Rumen Buffer and performance in Dairy Cattle

Dr. Parasu Ram singh, Ph. D. (Animal Nutrition)

Managing Director, Burlyvets Nutritional Technologies Pvt. Ltd. Moga-142001, Punjab

ABSTRACT

The dairy industry is under pressure to fulfil the increasing demands of milk and milk products. For this reason, dairy farms are growing in size and utilizing state-of-art technologies in an attempt to improve their productivity and efficiency. Additionally, dairy farmes face the challenge of maintaining the quality of milk. Higher concentrate mixture is required to maintain the production of lactating animals. Feeding high concentrates to high producing animals often upset the rumen environment and compromising the productivity of animals. Different feed additive is used to prevent the occurrence of sub-acute rumen acidosis, among them buffers are commonly used. Buffers in dairy rations are compounds that neutralize excess acid within the animal's digestive system and help resist changes in rumen pH when high grain, low forage, fine-chopped and fermented forage (silage) are fed.. Dietary buffers have been very well researched and are widely used in the dairy industry. The term buffers is loosely applied to several compounds, including bicarbonates, carbonates, hydroxides, and oxides. The cow has three primary means of buffering acid ingested (from silage) or acid produced by rumen fermentation. These include buffer naturally occurring in saliva, buffering capacity of ingested feed, and added dietary buffers. Studies have shown that buffers not only maintain the rumen homeostasis but also increase the productivity of animals. The literature pertaining to the effectiveness of supplementation of dietary buffer on feed intake, milk production and rumen fermentation pattern in lactating animals is being presented in this review.

INTRODUCTION:

The dairy industry is under pressure to fulfil the increasing demands of milk and milk products. For this reason, dairy farms are growing in size and utilizing state-of-art technologies in an attempt to improve their productivity and efficiency. Formulating a nutritionally balanced dairy ration can be a continuous challenge to progressive dairy producers in India. Dairy cow diets require both quality forages and relatively large amounts of grain concentrates. Grain concentrates are largely made up of soluble carbohydrates and are considered an energy dense feed. Soluble carbohydrates formulated into the feed ration increase the overall energy density of the ration and aid in meeting the cow's nutrient requirements without body weight loss, minimizing digestive upsets, and maintaining health. Although concentrates are a significant feed component in the diet, high levels of concentrates can be detrimental to the overall health and productivity of the cow. Ingested carbohydrates are digested and fermented to large amounts of volatile fatty acids (VFAs) within the rumen. The copious quantities of VFAs within the rumen can result in a below neutral rumen pH (<7) creating an acidic rumen environment. Acidic conditions within the rumen may have damaging effects such as an increase in beneficial microbial death, rumen acidosis, milk fat depression, irreversible damage to rumen papillae and ultimately a decrease in milk production, dry matter intake and milk components. Rumen health and efficiency is at its highest when rumen pH is close to neutral, therefore, it is important to feed a diet conducive to the maintenance of a relatively neutral rumen pH. Many types of rumen buffer and conditioners included in dairy cattle diets are sodium bicarbonate and Sodium bicarbonate, Magnesium oxide, Calcium carbonate, Marine Red algae, Sodium Bentonite, Live Yeast Culture and combination of buffering agents are used to stabilize rumen pH, reduce rumen acidosis, and maintain milk fat percentages and dry matter intakes.

LITERATURE REVIEW

What is a buffer:

Buffers in dairy rations are a compound that neutralize excess acid within the animal's digestive system but technically, buffers and alkalizes are differ. A buffer maintains the acidity level, or pH, within a narrow range when either an acid or a base is added, as good examples is sodium bicarbonate. An alkalizer raises the pH in direct proportion to the amount added as example is Magnesium oxide. Both buffers and alkalizers are important for neutralizing excess acidity and both are called buffers in common usage. Buffers are compounds which in aqueous solution help resist changes in rumen pH .. Buffers are used largely to reduce the effect of acidic conditions produced by the relatively high grain rations fed to dairy cows. Dietary buffers have been very well researched and are widely used in the dairy industry. The term buffers is loosely applied to several compounds, including bicarbonates, carbonates, hydroxides, and oxides. The cow has three primary means of buffering acid ingested (from silage) or acid produced by rumen fermentation. These include buffer naturally occurring in saliva, buffering capacity of ingested feed, and added dietary buffers.

Rumen Digestion and Fermentation

Ruminants have the ability to convert otherwise unusable plant materials into nutritious food and fiber via microbial digestion and fermentation. Ingested nutrients within the rumen are exposed to pregastric fermentation via various species of microbes that inhabit the rumen. The ingested feedstuffs, both soluble and insoluble carbohydrate, are then swallowed and descend down into the rumen. The dense material sinks to the bottom of the rumen, into the rumen liquor, while more fibrous components of the feedstuffs remain afloat on top of the rumen liquor. Rumination then occurs, beginning with the muscle contraction of the rumen. The fibrous material of the feedstuffs is packaged into the reticulum were it is compacted and regurgitated back up through the esophagus into the mouth. The regurgitated bolus is then re-masticated and re-swallowed. The fibrous material, now more dense, submerges to the bottom of the rumen saturated in the rumen liquor where it becomes available to rumen microbes.

Volatile Fatty Acids

Microbial digestion and fermentation is carried out by a broad spectrum of rumen micro flora (microbes) that thrive in the anaerobic environment within the rumen.. Volatile fatty acids provide approximately 60- 80% of the ruminant's daily energy requirement and are therefore a vital component in the overall energy balance of the ruminant. The proportions of VFAs are significant in regards to energy produced and energy utilized. Predominant VFAs produced include acetate, propionate and butyrate **(Bergman, 1990).** In general, **Ishler et al. (1996)** showed as the forage to concentrate ratio within a diet decreases the acetate to propionate ratio also decreases (Table 1). These VFAs serve as components for milk synthesis; acetate is a necessary component of milk fat, while propionate is used for glucose production, vital to the synthesis of milk sugar **(Dijkstra et al., 2005)**

Table 1; Effect of forage to concentrate ratio on VFA proportions in lactating cows

Forage to Concentrate Ratio	% Acetate	% Propionate	% Butyrate
100:00	71.4	**16.0**	**7.9**
75:25	**68.2**	**18.1**	**8.0**

50:50	**65.3**	**18.4**	**10.4**
60:40	**59.8**	**25.9**	**10.2**
20:80	**53.6**	**30.6**	**10.7**

High Concentrate Diet

A high concentrate diet formulation for lactating dairy cows has become increasingly common practice within the dairy industry. A high concentrate diet can be defined as a concentrate to forage ratio that is a diet made up of more than 50% concentrate. Dairy cow diets are frequently composed largely of grain concentrates to provide a more energy dense feedstuff while enhancing the digestion and absorption of nutrients within the ruminant animal. Due to the high levels of starch associated with grain concentrates, feeding a diet high in soluble carbohydrates can increase total volatile fatty acid production, specifically a significant increase in propionate.

Rumen pH

Although supplementing lactating rations with high levels of concentrates can create a more energy balanced diet, there are damaging attributes associated with doing so. Due to the increase in overall VFA production, there is an immense increase in hydrogen ion concentration within the rumen. Increases in hydrogen ions decrease rumen pH and can greatly alter the rumen environment **(Briggs et al., 1957; Rumsey et al., 1970)**. Ideally, the rumen environment should be relatively (pH of 7). Rumen micro floras are most efficient at a rumen pH between 6.8 and 7.6 **(Stewart, 1977).**

Rumen Acidosis

Rumen acidosis is a major health problem in modern dairy farming. It causes decreased intake, poor digestion and production losses. Health costs can also increase due to an increased risk of hoof problems and displaced abomasums. The definition of sub-acute ruminal acidosis (SARA) is a decline in rumen pH below 5.6 for more than 3 hours per head per day. On farm diagnosis of SARA is difficult. The most common method of diagnosis is through rumenocentesis carried out 2 to 4 hours after feeding and SARA is defined as > 3 cows out of 12 measuring a rumen pH of less than 5.5.The prevalence of SARA is significant with up to 20% of dairy cows, in herds throughout the world, suffering from SARA.

The following periods and feeding strategies increase the risk of SARA:

> *Transition period , peak milk production, peak dry matter intake, feeding cattle diets high in starch & sugar, cattle diets lacking in physically effective fibre, Prolonged periods of low rumen pH or SARA can have many negative health and productive consequences, such as: reduced abundance of beneficial rumen microbial populations, reduced milk composition, especially milk butterfat production, reduced fibre digestion, inflammation, diarrhoea, liver abscesses .*

Buffers are favoured when the following situations exist:

- The forage portion of the diet is low, 45% of DM or less
- Corn silage or other wet, fermented forages are the primary forage sources
- Forages are finely chopped (less than 1.3 cm)
- Dry matter intake is below expectations during early lactation

- Erratic intake or off-feed conditions exist during early lactation
- Hay is limited to 2¼ kg or less per cow daily
- Rations are low in fibre (less than 19% ADF)
- The diet is very wet (less than 50% DM)
- The fat test is abnormally low
- Subclinical acidosis is suspected
- Foot problems such as laminitis, soft soles, or subsolar abscesses exist

Milk Fat Depression

Milk fat depression syndrome (MFDS) is another common challenge to the cow herself as well as producers. This condition, which is closely associated with high concentrate diets, can have a direct impact on the milk component, fat . Dietary constituents may significantly alter milk components. However, fat is the most influenced component relative to dietary effects . Altered VFA production within the rumen can cause changes in metabolism, frequently resulting in changes in milk fat concentrations . Cows affected by MFDS can have a reduced milk fat percentage, even as low as 50-60% reduction.

Buffers and performance of heifers

In one study, weight gains by the heifers fed the buffered diet were greater. Faeces from the heifers fed the buffered diet had less starch and a higher pH value. The most remarkable result was a 44% decline in feed required per unit gain by the heifers fed the buffered diet.

Milk yield and composition

Dietary buffer supplementation tends to increase DM intake and nutrient digestibility and hence maintains high productivity in lactating animals. Buffers also maintain high milk fat through the mechanisms indicated above. The effect of dietary buffers on milk protein content, however, is not as well defined as the effect on milk fat.

The Following Types of Ingerdeints used as Rumen Buffer

1. Limestone (CaCo3) may be used as a buffering agent in place of sodium or potassium bicarbonate. However, it has very low solubility in the rumen and thus plays a minor role in controlling the rumen pH and enhancing animal performance.

2. Magnesium oxide (MgO) may also be considered for this purpose, but it has low palatability and may not thus be consumed in sufficient amounts to enable its biological functions.

3. Traditionally Sodium bicarbonate ($NaHCO_3$) has been used to buffer dairy diets as rumen buffers. Sodium bicarbonate is highly soluble and is rapidly eliminated from the rumen. Consequently bicarb works for a very limited time and is unable to provide any long term stabilising effect.

4. Ionophore (e.g. monensin, lasalocid, etc.) may nullify the effect of the ionophore on feed efficiency. If buffers are to be supplemented into the diet, it may not be cost-effective to use an ionophore there with.

5. **Proprietary Rumen Buffers Such as pHmin, pHmin Plus**, is a multi ingredients Rumen buffer should always be used on a routine basis to compensate for suboptimal feeding management. Its combination of Sodium bicarbonate, Magnesium Oxide, Marrine red lage, Live Yeast culture, sodium bentonite . Research has been Proves that multi element rumen Buffer is more effective than single ingredients rumen Buffer.

6.**Marine red Alage such as Attored Buff** is a natural product, derived from calcified seaweed with a very fine particle size. Its provides calcium, magnesium and a range of important trace minerals. It is normally fed at 100gms – 125gms / cow and has proven effective in reducing the acid load of wet, low pH silages as well as in raising rumen pH.

7.**Live yeast supplements** work quite differently to rumen buffers. They do however remove lactic acid from the cows rumen, lift rumen pH and stimulate increased rumen digestion both improving feed efficency and lifting animal output. Live yeast and rumen buffers compliment one another.

8.Sodium Bentonite a clay mineral used as a binder, shifts VFA patterns, slows rate of passage, and exchanges mineral. Feeding 450 to 700 g per as rumen effect With high grain diets, loose stool conditions, low fat test, and dirt eating.

Summary: The addition of Rumen Buffer to dairy cow diets based on a combination of or single buffer is effectively maintaining rumen pH throughout the day. These effects on rumen pH explains subsequent increasing milk yield and milk butterfat, long term pH optimisation in the rumen, healthy rumen functioning, reducing subclinical rumen acidosis (SARA), increasing productivity per kg dry matter intake and achieves the productivity and sustainability goals.

REFERENCES

Bergman, E. 1990. Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. Physiol. Rev. 70(2):567.

Briggs, P., J. Hogan, and R. Reid. 1957. The effect of volatile fatty acids, lactic acid and ammonia on rumen pH in sheep. Aust. J. Agric. Res 8:674-690.

Dijkstra, J., J. Forbes, and J. France. 2005. Qualitative Aspects of Ruminant Digestion and Metabolism. in Qualitative Aspects of Ruminant Digestion and Metabolism. 2nd ed.

Ishler, V., J. Heinrichs, G. Varga, P. S. U. C. E. Service, Church, and D. Co. 1996. From feed to milk: understanding rumen function. Penn State, College of Agricultural Sciences, Cooperative Extension Service.

Rumsey, T., P. Putnam, J. Bond, and R. Oltjen. 1970. Influence of level and type of diet on ruminal pH and VFA, respiratory rate and EKG patterns of steers. J. Anim. Sci. 31(3):608.

Stewart, C. S. 1977. Factors affecting the cellulolytic activity of rumen contents. Appl. Environ. Microbiol. 33(3):497.

Thomas, J.W. and R.S. Emery. 1984. Use of Buffers in Livestock Feeds. Proc. Distillers Feed Conf. Vol 39. P. 43