CHAPTER-2

**REVIEW OF LITERATURE**

* 1. **Ruminal acidosis**

**2.1.1 Characterization**

Acidosis is a pathological condition associated with the accumulation of acid or depletion of alkaline reserves in blood and body tissues, and characterized by increased hydrogen ion concentrations**.** Ruminal acidosis refers to a series of conditions that reflect a decrease in pH in the rumen of cattle. Rumen lactic acidosis (grain overload, grain poisoning, acute indigestion) develops in sheep and cattle that have ingested large amounts of unaccustomed feeds rich in ruminally fermentable carbohydrates **(Crichlow and Chaplin, 1985; Nocek, 1997).** The resulting production of large quantities of volatile fatty acids (VFA) and lactic acid decreases rumen pH to non-physiological levels, simultaneously weakening the buffering capacity of the rumen, and reduces the efficiency of rumen flora and fermentation.

**Owens *et al.* (1998)** defined as; acidosis is a decrease in the alkali (base excess) in body fluids relative to the acid (hydrogen ion) content. Because pH of body fluids is buffered by bicarbonate, the pH of body fluids may or may not be depressed during acidosis, depending on the degree to which bicarbonate compensation is possible. Central nervous system function can be disturbed by low bicarbonate concentrations even if blood pH is not depressed **(Owens *et al*., 1998).**

 **Hall (2005)** reported that, although the main focus in ruminal acidosis has been on the rumen, it might be more accurate to consider this nutritional disorder as a syndrome that can affect systems beyond the rumen and outside of the gastrointestinal tract. Notwithstanding that ruminal acidosis is by definition related to low ruminal pH and damage to that compartment of the gut, damage and impairment of function associated with ruminal acidosis has been reported for diverse systems. Among the signs associated with ruminal acidosis, mucin casts shed in feces are indicative of destruction of epithelium in the large intestine. It also suggests that excessive fermentation in other portions of the gastrointestinal tract may be involved in the syndrome of ruminal acidosis. The damage and changes reported with induced acute ruminal acidosis often indication of the array of systems that may be compromised: reduced oxidative metabolism of neutrophils, pneumonia, liver abscesses, laminitis, damage to various organ systems, gastroenteritis, fungal invasion of damaged tissues, and reduced saliva secretion.

**2.1.2 Categorization**

Acidosis can be divided into two categories – Acute or clinical ruminal acidosis and subacute ruminal acidosis (SARA). The following literature distinguishes between acute ruminal acidosis and SARA: Acute: ruminal pH <5 - 5.2 **(Nocek, 1997; Owens *et al.*, 1998)** and lactic acid concentrations of 50 - 150 mM **(Nagaraja and Titgemeyer, 2007)**; SARA: ruminal pH = 5 - 5.5 **(Nagaraja and Titgemeyer, 2007)**, threshold in the dairy cow's pH = 5.8 **(Zebeli *et al.*, 2008; Meissner *et al*., 2010)**, or ruminal pH below 5.6 for more than 3 h/24 h **(Plaizier *et al.*, 2008)** and VFA's at concentrations of 150 - 225 mM **(Nagaraja and Titgemeyer, 2007)**, or daily mean ruminal pH not lower than 6.16 and not lower than 5.8 for 5.24 h/24 h, whereas effective fiber in the total mixed rations (TMR) of dairy cows should be 30 - 33% **(Zebeli *et al.*, 2008)**.

The time threshold is crucial as SARA in dairy cows is characterized by short and long (>3 h) bouts of low ruminal pH; the long bouts of concern because they negatively affect fiber digestion, and decrease the absorptive capacity and damage the rumen epithelium. With time VFA's are absorbed, buffered or passed from the rumen causing the ruminal pH to rise. As a consequence, a cyclical pattern of ruminal pH occurs, causing repetitive periods of SARA **(Meissner *et al*., 2010). Krause and Oetzel (2006)** reported that SARA is characterized by episodes of low ruminal pH between 5.5 and 5.0.

**2.2 Etiology and risk factors of ruminal acidosis**

Ruminal acidosis occurs when there is a sudden large amount intake of rapidly fermentable carbohydrates, primarily starches and sugars. This normally manifests when feedlot cattle without proper adaptation are rapidly transitioned from roughage to high concentrate diets, or when dairy cow intake during transition pre- and post-partum is erratic **(Beauchemin and Penner, 2009)**. It is also depends on the total load of readily fermentable carbohydrates in the rumen **(Oetzel, 2003)**, since dairy cows often experience SARA at the time of maximum carbohydrate consumption **(Penner *et al.*, 2007)**.

**Owens *et al*. (1998)** reported that excessive intake of readily fermented starch often occurs when animals are first being adapted to a high-concentrate (feedlot) diet and/or when animals are switching from bulk fill to chemostatic intake regulation. Acidosis also can occur when grazing animals are fed a large amount of a starch-rich supplement. From a rumen fermentation perspective the main cause of the onset of ruminal acidosis is an imbalance between lactic acid producer and utiliser numbers **(Slyter, 1976)**, resulting in organic acid accumulation **(Wallace, 1994)**, particularly lactic acid in acute cases **(Nagaraja and Titgemeyer, 2007)** and high

concentrations of VFA in sub-acute (SARA) and chronic cases **(Nagaraja and Titgemeyer, 2007; Beauchemin and Penner, 2009)**.

Depending on the severity of the disorder, the result is a drop in ruminal pH to levels that impair proper ruminal and physiological functions. Ruminal acidosis caused mainly by a buildup of lactic acid in the rumen, which usually results from an abrupt increase in the intake of rapidly fermentable carbohydrates (**Krause and Oetzel, 2006).**

**Radostits *et al*. (2006)** stated that sudden ingestion of toxic doses of carbohydrate-rich feed, such as grain, is the most common cause of the acute form of the 'disease. Less common causes are engorgement with apples, grapes, bread, baker's dough, sugar beet, mangels, sour wet brewers' grain that was incompletely fermented in the brewery, and concentrated sucrose solutions used in apiculture. Subacute ruminal acidosis in dairy cattle is a disorder of ruminal fermentation in resulting from the ingestion of large amounts of concentrates and inadequate amounts of fiber administered in order to increase milk production in early lactation.

The etiology effects and prevention of ruminal acidosis have been extensively researched and reviewed **(Nocek, 1997 and Owens *et al*., 1998)**. Both *in vitro* and *in vivo* trials have been conducted, however much of this research has concentrated on feeding large amounts of starch-based concentrate as the cause of acidosis **(Crichlow and Chaplin, 1985).** These studies provide excellent information on acidosis in feedlot cattle and sheep on diets very high in starch. Ruminal pH in experimental cases was often less than 5 and caused severe acute clinical disease **(Nocek, 1997)**. This pH range appears to be lower than that of cattle solely fed on pasture where the mean daily pH has been reported between 5.6 and 6.4 **(O’Mara *et al*., 1997; Kolver *et al*., 1998),** with optimal ruminal pH being above 5.8 to 6.0 for fiber digestion **(Kolver and de Veth, 2002).**

There has been little research on the etiology of acidosis induced primarily by pasture feeding **(Wales *et al*., 2001)**, but more on the feeding of starch-rich concentrates to cows on pasture **(Lean *et al*., 2000; Wales *et al*., 2001).** **Wales *et al.* (2001)** found that cows fed solely on pasture or pasture supplemented with grain had a rumen pH lower than 5.5 during the day.

**2.3 Prevalence of ruminal acidosis**

**Radostits *et al.* (2006)** stated that all types of ruminants (Cattle, Sheep, Goat, Deer and farm ungulates) are susceptible to ruminal acidosis, but the disease occurs most commonly in feedlot cattle and dairy cattle fed on high-level grain diets. Animals being fed a low-energy ration are most susceptible to a rapid change to a high energy ration because satisfactory adaptation cannot occur quickly. This causes the rapid onset of abnormal fermentation.

**Radostits *et al.* (2006)** also reported that outbreaks of ruminal acidosis occurred when cattle have been turned into unripe, green corn standing in the field, when cattle or sheep have been placed on stubble fields in which considerable grain lost by the harvester was available on the ground, and due to the irregular feeding of large quantities of other less common animal feeds and by products, such as bread, baker's dough and wet brewers' grain.

**Bramley (2007)** found a herd prevalence of at least 3% in a survey of 100 Australian dairy cattle. **Krause and Oetzel (2006)** showed 4% prevalence of clinical acidosis in feedlot cattle. **Blom (1993)** showed 0.2% prevalence , this is probably not a reliable indication **(Enemark and Jorgensen, 2001).**

A number of researcher showed higher prevalence of subacute ruminal acidosis, i.e **Bramley (2007)** found 10%, **Garret *et al*. (1997)** found 19% in early lactation and 26% in mid lactation, **Kleen *et al.* (2004)** found 11% in early and 18% in mid lactation and **Radostits *et al.* (2006)** found up to 20% prevalence in ruminal acidosis.

**2.4 Mechanisms involve in development of acidosis and it’s sequel**

Increase in fermentable CHO

Cellubiose

**Polymer**

Maltose

CO2

VFA

Methane

Organic acids

Organic acids

Hexose

Xylose

**Sugar**

Glucuronides

Xylobiose

**1 microbe**

ATP

ADP

Decrease in *Staptococcus bovis* Increase in Lactobacilli

Decrease in growth rate of many bacteria

Increase in lactic acid

Increase in growth rate and increase in VFA (all bacteria )

pH < 5.0

Decrease in pH

Increase *Staptococcus bovis* growth rate

Decrease in pH

**2 microbes**

AA

NH3

CH2O

**Fig. 1:** Proposed sequence of events associated with the induction of acute ruminal acidosis. CHO= Carbohydrate, VFA= Volatile fatty acid, C$O\_{2}$= Carbon dioxide, N$H\_{3}$= Ammonia and AA= Amino acid **(Baldwin and Allison, 1983).**

Starch

Protein

Pectin

Hemicellulose

Cellulose

Sugars

H2

CO2





Pyrovate

Glucose



Oxaloacetate

Cellobiose

Succinate

Maltose

Propionyl Co-A

Lactate

Amino acids

Uronic acid

Xylobiose

Propionate

Butyrate

Acetate

Acetyl Co- A

Aceto-acetyl Co-A

Acetyl-P

Formate

Fructosee

Fructose-6-p

Methane

**Fig. 2:** Fermentation of carbohydrates in the rumen **(Baldwin and Allison, 1983; Lean 1987).**



**Fig. 3:** Key reactions in acidosis of ruminants **(Owens *et al.,* 1998).**

**2.4.1Changes in rumen bacteria**

Glucose is liberated from starch by amylase thus increase the concentration of glucose into the rumen , but whether it is simply a result of more rapid hydrolysis or of a reduction in the rate of glucose utilization by ruminal microbes is not clear **( Owners *et al*., 1998).**

Initially, this high concentration of glucose into the rumen increases the growth rates of all bacteria in the rumen, resulting in an increase in total volatile fatty acid production and a decrease in ruminal pH. It is likely that the provision of increased substrates for microbial production, e.g. ammonia and peptides, will favor bacterial growth rather than production of VFA. When large amounts of starch are added to the diet, the growth of *Streptococcus bovis* is no longer restricted by a lack of this energy source and this population grows faster than other species of rumen bacteria **(Russell and Hino, 1985).**

However, **Leedle (1993)** reported that concentrations of this organism in the rumen of cattle fed high-concentrate diets are very low. Other bacteria, those directly involved with starch fermentation, may be more important sources of lactate. *S. bovis* produces lactic acid, an acid 10 times stronger than acetic, propionic or butyric acid, the accumulation of which eventually exceeds the buffering capacity of rumen fluid.

 Glucose produced from the breakdown of starch and other carbohydrates are converted to fructose 1,6-diphosphate **(Fig. 2).** **Russell and Hino (1985)** found that fructose 1,6 diphosphate have a positive feedback on the conversion of pyruvate to lactate by activating lactate dehydrogenase. Fructose 1,6-diphosphate is also converted to triose phosphate in increasing concentrations. Triose phosphate acts to inhibit pyruvate formate lyase. The net effect of these changes is a switch from predominantly acetate and formate production to lactate production **(Russell and Hino, 1985).**

**2.4.2 Volatile Fatty Acid Production, Lactate Production and Utilization**

Bacteria rumen bacteria often are classified as “lactate producers” or “lactate users.” Whether lactate accumulates or not this depends upon the balance between these two groups **(Owens *et al*., 1998)**. End products of bacterial strains may change depending on substrate availability and culture conditions **(Russell and Hino, 1985).**

 **Owens *et al*. (1998)** reported that most lactate-using microbes cannot survive in low pH, whereas most lactate producers can. Under anaerobic conditions, pyruvate is converted to lactate to regenerate the NAD used in glycolysis **(Fig. 3, reaction 4).** Under “normal” conditions, lactate does not accumulate in the rumen at concentrations above 5 *mM*. In contrast, ruminal concentrations exceeding 40 *mM* are indicative of severe acidosis.

**Koers *et al*. (1976) and Slyter (1976)** stated that microbes of the rumen produce two forms of lactate, the D+ and L form. The L form, identical to that produced from glucose by exercising muscle, can be readily metabolized by liver and heart tissue. In contrast, D+ lactate, typically 30 to 38% of the total lactate found in the rumen, is not produced by mammalian tissues. In addition to D-lactate and VFA being involved with acidosis, other microbial products including ethanol, methanol, histamine, tyramine, and endotoxins often are detectable during acidosis and can exert systemic effects. Normally, VFA do not accumulate at higher concentrations in the rumen to reduce pH drastically. However, when the rate of acid production exceeds the rate of acid absorption, due either to rapid production, inhibited absorption, or reduced dilution, VFA accumulate to higher concentrations. In some studies, ruminal pH falls below 5.0 even without

lactate being present. This has led to the suggestion that total acid load is not only for lactate. **(Britton and Stock, 1987**).

Proportion of volatile fatty acids

pH range suitable

for cellulose digestion

5

6

7

10%

20%

40%

30%

60%

70%

50%

pH

Transition to pure lactic

acid fermentation

 = Acetic acid = Propionic acid = Butyric acid = Lactic acid

 = Propionic acid derived from breakdown of lactic acid

**Fig. 4:** Proportions of acids produced in the rumen when pH falls from 7.0 **(Kaufmann**

 **and Ruhr, 1979).**

**2.4.3 Changes in rumen pH and lactic acid absorption**

The increase in VFA concentrations may initially decrease reticulo-ruminal motility by acting on receptors in the rumen wall. These receptors, in sheep, are activated when non-dissociated VFA concentrations exceed 3.0 mM **(Crichlow and Chaplin, 1985).** A decrease in motility results in a decrease in rumination and less production of saliva. Saliva contains high concentrations of bicarbonate ions and is an important buffering mechanism for the rumen. A decrease in bicarbonate and increase in lactic acid concentrations in the rumen further decreases ruminal pH. When ruminal pH is maintained above 5.5, equilibrium exists between producers and utilisers of lactic acid, such that lactic acid does not accumulate in the rumen **(Nocek, 1997).** When pH is less than 5.5, no cellulolytic and relatively few saccharolytic bacteria, including *P. ruminicola*, a significant producer of VFAs, survive. In contrast, *S. bovis* multiplies until ruminal pH is less than 5.0, a pH that allows an increase in *Lactobacillus* growth. Both of these bacterial species produce D and L-lactic acid **(Fig. 4).** D-lactate and L-lactate are absorbed across the rumen wall and depress blood pH. As L-lactate is metabolised more rapidly than D-lactate, the metabolic acidosis is due in large part to the accumulation of the latter **(Bolton and Pass, 1988).**

**Lee *et al*. (1982)** reported that in low pH bacterial and mycotic organisms begin to invade the rumen wall causing ruminitis. Rumen papillae are damaged and can slough from the rumen wall. Absorption patterns change and endotoxins and histamine are released in the acute stages of the disease process **(Mullenax *et al.*, 1966).**

**Lean *et al*. (2000)** proposed that the following mechanisms could lower ruminal pH:

• Access to preformed acids in feeds, such as some silages

• A failure to produce buffering with endogenously derived buffers such as salivary bicarbonate

• Production of lactic acid in the rumen and

• Production of large amounts of weak volatile fatty acids, acetic acid, butyric acid and propionic acid

**2.4.4 Ruminal acidity and osmolarity**

The relative contributions of various organic compounds to ruminal acidity and to ruminal osmolality under normal and acidotic conditions are presented in **Fig. 5** based on ruminal concentrations and calculated extent of ionization based on data published by **Fulton *et al*. (1979)** combined with glucose measurements from **Horn *et al*. (1979).** When pH decreases to 5.0 during acidosis (**Fig. 5)**, ionization of acids increases slightly, but the added lactate is primarily responsible for the increased hydrogen ion concentration. Lactate depresses pH more drastically than similar amounts of other ruminal acids because its pK (the pH point of maximum buffering) is considerably lower (3.8 vs 4.8). With an acidotic pH, osmotic pressure is increased by greater ionization of acids and presence of free glucose. Absorption from the rumen normally prevents acid accumulation; but, **Tabaru *et al.* (1990)** reported that high osmolality of ruminal contents reduces the rate of acid absorption.

**Garza and Owens (1989)** reported that the normal range of ruminal osmolarity is from 240 to 265 mOsm/L with roughage diets and 280 to 300 mOsm/L with concentrate diets.

Contribution to acidity or osmolarity, mM or mOsM

Osmolarity acidotic

Osmolarity normal

Hydrogen ions pH= 6

Osmotic pressure

Hydrogen ion

**Fig. 5:** Relative contributions of various organic compounds to ruminal acidity and osmolality under normal or acidotic conditions. Heights of bars indicate relative contributions to hydrogen ion and osmolality from (bottom to top) butyrate, propionate, acetate, glucose, D-lactate, and L-lactate **(Owens *et al*., 1998).**

In acidosis condition the ruminal osmolarity become as high as 515 mOsm. In blood, dissolved protein contributes substantially to osmotic pressure that normally ranges from 285 to 310 mOsm. As a result due to high osmotic pressure of ruminal content in acidotic condition these pulls up water from systemic circulation **(Owens *et al.,* 1998).**

An elevation in osmotic pressure in the rumen is sensed by the wall of the reticulorumen to inhibit feed intake **(Carter and Grovum, 1990).** In addition, osmotic pressures above 350 mOsm inhibit bacterial digestion of fiber and starch, causing ruminal contents to become stagnant. High osmolality (> 300 mOsm) combined with distention of the abomasums, through inhibition of outflow, complicates removal of fluid and acid from the rumen **(Scott, 1975).**

**2.4.5 Changes in blood pH**

Presumably, VFA should not accumulate in blood plasma at sufficient concentrations to depress blood pH, but exactly how blood VFA concentrations change under acidotic conditions has not been determined. However, metabolism of the ruminal wall and the liver may be compromised during acidosis. Further complicating the situation, the liver is faced with L-lactate from tissue metabolism plus the D- and L-lactate absorbed from the digestive tract **(Owens *et al*., 1998).**

 Indeed, when ruminal glucose concentrations are high, as seen with acidosis, glucose being absorbed is partially converted to L-lactate by the digestive tract **(Seal and Parker, 1994)**; if excessive, capacity of the liver to catabolize lactate may be overloaded **(Naylor *et al*., 1984).** Individual animals with a larger or more adapted liver have greater capacity for metabolizing lactate and thereby may be less likely to experience blood acidosis **(Owens *et al*., 1998).**

**2.4.6 Sequel of acute ruminal acidosis**

**Bolton and Pass (1988)** reported that sequel to acute ruminal acidosis are hypocalcaemia resulting from calcium malabsorption, laminitis from the release of histamine and endotoxins into the circulation, polioencephalomalacia from an induced thiamine deficiency, ruminitis and liver abscessation. Bacteria implicated in liver abscessation are *Fusobacterium necrophorum* and *Archanobacterium spp.* These reach the liver through the portal circulation via damaged ruminal epithelium **(Bolton and Pass, 1988).**

**2.5 Clinical signs**

**2.5.1 Clinical signs of acute acidosis**

Cattle with mild clinical acidosis show anorexia, decreased milk production and scouring **(Underwood, 1992).** The severe form of the disease may progress to include metabolic acidosis, depression, dehydration, toxaemia and ‘downer cow’ syndrome **(Bolton and Pass, 1988).** Peracute acidosis may result in recumbancy, coma and death in eight to 10 hours. Clinical signs in the acute form develop within eight hours and precede the onset of metabolic clinical acidosis that peaks in 36 hours **(Underwood, 1992).**

**Krause and Oetzel (2006)** stated the clinical signs of acute acidosis include complete anorexia, abdominal pain, rapid beating of the heart, abnormally fast breathing, diarrhea, lethargy, and eventually death.

**Koers *et al*. (1976) and Owens *et al*. (1998)** stated the signs of acute acidosis include bloat, depressed or listless appearance, founder, laminitis, cessation or abrupt reduction of feed intake and potentially polioencephalomalacia (PEM), which occurs from thiamine deficiency. **Stock and Britton (2002) and Stock and Britton (1993)** reported that Cattle with PEM often wander aimlessly, stagger, or cannot stand and often give the impression of having brain damage. **Glock and DeGroot (1998)** stated that in severely acute cases, death may occur within 24 to 72 hours following grain engorgement.

**2.5.2 Clinical signs of SARA**

SARA affected cattle have no typical clinical sign of illness **(**[**Krause and Oetzel, 2005**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#446871_ja)**)**, but some clinical signs have been closely associated with it (**Tajik and Nazifi, 2011).**

***Changes in*** [***dry***](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=dry+matter) ***matter intake:*** Decrease in [**dry matter**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=dry+matter) intake is often presented as a consistent sign and sensitive indicator of SARA. A 25% decrease in Total Mixed Ration (TMR) intake has been observed during induced SARA periods **(**[**Kleen *et al*., 2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547239_ja)**).** Decrease in [**dry matter**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=dry+matter) intake is cyclic and a high intake on one day is followed by a low intake the following day **(**[**Gozho *et al*., 2005**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#445104_ja)**).** However, **Khafipour *et al*. (2009)** reported no decrease in the [**dry matter**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=dry+matter) intake during experimentally induced SARA. Furthermore, when animals are fed individually, such changes in feeding behavior are detectable.

***Laminitis:*** Laminitis, an aseptic inflammation of the hoof dermal layers, is the major source of lameness for dairy herds **(**[**Shaver, 2005**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#21251_con)**).** Acute and subacute ruminal acidosis is associated with laminitis. Although, the exact relationship between SARA and laminitis is not known **(**[**Stone, 2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#331831_ja)**)** but subacute or chronic laminitis has been noticed in SARA affected cows and its clinical signs are discoloration of the hoof, sole hemorrhages, sole ulceration and misshapen hooves **(**[**Nordlund *et al*., 1995**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547257_ja)**).** Some authors reported that chronic laminitis is the most consistent and significant clinical sign of a herd with SARA and a prevalence of more than 10% is maintained as being indicative of a SARA problem in a herd **(**[**Nordlund *et al*., 1995**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547257_ja)**;** [**Enemark *et al*., 2002**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603476_ja)**).** However, the causes of laminitis and associated claw horn lesions are multi-factorial in nature **(**[**Nordlund, 2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#105981_ja)**)** and a combination of many factors, such as genetics, conformation characteristics, manure handling system and the presence or absence of some infectious diseases affect the prevalence of SARA triggered laminitis in a herd **(**[**Shaver, 2005**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#21251_con)**;** [**Cook *et al*., 2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603466_ja)**).**

***Milk-fat depression:*** The relationship between SARA and milk fat depression is controversial and complex. Several factors, such as lactation state, breed and composition of feed rations affect the fat percentage of milk **(**[**Enemark *et al*., 2002**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603476_ja)**)**. [**Kleen *et al*. (2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547239_ja)**)** stated that SARA is a cause of depression of milk fat. In a case study of 500 dairy cows, a decrease in milk production of 3 kg/cow/day and decreased milk fat from 37 to 34 g kg-1 were calculated **(**[**Stone, 1999**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#21253_con)**).** [**Nordlund (2004)**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#105981_ja) believe that a milk fat percentage below 2.5% in 10% of the cows in a Holstein herd is possible evidence for SARA. On the other hand, low milk fat content was not observed during some of the experimental inductions of SARA **(**[**Enjalbert *et al*., 2008**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603490_ja)**)**  and some researchers have shown that SARA affected cows had no milk fat depression in farm condition **(**[**Tajik *et al*., 2009**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603612_ja)**;** [**Oetzel, 2005**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603564_ja)**)**. Some authors have suggested that the inconsistent response in milk fat in experimentally-induced SARA may be related to the duration of the bouts of SARA. [**Krause and Oetzel (2005**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#446871_ja)**)** believes that short-term SARA challenges have no effect on the milk contents. [**Enjalbert *et al*. (2008)**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603490_ja) observed that the experimental induction of SARA affects the milk [**fatty acid**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=fatty+acid) profile and believe that the fatty acid profile can be used as a diagnostic tool for SARA.

***Alterations in faeces:*** There are considerable changes in faecal consistency, structure and the pH of SARA affected cows have been described. It is believed that the pH of faeces in SARA affected cows is lower than normal and the size of ingesta particles may be larger than normal **(**[**Kleen *et al*., 2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547239_ja)**;** [**Grove-White, 2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603507_ja)**).** However, as the faecal alterations are usually transient and only a few animals have loose faeces at one time, these animals are usually not noticed **(**[**Kleen *et al*., 2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547239_ja)**;** [**Nordlund *et al*., 1995**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547257_ja)**)**. **Owens *et al*. (1998)** showed that in the SARA affected groups; there were no significant differences between individuals experiencing SARA and the rest of the population in faecal consistency and faecal undigested feed particles. [**Gakhar *et al*. (2008)**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#21260_con) found that experimental SARA induction had no effect on faecal pH.

***High-culling rate:*** [**Enemark *et al*. (2002**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603476_ja)**)** stated that in SARA affected herds the culling rate and number of unexpected deaths are exceptionally high. This high-culling rate is due to unexplained death, lameness, loss of body condition and non-responsive pathological conditions **(**[**Oetzel, 2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603561_ja)**;** [**Kleen *et al*., 2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547239_ja)**).**

***Loss of body condition:*** It is often believed that in SARA affected dairy herds there are a number of thin cows despite a high energy diet **(**[**Kleen *et al*., 2003**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547239_ja)**;** [**Nordlund *et al*., 1995**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#547257_ja)**).** However [**Kleen *et al*. (2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#7358_tr)**) and** [**Tajik *et al*. (2009**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603612_ja)**)** reported that the body condition score could not be used to differentiate between SARA affected and non-affected cows in a dairy herd.

***Other signs:*** Others minor signs and pathological changes includes rumenitis, rumen parakeratosis, liver abscesses and pulmonary bacterial emboli presence of fibrin casts in faeces, excessive body faecal soiling, continuous tail switching, dropping the cud while ruminating, poor[**reproductive performance**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=reproductive+performance) and environmental mastitis **(**[**Grove-White, 2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603507_ja)**).** [**Duffield *et al*. (2004**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#190447_ja)**)** reported that, rumen hypomotility also observe in SARA but, [**Tajik *et al*. 2009**](file:///C%3A%5CUsers%5CUser%5CDesktop%5CDiagnosis%20of%20Subacute%20Ruminal%20Acidosis%20%20A%20Review%20acidosis%2011.htm#603612_ja) stated that no difference was observed between the SARA affected and the non-affected cows in the number and quality of rumen contractions.

**2.6 Treatment strategy**

It is difficult to decide whether medical therapy will suffice or a rumenotomy will be required. In addition, if signs have been present for 24 hours or more, the amount of rumen mucosal damage has already been determined and may not be affected by any treatment. Treatment must correct the rumen acidosis and attempt to discourage further lactic acid production **(Divers and Peek, 2008).**

**Radostits *et al*. 2006** stated the principles of treatment are:

* Correction of the ruminal and systemic acidosis and prevent further production of lactic acid
* Restoration of fluid and electrolyte losses and maintaining of adequate circulating blood volumes
* Facilitate forestomach and intestinal motility to normal.

**2.6.1 Intraruminal alkalinizing agents and laxatives**

**Counotte *et al*. (1979)** reported that bicarbonate is the most prevalent and most important ruminal buffer and includes two major ionic forms: HC$O\_{3}^{-}$ and C$O\_{3}^{2-}$. The HC$O\_{3}^{-}$ is of importance to buffering the blood because it may be protonated to $H\_{2}$C$O\_{3}$and establish equilibrium with dissolved C$O\_{2}$ and $H\_{2}$O:

C$O\_{2}$ + $H\_{2}$ $H\_{2}$C$O\_{3}$ HC$O\_{3}^{-}$ + $H^{+}$

In moderately affected cases, the use of 500 g of magnesium hydroxide per 450 kg BW, or magnesium oxide in 10 L of warm water pumped into the rumen and followed by kneading of the rumen to promote mixing will usually suffice. Magnesium hydroxide is a potent alkalinizing agent for use in ruminants as an antacid and mild laxative. Administration of boluses of magnesium hydroxide (162 g) or a powdered form (450 g) dissolved in 3.5 L of water daily for 3 days resulted in a significant increase in rumen pH after 48 and 24 hours, respectively **(Radostits *et al*., 2006).**

**Divers and Peek ( 2008)** suggested powdered ruminotoric-laxative antacid products dissolved in water and 1 lb of activated charcoal administered through a stomach tube are will be beneficial. Affected cattle should not be allowed to engorge on water because their atonic rumens will only distend again.

**2. 6.2 Intravenous sodium bicarbonate, calcium and fluid therapy**

The systemic acidosis and the dehydration are treated with intravenous solutions of 5% sodium bicarbonate at the rate of 5 L for a 450 kg animal given initially over a period of about 30 minutes. This will usually correct the systemic acidosis. This is followed by isotonic sodium bicarbonate (1.3%) at 150 ml/kg body weight intravenously over the next 6-12 hours **(Radostits *et al*., 2006).** This hypertonic solution of sodium bicarbonate have two function, one in correction of dehydration which is caused by retraction of fluid into rumen due to high osmotic pressure resulting from accumulation of lactic acid into the rumen and other is the correction of systemic acidity.

Although **Divers and Peek (2008)** suggested treatment with systemic sodium bicarbonate but also reported excessive treatment with alkalinizing products should be avoided because these can result in hypermagnesemia and metabolic alkalosis, which will further decrease ionized calcium.

**Divers and Peek (2008)** also suggested to administer 500 ml of calcium borogluconate intravenously (IV) (slowly) or divided into four subcutaneous locations , because inappetence and gastrointestinal stasis coupled with calcium loss resulting from milk production often leads to hypocalcaemia in ruminal acidosis. IV fluids should initially be hypertonic saline followed by balanced electrolyte solutions such as lactated Ringer’s solution, and supplemental sodium bicarbonate should added if acidemia is severe (pH $<$7.15).

**2.6.3 Rumen lavage**

**Radostits *et al.* (2006)** reported that in less severe cases, in which the patient still standing but are depressed, heart rate is 90-100/min, there is moderate ruminal distension and the rumen pH is between 5 and 6, an alternative to a rumenotomy is rumen lavage may be perform in following way:

A large 25-28 mm inside-diameter rubber tube should passed into the rumen and warm water need to pumped in until there is an obvious distension of the left paralumbar fossa; the rumen is then allowed to empty by gravity flow. The rumen can be almost completely emptied by 10-15 irrigations. With successful gastric lavage, alkalinizing agents are not placed in the rumen but the systemic acidosis should be treated as described above.

**Divers and Peek (2008)** also suggest rumen lavage for Several flushes with 10 to 20 gallons of water, and return flow of fluid must be effective for this treatment to be successful. Following lavage, antacid solutions such as 2 to 4 quarts of milk of magnesia, activated charcoal, and ruminotorics should administer.

**2.6.4 Rumenotomy**

In severe cases of disease, in which there is recumbency, severe depression, hypothermia, prominent ruminal distension with fluid, a heart rate of 110-130/min and a rumen pH of 5 or below; a rumenotomy is the best this statement is suggested by **Redostits *et al*. (2006).** The rumen should emptied, washed out with a siphon and examined for evidence of and the extent of chemical rumenitis, and a cud transfer (10-20 L of rumen juice) should introduce into the rumen along with a few amount of hay.

An animal with a rumen pH of 5.0 or less, a heart rate greater than 100 beats/min, dehydration greater than 8%, and rumen distention and recumbency indicating a severe grain overload, a rumenotomy should be performed and the rumen contents should evacuated **(Divers and Peek, 2008).**

**2.6.5 Riboflavin and niacin**

It is well known that the microorganisms in the rumen synthesize B vitamins. But the use of riboflavin also important in the treatment of ruminal acidosis, because **Howard (1981)** reported that as pH is lowered, there is a change in the rumen microflora. First, the number of protozoa, then there is a decrease in the number of normal gram negative bacteria. These bacteria are replaced by an increased number of gram positive organisms (*Streptococcus bovis*). The changes cause the impairment of the B vitamins synthesis. Diseases affecting metabolic and digestive efficiencies are the most common factors causing B vitamins requirements. **Phillipson and Raid (1957)** stated that Streptococci which are rapidly overgrown in ruminal acidosis consume thiamine. Additionally, alteration in the normal rumen microflora where microorganisms such as *Clostridium sporogenes* or *Bacilus thiaminolyticus* produce thiaminase in ruminal acidosis **(Bartley and Brent, 1984; Streeve and Eolwin, 1974).** For that reason, the use of Thiamine hydrochloride is considered as a part of the treatment of ruminal acidosis to help prevent poliencephalomalacia.

**2.6.6 Other Treatments**

**Radostits *et al*. (2006)** reported the ancillary treatment includes antihistamines for laminitis, NSAIDs for shock therapy, thiamin to promote the metabolism of lactic acid, and parasympathomimetics to stimulate gut motility, orally administered antimicrobials including penicillin and the tetracyclines have been used to control growth of the bacteria that produce lactic acid.

**Divers and Peek (2008)** proposed the use of antimicrobials generally with penicillin (10,000 to 20,000 IU/kg administered intramuscularly [IM] or SC) in an effort to prevent bacteremia and liver abscess formation. Broad-spectrum antibiotics should not be used because these may predispose to fungal overgrowth and also suggested to use Flunixin meglumine (0.3 mg/kg every 8 hours interval) to combat excessive prostanoid production and shock.

**2.7 Prevention**

The most reliable prevention of acidosis is through management techniques, including close feed bunk monitoring which entails altering feeding practices such that cattle consume feed in a uniform manner incorporating smaller and more frequent meals **(Schwartzkopf-Gensewein *et al*., 2003).** As well, gradual adaptation to high grain diets over several weeks is necessary to achieve stability of the microbial population and to avoid accumulation of ruminal acids **(Huntington, 1988; Radostits *et al.,* 1994).**

**Huntington (1988)** reported that several feed additives are commonly used in conjunction with good management practices and include antibiotics that have either systemic effects or ruminal effects and dietary buffers designed to neutralize acidic conditions in the rumen. Antibiotics that have systemic effects, such as chlortetracycline and in particular tylosin, are useful in managing the incidence of liver abscesses and improve feedlot cattle performance **(Huntington, 1988; Nagaraja and Chengappa, 1998).** Antibiotics that have rumen effects include ionophores such as monensin and lascalocid. Ionophores have been shown to affect feed intake patterns by reducing intake depressions and altering ruminal fermentation patterns to facilitate microbial adaptation to increased concentrate intake **(Stock and Britton, 1993).**

 The concept of adding buffers to the diets of sheep and cattle has been of interest to ruminant nutritionists since the 1950’s **(Wheeler, 1980).** As well, it has been suggested that buffer additions may only be useful during the phase of early adaptation to high concentrate diets and lack of a sustained response is indicative of adjustment to the bicarbonate load by the animal **(Wheeler, 1980; Ha *et al*., 1983).**

Ruminants experiencing SARA have been shown to prefer feed containing sodium bicarbonate (SB). For example, **Phy and Provenza (1998)** demonstrated that sheep fed barley pellets containing SB or sodium chloride would actively select and preferred the pellet supplemented with SB. The authors concluded that the sheep selected the pellets containing SB in attempts to self-attenuate ruminal acidosis. Buffer supplementation of high concentrate diets has been shown to improve or stabilize feed intake and increase animal performance in some studies **(Solorzano *et al*., 1989; Zinn, 1991),** but not in others. Increases in mean ruminal pH have also been documented when concentrate diets were supplemented with buffers **(Ghorbani *et al*., 1989; Zinn, 1991)**; however these findings have not been consistent **(Russell *et al*. 1980; Hart and Polan, 1984).**

The effect of buffer supplementation on ruminal fermentation is variable. Some studies reported that buffers had no effect on total VFA **(Ha *et al*., 1983; Solorzano *et al*., 1989),** while others have reported that supplementation with buffers increased VFA concentrations **(Hart and Polan, 1984).**