2259-2273.
19. Duffield, T. (2000): Metabolic Disorders of Ruminants: Subclinical Ketosis in Lactating Dairy Cattle. *Vet. Clin. North Am. Food Anim. Pract.,* 16: 231-253.
20. Duffield, T. and Herdt, T. (2000): Subclinical ketosis in lactating dairy cattle. *Vet. Clin. North Am. Food Anim. Pract.,* 16: 231-253.
21. Duffield, T., Bagg, R., Des Coteaux, L., Bouchard, E., Brodeur, M., DuTremblay, D., Keefe, G., LeBlanc, S. and Dick, P. (2002): Prepartum monensin for the reduction of energy associated disease in postpartum dairy cows. *J. Dairy Sci*., 85: 397-405.
22. Duffield, T., Lissemore, K., McBride, B. and Leslie, K. (2009): Impact of hyperketonemia in early lactation dairy cows on health and production. *J. Dairy Sci*., 92: 571-580.
23. Esposito, G., Schneider, A., Absalôn Medina, V., Pelton, S. and Butler, W. (2013): Effect of dietary conjugated linoleic acid on reproduction and tissue responses in dairy cows. *S. Afr. J. Anim. Sci.,* 43: 33-37.
24. Goff, J. and Horst, R. (1997): Physiological changes at parturition and their relationship to metabolic disorders. *J. Dairy Sci*., 80:1260-1268.
25. Grohn, Y., Rajala, P., Allore, H., DeLorenzo, M., Herti, J. and Galligan, D. (2003): Optimizing replacement of dairy cows, modeling the effects of diseases. *Prev. Vet. Med.,* 61: 26-43.
26. Grummer, R. (1995): Impact of changes in organic nutrient metabolism on feeding the transition dairy cow. *J. Anim. Sci.,* 73: 2820-2833.
27. Grummer, R., Mashek, D. and Hayirli, A. (2004): Dry matter intake and energy balance in the transition period. *Vet. Clin. North Am. Food Anim. Pract*., 20: 447-470.
28. Hayirli, A. (2006): The role of exogenous insulin in the complex of hepatic lipidosis and ketosis associated with insulin resistance phenomenon in postpartum dairy cattle. *Vet. Res. Commun*., 30: 749-74.
29. Hayirli, A., Bertics, S., Grummer, R. (2002): Effect of slow-release insulin on production, liver triglyceride, and metabolic profiles of Holsteins in early lactation. *J. Dairy Sci.,* 85: 2180-219l.
30. Hoedemaker, M., Prange, D., Zerbe, H., Frank, J., Daxenberger, A. and Meyer, H. (2004): Peripartal propylene glycol supplementation and metabolism, animal health, fertility, and production in dairy cows. *J. Dairy Sci*., 87: 2136-2145.
31. Hoekstra, J. (2011): Negative energy balance in periparturient Thai dairy cows raised in small-holder farms. Research Project Veterinary Medicine University Utrecht, Pp 4-8.
32. Holtenius, K., Persson, K., Essén, B., Holtenius, P. and Hallén, C., (2004): Metabolic parameters and blood leukocyte profiles in cows from herds with high or low mastitis incidence. *Vet. J*., 168: 65-73.
33. Horst, R., Goff, J., Reinhardt, T. and Buxton, D. (1997): Strategies for preventing milk fever in dairy cattle. *J. Dairy Sci*., 80: 1269-1280.
34. Huzzey, J., VonKeyserlingk, M. and Weary, D. (2005): Changes in feeding, drinking, and standing behavior of dairy cows during the transition period. *J. Dairy Sci*., 88: 2454-2461.
35. Ingvartsen, K. (2006): Feeding and management related diseases in the transition cow: Physiological adaptations around calving and strategies to reduce feeding related diseases. *Anim. Feed Sci. Tech.,* 126: 175-213.
36. Ingvartsen, K. and Andersen, J. (2000): Integration of metabolism and intake regulation: A review focusing on periparturient animals. *J. Dairy Sci.,* 83: 1573-1597.
37. Ingvartsen, K. and Moyes, K. (2013): Nutrition, immune function and health of dairy cattle. *J. Anim. Sci.,* 7:112-122.
38. Jones, B., Fish, R. and Martin, A. (2008): Effects of supplemental linoleic and linolenic acids on reproduction in Holstein cows. *J. Anim. Sci*., 24: 500-5.
39. Jordan, E. and Fourdraine, R. (1993): Characterization of the management practices of

the top milk producing herds in the country. *J. Dairy Sci*., 76: 3247-3256.

40. Kadokawa, H., Martin, B. (2006): A new perspective on Management of reproduction in dairy cows: the need for detailed metabolic information, an improved selection index and extended lactation. *J. Reprod. Dev*., 52: 161-168.
41. Kehrli, M., Neil, J., Burvenich, C., Goff, J., Lippolis, J., Reinhardt, T., Nonnecke, B. (2006): Energy and protein effects on the immune system. Ruminant physiology: Digestion, metabolism and impact of nutrition on gene expression, immunology and stress, Wageningen Academic Pub., Pp 455-471.
42. Lacetera, N., Scalia, D., Bernabucci, U., Ronchi, B., Pirazzi, D. and Nardone, A. (2005): Lymphocyte functions in overconditioned cows around parturition. *J. Dairy Sci*., 88: 2010-2016.
43. Lacetera, N., Scalia, D., Franci, O., Bernabucci, U., Ronchi, B. and Nardone, A. (2004): Effects of non-esterified fatty acids on lymphocyte function in dairy heifers. *J. Dairy Sci*., 87: 1012-1014.
44. Lance, H., Laura J., Jane, K., Robert, P., Matthew, J. and Robert, J. (2006): Does negative energy balance (NEB) limit milk synthesis in early lactation? In: Proceedings of the 21st Annual Southwest Nutrition & Management Conference, February 23-24, Tempe, Arizona, Pp 181-187.
45. Lean, I., Van Saun, R. and DeGaris, P. (2013): Energy and protein nutrition management of the transition dairy cows. *Vet. Clin. North Am. Food Anim. Pract*., 29: 337-366.
46. LeBlanc, S. (2010): Monitoring metabolic health of dairy cattle in the transition period. *J. Rep. and Dev.,* 56: 29-35.
47. LeBlanc, S., Lissemore, K., Kelton, D., Duffield, T. and Leslie, K. (2006): Major advances in disease prevention in dairy cattle. *J. Dairy Sci.,* 89: 1267-1279.
48. Lomander, H., Frössling, J., Ingvartsen, K., Gustafsson, H. and Svensson, C. (2012): Supplemental feeding with glycerol or propylene glycol of dairy cows in early lactation-effects on metabolic status, body condition, and milk yield. *J. Dairy Sci*., 95: 2397-2408.
49. Melendez, P., Marin, M., Robles, J., Rios, C., Duchens, M. and Archbald, L. (2009): Relationship between serum non-esterified fatty acids at calving and the incidence of periparturient diseases in Holstein dairy cows. *Therio.,* 72: 826-833.
50. Moyes, K., Drackley, J., Morin, D., Rodriguez-Zas, S., Everts, R., Lewin, H. and Loor, J. (2010): Mammary gene expression profiles during an intramammary challenge reveal potential mechanisms linking negative energy balance with impaired immune response. *Physiol. Genomics,* 41: 161-170.
51. Mulligan, F. and Doherty, M. (2008): Production diseases of the transition cow. *Vet. J. 176*: 3-9.
52. National Research Council (1989): Nutrient requirements of dairy cattle. 6th rev. ed. Natl. Acad. Sci., Washington, D.C., Pp 66-76.
53. National Research Council (2001): Nutrient requirements of dairy cattle.7th rev. ed. Natl. Acad. Press, Washington, D.C., Pp 1-363.
54. Nordlund, K. (2009): The five key factors in transition cow management of free stall dairy farms. In: Proceedings of the 46th Florida Dairy Production Conference, Gainesville, Fl, April 28. Pp 27-32.
55. Opsomer, G., Gröhn, Y., Hertl, J., Coryn, M., Deluyker, H. and Kruif, A. (2000): Risk factors for post partum ovarian dysfunction in high producing dairy cows in Belgium: A field study. *Therio.,* 53: 841-857.
56. Ospina, P., Nydam, D., Stokol, T. and Overton, T. (2010): Associations of elevated nonesterified fatty acids and beta-hydroxybutyrate concentrations with early lactation reproductive performance and milk production in transition dairy cattle in the northeastern United States. *J. Dairy Sci.,* 93: 1596-1603.
57. Pratik, R., Manimaran, A., Kumaresan, A., Jeyakumar, S., Ramesha, K., Sejian, V., Rajendran, D. and Minu, R. (2017): Metabolic and immunological changes in transition dairy cows. *Vet. World*, 10: 1367-1377.
58. Proudfoot, K., Veira, D., Weary, D. and Keyserlingk, M. (2009): Competition at the feed bunk changes the feeding, standing, and social behavior of transition dairy cows. *J. Dairy Sci.,* 92: 3116-3123.
59. Rabelo, E., Rezende, R., Bertics, S. and Grummer, R. (2003): Effects of transition diets varying in dietary energy density on lactation performance and ruminal parameters of dairy cows. *J. Dairy Sci.,* 86: 916.
60. Rastani, R. and Grummer, S. (2005): Reducing dry period length to simplify feeding transition cows: milk production, energy balance, and metabolic profiles. *J Dairy Sci*., 88: 1004-1014.
61. Ravi, K., Jakkula, R., Nagarjuna, R., Pandu, R. and Iqbal, H. (2016): Transition period and its successful management in dairy cows. *Ind. J. Natural Sci*., 7: 11691-11699.
62. Remppis, S., Steingass, H., Gruber, L. and Schenkel, H. (2011): Effects of energy intake on performance, mobilization and retention of body tissue, and metabolic parameters in dairy cows

with special regard to effects of prepartum nutrition on lactation. *J. Anim. Sci*., 4: 540-572.

63. Reynolds, C., Aikman, P., Lupoli, B., Humphries, D. and Beever, D. (2003): Splanchnic metabolism of dairy cows during the transition from late gestation through early lactation. *J. Dairy Sci.,* 86: 1201-1217.
64. Roche, J., Friggens, N., Kay, J., Fisher, M., Stafford, K. and Berry, D. (2009): Body condition score and its association with dairy cow productivity, health, and welfare. *J. Dairy Sci.,* 92: 5769-5801.
65. Rukkwamsuk, T. (2010): A field study on negative energy balance in periparturient dairy cows kept in small-holder farms: effect on milk production and reproduction. *Afr. J. Agricultural Res.,* 5: 3157-3163.
66. Rukkwamsuk, T., Rungruang, S. and Wensing, T. (2004): Fatty liver in high producing dairy cows kept in evaporative cooling system in a commercial dairy herd in Thailand. *Kat. J. Natural Sci.,* 38: 229-235.
67. Salasel, B., Mokhtari, A. and Taktaz, T. (2010): Prevalence, risk factors for and impact of subclinical endometritis in repeat breeder dairy cows. *Therio.,* 74: 1271-1278.
68. Šamanc, H., Kirovski, D., Jovanović, M., Vujanac, I., Bojković, S., Jakić, D., Prodanović, R. and Stajković, S. (2010): New insights into body condition score and its association with fatty liver in Holstein dairy cows. *Acta. Veterinaria (Beograd),* 60: 525-540.
69. Scalia, D., Lacetera, N., Bernabucci, U., Demeyere, K., Duchateau, L. and Burvenich, C. (2006): In vitro effects of non-esterified fatty acids on bovine neutrophils oxidative burst and viability. *J. Dairy Sci*., 89: 147-154.
70. Schirmann, K., Chapinal, N., Weary, D., Heuwieser, W. and von Keyserlingk, M. (2011): Short-term effects of regrouping on behavior of prepartum dairy cows. *J. Dairy Sci.,* 94: 2312-2319.
71. Schröder, U. and Staufenbiel, R. (2006): Methods to determine body fat reserves in the dairy cow with special regard to ultrasonographic measurement of backfat thickness. *J. Dairy Sci., 89*: 1-14.
72. Shanna, J. (2012): The association of negative energy balance, sub-clinical hypocalcemia, and periparturient disease with rate of weight loss and 30-day milk production in dairy cattle. Honors thesis, in partial fulfillment of the requirements for the research honors program, presented to the College of Agriculture and Life Sciences, Animal Science Department of Cornell University, Pp 1-54.
73. Sordillo, L. and Mavangira, V. (2014): The nexus between nutrient metabolism, oxidative stress and inflammation in transition cows. *Anim. Prod. Sci*., 54:1204-1214.
74. Sorensen, J. and Enevoldsen, C. (1991): Effect of dry period length on milk production in subsequent lactation. *J. Dairy Sci.,* 74: 1277.
75. Stelwagen, K., Phyn, C., Davis, S., Guinard, J., Pomiès, D., Roche, J. and Kay, J. (2013): Invited review: Reduced milking frequency: Milk production and management implications. *J. Dairy Sci*., 96: 3401-3413.
76. Trevisi, E. and Bertoni, G. (2008): Attenuation with acetylsalicylate treatments of inflammatory conditions in periparturient dairy cows. Aspirin and health research progress. Nova Science Publ., Hauppauge, NY, USA, Pp 23-37.
77. VanSun, R. and Davide, K. (2008): Diagnostic use of pooled metabolic profilesin in Czech dairy herds. In: Proceedings 41st Annual American Association Bovine Pract. Conv., Charlotte, N.C, Sept. 25-27, Pp 286.
78. Wallace, R., McCoy, G., Overton, T., Clark, J. (1996): Effect of adverse health events on dry matter consumption, milk production, and body weight loss of dairy cows during early lactation. *J. Dairy Sci*., 79: 205.
79. Wathes, D., Bourne, N., Cheng, Z., Mann, G., Taylor, V. and Coffey, M. (2007b): Multiple correlation analyses of metabolic and endocrine profiles with fertility in primiparous and multiparous cows. *J. Dairy Sci.,* 90: 1310-1325.
80. Wathes, D., Cheng, Z., Bourne, N., Taylor, V., Coffey, M. and Brotherstone, S. (2007a): Differences between primiparous and multiparous dairy cows in the inter-relationships between metabolic traits, milk yield and body condition score in the periparturient period. *Domest. Anim. Endocrin*., 33: 203-225.
81. Wathes, D., Cheng, Z., Chowdhury, W., Fenwick, M., Fitzpatrick, R., Morris, D., Patton, J. and Murphy, J. (2009): Negative energy balance alters global gene expression and immune responses in the uterus of postpartum dairy cows. *Physiol. Genomics*, 39: 1-13.
82. Weiss, W., Todhunter, D., Hogan, J. and Smith, K. (1990): Effect and duration of supplementation of selenium and vitamin E on periparturient dairy cows. *J. Dairy Sci*., 73: 3187-3194.

1/21/2021