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Ruminal pH

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Keywords: indwelling boluses, pH sensor, drift, temperature, antenna

Introduction

Monitoring ruminal pH and temperature provides important information about rumen health and fermentation processes. Rumen pH can be used to assess diet adequacy or success of diet formulation. The normal rumen pH is highly variable, varying across the day and within animals. However, generally, the physiological pH range is considered to be between 5.5–6.8, dependent on the type of ration fed [1]. For example, Smith [2] determined a normal pH value of 5.5–7.0 for cattle grazing high-quality forage that includes up to 50% concentrate supplement. Decrease in ruminal pH below 5.6 for at least 180 min/d [3], or below 5.8 for more than 5–6 h/d [4], can result in digestion disorders, eventually facilitating the development of health problems such as acidosis, particularly sub-acute ruminal acidosis (SARA), in high producing dairy cows [5]. Common methods to collect rumen fluid for determining rumen pH include stomach tube or rumenocentesis [6]. Frequent sampling using either of these techniques – although they can be carried out with minimal distress – raises concerns regarding animal's comfort and ethical issues. Utilisation of sensors enables a non-invasive and affordable approach to monitor reticulorumen pH, as well as acquiring other information e.g., time spent below threshold, pH range, etc., which may be more useful than rumen pH alone [7]. These sensors or probes are greatly advantageous, due to the possibility of recording diurnal variation, and they have been used in many different studies in recent years [8], [9], [10]. Indwelling pH probes can be placed in the rumen or the reticulum depending on how they are manufactured [11], [12], and enable researchers to continuously measure reticulorumen pH for a long period, using wireless data transmitting that does not require rumen cannula [13]. Most newly designed instruments for measuring rumen pH are also capable of recording rumen temperature, providing an ability to link body temperature and rumen pH measurements. With improvements in rumen pH probes, the drift in sensors remains the major disadvantage which can limit the lifespan of these instruments. In addition, the majority of indwelling pH probes is not reusable unless used in cannulated animals. Therefore, indwelling sensors must be corrected by calibrating the probes to overcome this drift. Recently, Villot et al. [14] deployed mathematical modelling in their work to analyse and delete noise and offset/drift from the pH sensors. The authors proposed the exploitation of relative pH indicators, which can overcome potential drifts and inter-animal variations.

Monitoring rumen pH

Prerequisites

This guideline details steps on performing rumen pH and temperature measurements in cows on pasture or intensive loose housing. Most of the current commercially available pH boluses also collect ruminal temperature data. Therefore, the current guideline is applicable to ruminal temperature measurement as well. In order to determine the potential drift of pH sensors during/after the experiment, the presence of fistulated/cannulated cattle in the experimental unit is necessary. However, some recommendations are given to deal with potential drifts where intact animals are used for the experiment. The Animal Trait Ontology (ATOL) and Environment Ontology (EOL) for Livestock numbers linked with this guideline are: **ATOL_0001284, ATOL_0000361** and **EOL_0001706** (for complete list of ATOL please visit https://www.atol-ontology.com/en/erter-2/).

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Co-funded by the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n°730924
LEIBNIZ INSTITUTE FOR FARM ANIMAL BIOLOGY

A – Calibrating and validating the new probe

1. The bolus must be calibrated before and after pH measurement using standardised pH buffers (pH of 4 and 7) unless the pH boluses are delivered with a calibration certificate. When using multiple boluses in an experiment, the calibration process must be done for each one.
2. The pH drift for the dedicated buffer at the end of the experiment must be calculated for each bolus separately. The *in vivo* pH measurement must be corrected for the drift. In case the experiment is conducted in intact cattle, apply the calculations as proposed by Villot [14] or subject the acquired data to a set of statistical models, as highlighted by Denwood [15].
3. Temperature data validation must be conducted by putting the bolus into a water bath and comparing the data intervals with a reference thermometer placed roughly at the same location as the probe. The reference thermometer must be certified according to a national reference centre of standards.
4. The temperature in the water bath for validating the bolus should be in the range of 35–42°C (the ruminal temperature will be covered by this range).

B – Measuring ruminal pH and temperature

1. Do not use a bolus which has not been particularly designed and manufactured for harsh environments within the body of the cattle e.g. rumen-acid.
2. The bolus should be administered orally or via a rumen fistula. Oral bolus administration should be done by gavage and operatives should allow a minimum time for the probe to settle in the reticulum before interpreting the data. In case the bolus is going to be inserted through fistula, the operator **must not** tie the bolus to the fistula as it will not allow the device to reach its preferred location – the reticulum in case of weighed boluses – which will eventually generate inaccurate measurements.
3. Handling and restraining the animal during bolus administration should be carried out with great care. Operatives **should not** use excessive force during oral administration as the animal's throat may get damaged. During insertion via fistula, the operator should be aware of any sudden movements of the animal. It is recommended to log the time of bolus administration in a log book.
4. Boluses can be used, without a concern for potential drift, for the duration recommended by the manufacturer. However, operatives are still encouraged to evaluate potential drift (see point 2 of section A) by themselves before starting experiments.
5. Drinking water greatly impacts the rumen temperature. Therefore, the operator must consider this during analysis of diurnal rumen temperature.
6. For boluses that require an antenna, animals should be placed within approximately 30–50 m from the antenna to allow data to be transmitted to the receiving unit. The operator should consider the position of the antenna relative to the animal, as for some manufacturers the receiving antenna should be placed directly beside the animal.
7. Data with high level of consistency (captured data for most of the experiment relatively close to the average capture data) can be included for final analysis.

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Citation note: Danesh Mesgaran S, Kuhla B, Dineen M, Silberberg M. Ruminal pH. In: Mesgaran SD, Baumont R, Munksgaard L, Humphries D, Kennedy E, Dijkstra J, Dewhurst R, Ferguson H, Terré M, Kuhla B, (editors). Methods in cattle physiology and behaviour – Recommendations from the SmartCow consortium. Cologne: PUBLISSO; 2020-. DOI: 10.5680/mcpb005