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Review Article

Buffers and Feed Additives for Productivity Augmentation in Dairy Cattle: A Review

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Introduction

Dairy Husbandry became a precision farming system with the single most objective of "cost cutting" and "profit maximization". The challenge in feeding high producing dairy cows is to maximize dry matter intake and energy density of the ration, while maintaining the rumen health. The major risk to rumen health in current feeding practices in India is feeding too much readily digestible starch diet (e.g. finely ground grain) or too little good quality fiber (roughage). Owing to shrinking pasture land and water resources, green fodder or roughage feeding was very minimal today.

Fiber forms a matrix in the rumen which is essential for the functioning of the rumen microbes. Fiber is a powerful stimulus of cud chewing. Cud chewing is important because it in turn stimulates saliva production. Saliva contains a lot of bicarbonate buffer, which prevents the rumen becoming too acid. Usage of highly fermentable lactating rations which are high in grain and /or deficient in fiber ends up in chronic rumen acidosis besides challenging the animal's buffering systems (Drackley, 1999). To augment the buffering capabilities and to minimize the effects of acidosis several kinds of feed additives are used. Several studies had documented the beneficial effects of feed additives towards loss minimization and productivity enhancements (Jordan and Fourdraine, 1993). This paper reviews the basics of feed additives which serve as rumen buffers and their beneficial exploitation.

What are Buffers / Feed additives?

Buffers are compounds that neutralize excess acid within the cow's digestive system. They supplement the cow's natural buffers that occur in saliva and increase the animal's ability to overcome the harmful effects of too much acid production.

Technically, buffers and alkalizers differ (Hutjens, M. F. 1991). A buffer (eg. Sodium bicarbonate and Sodium sesquicarbonate) maintains the acidity level, or pH, within a narrow range when either an acid or a base is added. In contrast an alkalizer raises the pH in direct proportion to the amount added. (eg. Magnesium oxide and Magnesium hydroxide).

Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as pH shift, growth, or metabolic modifier (Hutjens, 1991). Several feed additives contain nutrients such as sodium in sodium bicarbonate or protein in yeast culture.

Why we require Buffers?

Cows produce 10 to 32 L of saliva per kg of feed dry matter (DM) with an average of 18.2 L/kg DM. The production of saliva is much higher when roughage is consumed than when grains are consumed (Downer and Cummings, 1987). Factors that are important in saliva secretion are the dry matter content of the feed, forage intake, and forage particle size (Erdman, *et al* 1980). The saliva produced by cattle, contains 125 milliequivalents (meq)/L of bicarbonate and has a pH of 8.4. Rumen pH ranges from 5.5 to 7.0 and, therefore, the buffering effect of saliva becomes very important in maintaining a desirable rumen pH. The fermentation of grain by rumen microorganism results in acid production, and silage contributes preformed acid in the rumen. This acid must be neutralized or buffered by cows via their saliva to maintain rumen pH within 5.5 to 7.0 (Erdman *et al.,* 1982).

Cows fed 20 kg of dry matter can produce the equivalent of 3418 to 3617 g/d sodium bicarbonate in their saliva, depending on the level of forage in the diet. Thus, forage intake plays an important role in amount of buffer required by the animal. If a cow is fed a diet with a 70:30 grain to forage ratio, the diet would have to be supplemented with about 0.5% sodium bicarbonate to produce the same natural buffering capacity as a cow fed a diet with a 50:50 grain to forage ratio. Therefore, it is clear that the manner in which we feed dairy cows contributes to the need for supplemental dietary buffer (Thomas and Emery, 1984).

Dietary Buffering Requirements of Lactating Dairy Cows

Requirements for buffering agents in dairy cow diets are a function of salivary buffer secretion, feedstuff buffering capacity, acid-producing potential of the diet and feed acidity (National Research Council. 2001). The cow has three primary means of buffering the 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.

The most common reasons for adding buffers to the diet are to compensate for reduced saliva secretion of cows fed inadequate amounts of forage and to neutralize excess rumen acidity resulting from fermentation of starchy grains. Ideally, buffers should be released during the interval of most severe acid production in the rumen or they should provide a continuous release to prevent sudden drops in rumen pH. Palatability is a consideration when selecting a buffer. Palatability is usually not a problem when mixed with the silage portion of the ration. Because high-energy diets are fed in early lactation, it is practical to include buffers during this stage.

Major Benefits of Buffer Feeding

a) To minimize the effects of Ruminal Acidosis

Ruminal acidosis can reduce feed intake, decrease ration digestibility, lower milk production and decrease butterfat test. Ruminal acidosis can lead to fatty liver syndrome, liver abscesses, rumenitis and laminitis (Overton, *et al* 2000). When excess acidity may be a problem, addition of a buffer is good insurance.

b) During usage of rations which enhances acidity

I. Usage of high silage rations, which are high in moisture and soluble carbohydrates and are low in pH. These factors combined with less salivary secretion can lead to more acidity in the rumen.

II. Wet rations with fermented feeds, which can depress total dry matter intake.

III. Lower fiber rations, which depress rumination and result in depressed feed intake and lower butterfat percentage.

IV. Fine chopped hay which results in reduced chewing time and lower fiber digestion in the rumen.

V. High concentrate rations, which can be fermented rapidly and lead to subclinical acidosis.

c) To meet out challenges of lactational stress

a) During early lactation / high production, where in buffers help to make the transition to high concentrate rations after calving. The risk of acidosis is greatest at this time.

b) During Heat stress, as it can reduce dry matter intake and affect electrolyte balance. Buffers can help restore feed intake and replace lost electrolytes.

d) To meet out challenges of "low milk fat"

Recent Research shows that buffer can help restore a depressed fat test.

Beneficial Exploitation of Buffers/Feed Additives

Goals of a successful feeding program in any dairy farming is to

- Optimize milk yield
- Produce desirable milk components
- Maximize rumen microbial yield
- Stimulate dry matter intake

- Produce key nutrients for mammary gland synthesis

Feed additives can cause a desired animal response in a non-nutrient role such as pH shift, growth, or metabolic modifier (Hutjens, 1991). However, it has to be kept in mind that feed additives are not a requirement or guarantee for high productivity or profitability.

Rumen buffering agents such as Sodium bicarbonate are included in concentrate diets to stabilize ruminal pH, increase acetate production, and increase milk fat percentages .It was suggested that the primary effects of feeding Sodium bicarbonate may be mediated through increased water intake, decreased ruminal fluid osmolality, increased flow of starch from the rumen, and decreased ruminal propionate production (Thomas and Emery, 1984).

Common Buffers and Feed Additives in Dairy Cattle Practice

Though several agents are used as feed additives, the commonly used agents (as per Hutjens, 1991) are listed below.

Magnesium oxide: Used as Alkalinizer (raises rumen pH) and increases uptake of blood metabolites by the mammary gland raising fat test. Included at the rate of 45 to 90 g per day. It is usually fed along with sodium-based buffers in the ratio of 2 to 3 parts sodium bicarbonate to 1 part of magnesium oxide.

Sodium bicarbonate/sodium sesquicarbonate: They increase the dry matter intake and stabilize rumen pH. Usually fed for 120 days postpartum with diets that are high in corn silage (over 50%), wet rations (over 55% moisture), lower fiber ration (<19% ADF), little hay (<2.5 kg), finely chopped forage, pelleted grain and during heat stress conditions.

Sodium bentonite: It is a clay mineral used as a binder in several countries. It shifts VFA patterns, slows rate of passage, and exchanges mineral ions. Field claims to tie up mycotoxins have been reported. It is included at the rate of 450 to 700 g per day.

Yeast culture and yeast: Most commonly used feed additive. It stimulates fiber-digesting bacteria, stabilize rumen environment, and utilize lactic acid. It is included at the rate of 10 to 120 g depending on yeast culture concentration (Dann et al, 2000). It is fed for two weeks prepartum to ten weeks postpartum and during off-feed and stress conditions.

Probiotics (Bacterial direct-fed microbes): They produce metabolic compounds that destroy undesirable organism and provide enzymes improving nutrient availability, or detoxify harmful metabolites. Fed to calves on liquid diet, transition cows, and during stress conditions

Anionic salts: These agents cause the diet to be more acidic and increase blood calcium levels by stimulating bone mobilization of calcium and calcium absorption from the small intestine. Calcium chloride and Ammonium chloride are commonly used. They were fed to dry cows two to three weeks before calving. Dietary calcium levels needs to be adjusted to 150 g per day (50 g inorganic). Dietary magnesium levels needs to be raised to 0.4 percent.

***Aspergillus oryzae*:** It stimulates fiber-digesting bacteria, stabilize rumen pH, and reduce heat stress. It is fed to cows during high grain diets, low rumen pH conditions, and under heat stress and for calves receiving a liquid diet at the rate of 3 g per day.

Biotin: It is used to improve hoof health by reducing heel warts, claw lesions, white line separations, sand cracks, and sole ulcers and increase milk yield through a metabolic route (Seymour, 1998). It is included at the rate of 10 to 20 milligrams per cow per day for 6 months to one year. Biotin is supplemented in Herds with chronic foot problems.

Beta-carotene: It is used to improve reproductive performance, immune response, and for mastitis control. It is fed at the rate of 200 to 300 mg per day. It is usually fed during early lactation and during mastitis-prone periods.

Protected choline: It acts as a methyl donor and is used to minimize fatty liver formation and to

improve fat mobilization. It is fed at the rate of15 to 30 g per day. It is fed two weeks prepartum to eight weeks postpartrum to cows experiencing ketosis, weight loss, and high milk yield.

Methionine hydryoxy analogs: They minimize fatty liver formation, control ketosis, and improve milk fat test. They are included in the ration and fed to cows in early lactation receiving high levels of concentrate and limited dietary protein.

Monensin: It is used to improve feed efficiency for lactating cow, reduce ketosis and displaced abomasums in transition cows by shifting rumen fermentation and microbial selection(Symanowski et al ,1999) It is included at the rate of 11 g to 22 g per ton of total ration dry matter consumed (250 to 400 mg / cow / day).

Niacin (B3, Nicotinic acid, and Nicotinamide): They act as Coenzyme systems in biological reactions, improve energy balance in early lactation cows, control ketosis, and stimulate rumen protozoa (Riddell *et al* ,1981) It is given at the rate of 6 g per cow (preventive and prepartum) and 12 g per cow (treatment and postpartum). It is given to high producing cows in negative energy balance, heavy dry cows, and ketosis prone cows.

Zinc methionine: It improves immune response; harden hooves, and lower somatic cell counts (Heinrichs *et al,* 1984) It is given to cows experiencing foot disorders, high somatic cell counts and wet environment.

The above list and descriptions of feed additives is far from all inclusive. It does however give an idea about some of the additives available, which can be quite helpful in the prevailing feeding and management programs at Indian farming conditions. Remember that each of these is a tool and has a specific purpose. It is important for the veterinarian or nutritional adviser to carefully monitor the use and effects of these additives to insure we are getting a return on our investment.

What Kind of Buffer is best?

Feed additives are always for prevention and not treatment. They are not a substitute for good feeding management but can play a role in managing the risk of acidosis associated with low effective fiber and high grain/concentrate diets. Feed additives work in different ways.

Buffering the ration with sodium bicarbonate can help greatly to overcome the effects of excess acidity. However, studies show that feeding a combination of Magnesium oxide and Sodium bicarbonate can maintain a more desirable rumen pH and improve milk yield and butterfat test more than sodium bicarbonate alone.

Two research trials (Erdman, et al., 1980 & 1982) compared Magnesium oxide alone, Sodium bicarbonate alone and a combination of the two in cows during the first 8 or 12 weeks of lactation. Cows fed the combination buffer with Magnesium oxide maintained their rumen pH in the near ideal range of 6.2 to 6.8. Also, those fed the combination produced more milk and maintained a higher fat test than those fed either single buffer alone. Feeding Magnesium oxide along with sodium bicarbonate in these trials gave an economic advantage of $0.95 per head per day in return over feed costs.

Rations that utilize a blended “buffer pack” containing two parts sodium bicarbonate for each one part magnesium oxide, or a 2:1 ratio was proved to be beneficial for best performance. A Recent Indian Study also documented the benefits of combinations of buffers and feed additives as a blended “buffer pack”(BUFZONE- A Formulation of Intas Pharmaceuticals Ltd, Ahmedabad).

Conclusions

Feed additives fall into many different forms and can be helpful in reducing effects of ruminal acidosis, improving feed efficiency, rate of gain, heat suppression and bloat control to name a very few. When properly used in a well managed environment, many of these additives can improve performance and profitability substantially. This paper discussed some of the more common additives available on the market, some basic background on the products and what they are designed to do. This article is not designed to be an exhaustive summary of all products available but a guide to some of the more common.

Interest in feed additives will continue and will be influenced by new research results. While they can greatly improve profitability they can also be very expensive if used incorrectly or if used as a "cure-all" for poor management.

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