

Table S1. P-values of carryover effect and linear mixed effect (LME) models reported in the study. “NA” indicates the effect was not included in the model.

	Carryover Effect <i>P</i> -value	LME Model <i>P</i> -values					Baseline	
		T _i ¹	T _i x P _j ²	P _j ³	C _k ⁴	S _i ⁵	Baseline	Trajectory
Animal performance								
DMI ⁶ , kg/d	0.794	0.975	NA	< 0.001	< 0.001	0.616	0.032	NA
ADG ⁷ , kg/d	0.872	0.037	NA	< 0.001	0.195	0.110	NA	NA
G:F ⁸	0.891	0.055	NA	0.068	0.517	0.100	NA	NA
Endpoint BW ⁹ , kg	0.486	0.698	NA	NA	< 0.001	0.174	0.001	NA
Blood chemistry								
Temperature, °C	0.637	0.255	NA	0.485	0.386	0.274	NA	NA
pH	0.884	0.553	NA	0.422	0.318	0.932	NA	NA
TCO ₂ ¹⁰ , mM	0.300	0.931	NA	0.973	0.792	0.119	NA	NA
pCO ₂ ¹¹ , mmHg	0.335	0.410	NA	0.236	0.552	0.084	NA	NA
HCO ₃ ⁻¹² , mM	0.218	0.946	NA	0.645	0.655	0.065	NA	NA
pO ₂ ¹³ , mmHg	0.798	0.523	NA	0.393	0.161	0.416	NA	NA
sO ₂ ¹⁴ , %	0.576	0.314	NA	0.612	0.070	0.455	NA	NA
BE _{Ecf} ¹⁵ , mM	0.285	0.853	NA	0.913	0.433	0.163	NA	NA
Lactate, mM	0.526	0.531	NA	< 0.001	< 0.001	0.386	0.034	NA
Rumen chemistry								
Temperature, °C	0.668	0.047	NA	0.001	< 0.001	0.436	NA	NA
pH	0.380	0.496	NA	< 0.001	0.021	0.135	NA	NA
dCO ₂ ¹⁶ , %	0.797	0.828	NA	< 0.001	< 0.001	0.751	NA	NA
dCO ₂ ¹⁶ , mg/L	0.862	0.688	NA	< 0.001	0.026	0.635	NA	NA
pCO ₂ ¹¹ , mmHg	0.910	0.285	NA	0.001	0.015	0.604	NA	0.096
Lactate, mM	0.944	0.810	NA	0.882	< 0.001	0.062	NA	NA
Acetate, mM	0.517	0.986	NA	0.073	0.942	0.314	NA	NA
Butyrate, mM	0.866	0.411	NA	0.002	< 0.001	0.387	NA	0.068
Propionate, mM	0.557	0.421	NA	0.088	< 0.001	0.152	NA	NA
Total VFA ¹⁷ , mM	0.772	0.531	NA	0.003	< 0.001	0.328	NA	NA
Rumen microbial diversity								
Bacteria Count, cells/ml	0.797	0.931	NA	0.088	< 0.001	0.569	NA	NA
Shannon's H Diversity Index	0.867	0.693	NA	< 0.001	0.021	0.889	NA	NA
Pielou's Evenness	0.721	0.039	0.064	0.183	0.006	0.600	NA	NA

¹Treatment effect (Treatments: CON = periods when animals received media carrier without NRM; NRM = periods when animals received NRM)

²Treatment by study period effect

³Study period effect (Study periods: pre-challenge dosing period; acidosis challenge period)

⁴Crossover period effect (Crossover periods: crossover period 1; crossover period 2)

⁵Crossover period specific treatment effect

⁶Dry matter intake.

⁷Average daily gain.

⁸Gain to feed ratio.

⁹Body weight of animals at the end of the grain challenge.

¹⁰Total carbon dioxide.

¹¹Partial pressure of carbon dioxide.

¹²Bicarbonate.

¹³Partial pressure of oxygen.

¹⁴Oxygen saturation.

¹⁵Base excess in extracellular fluid

¹⁶Dissolved carbon dioxide

¹⁷Total volatile fatty acids: sum of acetate, butyrate, and propionate

Table S2. The crossover period specific treatment effect of the measurements with $S_I \leq 0.1$.

	Crossover period 1			Crossover period 2		
	CON ¹	NRM ²	<i>P</i> -value	CON ¹	NRM ²	<i>P</i> -value
Animal performance						
G:F³	0.189 ± 0.026	0.168 ± 0.022	0.536	0.129 ± 0.020	0.190 ± 0.024	0.050
Blood chemistry						
pCO₂⁴, mmHg	28.52 ± 0.68	30.44 ± 0.69	0.054	30.25 ± 0.77	29.34 ± 0.77	0.402
HCO₃⁻⁵, mM	25.31 ± 0.55	26.71 ± 0.56	0.085	26.50 ± 0.60	25.15 ± 0.60	0.115
Rumen chemistry						
Lactate, mM	24.59 ± 4.57	33.43 ± 4.56	0.177	88.00 ± 4.63	77.30 ± 4.70	0.105

¹CON = periods when animals received media carrier without NRM²NRM = periods when animals received NRM³Gain to feed ratio.⁴Partial pressure of carbon dioxide.⁵Bicarbonate.

Table S3. The crossover period effect of the measurements with $C_k \leq 0.1$.

	Crossover period 1	Crossover period 2	P-value
Animal performance			
DMI ¹ , kg/d	8.35 ± 0.33	11.07 ± 0.37	< 0.001
Endpoint BW ² , kg	474 ± 6.73	537 ± 7.71	< 0.001
Blood chemistry			
sO ₂ ³ (%)	87.03 ± 1.45	83.55 ± 1.60	0.074
Lactate, mM	1.05 ± 0.09	0.65 ± 0.10	< 0.001
Rumen chemistry			
Temperature, °C	38.54 ± 0.06	39.02 ± 0.07	< 0.001
pH	6.39 ± 0.04	6.31 ± 0.04	0.033
dCO ₂ ⁴ , %	44.95 ± 1.99	51.56 ± 2.20	0.017
dCO ₂ ⁴ , mg/L	424.70 ± 8.80	456.96 ± 9.64	0.004
pCO ₂ ⁵ , mmHg	310.44 ± 6.23	337.91 ± 6.96	0.001
Lactate, mM	29.01 ± 3.23	82.65 ± 3.35	< 0.001
Butyrate, mM	10.13 ± 0.57	14.86 ± 0.64	< 0.001
Propionate, mM	34.28 ± 2.55	74.02 ± 2.84	< 0.001
Total VFA ⁶ , mM	90.26 ± 3.04	133.87 ± 3.38	< 0.001
Rumen microbial diversity			
Bacteria Count, cells/ml	1.32E8 ± 0.29E8	6.22E8 ± 0.31E8	< 0.001
Shannon's H Diversity Index	7.48 ± 0.08	7.22 ± 0.08	0.006
Pielou's Evenness	0.7 ± 0.01	0.72 ± 0.01	0.003

¹Dry matter intake.²Body weight of animals at the end of the grain challenge.³Oxygen saturation⁴Dissolved carbon dioxide⁵Partial pressure of carbon dioxide.⁶Total volatile fatty acids: sum of acetate, butyrate, and propionate

Table S4. The study period effect of the measurements with $P_j \leq 0.1$.

	Pre-challenge Dosing	Acidosis Challenge	P-value
Animal performance			
DMI¹, kg/d	8.54 ± 0.35	10.85 ± 0.38	< 0.001
ADG², kg/d	1.22 ± 0.14	2.07 ± 0.18	0.002
G:F³	0.14 ± 0.01	0.19 ± 0.02	0.122
Blood chemistry			
Lactate, mM	0.99 ± 0.09	0.71 ± 0.09	0.007
Rumen chemistry			
Temperature, °C	38.67 ± 0.07	38.89 ± 0.06	0.001
pH	6.52 ± 0.04	6.18 ± 0.04	< 0.001
dCO₂⁴, %	49.58 ± 2.14	46.93 ± 2.04	0.336
dCO₂⁴, mg/L	463.21 ± 9.39	418.45 ± 9.05	< 0.001
pCO₂⁵, mmHg	340.18 ± 6.66	308.17 ± 6.50	< 0.001
Acetate, mM	43.64 ± 1.45	47.3 ± 1.30	0.065
Butyrate, mM	10.85 ± 0.63	14.13 ± 0.58	< 0.001
Propionate, mM	50.46 ± 2.84	57.84 ± 2.55	0.058
Total VFA⁶, mM	104.75 ± 3.39	119.38 ± 3.05	0.002
Rumen microbial diversity			
Bacteria Count, cells/ml	4.87E8 ± 0.31E8	2.66E8 ± 0.30E8	< 0.001
Shannon's H Diversity Index	7.68 ± 0.08	7.02 ± 0.08	< 0.001

¹Dry matter intake.²Average daily gain.³Gain to feed ratio.⁴Dissolved carbon dioxide⁵Partial pressure of carbon dioxide.⁶Total volatile fatty acids: sum of acetate, butyrate, and propionate

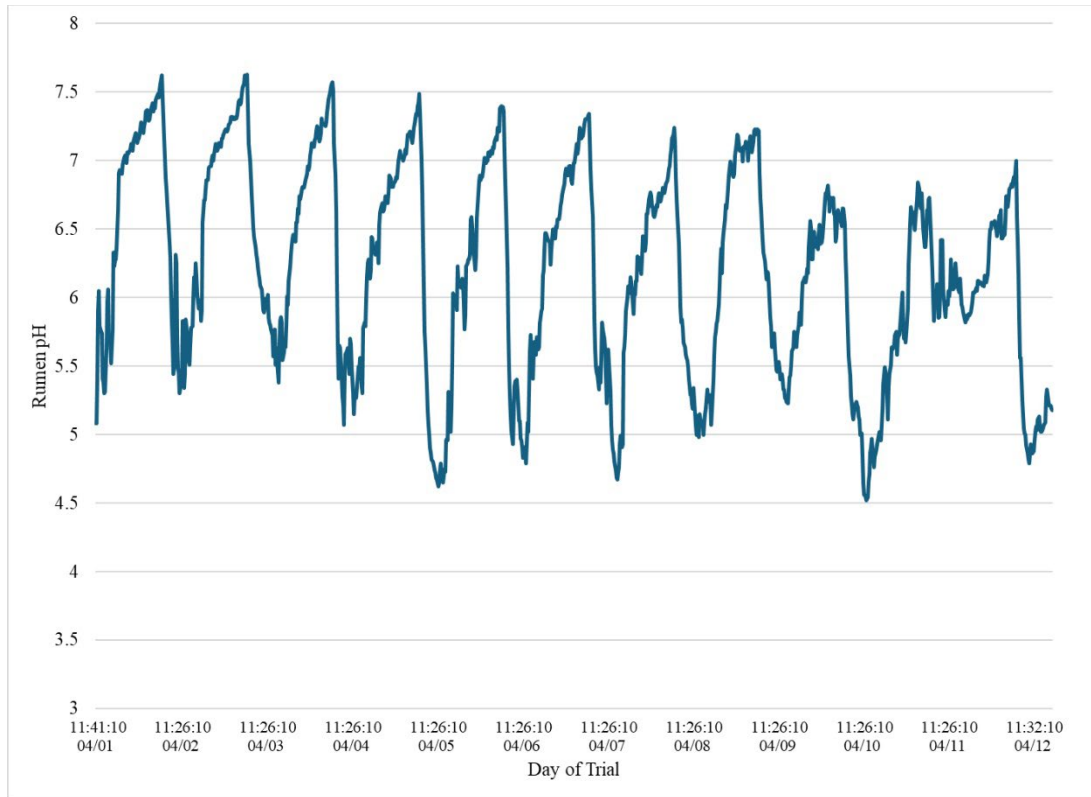


Figure S1. Example eCow bolus rumen pH variation over 12 days of the trial. The chart depicts ruminal pH of an example individual heifer from the trial over a representative 12-day span. Ruminal pH data is collected in real-time with pH measurements taken every 15 minutes, where time of day is listed as HH:mm:ss on a 24-hr format. Across the grain challenge phases, the daily median eCow (eCow limited, Glasgow, UK) bolus ruminal pH consistently fell within the range of 5 to 5.5 and sometimes below 5, aligning with expectations of SARA and acute ruminal acidosis.