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Ketosis in Dairy Cattle: A Silent Threat to Production and Fertility

*Aashish[1], Ravi Kumar Yadav[2] and Ashok Kumar[3]
[1]Assistant Professor, Department of Veterinary Gynaecology and Obstetrics, M. R. Veterinary College & Research Center, Jhajjar, Haryana, India
[2]Ph.D Scholar, ICAR-Indian Veterinary Research Institute (IVRI), Izatnagar, Bareilly, UP, India
[3]MVSc Scholar, College of Veterinary and Animal Science, Navania, Vallabhnagar, Udaipur, India
*Corresponding Author's email: aashishdhull1998@gmail.com

Ketosis is an important metabolic disorder of dairy cattle particularly during the transition period and early lactation. It develops mainly because of negative energy balance when the energy required for milk production exceeds dietary energy intake. The resulting mobilization of body fat increases circulating non-esterified fatty acids (NEFAs), which are taken up by the liver and converted into ketone bodies principally β-hydroxybutyrate (BHB), acetoacetate and acetone. Ketosis may occur in clinical or subclinical forms. Clinical ketosis is associated with reduced appetite, decreased milk production, weight loss and in severe cases nervous signs whereas subclinical ketosis may occur without obvious clinical signs but can adversely affect production, health and fertility. Diagnosis is primarily based on measurement of BHB in blood or milk with cow-side testing providing opportunities for early detection. Effective management depends on maintaining adequate energy intake during the transition period, avoiding excessive body condition at calving, gradual dietary adaptation and early identification of affected animals. Treatment commonly involves glucose or dextrose administration and oral propylene glycol. Early recognition and appropriate nutritional and herd-level management are therefore essential to reduce the impact of ketosis on dairy production.

Keywords: Ketosis, dairy cattle, negative energy balance, β-hydroxybutyrate, transition period, subclinical ketosis

Introduction

The transition from late pregnancy to early lactation is one of the most metabolically demanding periods in a dairy cow's life. Around calving the demand for nutrients increases rapidly because of the onset of milk production while feed intake increases more slowly. This creates a negative energy balance (NEB).To compensate for this energy deficit, the cow mobilizes stored body fat. This results in increased release of non-esterified fatty acids (NEFAs) into the bloodstream. The liver takes up these fatty acids and when their supply exceeds its capacity for complete oxidation produces ketone bodies. The major ketone bodies are β-hydroxybutyrate (BHB), acetoacetate and acetone.When ketone production becomes excessive the condition is referred to as ketosis or acetonemia.

Ketosis

Ketosis is primarily associated with the negative energy balance that develops around calving. Hormonal changes before and after parturition promote mobilization of body fat. Reduced insulin concentrations and increased lipolytic activity facilitate the release of NEFAs from

adipose tissue.The problem becomes more important in high-producing cows because milk production places a very high demand on glucose and energy. If feed intake cannot meet this demand, fat reserves are increasingly mobilized.

Several factors can further increase the risk, including:

- Excessive body condition at calving
- High milk production
- Reduced feed intake
- Prolonged dry period
- Milk fever
- Retained placenta
- Lameness
- Hypomagnesemia
- Mastitis, metritis and other postpartum diseases
- Poor-quality or poorly fermented feed
- Inadequate dietary energy

Poorly fermented silage containing high concentrations of butyrate can also contribute to ketosis because butyrate is converted to β-hydroxybutyrate in the liver.

Mechanism of ketosis

During negative energy balance triglycerides stored in adipose tissue are broken down and NEFAs are released into the circulation. A proportion of circulating NEFAs is taken up by the liver. Normally fatty acids are oxidized to acetyl-CoA which enters the tricarboxylic acid cycle. However when the supply of fatty acids exceeds the liver oxidative capacity, acetyl-CoA is increasingly directed toward ketone-body formation. The resulting increase in BHB, acetoacetate and acetone produces hyperketonemia and when sufficiently severe clinical ketosis. This metabolic disturbance may also affect immune function. High concentrations of BHB have been associated with reduced respiratory burst activity of neutrophils, increasing susceptibility to postpartum infections.

Clinical and Subclinical Ketosis

Ketosis can broadly be recognized in two forms.

Clinical ketosis

Clinical ketosis is the more obvious form and is generally seen during the first several weeks after calving. Affected cows may show:

- Reduced or complete loss of appetite
- Reduced milk production
- Rapid weight loss
- Hard, dry feces
- Refusal of concentrate
- Ketonemia and ketonuria
- Hypoglycemia
- Acetone-like smell

Some cows may develop nervous signs including abnormal behaviour, excessive licking, aggression, abnormal head posture, circling, staggering, muscle tremors and in severe cases seizures or apparent blindness.

Subclinical ketosis

Subclinical ketosis is more difficult to recognize because obvious clinical signs are absent. Nevertheless ketones concentrations particularly BHB are elevated. This form is important because apparently normal cows may already be experiencing metabolic consequences. Subclinical ketosis has been associated with reduced milk production impaired reproductive performance and increased risk of other health problems. Therefore relying only on visible clinical signs can allow a considerable proportion of affected cows to remain undetected.

Different Forms of Ketosis

Based on its underlying cause, ketosis may occur as:

Primary ketosis: Develops mainly because energy demand for milk production exceeds energy intake, particularly in high-producing cows during early lactation.

Secondary ketosis: Develops when another disease such as displaced abomasum, traumatic reticulitis, metritis or mastitis, reduces feed intake and consequently aggravates the energy deficit.

Alimentary ketosis: Associated particularly with poorly fermented, high-butyrate silage and dietary disturbances.

Starvation ketosis: Develops when prolonged inadequate energy intake results in extensive mobilization of body fat.

Nutritional deficiency-associated ketosis: May occur when deficiencies affecting energy metabolism, including inadequate dietary carbohydrate or certain nutrients, compromise energy metabolism.

Nervous ketosis: A rare and severe form associated with neurological abnormalities.

Diagnosis

The most useful indicator for identifying ketosis is measurement of β-hydroxybutyrate **(BHB)**. BHB can be measured in:

- Blood
- Milk
- Urine

Cow-side BHB analyzers allow rapid testing at the farm and can help identify subclinical cases before obvious clinical disease develops. Laboratory methods include spectrophotometric assays while advanced analytical approaches include infrared spectroscopy, gas chromatography and nuclear magnetic resonance-based techniques. Monitoring metabolic indicators and milk-based measurements can therefore form an important part of herd-level ketosis surveillance.

Treatment

The main objective of treatment is to correct the energy deficit and reduce excessive ketone production.Common treatment approaches include:

Dextrose/glucose: Intravenous administration provides a rapid source of glucose and is particularly useful in clinically affected cows.

Propylene glycol: Oral propylene glycol provides a gluconeogenic substrate and can help increase blood glucose while reducing ketone production.

Additional supportive measures may be required depending on the condition of the animal and the presence of concurrent disease. Underlying disorders such as mastitis, metritis or displaced abomasum must also be identified and managed.

Prevention Is Better Than Treatment

The most effective strategy against ketosis is prevention of excessive negative energy balance. Good transition-cow management should focus on:

- Providing a balanced and highly palatable diet
- Meeting energy and protein requirements
- Gradually adapting cows to the lactation diet
- Avoiding excessive body condition at calving
- Monitoring body condition score
- Maintaining good-quality forage
- Minimizing unnecessary stress
- Monitoring feed intake during the transition period
- Screening high-risk cows for ketosis
- Detecting and treating postpartum diseases early

Concentrates should be introduced gradually before calving so that the rumen can adapt to the nutritional demands of early lactation. Regular monitoring of cows during the transition period can help identify metabolic problems before they progress to clinical disease.

Impact on Production and Reproduction

Ketosis is not simply a disorder of ketone metabolism. Its consequences can extend to the overall productivity and reproductive efficiency of the herd.Affected cows may experience reduced milk production, excessive body-weight loss and increased susceptibility to other diseases. Metabolic disturbances during the postpartum period may also impair reproductive performance, contributing to delayed return to estrus, endometrial problems and reduced conception following first insemination.Thus, controlling ketosis is important not only for individual animal health but also for the economic sustainability of dairy farming.

Conclusion

Ketosis is a major metabolic challenge of dairy cattle particularly during the transition from late pregnancy to early lactation. The fundamental problem is negative energy balance which stimulates mobilization of body fat and excessive production of ketone bodies especially β-hydroxybutyrate. While clinical ketosis is readily recognized, subclinical ketosis can remain unnoticed despite its potential effects on milk production, health and fertility.Early detection through BHB monitoring combined with appropriate treatment using glucose or propylene glycol when indicated, can reduce the severity and consequences of the disorder. However, prevention remains the most effective approach. Proper transition-cow nutrition, maintenance of appropriate body condition, gradual dietary adaptation, good-quality feed, reduced stress and early management of postpartum diseases are central to controlling ketosis.

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