Malate – useful energy for dairy cow rations

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Starch is an important source of energy for ruminants. It is easily fermented by amylotitic bacteria, leading to propionic acid generation which is the main precursor for glucose synthesis in the liver.

However, excessive inclusion of starch in feed can be harmful for the animal due to the increased risk of ruminal acidosis and paraqueratosis.

Non-structural carbohydrates (NEC) enhance amylolitic bacteria proliferation, mainly Streptococcus bovis that produces lactic acid as final product.

Lactic acid at low concentration can be metabolised by Selenomonas ruminantium (Fig. 1), but with excessive substrate, lactic acid exceeds metabolic capacity of this bacteria and high accumulation in the rumen will produce acidosis.

Moreover, reduction of ruminal pH enhances proliferation of other lactic acid bacteria impairing acidotic process, inhibiting cellulolytic bacteria and decreasing dietary fibre profitability (Fig. 2). Thus, an important task in dairy nutrition would be the possibility of increasing starch inclusion in the ration avoiding risk of ruminal acidosis.

In this sense, malate stimulates lactic acid utilisation by S. ruminantium when environmental pH falls down. Malate is an organic acid salt widely present in nature.

It has a key role in enhancing the inverse cycle of citric acid (succinate-propionate way) by which lactic acid is transformed to succinate and propionate by S. ruminantium.

Moreover, in this process hydrogen acts as a reducing factor, decreasing its disposability for methane production. Obtained benefits from malate inclusion are higher profitability of diet nutrients by improving starch and fibre fermentation and decreasing methane production, and lower incidence of acidosis with high dietary starch levels.

Effect on ruminal fermentation

To determine effectiveness of malate on starch ruminal fermentation, four different cereals (corn, wheat, barley and sorghum) were tested. Ground grains were incubated in vitro with sheep ruminal liquid and different concentrations of malate (Table 2).

After incubation at 39ºC during 17 hours (average retention time of feed in the rumen), ruminal pH, methane and VFA production and optic density were determined. Obtained results confirm effectiveness of malate on ruminal starch fermentation (Fig. 3).

Lactic acid decreased with malate in all studied cereals which was concomitant with a pH reduction. Increment in propionic acid suggests generation from lactic acid by S. ruminantium.

Propionic acid is the main precursor for glucose synthesis in the liver and lactose in the mammary gland and its carbon skeleton is used for protein synthesis.

Thus, the increment in propionic acid suggests higher feed energetic efficiency that will be accompanied by an increment in milk production.

As has been said above, reduction in ruminal pH below six, inhibits growth of fibrolitic bacteria. With the addition of malate pH is significantly increased, which improves fibre fermentation, as can be deduced by the observed increment in acetic acid. This specially is of interest, since it means that increased milk production, a consequence of higher propionic acid, will be accompanied by an increment in milk fat content.

Methane synthesis was reduced in all cereals, although with corn and sorghum differences were not statistically significant.

This effect could be a consequence of the utilisation of hydrogen as a reducing factor in the transformation of fumarate to succinate by S. ruminantium in the presence of malate. Reduction of disposable hydrogen limits methane production in the rumen, reducing energy losses from belching.

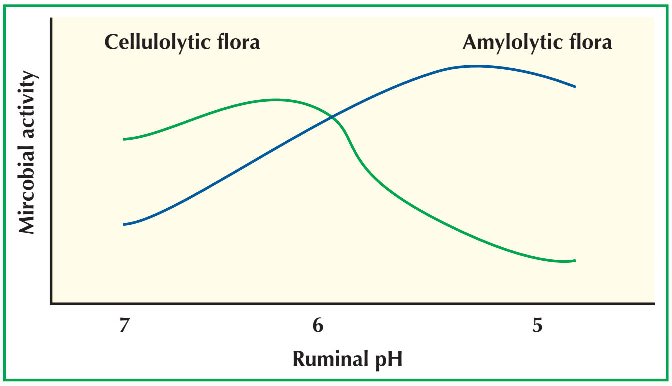


Fig. 2. Ruminal bacteria activity at different pH.

Digestibility (%)	Corn	Corn + malate	Barley	Barley + malate	SE	Sig
OM	81.0	84.5	82.2	85.6	0.6	0.001
CP	78.3	82.2	76.1	81.2	0.8	0.001
NDF	39.8	49.7	42.1	48.6	2.3	0.001
ADF	47.4	55.9	54.9	59.2	2.4	0.017
GE	80.6	83.4	81.4	84.5	2.4	0.003

Table 1. Nutrient digestibility after addition of malate to feed with a high level or corn or barley. Trial performed at Universidad Autónoma de Barcelona, Spain.

Fig. 1. Ruminal nutrient fermentation and VFA generation.

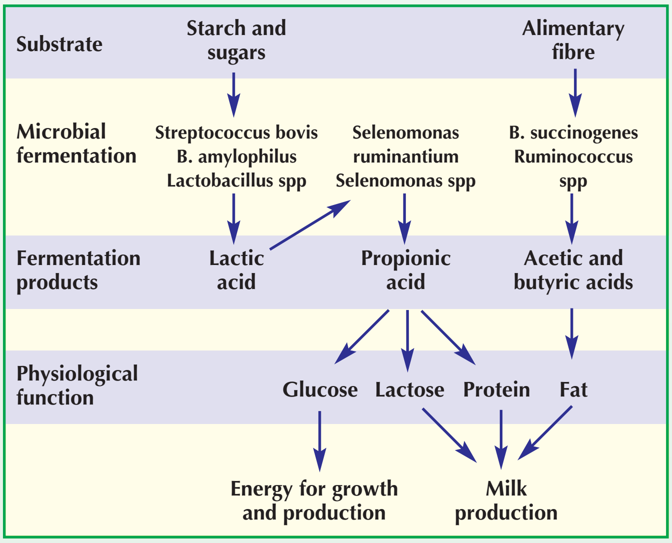


Table 2. Incubation doses of malate with cereals. Trial performed at Universidad de León, Spain.

Cereals	Malate* concentration in incubation bottle (mM)	Corresponding dose in feed (g/kg)
Corn	4	3
Barley	7	5
Wheat	10	7
Sorghum		

**Rumalato: Trade mark of malate. Marketed by Norel & Nature Nutrición.*

Gas production at different times, during a total of 120 hours of incubation at 39ºC, is presented in Table 3. Potential production of gas was linearly increased with wheat and sorghum.

However, malate added to corn and barley did not produce any change with respect to the control. Delayed time to gas production was decreased with the addition of malate to corn, barley and wheat.

Since ruminal gas production is related to rate of ruminal fermentation, these results suggest a stimulation of the initial degradation of these cereals. There are numerous studies that show efficiency of malate added to high starch diets of ruminants, producing higher performance parameters and better feed conversion ratio.

	Malate doses (mM)					Significance
	0	4	7	10	e.e.d.	Linear
Corn						
Potential production (ml)	192	197	196	195	2.5	NS
Production speed (h^{-1})	0.0810	0.0775	0.0756	0.0739	0.00275	*
Delay time (h)	2.95	2.66	2.55	2.73	0.184	NS
Barley						
Potential production (ml)	185	185	184	185	2.9	NS
Production speed (h^{-1})	0.0895	0.0889	0.0865	0.0843	0.00309	NS
Delay time (h)	1.99	1.65	1.41	1.36	0.195	**
Wheat						
Potential production (ml)	183	194	191	192	2.3	**
Production speed (h^{-1})	0.1058	0.1032	0.1017	0.0982	0.00232	**
Delay time (h)	2.29	2.28	2.24	2.15	0.184	NS
Sorghum						
Potential production (ml)	192	195	198	198	2.4	*
Production speed (h^{-1})	0.0710	0.0720	0.0681	0.0670	0.00206	*
Delay time (h)	3.71	3.84	3.53	3.74	0.296	NS

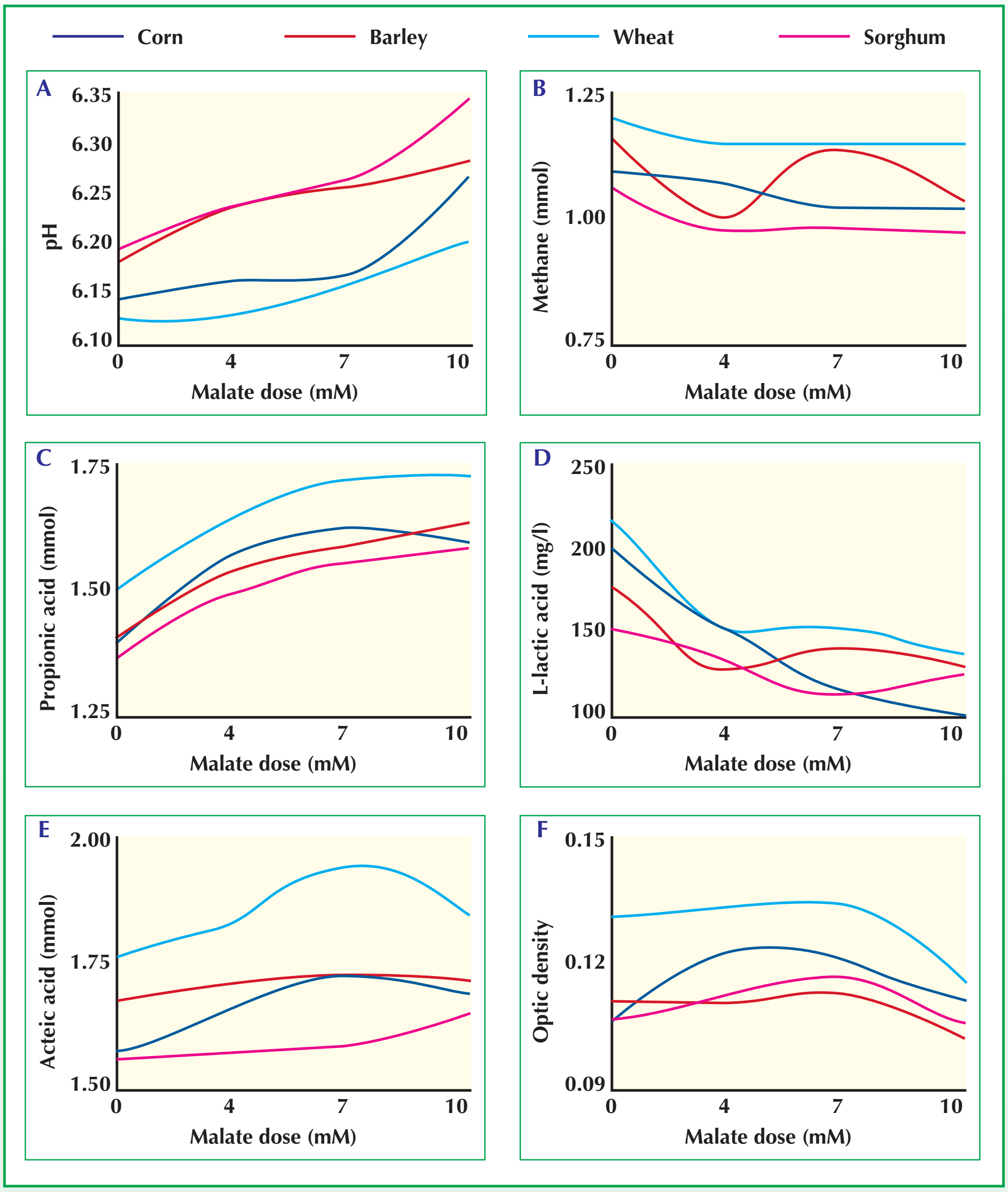
Table 3. Effect of different doses of malate on ruminal gas production on in vitro conditions after 120 hours of incubation. Trial performed at Universidad de León, Spain.

Although in dairy cows it is difficult to perform experimental trials, higher persistence of milk production curve was observed by Kung et al. (1982) that could result from the better profitability of feed nutrients and better maintenance of body condition in the first months of lactation.

These results are probably a consequence of higher profitability of feed nutrients as is supported by results obtained with lambs in digestibility chambers (Table 1).

Higher digestibility of organic material, protein, fibre and energy, reflects improvement of ruminal fermentation and allows ruminant animals to improve feed conversion ratio increasing productivity.

Fig. 3. Effect of different doses of malate added to four cereals (corn, barley, wheat and sorghum) on in vitro conditions, on ruminal pH (A), methane (B), propionic acid (C), L-lactic acid (D), acetic acid (E) production and optic density at 600nm (F) after 17 hours of incubation. Trial performed at Universidad de León, Spain.



Conclusions

Use of malate in ruminant animal nutrition enhances energy profitability of the ration and increases performance parameters as a consequence of higher digestibility of nutrients.

Malate avoids the appearance of acidosis by reducing lactic acid accumulation and regulates ruminal fermentation with high starch diets. Thus, use of malate in dairy cow rations allows formulation with higher starch levels, which means higher disposable energy for optimal body condition maintenance and higher milk production. ■

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