Australian Government
Department of Agriculture, Water and the Environment

AUSTRALIAN Pork®

Validating the use of pH/temperature data loggers to collect accurate measurements of muscle pH and temperature decline of pork carcasses during chilling for up to 24 hours

Final Report
APL Project 2020/0032

April 2021

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Acknowledgements

This project is supported by funding from Australian Pork Limited.

Executive Summary

The pattern of pH decline in pork carcasses during chilling is an important indicator of meat quality. The decline is determined by measuring pH and temperature within the carcass at specified time points post slaughter. Traditionally measurements are collected manually by handheld pH/temperature meters over a 24 hour period. The task is not only onerous, particularly if it must be conducted on a regular basis, but it can also be difficult to collect measurements at precise time points. pH/temperature loggers are available which enable consistent data to be collected at frequent time points. Their use will improve the convenience of collecting measurements and the accuracy of determining the pH/temperature decline during chilling.

The aim of this project was to validate an accurate and convenient methodology to measure pH/temperature declines of carcasses during chilling.

The outcomes have demonstrated that pH loggers can be used to effectively and efficiently determine the pH decline in pork carcasses within a commercial processing pig processing environment.

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1. Background to Research

Australian Pork Limited recognises that the pattern of pH decline in pork carcasses during chilling is an important indicator of meat quality. The measurement of pH and temperature in the loin muscle from chiller entry (~35 minutes post-slaughter) to 24 hours post-slaughter provides useful information to processors relating to pork quality outcomes – particularly in relation to aspects of colour, drip loss and tenderness. The decline is determined by measuring pH and temperature within the carcass at specified time points post slaughter. Traditionally measurements are collected manually by handheld pH/temperature meters. As the measures are spread over a 24 hour period the task is not only onerous, particularly if it must be conducted on a regular basis, but it can also be difficult to collect measurements at precise time points. Also to ensure accurate pH/temperature decline data the pH meter must be calibrated at each time point to a temperature that is equivalent to the measurement conditions if it is not fitted with automatic temperature compensation (ATC). pH/temperature loggers are available which enable consistent data to be collected at frequent time points. Their use will improve the convenience of collecting measurements and the accuracy of determining the pH/temperature decline during chilling. However these have not been validated against manual pH/temperature meters in a commercial setting.

This project aims to validate a convenient methodology for practical application in the pork processing environment to measure pH/temperature declines of carcasses during chilling. The methodology could be included as part of the regular auditing process of the Pork Eating Quality Standards program that is being developed by APL to improve eating quality of, and therefore demand for, fresh Australian pork.

2. Objectives of the Research Project

1. Develop standardised methodology for the use of pH/Temperature loggers to determine pH/temperature declines in pork carcasses during chilling.
2. Validate pH/temperature loggers against the handheld pH meter to determine pH declines in pork carcasses during chilling.

3. Introductory Technical Information

Start text here. Detail of previous research in this area.

4. Research Methodology

pH and temperature declines of pork carcasses were measured from chiller entry (approximately 35 minutes post slaughter) until approximately 24 hours post slaughter simultaneously using a handheld pH meter with temperature probe (pH-ORP Temperature, WP-80M, TPS) and a pH/temperature data logger (OM-CP-PHTemp2000, OMEGA).

A total of 47 carcasses were measured across 5 different slaughter days. Carcasses within each slaughter date were chilled within the same chiller.

pH probes were calibrated before each batch of carcasses were measured, as per the manufacturer's instructions, via a two point calibration using buffers of pH 7.00 and 4.01. Temperature was calibrated for the pH meter and the pH loggers prior to the first batch of carcasses being measured, as per the manufacturer's instructions.

The pH/Temperature loggers were inserted when the carcasses entered the chiller (~35 minutes after exsanguination) and measured pH and temperature at 2 minute intervals. The pH probes were inserted into the longissimus between the 10th and 11th ribs. The temperature probe was inserted between the 11th and 12 ribs.

Manual pH/temperature measurements were taken at: 35 mins, 1 hour, 2 hours, 3 hours, 4 hours, 6 hours, 12 hours and 24 hours post slaughter. The pH probe was inserted 1 point below the logger pH probe, between the 9th and 10th ribs. The manual temperature probe was inserted into the longissimus between the 8th and 9th ribs.

Data collected from the manual pH meter were compared with data from the corresponding loggers at the corresponding measurement time by calculating the Lin's concordance correlation coefficient (Genstat 20; VSN International Ltd).

5. Results

The strength of agreement between the pH measures of individual loggers relative to the handheld pH meter varied, with correlation for the majority of loggers sitting between 0.72-0.94. (Table 1.)

As the pH decline plots (Appendix 1) demonstrate, some loggers consistently measured pH at a similar level to that measured by the handheld meter. For other loggers, the measurement of pH decline followed a similar rate/curve but was at a different magnitude. In some cases there were logger measurements that did not correspond with the handheld meter suggesting an equipment failure (e.g. Logger 7 – 29 January, 9 February).

Table 2 shows that the agreement between loin muscle temperature measured by the manual pH meter and the pH logger was very strong with all correlations being greater than 0.95. The high level of agreement between the temperature measures taken by both devices suggests that the logger probes remaining in situ during the logging period did not impact the temperature decline of the muscle at the localised measurement site, therefore should not have impacted localised pH decline.

Determining pH decline over a 24 hour period with a manual pH meter is often onerous and taking measurements at precise time points to ensure the quality of the data set can be difficult under commercial processing conditions. Incorporating assessments of pH decline into regular auditing procedures at pork abattoirs is likely to be met with some resistance from the processor due to the requirements for skilled staff to measure across a 24 hour period. The outcomes of this project demonstrate that pH loggers and the methodology followed (Appendix 2), effectively and efficiently measured the pH decline in pork carcasses within a commercial processing pig processing environment.

Table 1. Agreement between pH measures for each logger and the corresponding measures made by the manual pH meter

		n	Concordance	Lower CI*	Upper CI*	Correlation	Correction Factor
Overall		376	0.801	0.762	0.833	0.801	0.999
Logger	1	40	0.725	0.585	0.823	0.878	0.826
	2	40	0.856	0.763	0.914	0.916	0.935
	3	40	0.803	0.663	0.889	0.828	0.969
	4	40	0.836	0.728	0.904	0.876	0.955
	5	40	0.805	0.674	0.887	0.869	0.926
	6	40	0.839	0.723	0.909	0.853	0.983
	7	16	0.412	0.100	0.651	0.658	0.627
	8	40	0.783	0.634	0.876	0.818	0.957
	9	40	0.780	0.630	0.874	0.800	0.976
	10	40	0.936	0.885	0.964	0.945	0.990

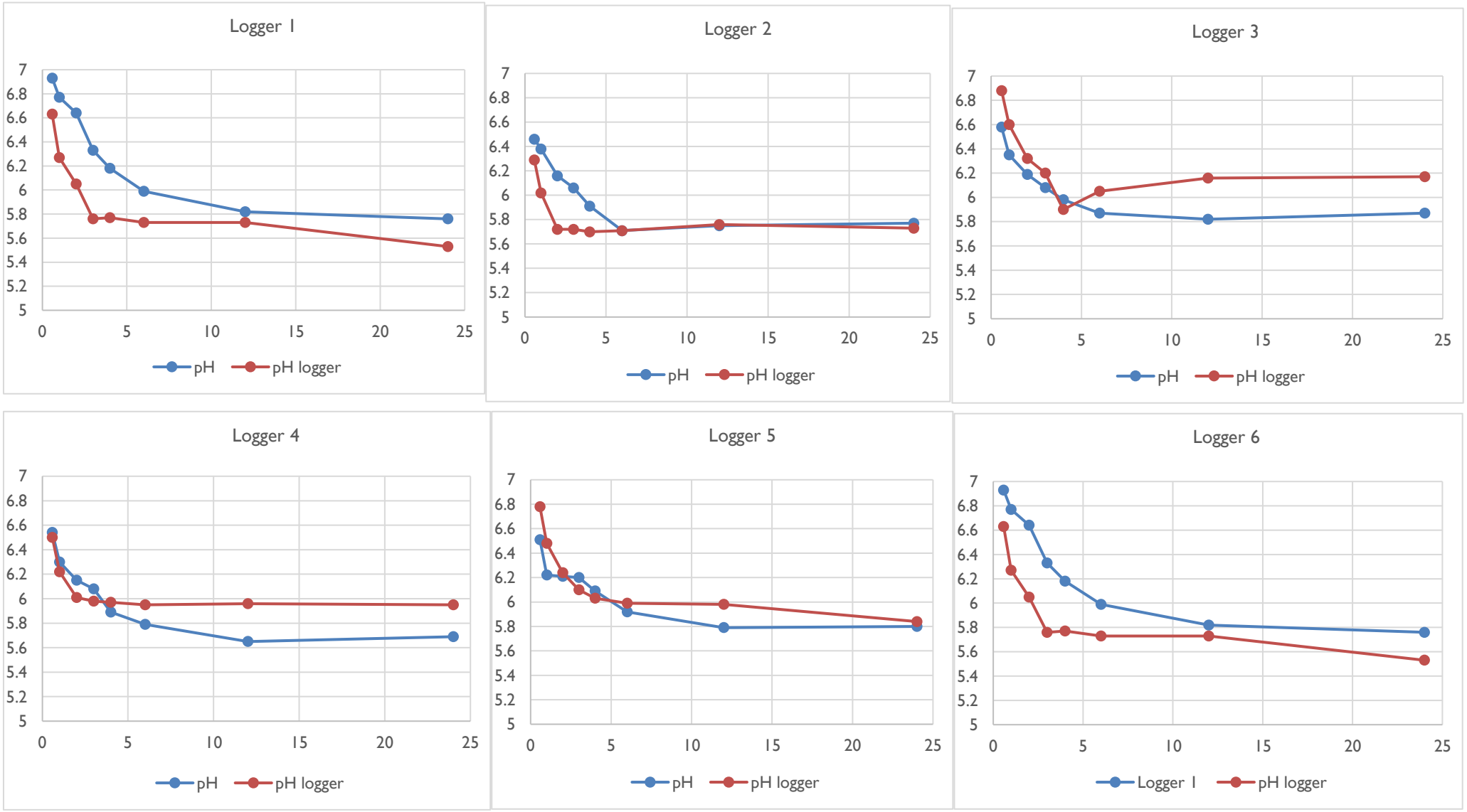
*95% confidence interval

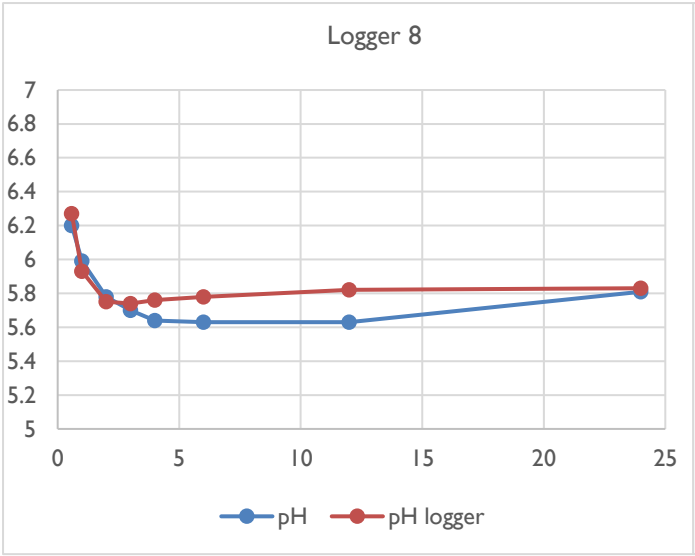
Table 2.

		n	Concordance	Lower CI*	Upper CI*	Correlation	Correction Factor
Overall		376	0.990	0.988	0.992	0.990	0.999
Logger	1	40	0.995	0.990	0.997	0.995	0.999
	2	40	0.983	0.969	0.990	0.988	0.994
	3	40	0.987	0.977	0.993	0.989	0.999
	4	40	0.976	0.957	0.987	0.984	0.992
	5	40	0.995	0.990	0.997	0.995	0.999
	6	40	0.986	0.975	0.993	0.988	0.998
	7	16	0.989	0.971	0.996	0.995	0.994
	8	40	0.996	0.993	0.998	0.996	0.999
	9	40	0.993	0.987	0.996	0.994	0.999
	10	40	0.996	0.993	0.998	0.996	1.000

*95% confidence interval

Figure 1. pH declines for individual pork carcasses – corresponding measures made by the manual pH meter and pH loggers
14th January 2021

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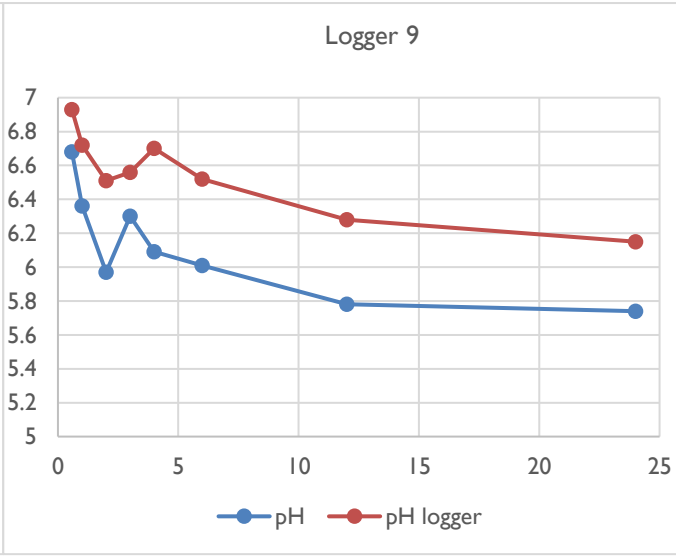
pH logger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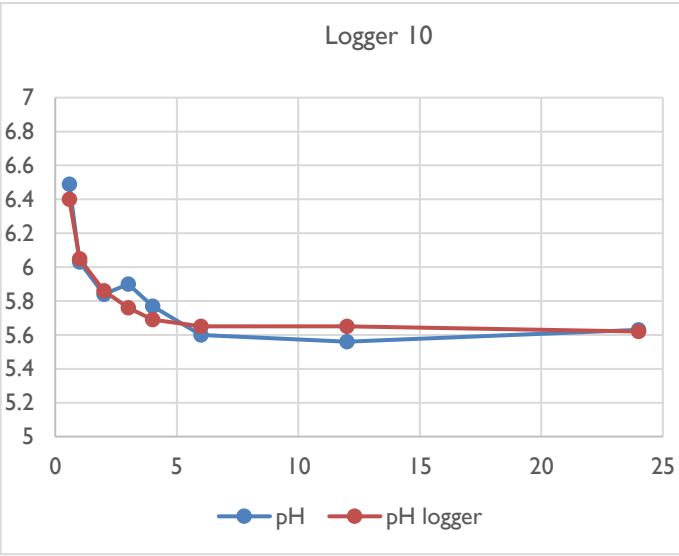
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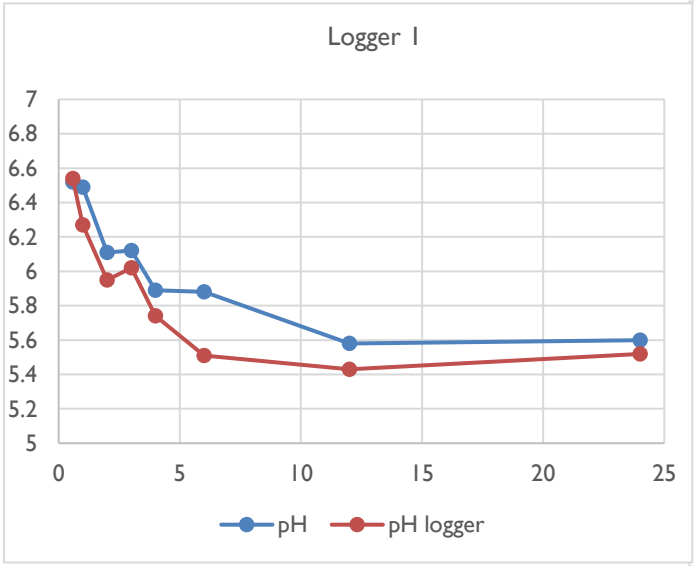
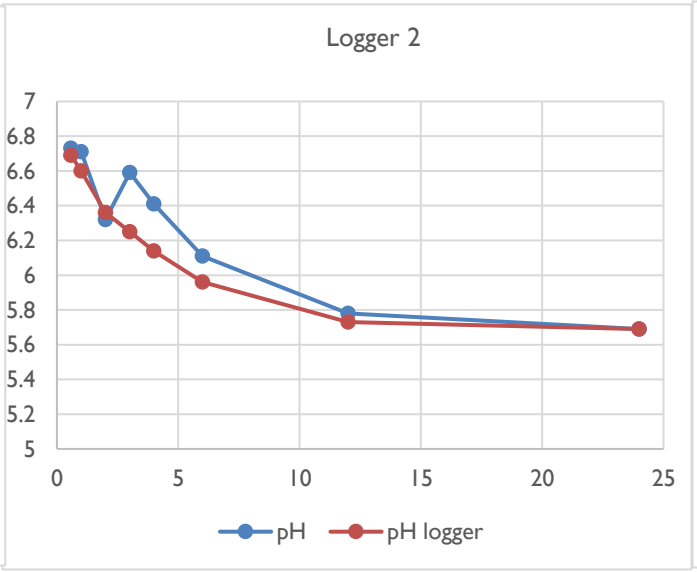
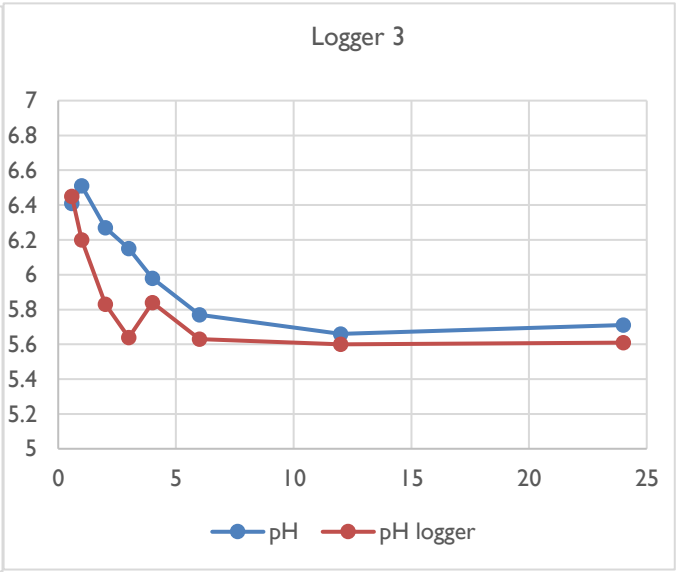
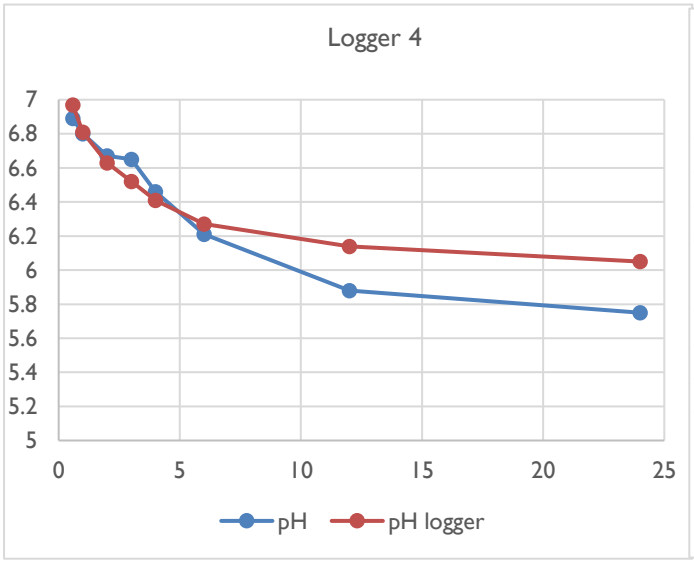
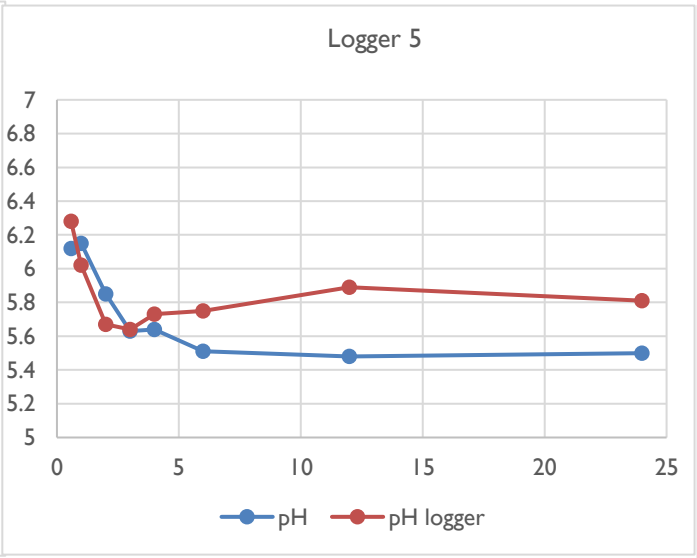
19 January 2021

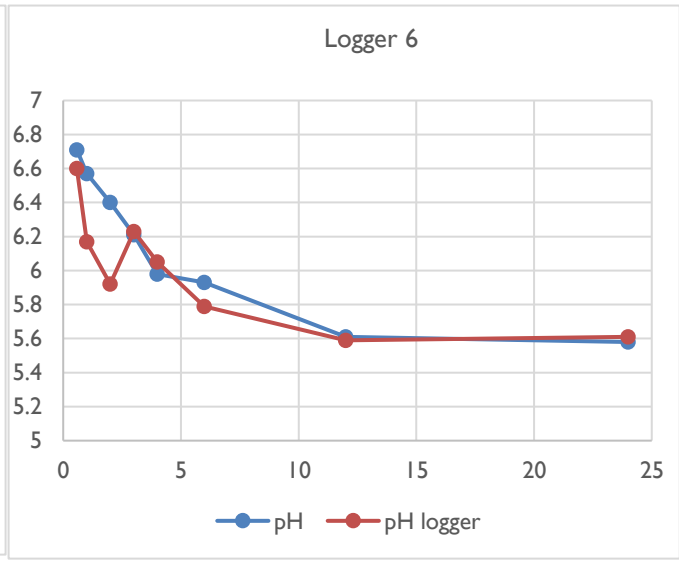












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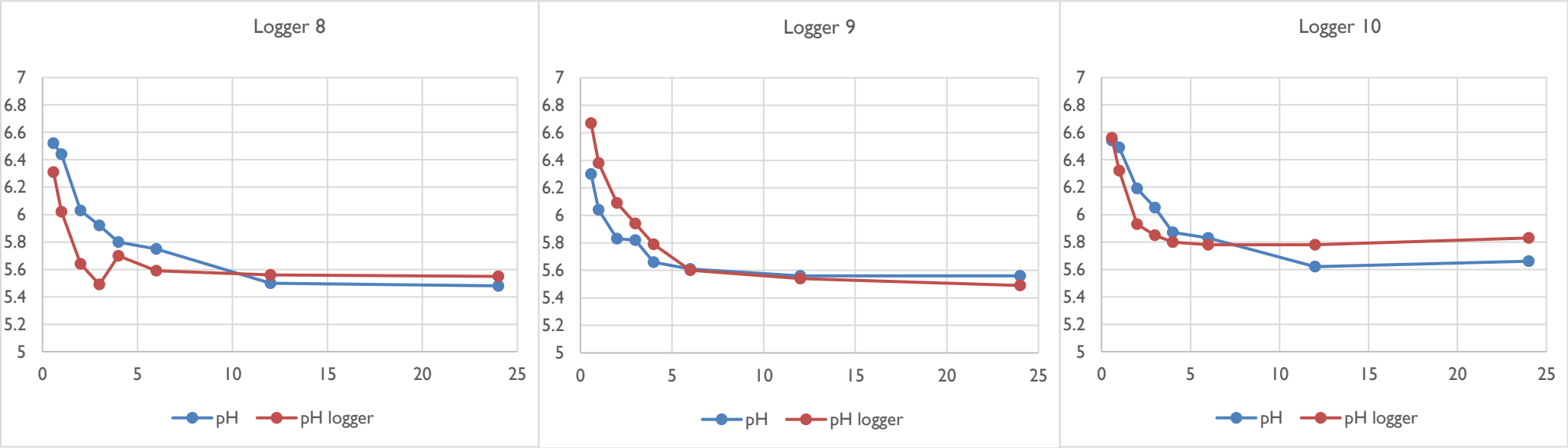

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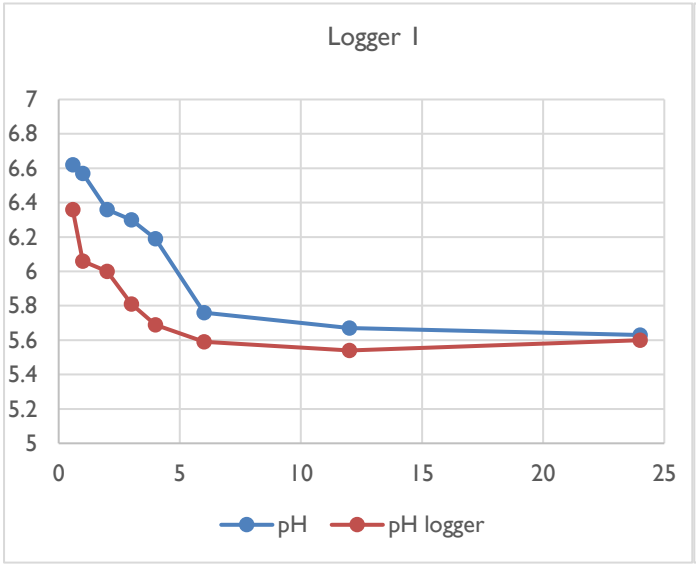

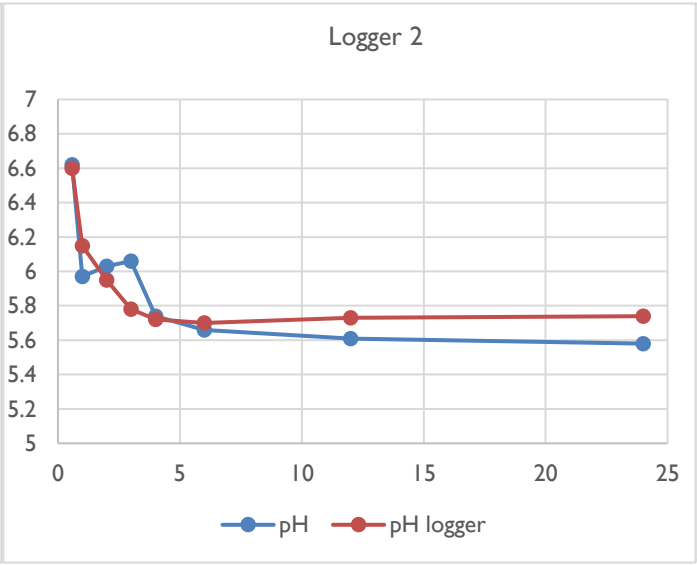

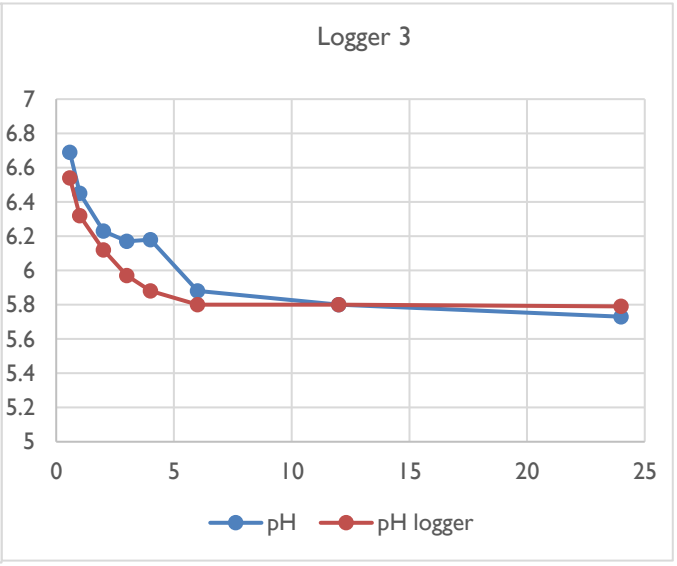

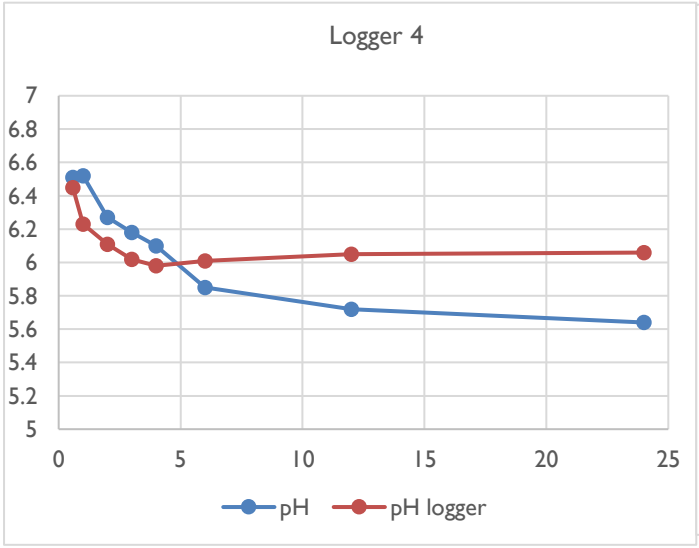

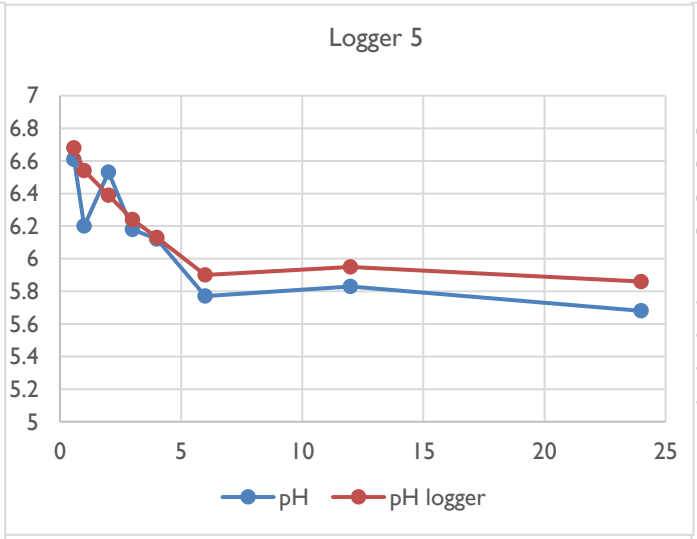

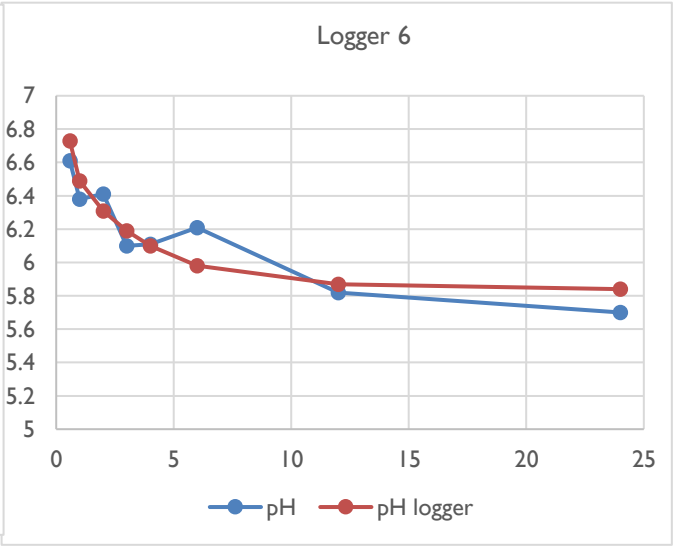

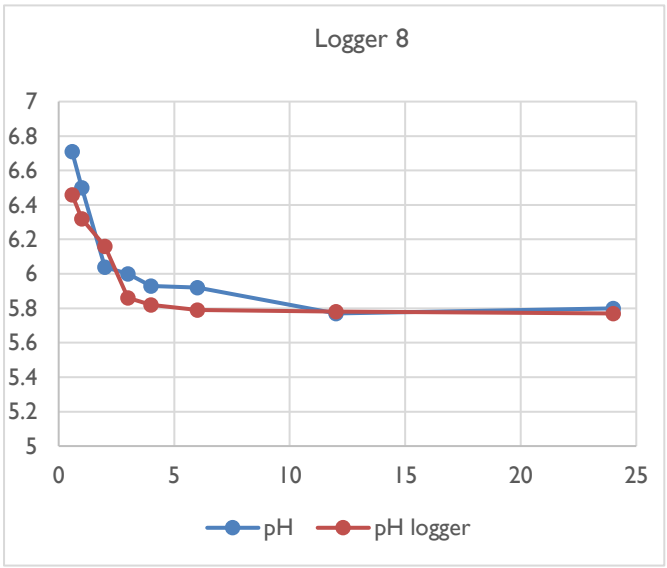
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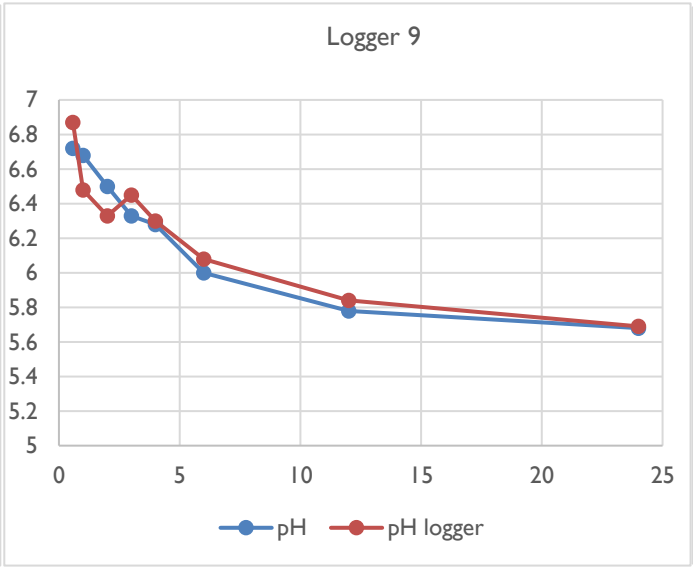
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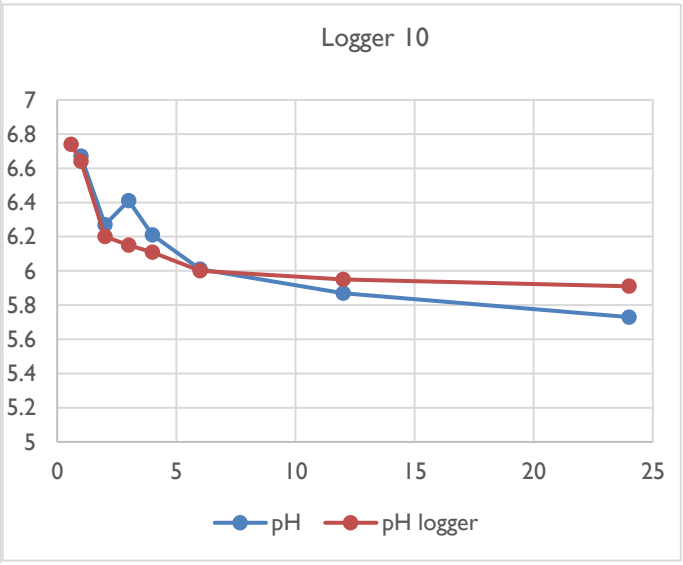
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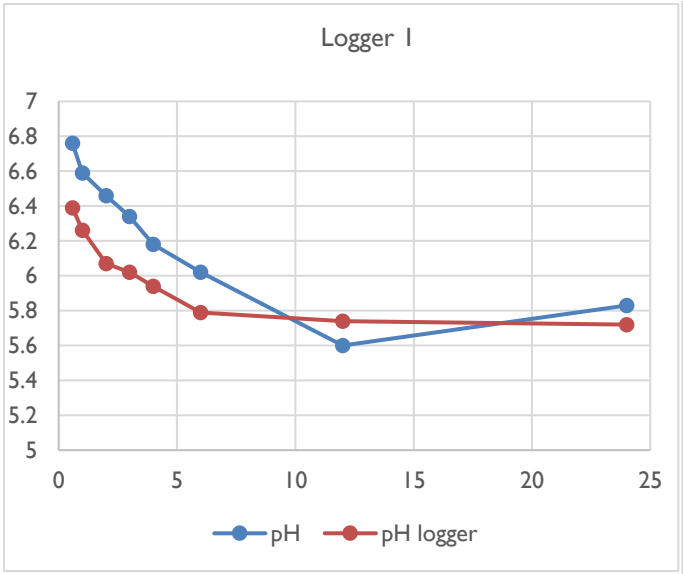

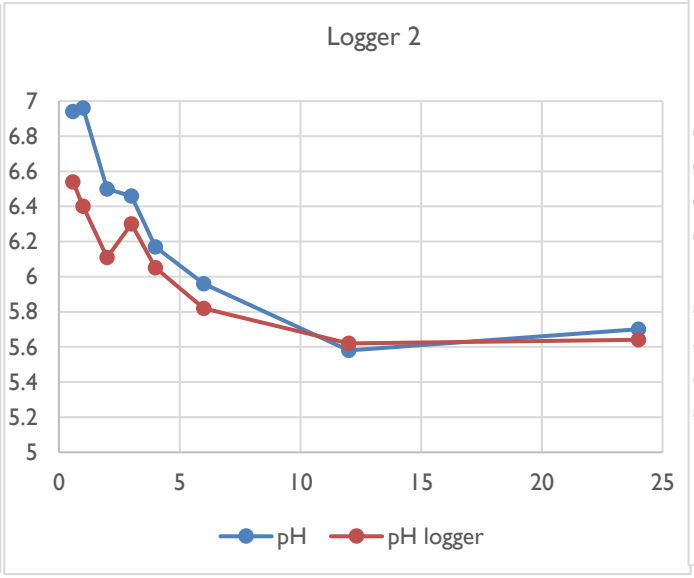

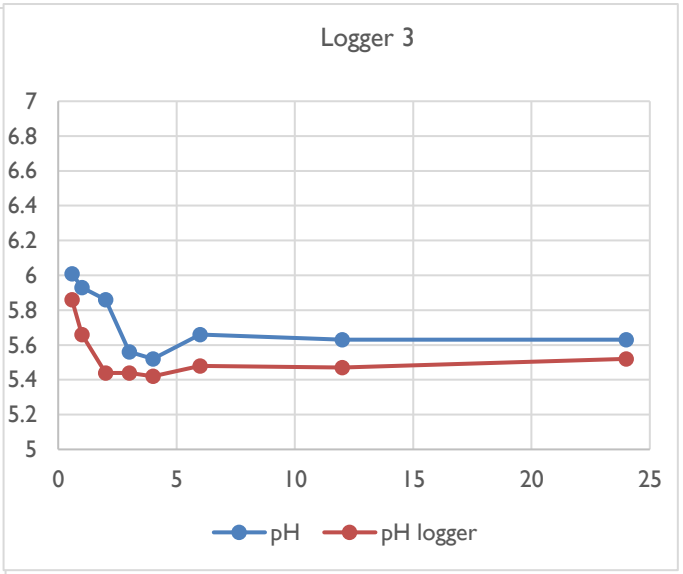

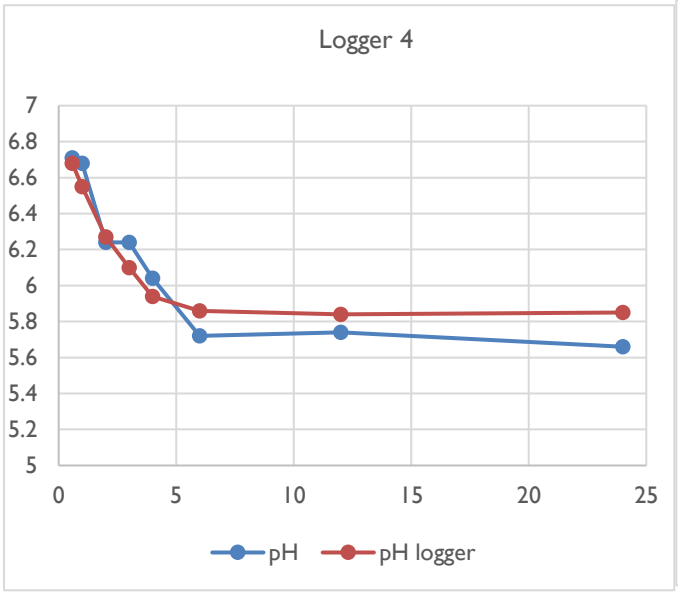

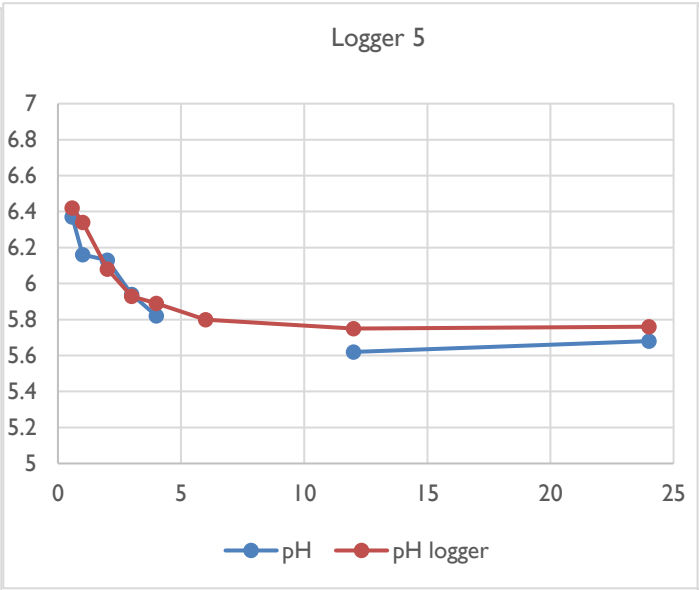

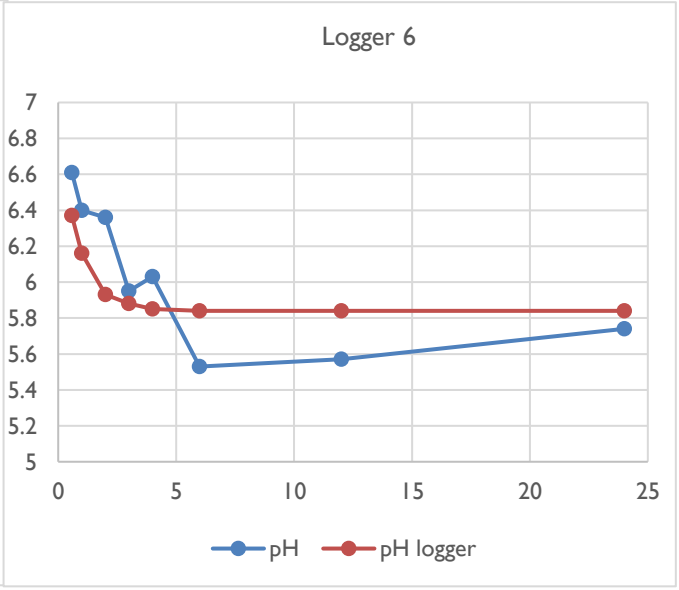

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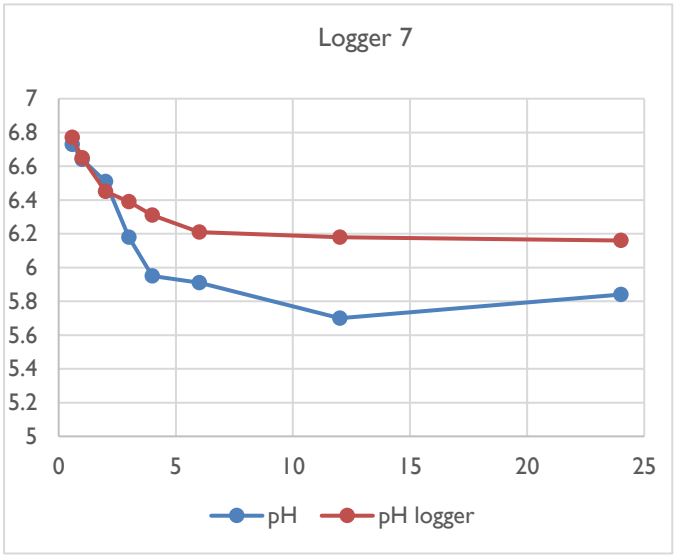

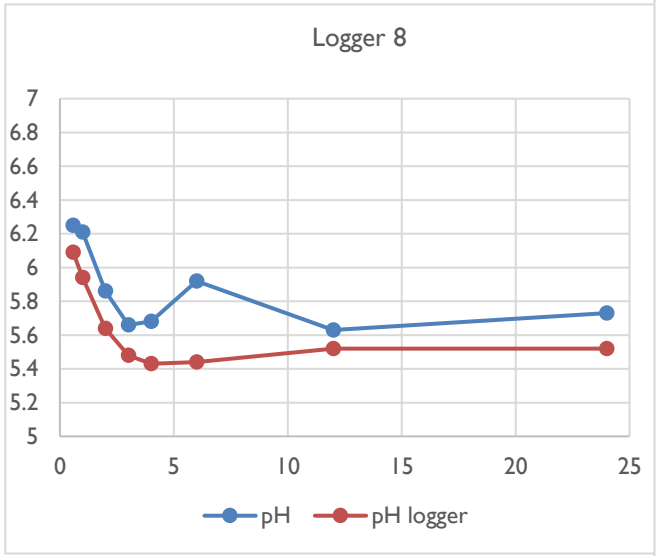

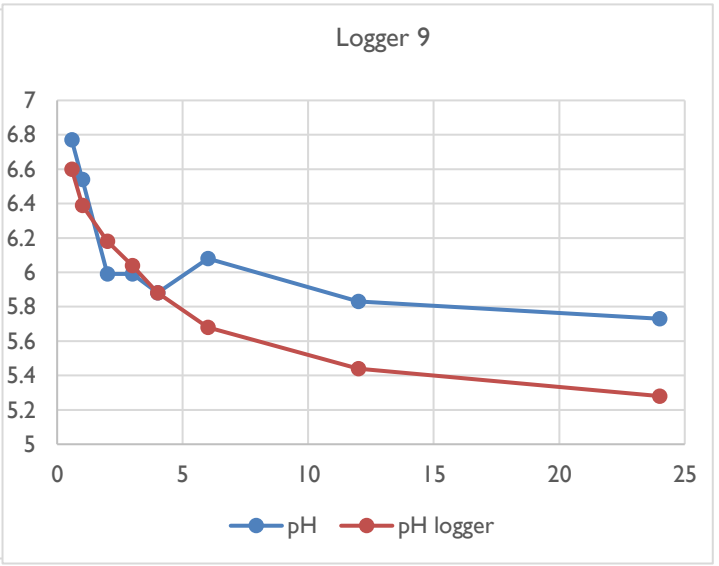

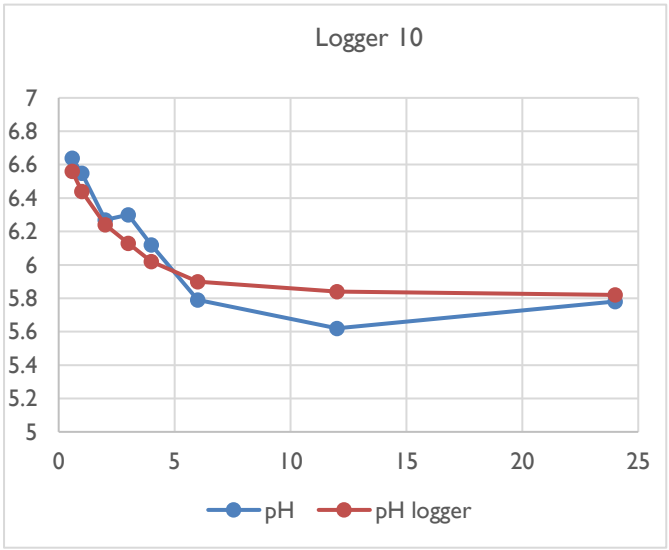

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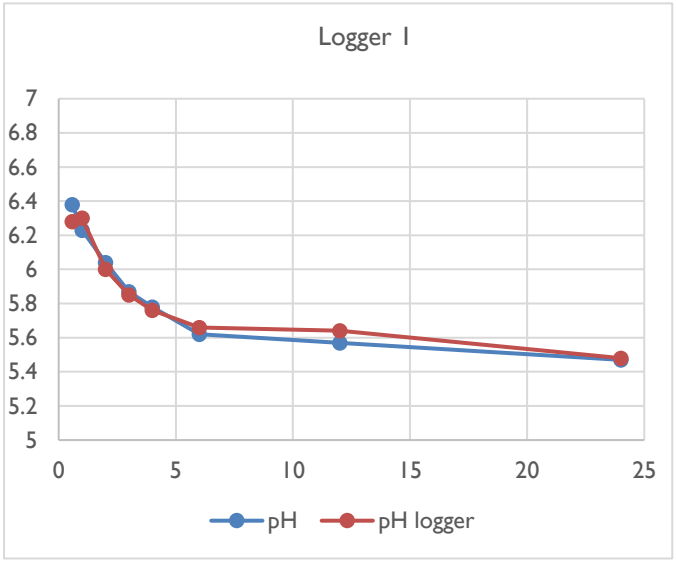

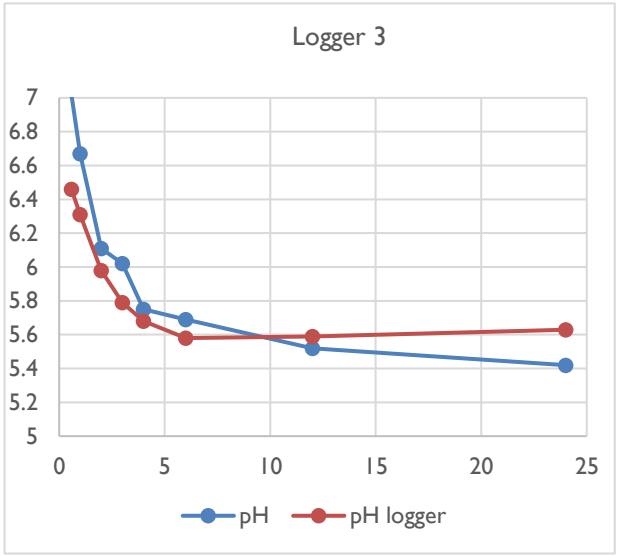

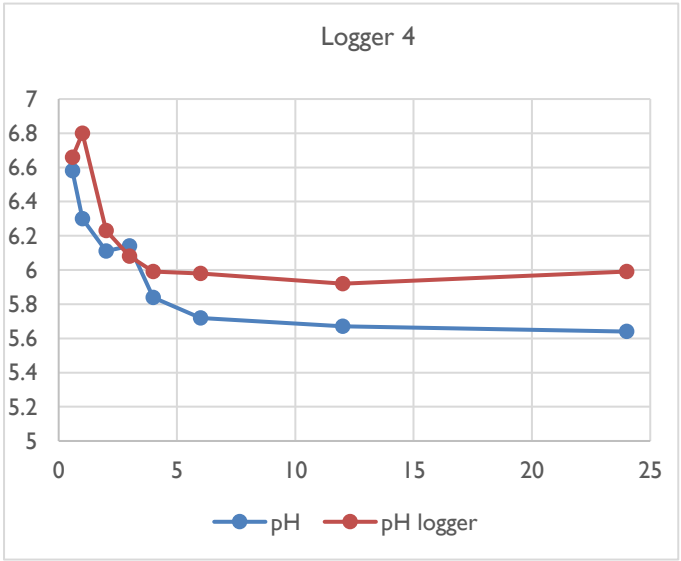

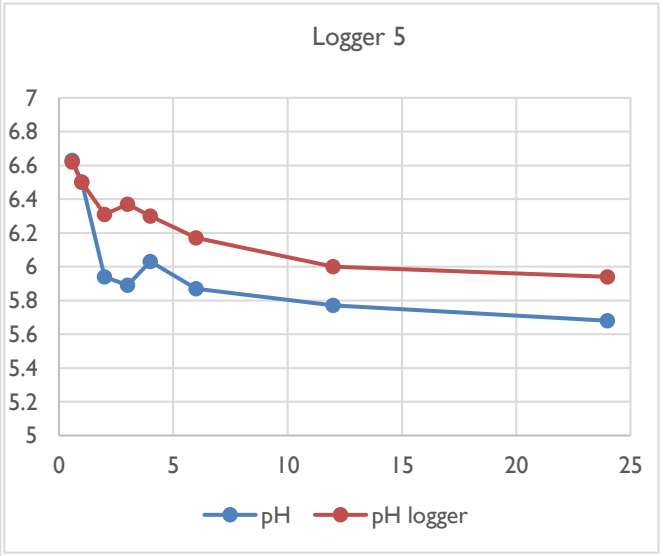

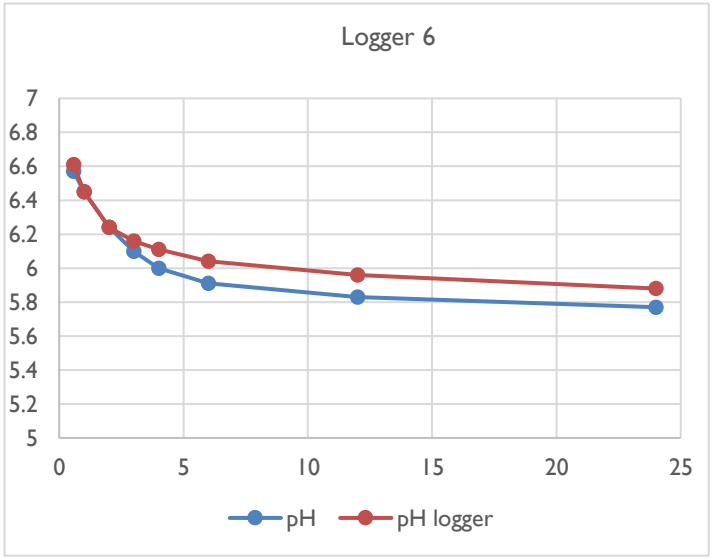

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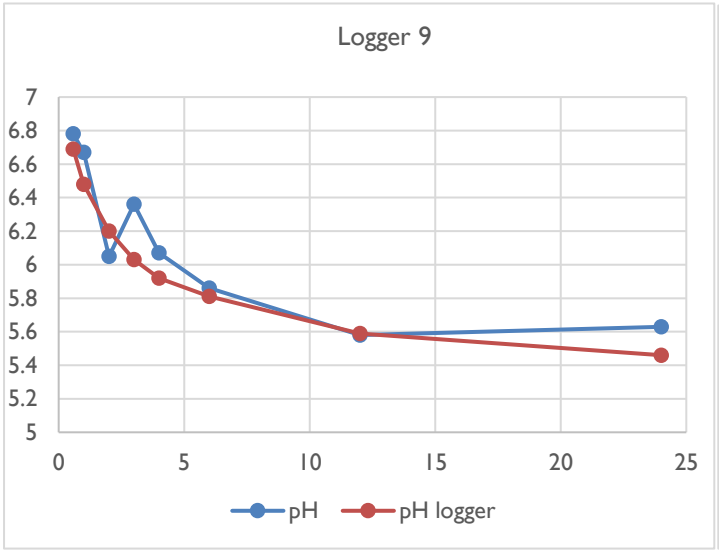

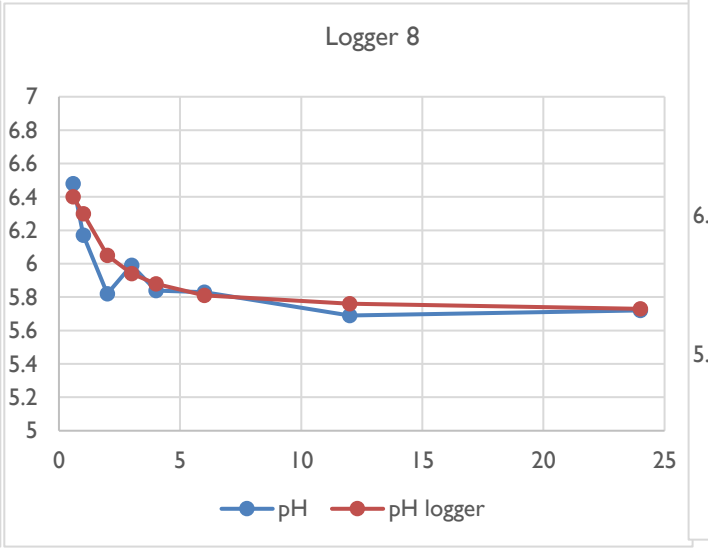

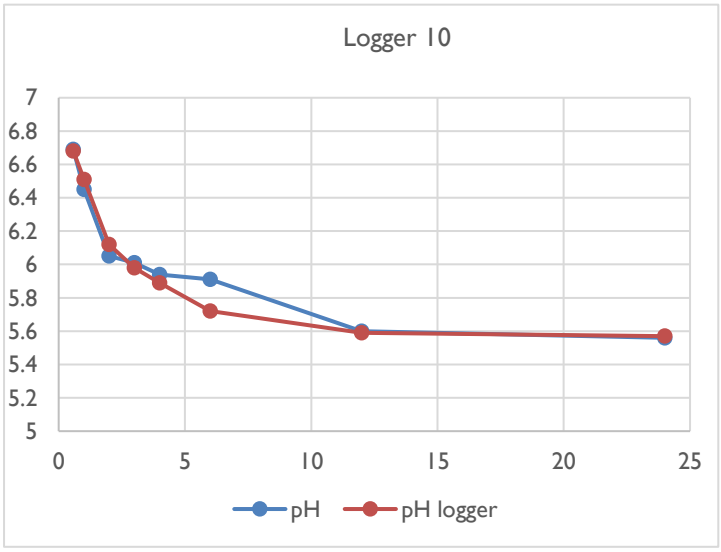

6. Discussion

Concordance correlation coefficient is one of the most popular scaled indices used to evaluate agreement (Feng *et al*., 2015) therefore Lin's concordance analysis was conducted to evaluate the agreement of the pH measurements collected between the two devices. The overall correlation between all the measurements collected from the handheld pH meter and the values recorded by the pH loggers (at the same time points) was 0.8 (Table 1).

Values near +1 indicate strong agreement between the measurements from the different devices. One approach is to interpret Lin's Concordance Correlation Coefficient similar to Pearson's correlation coefficient where values greater than 0.8 are excellent, however McBride (2005), in the evaluation of alternative laboratory techniques, suggests that the strength of relationship is poor when concordance is below 0.9. The circumstances of the measurements, what is being measured and the requirement for precise measurement results needs to be considered when determining the acceptable limits of correlation.

Some differences in pH measurements between loggers and the manual pH meter may be explained by localised variability within the muscle as the measurement sites differed for the two devices. Given that pH measurement within the same muscle can vary with small changes in the measurement site (Norman *et al*. 2004) we believe that correlation values around 0.8 are acceptable for the purpose of auditing the pH/temperature decline in pork carcasses in a commercial processing environment.

The high level of agreement between the temperature measures taken by both devices suggests that the logger probes remaining in situ during the logging period did not impact the temperature decline of the muscle at the localised measurement site, therefore should not have impacted localised pH decline.

Determining pH decline over a 24 hour period with a manual pH meter is often onerous and taking measurements at precise time points to ensure the quality of the data set can be difficult under commercial processing conditions. Incorporating assessments of pH decline into regular auditing procedures at pork abattoirs is likely to be met with some resistance from the processor due to the requirements for skilled staff to measure across a 24 hour period. The outcomes of this project demonstrate that pH loggers and the methodology followed, effectively and efficiently measured the pH decline in pork carcasses within a commercial processing pig processing environment.

7. Implications & Recommendations

Determining pH decline over a 24 hour period with a manual pH meter is often onerous and taking measurements at precise time points to ensure the quality of the data set can be difficult under commercial processing conditions. Incorporating assessments of pH decline into regular auditing procedures at pork abattoirs is likely to be met with some resistance from the processor due to the requirements for skilled staff to measure across a 24 hour period.

The outcomes of this project demonstrate that pH loggers and the methodology followed (Technical Summary), effectively and efficiently measured the pH decline in pork carcasses within a commercial processing pig processing environment.

In addition to a calibration schedule (as recommended by the manufacturer) it is suggested that concurrent measurements of pH and temperature be made by loggers and a manual pH meter (across a range pH and temperature combinations common to pork carcasses during chilling), be included into equipment maintenance procedures at regular time points to demonstrate that the probes and devices are measuring accurately and are in good working order.

8. Intellectual Property

NA

9. Technical Summary

The outcomes of this project demonstrate that pH loggers effectively and efficiently measure the 24 hour pH decline during chilling in pork carcasses within a commercial processing pig processing environment.

A recommended method is described below.

Methodology: Using pH/Temperature data loggers to determine pH decline in pork carcasses during chilling.

Calibration: Before use, follow the manufacturer's instructions for calibration, in short conduct a two-point calibration using buffers of pH 7.00 and 4.01. Temperature calibration is recommended by the manufacturer to be conducted annually.

Setting the device:
Set loggers to record measurements at preferred intervals (2 minute intervals are recommended for pH declines).

Note: To preserve battery life it is recommended that logger start and finish times, which overlap the actual logging times, be specified.

Logging pH decline:
Ensure the logging device/LCD display are protected from the wet processing environment by covering it with a disposable bag (which is acceptable for use in the abattoir). Clean the probes and cables appropriately.

When the carcass enters the chiller insert the probes adjacent to each other at the specified location e.g. pH between the 10th and 11th ribs and the temperature probe was inserted between the 11th and 12 ribs.

Note: Use the robust temperature probe to first create a hole to insert the fragile pH probe.

Determine slaughter time of the carcass.

Data:
Download the data from the device as per manufacturer's instructions. Observe when first measurement from the carcass occurred (e.g. indicated by a significant increase in temperature ~40-38◦C) to determine which measurements/time points are of interest.

10. Literature cited

Feng D, Baumgartner R, Svetnik V. (2015) A Bayesian estimate of the concordance correlation coefficient with skewed data. *Pharm Stat.* Jul-Aug; 14(4):p. 350-358. doi: 10.1002/pst.1692. Epub 2015 May 27. PMID: 26033433.

McBride GB (2005) A proposal for strength-of-agreement criteria for Lin's concordance correlation coefficient. NIWA Client Report: HAM2005-062. https://www.medcalc.org/download/pdf/McBride2005.pdf

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11. Publications Arising

NA