M273 - Associations between ruminal and reticular pH during induction and recovery from subacute ruminal acidosis in dairy cows

EVELINE SANDRI[1], YVON COUTURE[2], RACHEL GERVAIS[3], L. FADUL-PACHECO[4,5], JANIE LEVESQUE[1], DANIEL E. RICO[1]*

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Introduction

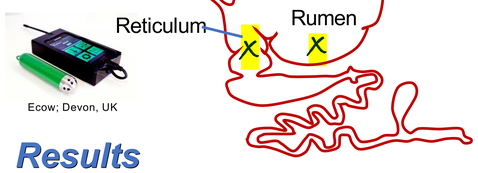
- ✓ Subacute ruminal acidosis (SARA) occurs when the pH is lower than 5.6 for long periods (> 3 hours/day), and it is normally associated with highly fermentable diets.
- ✓ The acidosis diagnosis is mainly based on measurements of ruminal pH, but it can be detected by changes in parameters that are modified during high concentrate feeding, such as milk fat content and profile.
- ✓ In dairy farms, telemetric pH boluses administered orally will remain in the reticulum, where pH measurements are generally higher, more stable, and less sensitive than measurements in the ventral sac of the rumen.

Objective

The objective of this study was to evaluate pH changes in the rumen and reticulum of dairy cows fed diets containing different fiber and starch contents and the correlation between them.

Material and methods

Twelve ruminally cannulated cows (120 ± 52 DIM; 35.5 ± 8.9 kg of milk/d; mean ± SD) were randomly assigned to either 1) SARA induction (Acidosis), 2) Recovery or 3) Control in a Latin square design with fixed sequences and 21-d periods. Using indwelling pH probes, pH was measured simultaneously in the reticulum and in the rumen ventral sac (every 5 min for 24 h) on d 0, 3, 7, 14, and 21 of each period



% of DM	Control	SARA
CP	17.2	16.1
NDF	31.0	24.0
ADF	20.5	15.8
Starch	20.0	29.3
Fatty acids	2.6	2.8

Results

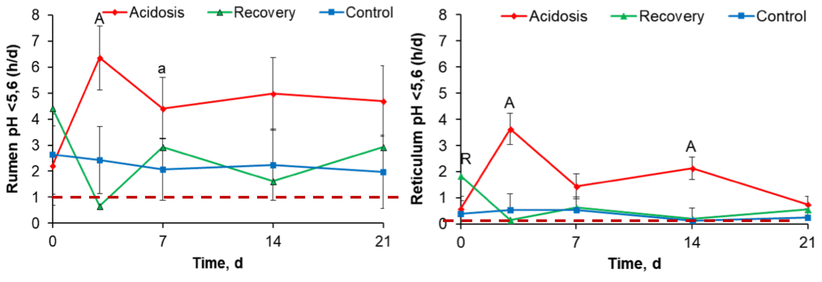


Figure 1: Evolution of ruminal and reticular time < pH 5.6 (h/d) A: Acidosis vs. Control = *P* < 0.05; R: Recovery vs. Control = *P* < 0.05; a: Acidosis vs. Control = *P* < 0.10).

Results

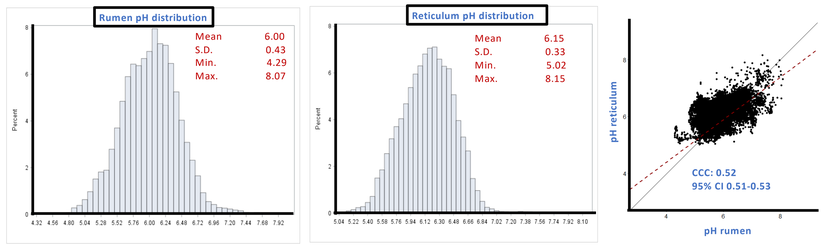


Figure 2: Distribution and concordance correlation coefficient (CCC) for ruminal and reticular pH measurements (n=33801). R^2 = 0.33, association not shown.

Table 1: Descriptive statistics for ruminal and reticular pH measurements (data averaged by day; n = 156)

	Rumen		Reticulum	
Variable	Mean	SD[1]	Mean	SD[1]
Average pH	6.13	0.23	6.02	0.29
Maximum pH	6.77	0.33	6.84	0.37
Minimum pH	5.67	0.29	5.33	0.32
pH range	1.10	0.37	1.51	0.47
pH variance	0.06	0.05	0.11	0.10
pH SD[1]	0.24	0.08	0.31	0.10
Time below pH 6.0 (h/d)	6.50	5.94	9.50	6.73
Time below pH 5.8 (h/d)	3.16	4.05	6.15	5.74
Time below pH 5.6 (h/d)	1.01	1.79	3.20	4.21

[1]SD= standard deviation

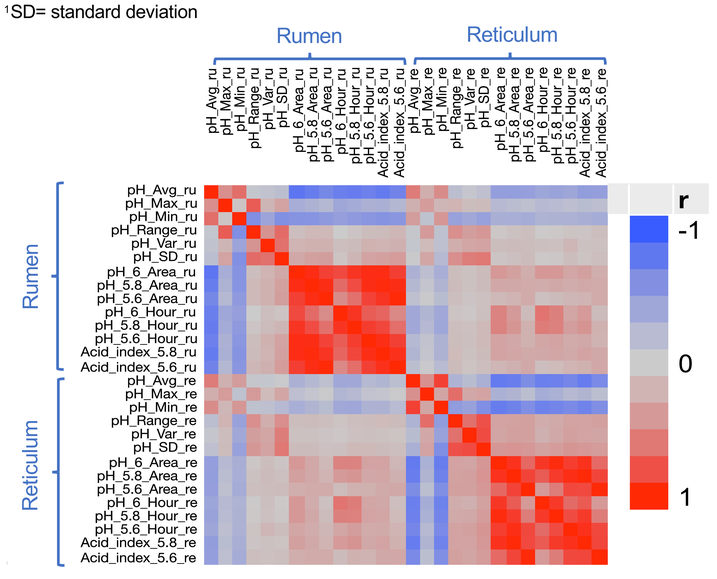


Figure 5: Pairwise correlations between ruminal and reticular pH parameters (data averaged by day; n = 156). Acidosis index 5.8 = area under a pH of 5.8 × DMI (kg/d)

Table 2: Production and pH parameters for observations classified as susceptible or tolerant to subacute ruminal acidosis induction

	Susceptible[1]	Tolerant[2]	SE	*P value*
DMI, kg/d	32.28	26.93	2.81	0.03
Milk yield, kg/j	38.48	33.02	3.87	0.06
Fat concentration, %	3.67	3.90	0.32	0.04
Fat yield, kg/d	1.39	1.29	0.24	0.73
Mean pH	5.50	6.16	0.19	0.03
Maximum pH	6.49	7.14	0.17	0.02
Minimum pH	4.83	5.34	0.10	0.40
pH variance	0.14	0.12	0.05	0.67
Time under pH 5.8, h/d	17.24	1.72	1.89	< 0.001
Time under pH 5.6, h/d	14.54	0.46	1.70	< 0.001
Acidosis index[3]	34.80	2.96	4.43	< 0.001

[1]Susceptible = AI > mean AI - 0.5 × SD; [2]Tolerant = AI < mean AI - 0.5 × SD;
[3]AI= area under pH 5.8/DMI (kg/d)

Summary

- ✓ The average and minimum ruminal pH in cows fed the acidosis diet were lower than that of cows fed the control diet on d 3, 14 and 21 (*P* < 0.05).
- ✓ As compared with control, ruminal pH remained below 5.6 for a longer time when cows received the SARA diet on d 3 (145 vs. 378 min/d; *P* < 0.05) and d 7 (124 vs. 264; *P* < 0.08).
- ✓ In the reticulum, the pH duration below 5.6 was greater in cows fed the acidosis diet on d 3 (31 vs. 218 min/d) and 14 (8.4 vs. 127 min/d) for control and SARA, respectively (*P* < 0.05).
- ✓ The association between the ruminal and reticular pH was low (R^2 = 0.33).
- ✓ Dry matter intake, milk and milk fat yield were greater in SARA-susceptible than in SARA-tolerant cows (*P* = 0.03, 0.06 and 0.04, respectively), whereas milk fat concentration was lower in the SARA-susceptible group (*P* < 0.05).
- ✓ Furthermore, SARA-susceptible cows had lower mean and maximum pH (*P* < 0.05), but minimum pH or pH variance were not different. In addition, SARA-susceptible cows had greater values for time under pH 5.8 and 5.6 (*P* < 0.001).

Conclusion

The reticular pH measurements may underestimate the incidence of SARA and would require adjustment before this technology can be used on commercial farms. The production performance of dairy cows fed high-concentrate diets was related to their susceptibility to SARA, as higher producing cows were at increased risk.

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Introduction

- ✓ Subacute ruminal acidosis (SARA) occurs when the pH is lower than 5.6 for long periods (more than 3 hours/day), caused by feeding more non-fibrous carbohydrates (NFC) that alter the rumen fermentation profile
- ✓ The acidosis diagnosis is mainly based on measurements of ruminal pH, but it can be detected by changes in parameters that are modified during high concentrate feeding, such as milk fat content and profile
- ✓ In the dairy farms, telemetric pH boluses administered through the cow's mouth will be placed the reticulum, where pH measurements are generally higher, more stable, and less sensitive than measurements in the ventral sac of the rumen.

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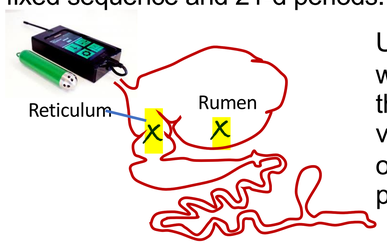

Using indwelling pH probes, pH was measured simultaneously in the reticulum and in the rumen ventral sac (every 5 min for 24 h) on d 0, 3, 7, 14, and 21 of each period

Results

Dry matter intake (DMI) and milk yield

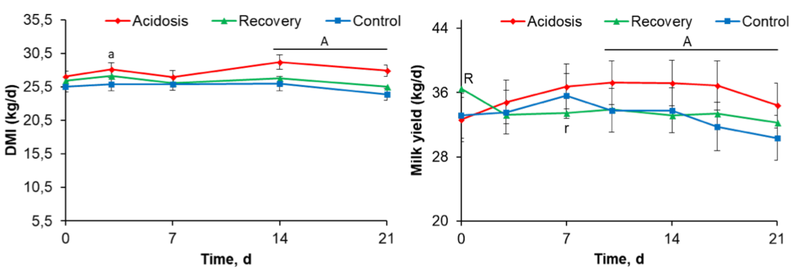

Figure 1: Evolution of DMI and milk yield. A: Acidosis vs. Control = $P < 0,05$; R: Recovery vs. Control = $P < 0,05$; a: Acidosis vs. Control = $P < 0,10$).

Results

pH values

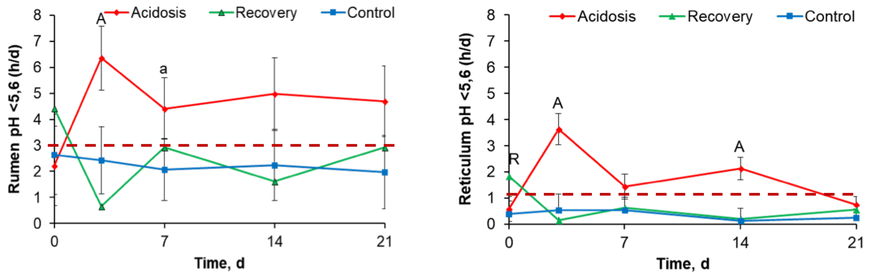

Figure 1: Ruminal and reticular < 5,6 (hours/day) of the cows under the 3 treatments (Acidosis, Recovery and Control) on days 0, 3, 7, 14 and 21 (A: Acidosis vs. Control = $P < 0,05$; R: Recovery vs. Control = $P < 0,05$; a: Acidosis vs. Control = $P < 0,10$).

Relationship between ruminal and reticular pH

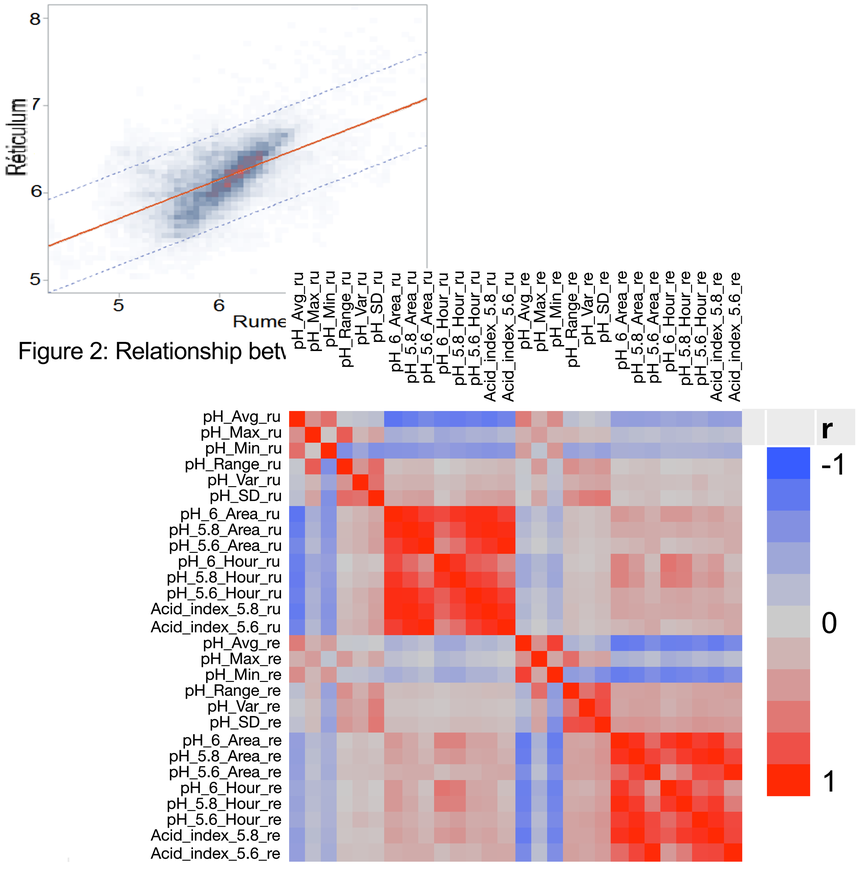

Figure 2: Relationship betv

Milk fat content and fat yield

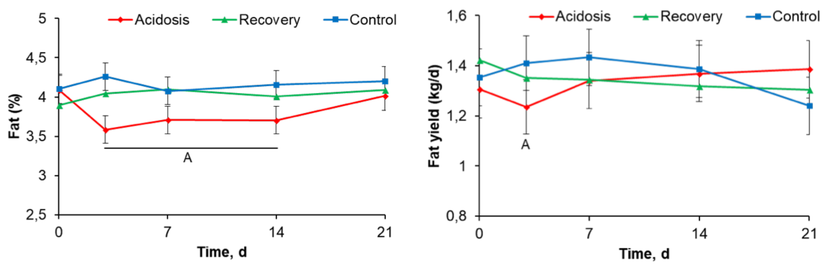

Figure 4: Evolution of milk fat content and fat yield of the cows under the 3 treatments (Acidosis, Recovery and Control) on days 0, 3, 7, 14 and 21 (A: Acidosis vs. Control = $P < 0,05$; a: Acidosis vs. Control = $P < 0,10$).

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	pH_Avg_ru	pH_Max_ru	pH_Min_ru	pH_Range_ru	pH_Var_ru	pH_SD_ru	pH_6_Area_ru	pH_5.8_Area_ru	pH_5.6_Area_ru	pH_6_Hour_ru	pH_5.8_Hour_ru	pH_5.6_Hour_ru	Acid_index_5.8_ru	Acid_index_5.6_ru	pH_Avg_re	pH_Max_re	pH_Min_re	pH_Range_re	pH_Var_re	pH_SD_re	pH_6_Area_re	pH_5.8_Area_re	pH_5.6_Area_re	pH_6_Hour_re	pH_5.8_Hour_re	pH_5.6_Hour_re	Acid_index_5.8_re	Acid_index_5.6_re
pH_Avg_ru	<.0001	<.0001	<.0001	0.4033	0.1629	0.0506	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0030	<.0001	0.0533	0.4249	0.0884	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_Max_ru	<.0001	<.0001	0.4525	<.0001	0.0217	<.0001	<.0001	0.0005	0.0078	<.0001	<.0001	0.0003	0.0001	0.0039	0.0054	<.0001	0.0308	0.0129	0.1100	0.1068	0.0103	0.0388	0.0985	0.0097	0.0167	0.0805	0.0281	0.0779
pH_Min_ru	<.0001	0.4526	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.1356	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0007	0.0004	0.0503	<.0001	<.0001
pH_Range_ru	0.4033	<.0001	<.0001	<.0001	<.0001	<.0001	0.1525	0.0604	0.0342	0.9653	0.4393	0.1090	0.0858	0.0317	0.4707	<.0001	0.1149	<.0001	<.0001	<.0001	0.5858	0.3087	0.1462	0.8609	0.6832	0.3594	0.4057	0.1738
pH_Var_ru	0.1629	0.0217	<.0001	<.0001	<.0001	<.0001	0.0152	0.0075	0.0069	0.1666	0.0810	0.0069	0.0115	0.0056	0.3925	0.0688	0.0883	0.0020	0.0001	<.0001	0.1282	0.1084	0.1287	0.1931	0.2179	0.0258	0.2832	0.2285
pH_SD_ru	0.0506	<.0001	<.0001	<.0001	<.0001	<.0001	0.0005	<.0001	<.0001	0.3531	0.0209	<.0001	<.0001	<.0001	0.8264	0.0001	0.0092	<.0001	<.0001	<.0001	0.3968	0.1922	0.0821	0.7347	0.5919	0.1237	0.3555	0.1346
pH_6_Area_ru	<.0001	<.0001	<.0001	0.1525	0.0152	0.0005	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0002	0.0724	<.0001	0.1152	0.2687	0.0819	<.0001	<.0001	0.0020	<.0001	<.0001	0.0002	<.0001	0.0021
pH_5.8_Area_ru	<.0001	0.0005	<.0001	0.0604	0.0075	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0063	0.3006	0.0011	0.1031	0.2648	0.1043	0.0003	0.0003	0.0011	0.0014	0.0006	0.0014	0.0005	0.0011
pH_5.6_Area_ru	<.0001	0.0078	<.0001	0.0342	0.0069	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0916	0.7697	0.0290	0.1397	0.3942	0.2179	0.0452	0.0118	0.0012	0.2236	0.0918	0.0247	0.0176	0.0011
pH_6_Hour_ru	<.0001	<.0001	<.0001	0.9653	0.1666	0.3531	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0019	<.0001	0.3600	0.5985	0.1929	<.0001	<.0001	<.0001	0.0721	<.0001	<.0001	<.0001	0.0820
pH_5.8_Hour_ru	<.0001	<.0001	<.0001	0.4393	0.0810	0.0209	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0092	<.0001	0.1377	0.2173	0.0547	<.0001	<.0001	0.0082	<.0001	<.0001	<.0001	<.0001	0.0087
pH_5.6_Hour_ru	<.0001	0.0003	<.0001	0.1090	0.0069	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0082	0.1945	0.0006	0.1259	0.1853	0.0569	<.0001	0.0003	0.0086	0.0001	<.0001	0.0008	0.0004	0.0090
Acid_index_5.8_ru	<.0001	0.0001	<.0001	0.0858	0.0115	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0020	0.2943	0.0004	0.0693	0.2626	0.0869	<.0001	<.0001	0.0007	0.0003	0.0002	0.0007	<.0001	0.0005
Acid_index_5.6_ru	<.0001	0.0039	<.0001	0.0317	0.0056	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0549	0.8472	0.0186	0.0881	0.3548	0.1707	0.0292	0.0062	0.0004	0.1728	0.0660	0.0143	0.0070	0.0003
pH_Avg_re	<.0001	0.0054	<.0001	0.4707	0.3925	0.8264	0.0032	0.0063	0.0916	<.0001	<.0001	0.0082	0.0020	0.0549	<.0001	<.0001	<.0001	0.0008	0.0225	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_Max_re	0.0030	<.0001	0.1356	<.0001	0.0688	0.0001	0.0724	0.3006	0.7697	0.0019	0.0092	0.1945	0.2943	0.8472	<.0001	<.0001	0.0001	<.0001	0.0002	<.0001	0.0002	0.0017	0.0556	<.0001	0.0002	0.0139	0.0013	0.0529
pH_Min_re	<.0001	0.0308	<.0001	0.1149	0.0883	0.0092	<.0001	0.0011	0.0290	<.0001	<.0001	0.0008	0.0004	0.0186	<.0001	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_Range_re	0.0533	0.0129	<.0001	<.0001	0.0020	<.0001	0.1152	0.1031	0.1397	0.3600	0.1377	0.1259	0.0693	0.0881	0.0008	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0016	0.0007	<.0001	<.0001	<.0001
pH_Var_re	0.4249	0.1109	<.0001	<.0001	0.0001	<.0001	0.2687	0.2648	0.3942	0.5985	0.2173	0.1853	0.2626	0.3548	0.0225	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0065	0.0005	<.0001	<.0001	0.0001
pH_SD_re	0.0884	0.1068	<.0001	<.0001	<.0001	<.0001	0.0819	0.1043	0.2179	0.1929	0.0547	0.0569	0.0869	0.1707	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_6_Area_re	<.0001	0.0103	<.0001	0.5858	0.1282	0.3968	<.0001	0.0003	0.0452	<.0001	<.0001	<.0001	<.0001	0.0292	<.0001	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_5.8_Area_re	<.0001	0.0388	<.0001	0.3087	0.1084	0.1922	<.0001	0.0003	0.0118	<.0001	<.0001	0.0003	0.0001	0.0062	<.0001	0.0017	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_5.6_Area_re	<.0001	0.0985	<.0001	0.1462	0.1287	0.0821	0.0020	0.0011	0.0012	0.0721	0.0082	0.0086	0.0007	0.0004	<.0001	0.0556	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_6_Hour_re	<.0001	0.0097	0.0007	0.8609	0.1931	0.7347	<.0001	0.0014	0.2236	<.0001	<.0001	0.0001	0.0003	0.1728	<.0001	<.0001	<.0001	0.0016	0.0065	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_5.8_Hour_re	<.0001	0.0167	0.0004	0.6832	0.2179	0.5919	<.0001	0.0006	0.0918	<.0001	<.0001	<.0001	0.0002	0.0660	<.0001	0.0002	<.0001	0.0007	0.0005	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
pH_5.6_Hour_re	<.0001	0.0805	0.0003	0.3594	0.1258	0.1237	0.0002	0.0014	0.0247	0.0001	<.0001	0.0008	0.0007	0.0143	<.0001	0.0139	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Acid_index_5.8_re	<.0001	0.0281	<.0001	0.4057	0.2832	0.3555	<.0001	0.0005	0.0176	<.0001	<.0001	0.0004	<.0001	0.0070	<.0001	0.0013	<.0001	<.0001	<.0001	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Acid_index_5.6_re	<.0001	0.0779	<.0001	0.1738	0.2285	0.1346	0.0021	0.0011	0.0011	0.0820	0.0087	0.0090	0.0005	0.0003	<.0001	0.0529	<.0001	<.0001	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001