Improving dairy cow health and productivity with natural rumen enhancers

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Instead of fighting against nature, we should aim to understand and emulate it. The rumen's microbial population and physiology are key aspects in dairy production. The understanding and control of the rumen ecosystem is necessary to both reduce the incidence of diseases and increase productive efficiency. The objective of the regulation of ruminal fermentation is to maximise the level of energy and protein in the cow optimising microbial development, keeping favourable conditions for the rumen and the microbiota, and improving the fermentation of the different carbohydrate fractions.

Today, increasing market competitiveness forces farmers to increase the ratio of concentrate:forage in highly productive cows, aiming at increasing milk production and the profitability of the farms they manage. This nutritional balance affects ruminal bacteria population: amylolytic bacteria are benefiting from it, whilst the cellulolytic flora diminishes. Hence there is a higher risk of acidosis and a reduction of milk fat, not to mention possible subsequent diseases. The combination of high production levels and the reduction in the risk of acidosis is not an easy task, and must be approached by the producer from different angles: management, environment and nutrition.

With regard to animal nutrition, farmers have been using rumen modifiers and growth promoters for many years. However, the increasing restrictions on these products pushes the industry to search for alternatives aiming at improving rumen fermentation and productivity in a natural way, working hand in hand with physiology.

Rumen bacteria

Thanks to increasing research on rumen microbiology, there is a better understanding of the rumen ecosystem and of the interactions that take place in it. Fermentation in the rumen is of critical importance for efficient production in ruminants, and it is carried out by a complex of rumen microbiota consisting of bacteria, archaea, fungi, and protozoa that are closely interrelated.

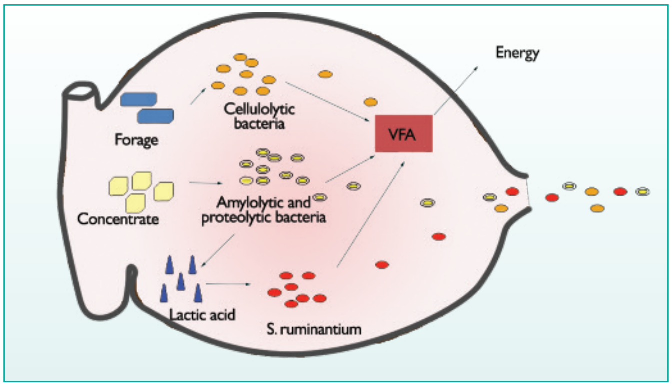


Fig. 1. Role of Selenomonas ruminantium in rumen fermentation.

Focusing on bacteria, Selenomonas ruminantium is worthy of mention, as it represents up to 51% in acceptable ruminal bacteria counts in animals receiving high rate concentrate rations, and is involved in rumen fibre digestion. It is involved in the metabolism of carbohydrates and in the production of propionic acid as a final rumen fermentation product, which is the main source of energy for ruminants.

In summary, the action of this bacterium increases the energy available for milk production (see Fig. 1 and 2), transforming the lactic acid into propionic acid via the succinate-propionate pathway.

Malate as an option

As seen in Fig. 2, the final product of the succinate-propionate pathway is propionate, whose production can be increased by means of the addition of intermediaries in the cycle. One of these intermediaries is malate. Its use as ruminal fermenter started after two important discoveries.

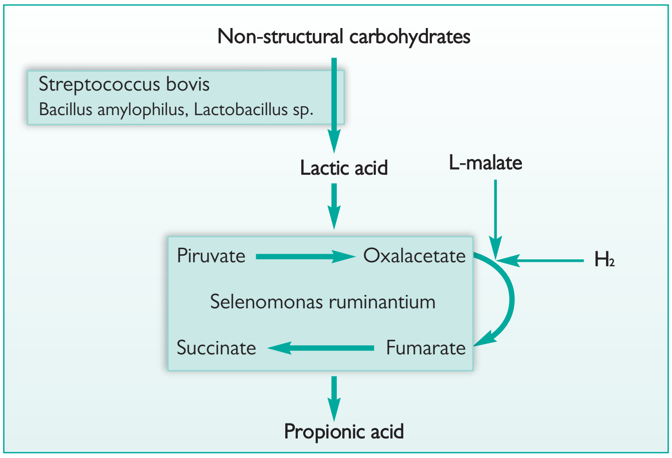
First, Linehan et al. (1978) discovered that substrates such as malate stimulated the growth of certain microbial populations which modified the fermentation patterns in the rumen, such as Selenomonas spp.

Later, Paynter and Elsden (1979) observed that bacteria of the Selenomonas family increased the propionate and acetate production by direct oxidation of lactate.

Thus, malate is not only useful to reduce the lactic acid in the rumen (which is the main cause of acidosis), but it is also a substrate for different bacteria populations. When the flora in charge of carbohydrate digestion increases, there are two different outcomes at the same time: first, an increased digestion of carbohydrates and secondly an increased production of microbial protein available in the intestine.

The addition of malate helps to modulate pH and promotes the growth of gut bacteria that can convert lactate to propionate. Due to this, malate has been used to reduce rumen D-lactic acid concentration in cattle, reducing body D-Lactate by converting lactate to propionate, as well as promoting a gut environment for favourable bacteria. Specifically, S. ruminantium is able to use malic acid salts as substrate, which is of great interest since it reduces the ruminal pH after feeding, leading to improvements in productivity and metabolic parameters, such as feed intake, milk production, NEFA and BHB.

Fig. 2. Diagram of the succinate-propionate pathway in carbohydrates' ruminal metabolism.



Nutrient digestibility

Several authors have observed an increase in the digestibility of organic matter (acid and neutral detergent fibre), availability of nutrients, microbial N production and efficiency of its synthesis when malate is included in the diet. These increases in the digestibility fit with the idea of malate as stimulant of the growth of different microbial populations which are involved in the degradation of carbohydrates.

The first studies in dairy cows were performed by Kung et al. (1982), who observed an increase in

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the persistence of the lactation curve in dairy cows when malate was added to the diet. Similarly, other authors found that the use of malate (salts of malic acid) increased milk production. Devant et al. (2007) observed that the addition of malate in rations for cows at the start of lactation increased milk production during the peak of lactation (Fig. 3).

Furthermore, Sniffen et al. (2006) identified an increase in the production of protein and lactose, as a result of this increase in production.

Norel has carried out many trials to assess the effects of the use of sodium-calcium salts of malic acid (Rumalato).

In a recent trial carried out in the spring of 2013 in Mexico, Norel assessed the effects of supplementing dairy cows with 40g of Rumalato (34g of malic acid salts) per animal per day.

The production was evaluated in a herd composed of Holstein cows, milked twice a day, with an average production level of 10,000kg/cow and lactation cycle. The supplemented group had 5% higher milk production compared to the control group, which meant 1.6kg cow/day and almost 500kg/cow and lactation cycle. The ROI was estimated to be 4.67.

Negative energy balance

Wang et al. (2009) investigated the effects of the addition of malate on blood parameters such as BHB, NEFA, glucose and insulin during the peripartum period and observed that the addition of malate increased the levels of glucose and insulin in blood and reduced the levels of BHB and NEFA.

They also observed a decrease in weight loss in the peripartum period when the dose of malate was increased. The loss of weight was lower when increasing the doses of malate per cow and day.

Based on these results, the authors concluded that the inclusion of malate improved the energetic balance, decreased the fat mobilisation during the postpartum period and improved the biochemical parameters indicators of ketosis. Therefore, malate can be an effective tool in improving the NEB during the prepartum and peripartum periods.

Malate can also be used as a preventative of ketosis and to improve the NEB in the postpartum.

Acid malic or malate?

It is interesting to note that the way in which these compounds are administered also modulates the response thereto. According to Castillo et al. (2004), the use of salts of organic acids appears to be more effective. Castillo et al. (2007) found that malic acid salts had an alkaline effect in blood since it significantly reduced the PCO2, whereas when giving malic acid they did not find differences compared to the control. The reason may be that only the malic acid is absorbed, not the malate; this one needs to be combined with a hydrogen proton to pass through S. ruminantium wall via passive diffusion. When given as a salt it will be dissociated in malate plus the cation, and malate will be an electron sink for protons, which will reduce the acidity in rumen.

In addition, when provided as a sodium salt or calcium salt, it will also play an important role in rumen since it actively enhances cell survival, has an effect on rumen dilution rate, and has some cations that are known to have an effect on lactate uptake by S. ruminantium.

Moreover, the addition of malic acid at normal dose (2kg/t) will reduce the ruminal pH about 0.2.

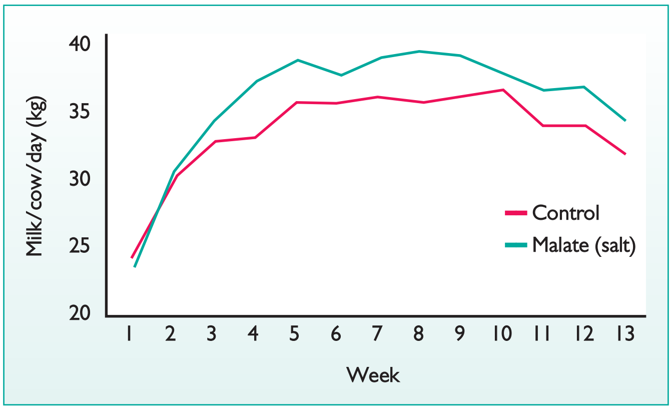

Fig. 3. Effect of malate supplementation on milk production (Devant et al. 2007).

Ruminal pH

As can be seen in Fig. 4, the addition of malic acid salts (Rumalato) improves rumen fermentation, and prevents the decrease of ruminal pH, despite cows supplemented with this product showed a higher dry matter intake. Other authors have also observed that the administration of malic acid salts increase DMI without decreasing ruminal pH.

It has also been observed that the addition of malate increases the production of volatile fatty acids (propionic acid, in particular), thus reducing both the accumulation of lactate and the ratio acetic:propionic acid. Moreover, this increase in volatile fatty acids (VFA) gives extra energy to the cows. As a consequence, the incidence of diseases related to ruminal acidosis is reduced and feed efficiency is improved.

Conclusions

The addition of malate (salts of malic acid) has been shown to be beneficial in the diet of dairy cows, since these compounds help both to control ruminal population and improve fermentation. This improves the energy and protein metabolism of ruminants, reducing the risk of metabolic disorders. Moreover, malate increases milk production, the persistence of lactation curve, and reproductive performance.

Generally, these benefits are more pronounced when malic acid salts are administered instead of malic acid as such. ■

References are available from the authors on request

Fig. 4. Effect of the addition of malate (malic acid salts) on ruminal pH and the production of volatile fatty acids in the rumen in comparison with malic acid (Newbold et al. 2005).