The effects of malate supplementation on productive, metabolic and acid-base balance parameters in calves fed a corn-based high-grain diet

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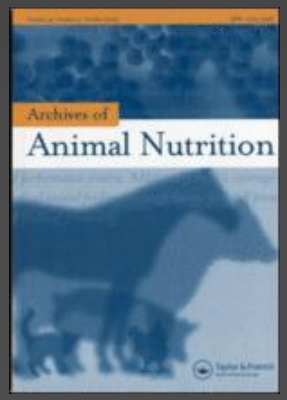

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Effects of malate supplementation on acid-base balance and productive performance in growing/finishing bull calves fed a high-grain diet

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INTRODUCTION and OBJECTIVES

Increasing concern over the widespread use of antibiotic additives in feedlot nutrition, and the corresponding new regulations proposed by the European Commission, have prompted an interest in possible alternatives with effects analogous to ionophores, such as **malate.**

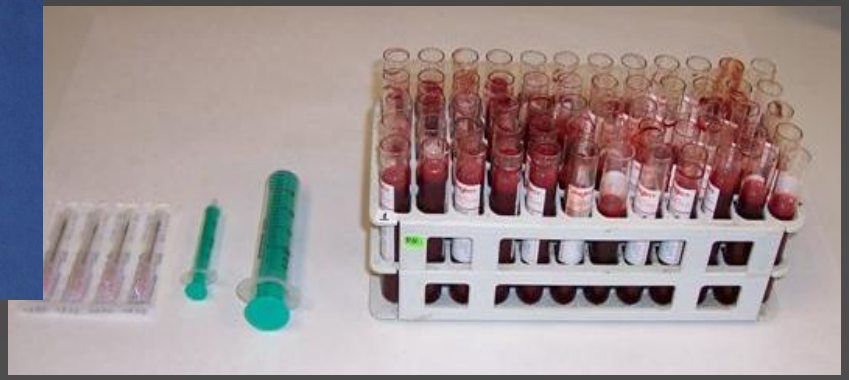
Malate is an organic acid that is an intermediate in the succinate-propionate pathway of ruminal bacteria. In vitro, malate has stimulated lactate uptake by Selenomonas ruminantium, the main bacterium within the rumen; increased concentrations of propionate and total volatile fatty acids; increased pH; decreased methane production; decreased lactate concentration (Martin and Streeter 1995; Callaway and Martin 1996; Martin 1998; Carro and Ranilla 2003); and increased digestibility of dry matter, organic matter, neutral detergent fibre and hemicellulose (Carro et al. 1999).

The present study evaluates the effects of malate on blood acid-base balance and serum L-lactate level in bull calves during an entire productive cycle (i.e. the growing and finishing periods)

Blood acid-base balance is of interest because blood pH is closely associated with ruminal pH, especially when the animal is receiving a high-grain diet; blood L-lactate levels are of interest due to the close association between ruminal and blood L-lactate.

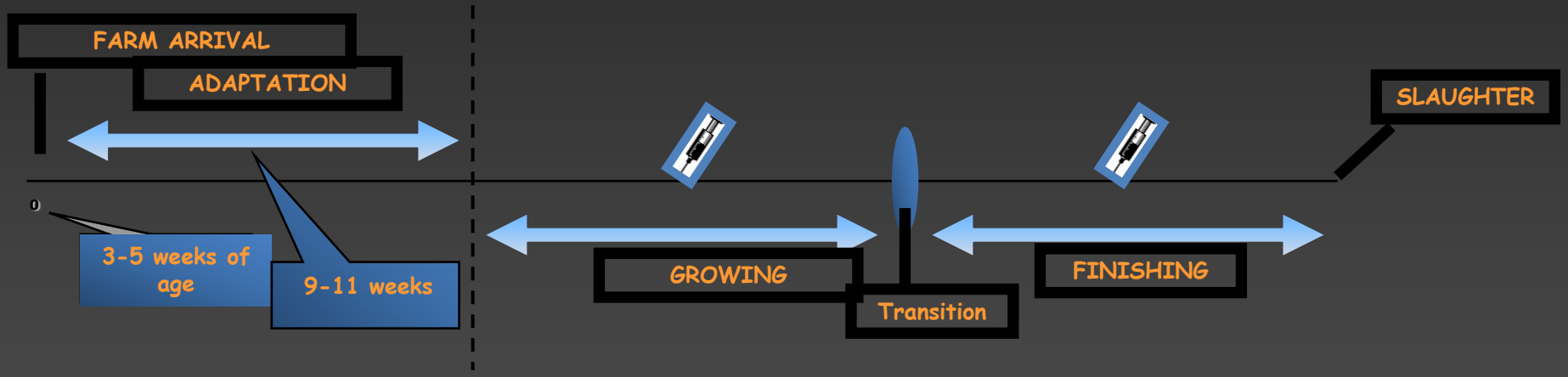
Productive data were additionally taken into account as complementary information associated with supplementation.

MATERIALS and METHODS



A 137-day feedlot metabolic study was conducted using 26 Belgian Blue bull calves.

The animals were approximately four weeks of age on arrival at the study location, a commercial farm (Coren S.C.L., Ourense, NW Spain). The study ran between 14 and 35 weeks of age, i.e. the growing and finishing periods in the Spanish feedlot system.



Animals were allotted randomly to one of the two experimental groups: 1) control group [no supplementation; n=10, group C]; 2) supplementation with 2.8 g of disodium malate-calcium malate (Rumalato®) per kg (DM basis) [n=16, group MS]

DIETARY COMPOSITION

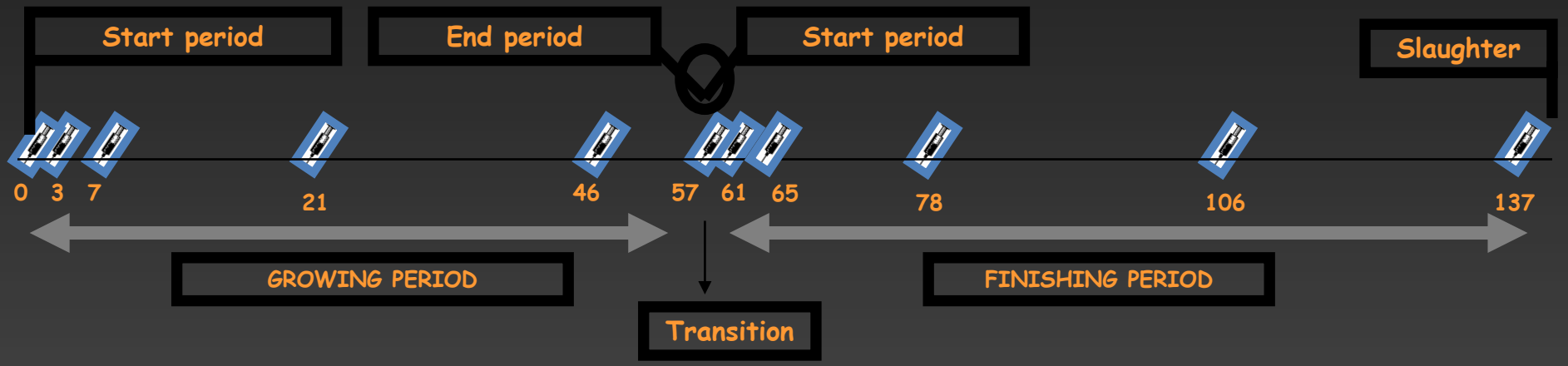
Consisting mainly of barley plus other components in proportions depending on the production phase. All grains were ground through a hammer mill (coarse grind, 5 mm diameter) before feeding

INGREDIENT (% DM)	PERIOD	
	Growing	Finishing
Barley	15.5	15.8
Corn	30.0	30.0
Rye	-	6.0
Sunflower meal	4.0	-
Molasses	3.0	2.5
Palm oil (98 % bypass)	2.0	0.5
Soybean meal (44 % CP)	14.3	13.5
Corn gluten feed	10.0	10.0
Barley sprouts	2.0	-
Wheat bran	9.0	5.3
Soybean hulls	8.0	10.0
Vitamin / mineral premix	3.2	2.1
Sodium bicarbonate	0.6	0.3

Chemical composition (% DM)	PERIOD	
	Growing	Finishing
DM	88.3	87.8
CP	26.6	15.0
CF	7.67	7.3
NDF	21.3	20.8
ADF	10.8	11.1
EE	4.90	3.54
NFC	50.9	57.2
Ash	6.3	3.45
Starch	32.2	34.1
Starch + sugar	37.6	39.7

Animals were allowed free access to feed, water and barley straw

BLOOD SAMPLES



Blood pH, pCO_2, HCO_3^- and BE were determined in whole blood, using a hand- held portable analyser (i-STAT EC8+, East Windsor, NJ, USA).

Lactate was determined in serum using a commercial kit (Spinreact S.A., Girona, Spain)

STATISTICAL ANALYSES

Statistical analyses of blood parameters were done for each different period (growing and finishing) separately. Data were tested for normal distribution using the Wilk-Shapiro test (NIST 2006).

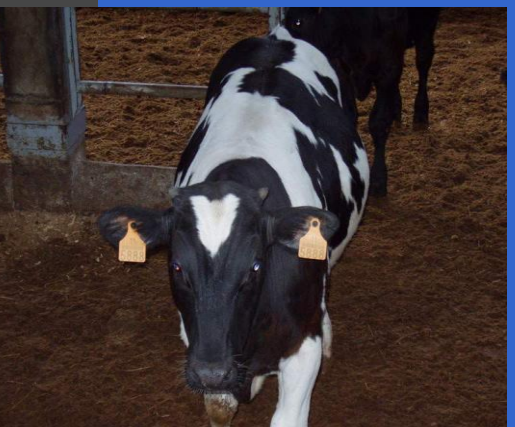
Data were subjected to analysis of variance (ANOVA) with group as the fixed main effect and sampling date as a repeated-measure effect; thus the model considered the effects of treatment (TR), time (T) and the T x TR interaction.

Differences between groups in body weight and ADG were analysed by ANOVA.

All statistical analyses were performed using the SPSS 12.1 package.

Significance was declared at $p \leq 0.05$ and trends at $0.05 < p \leq 0.1$

RESULTS and DISCUSSION



PRODUCTIONS DATA

The MS calves showed slightly lower mean ADG and mean feed intake than the C animals, but the difference in ADG was not statistically significant. Feed-to-gain ratio was similar in the two groups.

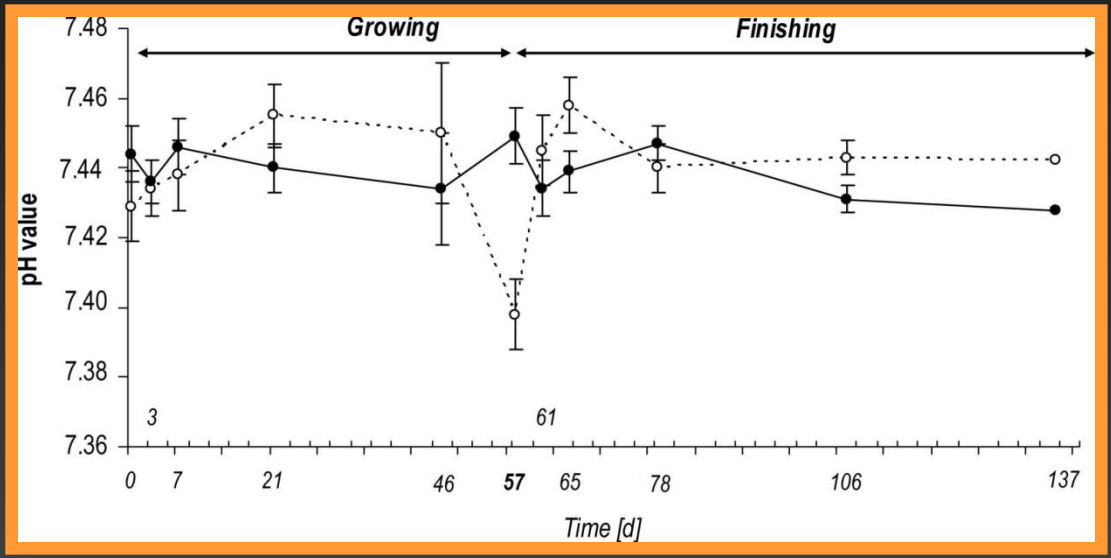
	GROUPS		
	C	MS	SL
Initial live weight (kg)	222 ± 3.0	233 ± 3.5	0.514
Final live weight (kg)	463 ± 6.3	474 ± 6.9	0.301
ADG (kg)	1.57	1.54	0.707
Daily intake (kg/d)	7.9	7.7	—
Feed:gain ratio	5.0	5.0	—

Malate supplementation did not have any significant effect on growth performance by comparison with the non-supplemented control group.

This lack of effect is probably attributable to the grain composition of the diet which determines the amount of rapidly fermentable substrates in rumen, the amount and quality of the fibre, and even the malate dose used.

BLOOD PARAMETERS

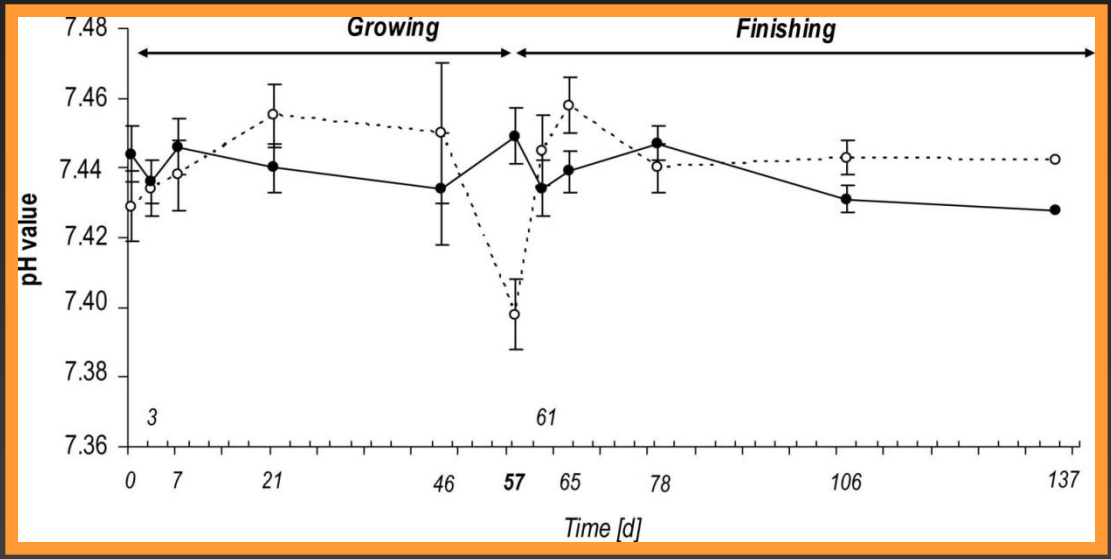
blood pH



The effect of T*TR interaction on blood pH was observed in both the growing and finishing periods: In the growing period, values on day 7 tended to be different from day 21 (p = 0.058) showing different evolution (increase in C and decrease in MS, lower values in non-supplemented calves), and values on day 46 were different from day 57 (p = 0.011) with a decrease in C group and increase in MS group. The non-supplemented animals reached the lowest values of the study. In the finishing period, only values on day 57 were near-significant different from day 61 (p = 0.065; increase in C group and decrease in MS)

BLOOD PARAMETERS

blood pH



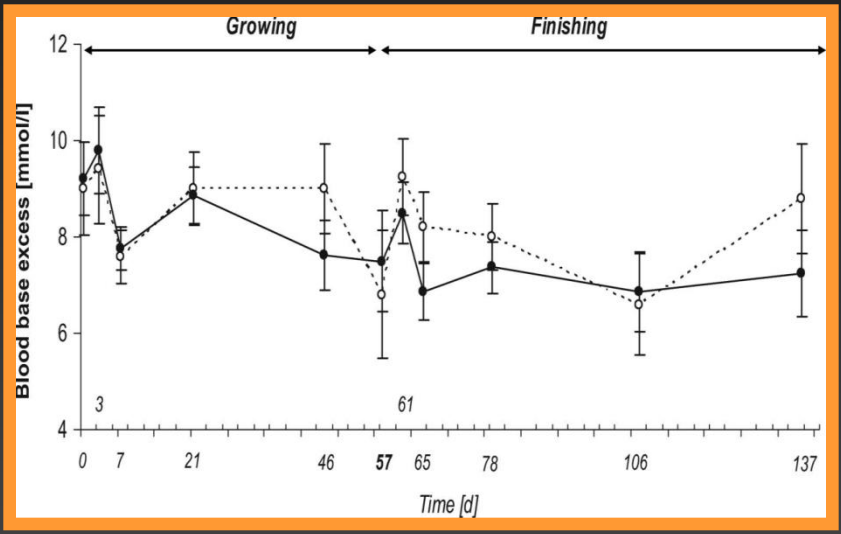
A **high-grain feedlot diet** was supplied in present study (NRC 2000) However, mean blood pH and HCO_3^- values in C group were higher than reported in previous studies. Probably attributable:

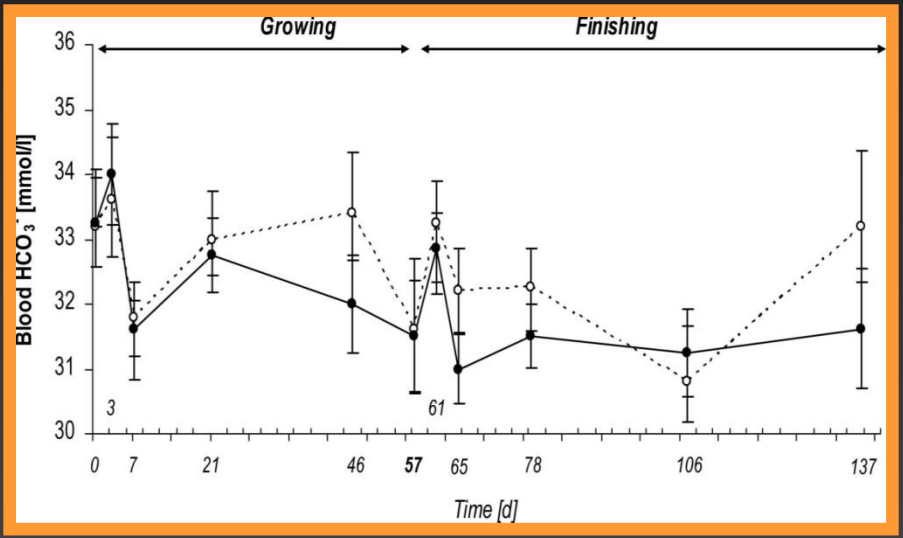
- High crude protein content of the ration, which may have acted as a pH buffer.
- The effect of sodium bicarbonate as a ruminal buffer.

During the study, blood pH values were within the normal range of 7.35-7.50. However, the effect of T*TR interaction observed suggests that their values were influenced by both the addition of malate and the diet fed in each stage. Thus, supplemented animals showed more stables values.

BLOOD PARAMETERS

HCO_3^- and BE





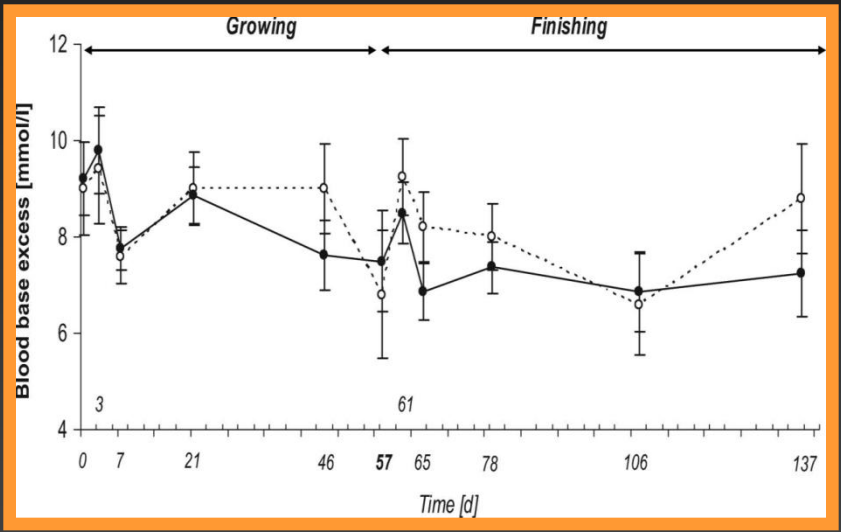
Both HCO_3^- and BE showed a **significant time effect**.

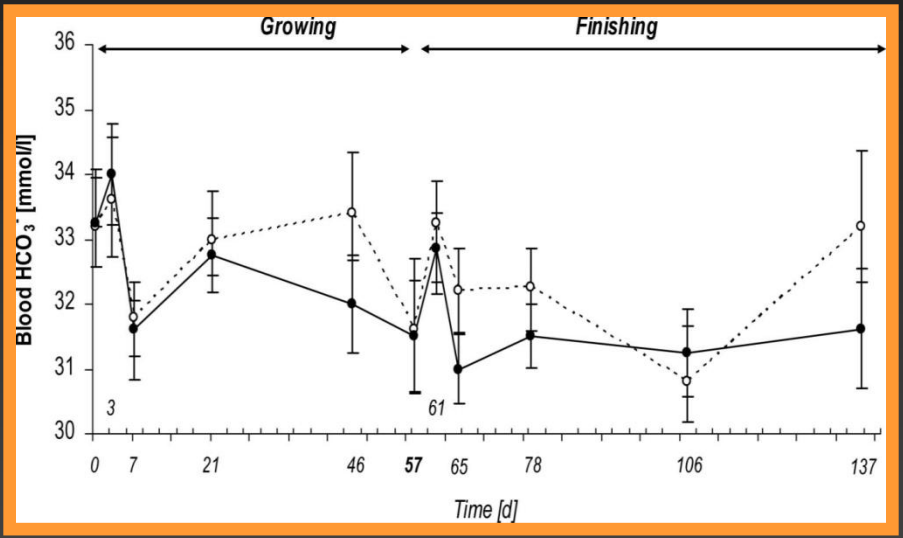
- **Growing period**: significant differences between days 3 and 7 with a decrease in both groups; and tended to be different between days 7 and 21 showing a recovery.
- **Finishing period**, significant effect was observed only in HCO_3^-: values on day 57 were lower than day 61; on day 61 higher than day 65 and on day 106 were lower than day 137.

Data indicated no significant effect of malate supplementation on blood HCO_3^- or BE ($p > 0.1$) but on several days the MS group showed numerically lower values than controls.

BLOOD PARAMETERS

HCO_3^- and BE

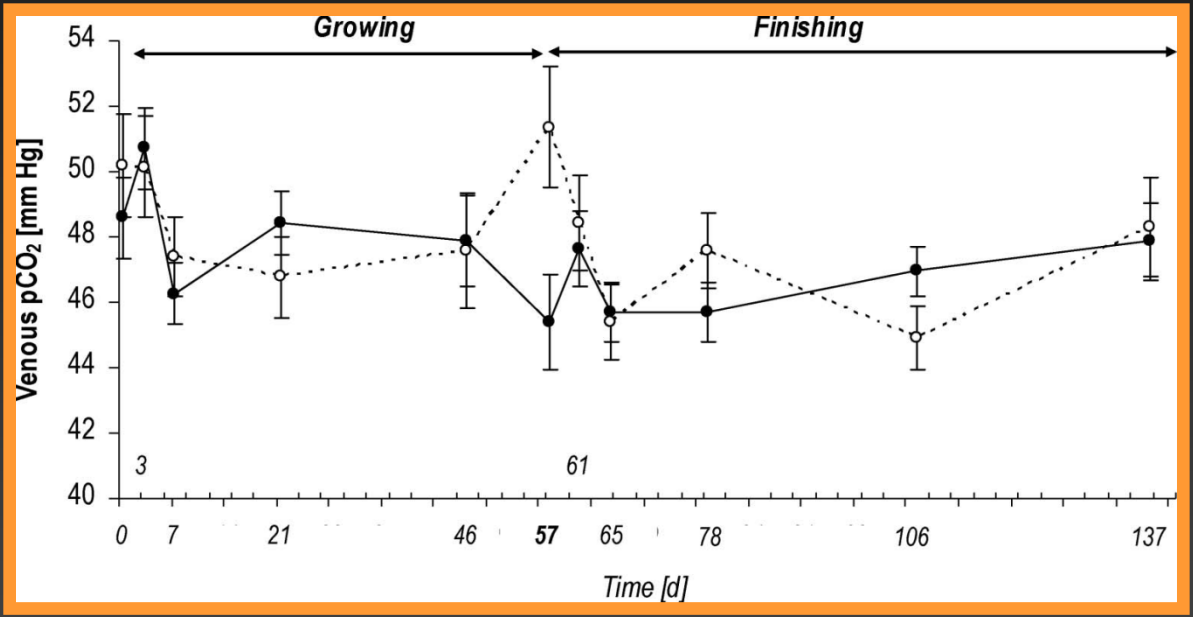




Changes in blood buffer bases (HCO_3^- and BE), were attributable only to diet characteristics fed in each stage. Our data show that malate addition did not give any beneficial response in comparison with controls, probably attributable to diet composition.

BLOOD PARAMETERS

pCO_2

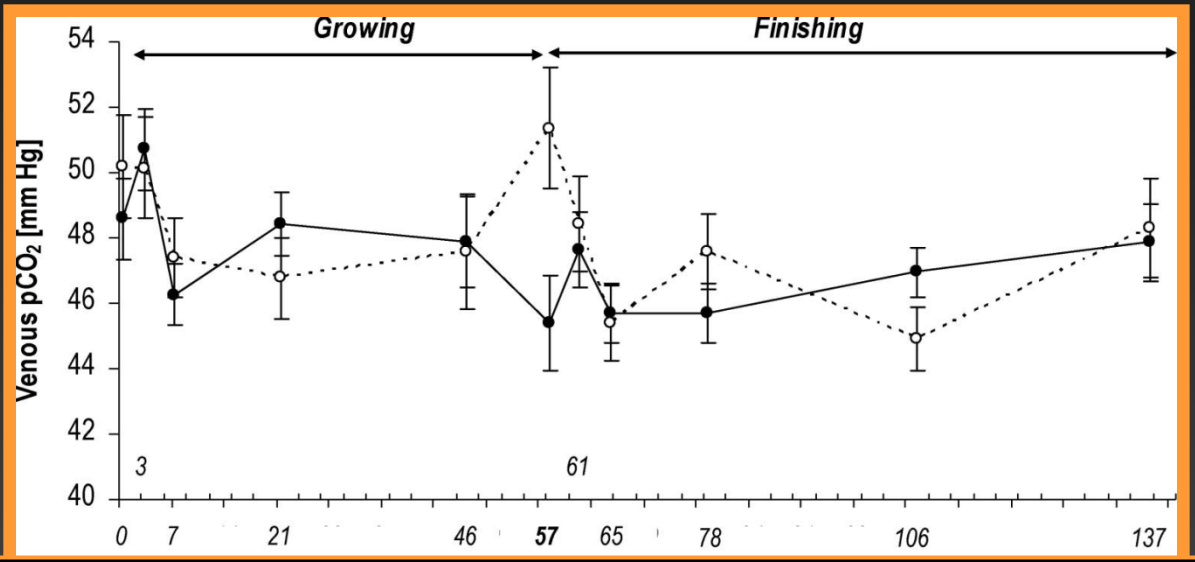


A near-significant effect of time on blood pCO_2 was observed throughout the study period: Mean values on day 3 were higher than day 7 values; day 61 values tended to be higher than day 65 values; and day 106 values were lower than day 137 values.

The effect of T*TR interaction on blood pCO_2 was also observed in both growing and finishing periods: In the trend observed between day 46 and 57 it is noteworthy to recognise the increase in C and the decrease in MS animals, with higher values in C group. In the finishing period, values on day 57 tended to be different from day 61 (decrease in C and increase in MS) and values on day 78 were nearly significantly different from day 106 (decrease in C and increase in MS)

BLOOD PARAMETERS

pCO_2

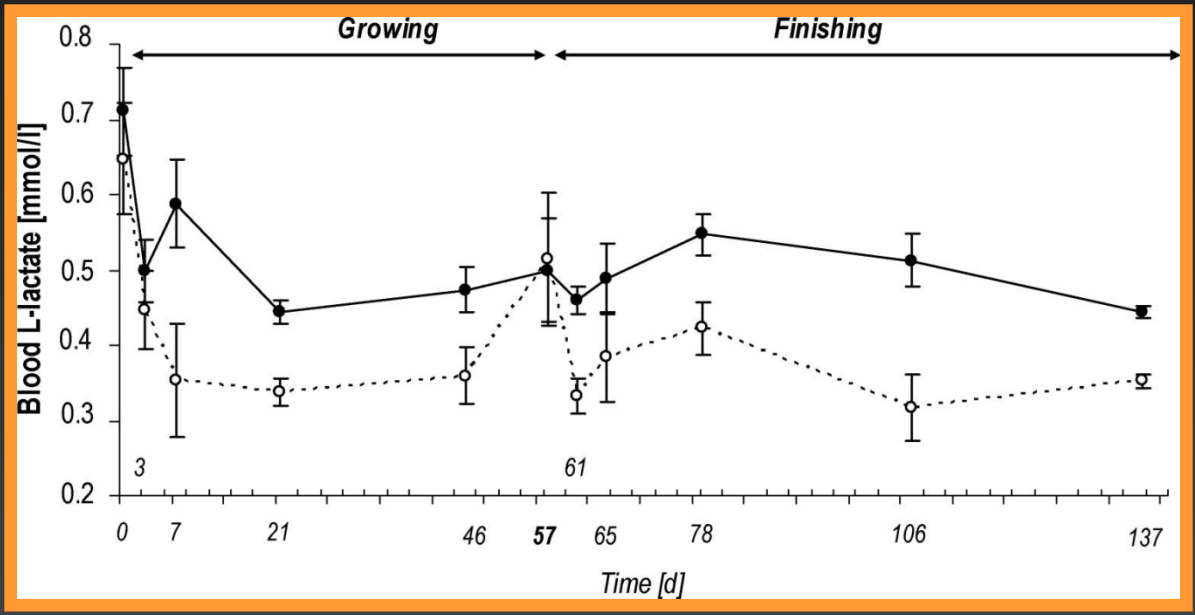


The observed fluctuations in blood pCO_2 did not allow us to establish a clear trend, despite the effect of T*TR interaction. Nevertheless, note that in the transition period (day 57), both groups had an opposite evolution (increase in C and decrease in MS), and this is coincident with the changes observed in blood pH (decrease in C and increase in MS) suggesting a close association between the two parameters. Traditionally, low levels of blood pCO_2 have been considered as evidence of a compensatory mechanism that minimises the risk of acid overload.

Can diet characteristics contribute to increasing pCO_2? Which is the role played by malate in this time-course? In view of these results, more research is needed about the metabolic effects of malate on supplemented animals.

BLOOD PARAMETERS

serum L-lactate

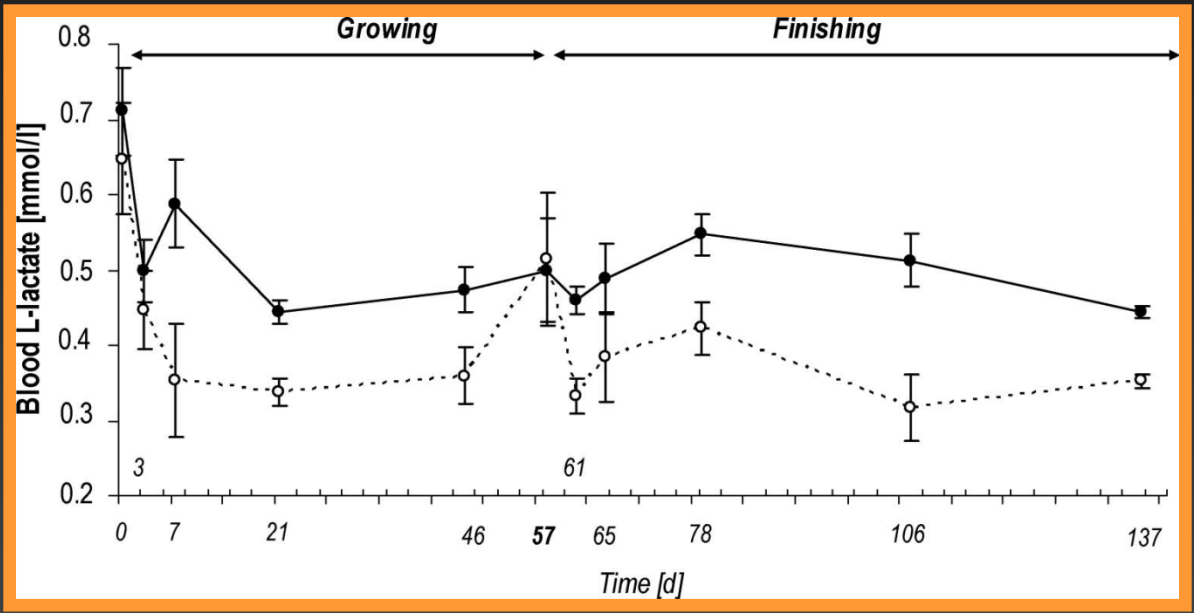


Serum L-lactate was significantly affected by time only in the growing period: Values on day 0 were different from values on day 3 and values on day 7 tended to be different from values on day 21.

In the finishing period, only a treatment (TR) effect was observed: on all of these days, the treated group showed higher concentrations than the control group (this finding, although without statistical relevance ($p > 0.1$), was also observed in the growing period

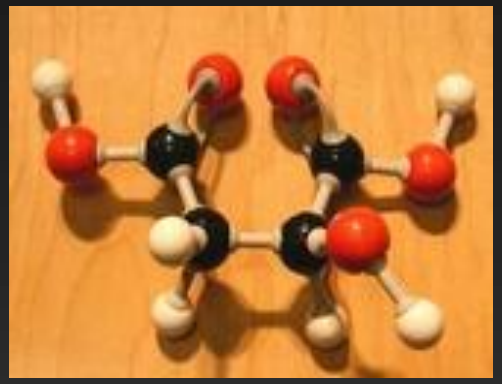
BLOOD PARAMETERS

serum LACTATE



Despite the well-known stimulatory in vitro effects of malate on lactate uptake by ruminal bacteria, the time-course of serum L-lactate levels observed in the present study in both the growing and the finishing periods suggests that malate does not have beneficial effects in animals fed a high-grain high-protein diet.

This finding is attributable to dietary composition and differences in the general nature of substrate influencing the effectiveness of the malate.



CONCLUSIONS

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If we take into account only productivity parameters, malate supplementation of a corn based diet for feedlot beef cattle appears to have no beneficial effects. Furthermore, and even if we accept that malate supplementation may be beneficial, the observed effects on internal acid-base balance, suggest a need for more research about malate effects on internal balance since although supplemented animals showed more stable pH values than controls their blood buffer bases were in several moments lower than non-supplemented animals. Finally, despite the well-known in vitro effects of malate on lactate levels, in the present study serum L-lactate remained higher in malate-supplemented animals than in controls, suggesting that the effects of malate can be dependent on the characteristics of the diet being fed.

THANK YOU

MOLTES GRACIES

MOITAS GRAZAS

MUCHAS GRACIAS