# Malate improves cow performance

By M. Cerrato-Sánchez and M. L. Locatelli, Norel and Nature SA, Jesús Aprendiz 19, 1, A-B, 28007 Madrid, Spain.

Annual milk production per cow has increased in the last 20 years and as a result the economic efficiency of animal production has improved. The increase can be attributed to improved genetics, reproduction, management and nutrition. Developments in nutrition have contributed to a better understanding of the cow's nutrient requirements and the nutrient composition of the feedstuffs.

## Continual challenge

Feeding the high producing dairy cows is a continual challenge. With feed costs representing approximately 50-60% of the annual variable costs of milk production, one aim is to achieve a good feed efficiency (pounds of milk produced per pound of dry matter consumed) because it directly affects the profitability of the farm. Another challenge is to meet the high energy requirements specially in early lactation, where capacity for feed intake is limited.

Therefore, cows are fed considerable amounts of non-fibre carbohydrates (NFC), which may increase the incidence of acidosis.

Over the last years, nutritionists have given particular interest in the supplementation of dairy rations with feed additives to increase feed efficiency and prevent acidosis.

Antibiotic ionophores have been very successful in this issue. However, since there is a reduced social acceptance and a ban of antibiotics in the EU (started on January 1st 2006 Community Directive 1831/2003/EC), alternatives were sought.

One solution for replacing antibiotics is adding natural organic acids and/or their salts to the diet to favourably modify the ruminal micro-organism fermentation pattern and improve dairy cattle performance.

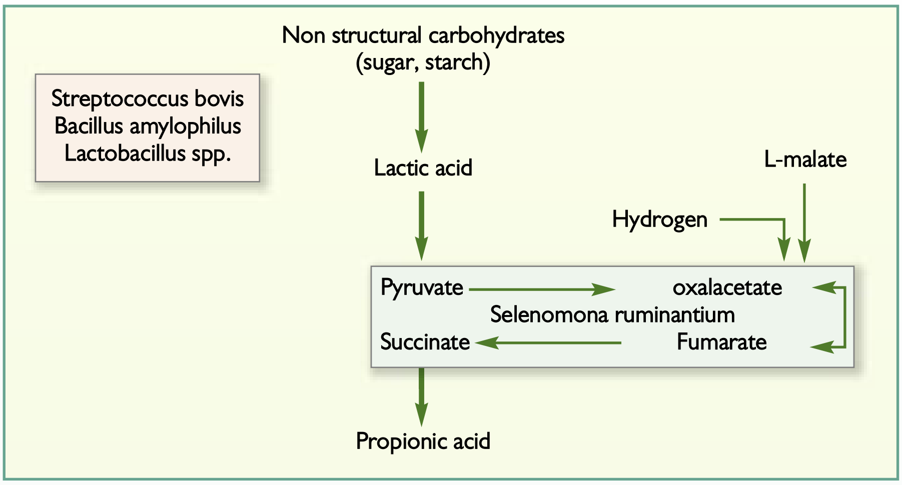
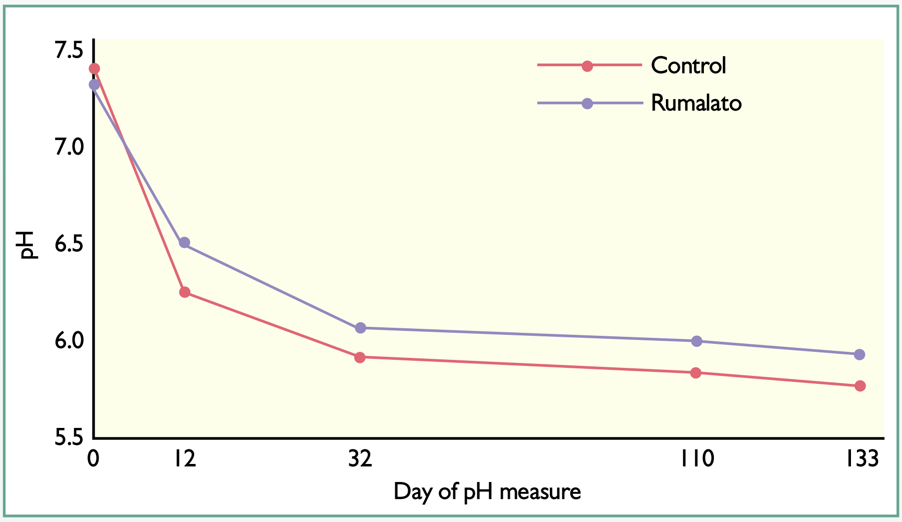



***Fig. 1. Malate stimulates the metabolism of Selenomona ruminantium and prevents a drastic drop in rumen pH.***

***Fig. 2. Effect of supplementing malate salts (Rumalato, Norel & Nature, Spain) on in vivo ruminal pH of beef cattle fed a 10:90 concentrate:forage***




## Rumen dysfunction

Ruminants establish a symbiotic relationship with a resident microbial population: the animal provides nutrients and a suitable habitat for their growth, and the microbes degrade the feed, supplying nutrients (energy, protein and vitamins) for the animal.

This population exists in a highly dynamic state: the number and type of micro-organisms can change dramatically depending on the type and amount of diet.

For example, structural carbohydrates (fibre) are degraded by cellulolytic bacteria producing acetic acid as a main end product; whilst non-structural carbohydrates (NSC) are degraded by amylolytic bacteria, whose main product propionic acid is a glucose precursor serving as an energy source for the cow. Lactic acid is another common product of the fermentation of NSC.

Under normal conditions volatile fatty acids (VFA) produced are absorbed effectively through the rumen wall and lactic acid is rapidly converted to propionate by lactate utilising bacteria, including Selenomonas

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ruminantium and Megasphera elsdenii. The equilibrium between acid production, acid absorption and lactate utilisation prevents acid accumulation in the rumen and avoids a dramatic reduction of ruminal pH.

However, excessive intake of readily fermented starch of readily fermentable carbohydrates stimulates a growth of amylolytic bacteria in the rumen which ferment starch and sugars rapidly.

This fast fermentation can affect the aforementioned equilibrium resulting in accumulation of acid and pH reduction in the rumen.

These conditions favour a rapid proliferation of Streptococcus bovis and Lactobacillus spp that produce lactate. The fall in pH (pH < 5.0) strongly inhibits pH sensitive bacteria such as cellulolytic bacteria and lactate utilisers bacteria like S. ruminantium and M. elsdenii.

All this rumen imbalance leads to ruminal acidosis: decreasing fibre digestion, food intake and ending up with diarrhoea, ruminal ulcers and even death.

A sub-clinical acidosis in ruminants, mostly asymptomatic, can indeed reduce the absorption of VFA over a long period of time due to an abnormal keratinisation of the ruminal epithelium, reducing the supply of metabolisable energy to the animal.

These changes results in economic losses, not only due to poor production, but also due to health related problems, beside the negative impact on the animal's well being.

## The role of malate

Malate is a four carbon dicarboxylic anion commonly found in biological tissues because it is an intermediate of the citric acid cycle in the cells. Research has shown that malate stimulates lactate utilisation by S. ruminantium which represents about 51% of the rumen bacteria in animals fed rich concentrate rations.

S. ruminantium is a Gram negative bacteria that metabolises lactic acid to propionic acid through a reverse citric acid cycle (succinate-propionate pathway), via pyruvate, oxalacetate, fumarate and succinate.

Malate not only is a key intermediate in this metabolic pathway, but also takes hydrogen from the rumen, increasing the use of lactate by S. ruminantium.

Propionate is, therefore, produced at the expense of lactate with benefits for both, rumen function and ruminant nutrition. If this is done efficiently lactate will not be accumulated in rumen, preventing a drastic pH drop (Fig. 1).

Several in-vitro studies have shown positive responses to malate supplementation on ruminal pH. However, at present there are limited in-vivo studies that evaluate this effect in dairy cows.

Devant and Bach (2007) found that early lactating cows fed a diet supplemented with 65g of malate consumed more concentrate compared to the control ones, but had similar ruminal pH. This indicates that malate can be effective in preventing ruminal acidosis.

Also in-vivo but using beef cattle Rossi et al. (2007) found that malate supplementation (20g/animal/day) to animals fed with a 10:90 forage:concentrate diet consistently maintained a higher ruminal pH (Fig. 2).

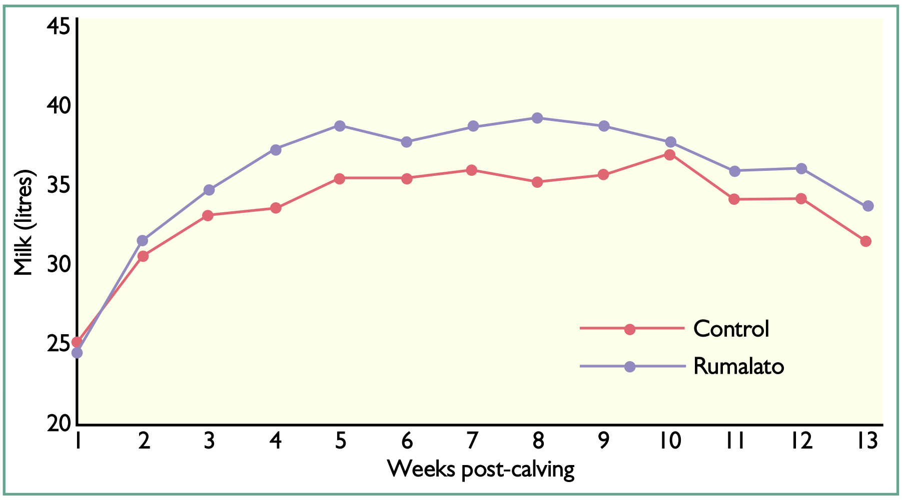


***Fig. 3. Effect of supplementing malate salts (Rumalato, Norel & Nature, Spain) during 28 days prior to calving and afterwards on milk production using Holstein cows (Devant et al., 2007).***

## Performance parameters

Methane production in the rumen represents a loss of energy (5-15%) and, therefore, reduces animal performance.

Additionally, methane eructated by ruminants contributes to a greenhouse effect and global warming.

One of the main factors which affects methane production is feed efficiency. This efficiency can be improved by modulating the activity of specific rumen microbial populations involved in specific metabolic pathways.

For example, methanogenesis can be reduced by promoting alternative metabolic pathways that increase the utilisation of hydrogen, competing with methanogenesis for hydrogen uptake.

Malate supplementation increases propionate production by bacteria using hydrogen from the rumen pool, and therefore, reduces methane production.

Multiple in-vitro trials have proven the positive effects of malate on rumen fermentation. Several in-vivo trials have shown that malate improves performance parameters such as feed conversion rate and weight gain.

Conversely, there are only a few in-vivo trials reported with dairy cows in the literature. Kung et al. (1982) reported increased milk persistency of dairy cows supplemented with malate.

A high malate content of forage used in basal diets has hidden a possible effect on goat milk production when supplemented with malate.

More recently, Devant et al. (2007) evaluated the effects of pre- and post-partum malate supplementation (65g/animal/day) on rumen fermentation and milk production using Holstein cows.

Malate supplementation had a positive effect on milk production (Fig. 3) resulting in higher milk yield at fourth and fifth weeks postpartum compared with control cows (37.1 and 38.4kg/d vs 33.4 and 35.7kg milk/d, respectively).

Milk composition was not affected (3.77 and 3.15% average fat and protein contents, respectively for both groups). Those results suggested that malate supplementation during peak of lactation may, in fact, increase milk production.

## Conclusion

Malate supplementation to dairy and beef cows fed high levels of rapidly fermentable carbohydrates (cereal grains) could help in the prevention of acidosis by reducing lactic acid accumulation in the rumen and, therefore, avoiding the associated economical losses.

The use of malate enhances feed energy utilisation and increases feed efficiency, which means higher available energy for optimal body condition maintenance and could certainly result in higher milk production.

Moreover, high yielding dairy cows supplemented with malate at peak of lactation increased milk yield with a non significant effect on milk composition. This is clearly an economic advantage under the current milk pricing system which emphasises fat and protein percentages.

Nevertheless, further research is needed with dairy cows in order to adjust optimal doses and practical feed management of malate addition suitable for different dairy farm systems. ■

*References are available from the authors on request*