International Journal of Livestock Research, Vol. 10 (6) June' 2020
http://www.ijlr.org
eISSN: 2277-1964
NAAS Rating 2020 – 5.36

Review Article

Incidence, Causes and Treatment of Ketosis in Lactating Bovines

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How to cite this paper: Kushwah, N., Upadhyay, V., Roy, A. K., & Singh, M. (2020). Incidence, Causes and Treatment of Ketosis in Lactating Bovines. *International Journal of Livestock Research*, 10(6), 1-10. doi: http://dx.doi.org/10.5455/ijlr.20200317053918

Received : Mar 17, 2020
Accepted : Apr 22, 2020
Published : Jun 30, 2020

Abstract

The demand of energy is increased during transition and early phase of lactation due to the synthesis of milk for calf. However, the energy requirement is not met because of the decreased dry matter intake. The mobilization of adipose tissue and release of free fatty acids compensate the additional energy requirements as a result of which the body weight also declines. It may lead to the incidence of metabolic disorders like retention of fetal membrane, milk fever, subclinical or clinical ketosis, mastitis, metritis etc. The incidence of these disorders is interlinked with negative energy balance. The incidence of ketosis varies from herd to herd due to the different management factors and varying climates. The clinical ketosis results in significant losses in milk yield and negatively impact the reproductive efficiency of animals resulting in huge economic loss in terms of income to dairy farmers. Therefore, the detection of ketosis at subclinical stage is important to minimize the losses and maintain good health of lactating bovines. The incidence of ketosis during different physiological stages and the factors making animals prone to ketosis have been discussed in the present review.

Keywords: Adipose, Ketosis, Lactation, Metabolic Disorders, Milk Production, Transition

Introduction

Lactating animals have three distinct phases namely; milk production, pregnancy and transition. Though each physiological stage has its own significance, but transition phase is the most crucial phase to determine the ensuing lactation and reproductive performance. It is the period from 3 weeks prior to parturition to 3 weeks after parturition (Smith and Risco, 2005). During this period dairy cattle are at a higher risk for most of the metabolic diseases due to marked changes in their endocrine status and a reduction in feed intake when the nutrient demand for the developing fetus and lactogenesis are very high. Therefore, this period is very critical for health and subsequent production performance of dairy cows (Castillo *et al*., 2005; Sordillo *et al*., 2007; Sharma *et al*., 2011). Physiological changes that occur during this phase are rapid differentiation of secretory parenchyma, intense growth of mammary glands, milk synthesis and secretion, high-energy demand and an increased oxygen requirement (Gitto *et al*., 2002); and the high production of oxygen-derived reactants termed as reactive oxygen species (ROS). ROS are produced much faster than they could be safely neutralized by antioxidant mechanisms (Trevisan *et al*., 2001). The increase in oxidative stress and negative energy balance may lead to calving-related complications in animals (Orhan *et al*., 2003; Castillo *et al*., 2005; Dimri *et al*., 2010). Trace minerals with an antioxidant function include selenium (Se), copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe). Some nutrients directly quench free radicals, (Waldron, 2013), while enzymatic antioxidants such as superoxide dismutase (SOD), glutathione peroxidase (GSH-Px) and catalase are considered to be an important defense system against free radical accumulation. Superoxide dismutase converts superoxide to hydrogen peroxide while GSH-Px and catalase convert hydrogen peroxide to water. Superoxide dismutase enzyme is Cu, Mn and Zn dependent, GSH-Px is Se dependent and catalase is Fe dependent (Bowman *et al*., 2008; McDowell *et al*., 2007; Weiss, 2005).

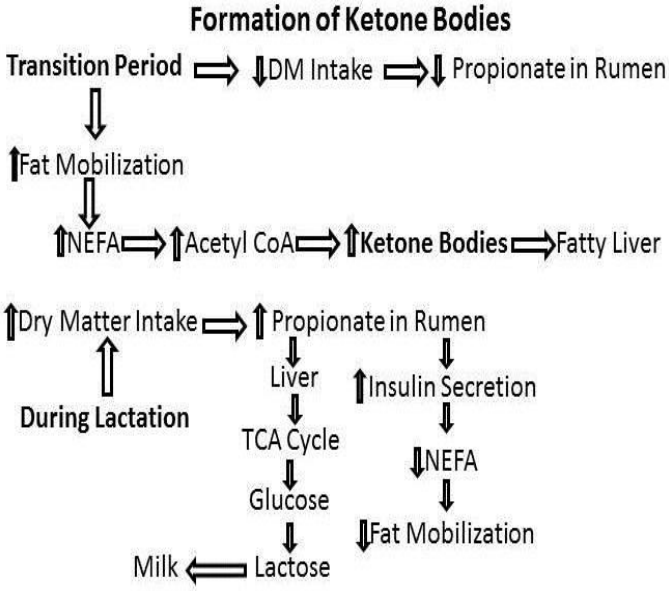
Elite dairy cows suffer from negative energy balance (NEB) during the first week of lactation or longer period due to high energy expenditure associated with milk production and limited feed intake, which result in mobilization of body fat reserves and hypoglycaemia (Bobe *et al*., 2004; Djokovic *et al*., 2007, 2011). Factors like low plane of nutrition, age, heredity, poor body condition score and impaired energy imbalance are possible causes of NEB that may lead to periparturient fatty liver and ketosis (Bobe *et al*., 2004). The NEB of cows during prepartum period renders them more vulnerable to develop displacement of abomasum, impaired lactation and reproductive performance in the lactation (Le Blanc *et al*., 2005). There are certain indirect effects also which make an animal more prone to infections of udder and uterus, reduce fore rumen motility, decrease appetite and hence decreased milk production (Randhawa and Chand, 2011). Over-conditioned dry cows are more vulnerable for ketosis and fatty liver, which may suppress immunity directly or through an excessive negative energy balance route (Ingvartsen *et al*., 2003) and cause retained placenta (Le Blanc, 2008; Houe *et al*., 2001). It has been reported that ketosis and milk fever are both related to each other and may cause retention of fetal membrane via more than one etiological pathway. Diagnosis of bovine ketosis at an early or subclinical stage is a must to prevent the economic loss to the farmers in terms of reduced milk yield. Some workers have considered the blood glucose (Gupta and Rai, 1987; Kumar *et al*., 1987) others the blood ketones (Geishauser *et al*. 1998) and few to the non-esterified fatty acids (Simeonovet *et al*., 1977) to be associated with ketosis of cows. However, no concerted efforts have been directed to correlate the blood biochemical parameters with blood ketones.

Incidence of Ketosis

Duffield (2000) reported early phase of lactation as the most important variable with 40 to 60% cases of subclinical ketosis in cows and 2-15% incidence of clinical ketosis. Bihani *et al*. (2002) reported a low prevalence of ketosis at 9.90% during the second to fifth parity of 60 to 80 days postpartum which was maximum during November to January (Akamatsu *et al*., 2007). Mir and Malik (2002) recorded highest prevalence in the age group of 8-9 years (47.36%) in the third lactation (45.10%) and during 1-2 months (42.10%) post-partum. Singh (2002) described ketosis as a common metabolic disease of high producing animals occurring during the first 10-60 days after parturition. The high producing Holstein cows have higher prevalence of subclinical ketosis (38%) than low producer dairy cows (Pourjafar and Heidari, 2003). Chakrabarti (2006) reported higher prevalence of ketosis in high yielding cows generally within a month after calving. Sakha et al., (2007) in a study during 3-6 weeks postpartum in 90 cows reported 14.4% and 5.55% ketonemia with BHBA level at >1.2 and >1.7 mmol/L, respectively. Arya (2008) has reported the prevalence of ketosis as 9.85% in and around Bikaner. Thirunavukkarasu *et al*. (2010a) in State of Tamil Nadu, has reported the incidence of clinical cases of ketosis from 9.38 to 11.42% in cows. Cows suffer more (9.38%) as compared to buffaloes (2.92%) as reported by Thirunavukkarasu *et al*. (2011). There was higher prevalence of ketosis in rainy and summer seasons in comparison to winter. The incidence was 37.01, 37.25

and 28.24% during summer, rainy and winter seasons respectively. Approximately 75% diseases in dairy cattle occurred during 30 days postpartum and 50% dairy cattle suffered from metabolic and infectious diseases during the transition period (LeBlanc, (2010). Ospina *et al*. (2010) has reported higher incidence of ketosis (40%) in cows having higher post-partum BHBA concentrations i.e. >1.2 mmol/L. The Holstein cows suffering from subclinical ketosis were 63, 68 and 59% respectively during 2, 4 and 6 weeks after parturition (Asl *et al*., 2011). Borchardt *et al.* (2012) found an overall prevalence of 30.7, 19.3 and 13.6%, as determined by BHBA threshold concentrations of 1,000, 1,200 and 1,400 µmol/L, respectively in the pooled serum samples for herd-based detection of subclinical ketosis in dairy cows after calving. Chapinal *et al*. (2012) recorded a prevalence of 15% in the herds of US and Canada in which >25% of sampled cows had increased post-partum BHBA concentrations of >1.4 mmol/L within a week post-partum. McArt *et al*. (2012) reported a peak incidence and prevalence of SCK (BHBA concentration of 1.2-2.9 mmol/L) at 5 DIM.

Physiology of Ketosis



Glucose and Fat Metabolism

The concentrations of glucose and lactate gradually declined with the increasing severity of ketosis. Lactate is an end-product of glycolysis and precursor of gluconeogenesis. When plasma glucose and lactate both decreased, then the gluconeogenesis cannot maintain the normal glucose levels and results in NEB. Fat mobilization is increased to maintain milk and glucose. The fatty acid oxidation gets enhanced with an increase in ketone bodies. The concentration of ketone bodies in plasma was higher with the increased severity of ketosis as an outcome of incomplete fatty acid oxidation. Low-density lipoprotein (LDL) is combined with its receptor in the body and enters cells to obtain lipids, cholesterol ester is hydrolyzed to free cholesterol and fatty acids by the action of lysosome. Acetyl coenzyme A (acetyl-CoA) is obtained after further fatty acid oxidation and supplies energy through the Krebs cycle. When the Krebs cycle is hampered, excessive acetylCoA can generate ketones. When ketosis occurs in a dairy cow, body fat mobilization is required to supply energy to counteract the NEB, which results in decreased contents of LDL and very low-density lipoprotein (VLDL) (Klein and Buttchereit, 2012).

Citrate which participates mainly in the Krebs cycle shows decreased levels during ketosis. Citric acid is a synthetic product of oxaloacetic acid and acetyl-CoA which is an intermediate of the Krebs cycle. Therefore, decrease in citric acid is related to the decrease in oxaloacetic acid, as excess of acetyl-CoA of fatty acid decomposition is blocked in the Krebs cycle due to decreased citric acid and provide energy to synthesize ketones. However, the limited ability of the body to use ketones results in accumulation of ketones in the blood to cause ketosis. As a decomposition product of non-esterified fatty acid (NEFA), the main function of acetic acid is to be activated as acetyl-CoA for energy. The lipid mobilization and NEFA decomposition were improved when ketosis occurred, contents of acetic acid were increased and this would maintain butter-fat percentage and promote ketosis. According to metabolic pathways, formic acid is the product of pyruvic acid. The format generated by pyruvic acid decreases and instead

the pyruvic acid generates acetyl-CoA that results in ketogenesis and elevated blood ketone contents (Yanhui *et al*., 2016).

Classification of Ketosis

The terms subclinical and clinical ketosis are favored for ketosis categorization (Duffield, 2000). Clinical ketosis is characterized by increased ketone bodies in blood, urine or milk; in conjunction with other visible signs such as in appetence, obvious rapid weight loss and dry manure. Subclinical ketosis (SCK) is defined as an increase in blood, urine, or milk ketone bodies above a threshold level associated with undesirable outcomes in the absence of obvious clinical signs. However, it is difficult to determine if a specific animal is showing clinical signs of ketosis in large groups of loose-housed cattle. Attempts have been made to classify ketosis as clinical or subclinical based upon the blood BHBA concentrations (McArt *et al*., 2011). The clinical and research experience has shown that the animals with high levels of ketonemia may show no clinical signs and animals with relatively low levels may show illness. The severity of clinical signs appears to depend upon the animal's ability to process and tolerate the ketone bodies (Herdt, 2000). The disorder may therefore be best named as hyperketonemia rather than clinical or subclinical ketosis.

Biomarkers for Ketosis

There are several biomarkers of ketosis used for testing ketosis in animals as described below-

BHBA

The gold standard for the diagnosis of ketosis is the measurement of ketone bodies in serum or plasma by photometrical procedure in a diagnostic laboratory. BHBA is the most frequently used test due to its stability in samples (Duffield, 2000; Herdt, 2000). The Ketolac BHBA test strip (with a cut-off threshold of 200 mM of BHBA in milk) is potentially useful tool for the routine monitoring of SCK in early postpartum dairy cows (Zhang *et al*., 2012).

NEFA

According to Drackley, (2000) normal NEFA levels for cows in positive energy balance are <0.2 mM. During the close-up dry period, values increased slowly as the cow approached calving; and usually ranged between 0.5 and 1.0 mM during the last week before calving which opposes the range of <0.5 to 2 mM. Values increased from 2 to 3 days before parturition and generally peaked at 0.8 to 1.2 mM on the day of calving due to hormonal changes and the stress of calving. NEFA levels decrease after calving and values greater than 0.7 Mm after calving, indicate severe NEB and by six weeks after calving, the values reach below 0.3 mM again. Djokovic *et al*. (2013) reported that Cows in early lactation had significantly higher levels of serum BHB and NEFA, lower glycaemia and high lipomobilization (NEFA>0.4 mmol/L) was detected in 6 (40%) of early lactation cows but in none of the late pregnant cows while subclinical ketosis (BHB>1.2 mmol/L) was detected in 14 (94.4%) of the early lactation cows and 4 (26.6%) of the late pregnant cows. Triglycerides (TG) below 0.12 mmol/L and glucose levels below 2.5 mmol/L were found in 7 (44%) and 10 (66.6%) of the early lactation cows respectively and in none of the late pregnant cows. The blood serum levels of glucose, TG, BHBA, NEFA and AST in early lactation cows suggest metabolic disorders associated with ketosis and some degree of hepatic lesions probably due to fat infiltration.

Glucose

Djokovic *et al*. (2010) reported significantly lower (P<0.05) blood levels of triglycerides, total protein, albumin and urea in the puerperal cows, suggesting the decreased synthetic capacity of liver cells. Blood bilirubin levels were significantly higher (P<0.01) in the puerperal cows as compared to the late pregnant cows indicating the decreased excretory capacity of the liver. Blood calcium, phosphorus and magnesium levels in the postpartum cows were lower (P>0.05), suggesting a reduced supply of these minerals from alimentary sources and/or increased utilization by the mammary gland. Ambore *et al*. (2001) studied biochemical alterations in clinical ketosis in buffaloes which revealed significant decrease in blood glucose (47.8±0.76 mg/dl) as compared to healthy control group (61.04±0.35 mg/dl). Constable et al. (2017) has also reported the reduction of blood glucose from normal levels of 50mg/dl to 20-40mg/dl in ketotic cows.

Other Biomarkers

Mordak and Nikpon (2006) compared the values of selected blood parameters in 30 clinical healthy cows in periparturient period and found significant differences in the value of total bilirubin, SGOT, inorganic phosphorus, calcium and chloride before and after calving. However, large differences were observed in the values of total proteins, glucose, and creatinine without any significant difference. Kalaitzakis *et al*. (2006) observed a strong correlation between serum AST activity and triglyceride and total lipid concentration, serum bile acids, total bilirubin in cows with fatty liver.

Factors Responsible for Ketosis

Information regarding nutrition and management of transition cows has greatly increased over the last few years. However, there is still a lack of information on many ketosis risk factors regarding individual cows and herds. Following factors render the animal more prone to ketosis.

i. Body Condition Score and Parity

Body condition score (BCS) at calving is a measure of adipose tissue reserves that can be used during lactation to supply energy and precursors for milk fat. Excessive BCS at calving increases losses in body condition during the lactation and decreases dry matter intake and milk production (Roche *et al.*, 2009). Fatty cows are in a greater NEB and have higher plasma concentration of NEFA (Melendez *et al*., 2003). Excessive body condition at calving contributes to the development of metabolic disorders such as fat cow syndrome, mastitis and metritis (Roche *et al*., 2009). Generally, higher than 3.25 or 3.5 BCS on a 5-point scale at calving is associated with a higher risk of ketosis. McArt *et al*. (2013) found that cows with a BCS during the close-up period at or above the herd median had a significantly increased risk of development of SCK between 3 and 16 days in milk (DIM). However, interpretation of this information is challenging as the median BCS and the exact timing of scoring were not reported. Furthermore, the amount of body condition lost after calving was not examined and this appears to be more important than the absolute BCS in some studies (Gillund *et al*., 2001).

ii. Dry Period

Studies have found a decreased risk of ketosis in animals that have a shortened dry period (35 days or less) with little or no effect on production or reproduction in the subsequent lactation (Rastani *et al*., 2005; Watters *et al*., 2008; Santschi *et al*., 2011). It should be noted that there were differences between herds in days open in response to shortened dry period (Santschi *et al*., 2011), suggesting that other management factors may affect the success of a short dry period in a herd. Nutritional management of the transition cow is examined as an important area for ketosis prevention.

iii. Feeding

The lowest dry matter intake occurs at calving. Milk production typically peaks between 5 to 7 weeks postpartum while maximum dry matter intake is reached between week 8 and 22 after calving and during the early lactation leads to a lack of ruminal propionate supply to the liver (Drackley 1999, DeFrain *et al*., 2005). Propionate produced in the rumen after fermentation of carbohydrates is the major glucogenic volatile fatty acid (DeFrain *et al*., 2005). Propionate stimulates insulin secretion, which suppresses NEFA mobilization (Pehrson *et al.*, 1998, Drackley, 1999). Richert *et al*. (2013) also found that increasing levels of concentrates in the diet was associated with an increase in farmer reported ketosis incidence. The negative effect of increased concentrate was more pronounced in herds that used grazing to meet a portion of their energy requirements potentially due to these herds being more likely to feed concentrate separately and at fewer times during the day, increasing the risk of acidosis. Butyrate may be high in silages that are not properly preserved, which may lead to increased blood ketone concentrations due to increased uptake from the rumen or decrease in feed intake due to palatability (Ingvartsen, 2006).

iv. Season

Thirunavukkarasu *et al*. (2011) reported the higher prevalence of ketosis in rainy season and summer season as compared to winter. The respective incidence was 37.01, 37.25 and 28.24% in summer, rainy and winter seasons

respectively.

v. Effect on Milk Production

Several studies have described the detrimental effects of ketosis on milk production (Duffield *et al*., 2009; Ospina *et al*., 2010b; McArt *et al*., 2012b). Yameogo *et al*. (2008) reported that SCK decreased milk yield by 12.4 and 15.6% respectively in Holstein cows, whereas clinical ketosis reduced milk yield in their second month of lactation from 18.6 to 26%. Such cows have lower blood glucose and higher average levels of blood urea than cows with normal blood beta-hydroxy butyrate levels in ketogenic cows. Samiei *et al*. (2013) reported the mean daily peak milk yield for clinical ketosis, SCK and healthy cows in study were 28, 35 and 45 kg, respectively, suggesting a decline ranging from 22 to 38 % compared to the healthy cows. Teli and Ali (2007) recorded lactation stage wise drop in milk yield in clinically ketotic buffaloes. The average drop in daily milk yield was recorded to be 3.52±0.16 litres (36.70%) and the recovery after treatment could restore only 1.73±0.15 litres (25.30%) milk per day. Bali *et al*. (2016) studied 18 clinical cases of ketosis in buffaloes and found variable degrees of frequency of occurrences of symptoms with sudden decline in milk yield being present in 100 percent of the cases. McArt *et al*. (2012b) reported that each 0.1 mmol/L increase in blood BHBA level above 1.2 mmol/L at 3 to 16 DIM decreased milk production by 0.5 kg/d for the first 30 days of lactation. A herd level study in which herds were classified as high risk if > 15% of mature cows had blood BHBA > 1 mmol/L or > 20% of heifers had blood BHBA > 1.2 mmol/L) showed high risk herds had 358 and 534 kg decreases in projected 305 ME milk yield for cows and heifers respectively (Ospina *et al*., 2010c).

vi. Effects on Reproductive Efficiency

Walsh *et al*. (2007b) found that cows suffering from SCK during the first two weeks of lactation were 50% less likely to conceive at first service and remained open for 16 to 22 days more than animals that were not diagnosed with SCK. They also showed that cows with higher BHBA concentrations were less likely to become pregnant, suggesting it is not just the presence of ketone bodies but the degree of ketosis that is important to future reproductive success. In another study, the same investigators found that cows diagnosed with SCK based on milk BHBA during the first two weeks after calving had 1.5 greater odds to be an ovulatory at 46 and 60 DIM (Walsh *et al*., 2007a). McArt *et al*. (2012b) showed that cows that were diagnosed with SCK based on blood BHBA concentrations between 3 and 16 DIM were 30% less likely to conceive to first service than unaffected herd mates. A study examining the relationship between reproduction and SCK diagnosis in 4 regions of the US found no association between blood BHBA levels and pregnancy at first service (Chapinal *et al*., 2012). It is possible that there are differences between regions or seasons that affect the relationship between SCK and reproduction. Ospina *et al*. (2010b) classified herds as high risk for metabolic disease if > 15% of animals sampled once between 3 and 14 DIM had blood BHBA concentrations of > 1.2 mmol/L. They found that high-risk herds had a 0.8% lower pregnancy rate than low-risk herds. Though this is not a large difference, it shows that higher prevalence of SCK can affect herd performance. Considering that most herds have a cumulative lactational incidence higher than 15% (Duffield, 2000), it would be interesting to determine the mechanisms by which an increased incidence of SCK affects overall herd reproductive performance. High NEFA concentration is toxic to peripheral tissue and negatively affects fertility (Adewuyi *et al*., 2005; Leroy *et al*., 2005).

vii. Association with other diseases

SCK (Blood BHB > 1.2 to 1.4 mmol/L) in the first or second week after calving is associated with increased risk of displacement of abomasum (3 to 8 times), clinical metritis (3 times), clinical ketosis (4 to 6 times), Increased probability of subclinical endometritis at week 4 postpartum, a prolonged postpartum anovulation period, increased duration and severity of mastitis, 1.8 times increased odds of culling at < 60 DIM and lower milk production in early lactation (Roberts *et al*., 2012).

Diagnosis

Gutzwiller (1998) determined BHBA contents in milk samples from healthy, ketotic and high yielding cows using new dipstick semi quantitative method. The dipstick test was found suitable for diagnosing clinical ketosis and for monitoring the energy status of high yielding dairy cows. Geishauser *et al*. (2000) stated that the semi quantitative tests detected primarily acetoacetate and to a lesser degree acetone, without detection of BHBA. The ketolac BHBA

strip at 50 and 100 µmol of BHBA per litre of milk showed sensitivity of 92 and 72% respectively. This test was more sensitive for detection of subclinical ketosis than any of the Rothera's test. The Rothera's tests were found to be highly specific whereas, the ketolac BHBA strip at 200, 500 and 1000 µmol of BHBA per litre of milk had more than 97% specificity. The Precision XtraTM meter is a useful cowside ketone test for the diagnosis of SCK in postpartum dairy cows (Heuwieser *et al*., 2007; Konkol *et al*., 2009). Cows with blood BHBA levels above 1.4 mM (14.4 mg/dl) are considered positive for ketosis according to the reference provided by the manufacturer. The first report to use an electronic human BHBA meter for dairy cows described a high correlation (r2=0.99) with BHBA concentrations determined spectrophotometrically and considered the test suitable for detecting SCK in dairy cows (Jeppesen *et al*., 2006). (Iwersen et al. 2009) reported that the Precision Xtra test had sensitivity levels of 88 and 96% at 1.2 mM and 1.4 mM BHBA of whole blood, respectively, and specificity levels of 96 and 97%, respectively. In the study of (Voyvoda and Erdogan, 2010), when SCK was defined as plasma BHBA levels above 1.2mM, the sensitivity and specificity of the hand-held meter ketone testing in determining SCK were 85 and 94%, respectively.

Treatment

Venkateshwarlu and Choudhuri (2000) concluded that parenteral therapy with 540 ml of 25% dextrose for two days was the most efficacious with respect to early recovery time and restoration of milk yield in comparison to different combinations of sodium propionate, nicotinic acid, methionine, propylene glycol and jaggery. Baishya *et al*. (2002) found earliest restoration of milk yield with the treatment combination of Fructodex (10% fructose 500 ml *i/v* for 2 days) and Vetalog (6 mg @1 ml *i/m*) followed by dextrose (10% 500ml *i/v*) plus Dexona (2-2.5 ml *i/m*), in Jersey cows suffering from SCK. Zialitis *et al*., (2007) treated 10 cows suffering from SCK for 10 days with daily doses of 250 g of propylene glycol which was fed with the concentrate mixture for 7 days along with daily doses of 12 g nicotinic acid (Niacin). Both groups displayed a negative blood hydroxybutyrate test, reduced milk fat and hypoglycaemia, after the treatment. Stanislaw and Przemyslaw (2009) found that supplementation of *S. cerevisiae* increases serum glucose level and milk production in animals. Tufani *et al*. (2011) conducted a study on 40 ketotic cows and compared efficacy of 1 liter of 25% glucose *i/v* followed by 500 ml *i/v* once daily for next 2 days. Vitamin B Complex (B_1, B_6 and B_{12}) was added with the drip. Dexamethasone (5 ml *i/m* as single dose) was also given. The mean recovery time (days) was recorded to be highest at 1.7±0.26 days. Gupta (2012) found that propylene glycol was more effective as compared to the bolus of niacin, tannic acid and jaggery for the treatment of SCK in lactating buffaloes. Dar *et al*. (2014) found that glucose administration in combination with gluconeogenic precursors fortified with B-complex vitamins, insulin, sodium bicarbonate and isoflupredone acetate gave excellent recovery results. Bakr *et al*. (2015) observed that *S. cerevisiae* supplementation of dairy cows during transition and early lactation improves health, milk production and reduces the risk of ketosis, milk fever, retained placenta, displaced abomasum and suppressed immune functions. Nigam (2016) found that nicotinic acid and propylene glycol were the most efficacious treatment for subclinical ketosis in cattle.

Economic Losses

McLaren *et al*. (2006) estimated that a reduction of 1% in SCK incidence would amount to a saving of 584 USD per year. McArt *et al*. (2015) has calculated the average total costs of hyperketonemia (blood BHBA concentrations ≥ 1.2 mmol/L) to be 289 USD per case diagnosed. Thirunavukkarasu *et al*. (2010a) revealed that cows in milk at Erode and Coimbatore districts of Tamil Nadu had relatively better feeding and management where the loss due to ketosis was estimated Rs. 577.09 per affected cow, including the cost of medicines (Rs. 262.99, 45.57%), Veterinarian's fee including additional labour cost (Rs. 224.98, 38.99 percent) and expenses on feed supplements (Rs. 89.12, 15.44 percent). However, the loss per affected buffalo was slightly less at Rs. 510.80 of which Rs. 240.80 (47.14 percent), Rs. 187.50 (36.71 percent) and Rs. 82.50 (16.15 per cent) were contributed by medicine cost, veterinarian's fee (including additional labour cost) and cost of feed supplements, respectively.

Conclusion

There are many factors like the plain of nutrition, heredity, body condition score, and energy balance which could make the cows more vulnerable to ketosis and fatty liver. A lot of work has been done to diagnose ketosis at an early stage but many cows are not detected for ketosis under field conditions. There is a need to address this problem to avoid decline in milk production and reproductive performance.

Acknowledgements

I would like to express my gratitude to Dr. Mahendra Singh and Dr. A.K. Roy for their contribution in reviewing and editing the manuscript to make it suitable for publication

Conflict of Interests

There is no conflict of interest.

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