Is monitoring rumen pH a routine tool or a seasonal adjustment to new forage quality?

T.T.F. Mottram[1]
[1]*Royal Agricultural University, Cirencester, GL7 6SJ, UK.*
Correspondence: toby.mottram@rau.ac.uk

Abstract

This essay reviews field experience of using rumen pH telemetry and points out directions for engineering development in the future. Wireless rumen telemetry addresses directly a long standing problem in nutrient management of knowing what a cow has eaten by measuring pH which is directly affected by nutrient intake and bacterial activity. We are establishing reticulo-rumen pH of 5.8 as the threshold below which the cow should spend less than an as yet undefined percentage of time. My experience highlights two different uses of rumen pH data, one to correct an immediate nutritional problem detected by observation of other data and the second to continuously monitor a rotating subset of cows to provide early warning of deviation from a planned management target. Each method needs a slightly different approach to bolus design. Rumen pH boluses have shown a real benefit to farm management and have a great future.

Introduction

In 2003 I was approached by a major pharmaceutical company to develop a tool to help them monitor the efficacy of a new compound to raise rumen pH to prevent sub-acute rumen acidosis (SARA). Although the company withdrew this request when their compound license was blocked by the regulators that call started the scientific and engineering adventure that has led me to be able to monitor cows for SARA all over the world. Prior to this invention, invasive methods were the only tool to diagnose SARA (Tajik and Nazifi,2011) with the definition being extended periods of low rumen pH which was generally taken to be 5.5. Others have also developed boluses (Kahne Animal Health, Smaxtec, Well Cow) and there is a general acceptance in the industry that the bolus approach is a useful tool.

In 2003, we were told that no pH sensor could stay uncalibrated for more than a couple of days, that proteins would coat the probe, that cows would choke or spit out a bolus and that low power radio frequencies could not penetrate tissues. None of these predictions turned out to be true and although we have had to overcome many problems none were insurmountable. We can now routinely monitor rumen pH and temperature of dairy cows in field conditions and it is my opinion that we should immediately outlaw rumenocentesis and oro-rumen sampling as inaccurate, and dangerous to the health and welfare of cows. All veterinarians should use rumen telemetry to diagnose SARA as a routine investigation tool. After only five years since the first commercial system became available we now know that the previous methods often failed to identify the real reasons why some herds have poor performance when rationing appears to be correct.

Description of rumen telemetry

The bolus that I invented is now the eBolus from eCow Ltd. The bolus is 125 mm long by 27 mm diameter weighing 200 g. The sensor end is made of stainless steel which inverts the bolus into a normally sensor down position in cows with a normal shaped reticulum. The electronics are encapsulated with a cold poured resin coat that has proved resilient against rumen liquor in trials and obviates the need for vulnerable seals. The sensor is a combined electrode pH probe routinely used in applications in industry. The temperature probe is embedded in the stainless steel end cap, which has machined holes to allow rumen liquor to flow past the sensor tangentially without permitting direct impact of stones or grit on the glass sensing bulb.

The density of the bolus (specific gravity greater than 2) allows it to remain in the reticulum for the life of the cow while data is collected wirelessly. The bolus measures pH and temperature every 60 s and takes an average value every 15 minutes and stores up to 2700 lines of data in a text file format of date, time, pH, temp, battery V. If data is not collected within 28 days, the file on the bolus is overwritten starting from the beginning.

The boluses are administered to the cow by mouth with a standard bolling gun, the only restriction on operation is that a period of 2 hours should be allowed before reading to allow it to migrate to the reticulum. The bolus has a temperature switch which causes it only to activate when the temperature is above 31°C, to extend shelf life. The device is calibrated at the factory before use and the calibration is accurate for four weeks in normal storage. The radio frequency used is in the 433 MHz ISM band. We have used the higher frequency of 868-926 MHz but propagation is better through tissue at lower frequencies.

Data is collected wirelessly using an antenna connected to an adapted mobile phone via micro USB. The user collects the data with the adapted mobile phone handset by standing near the cow, usually on the left front side. Fixed antennas can be installed in milking parlours or other loafing areas to collect data without human presence which is required for routine management. However, due to the attenuation of the radio signal by tissues of other cows around the target, this is not always reliable.

The customer normally administers 3 boluses to 3 normal healthy cows for a feeding group of 100 animals. Cows in the ante-partum period are often used for monitoring through the transition phase and early lactation. Our data is available for comparative analysis on the eCow website where users can compare data between and within their herd.

The accurate life of the bolus is determined by the sensor (batteries can last for years) which becomes contaminated by rumen liquor in a non-linear manner at some time after 90 days. We anticipate that the life of the sensor can be extended by a few weeks but it is extremely unlikely that it can extend to the life of the cow. The main focus of engineering developments is to increase reliability and extend the radio range while making the bolus smaller and cheaper.

Sampling strategies to maintain continuity of representative data from a herd can be achieved by putting boluses into a rotating group of cows every 3-5 months. We anticipate that systems that meet this specification will become common over the next few years.

Results from research herds

The initial requirement for rumen telemetry was to replace the heavy tethered systems with which fistulated cows were monitored. The majority of eBolus sales have been to research scientists needing accurate data and ease of recalibration between experimental phases. Whilst fistulated animals have provided invaluable data to advance the science, they are inherently limited in scale and pose a high health risk to the animal. Various studies (Gasteiner et al. 2010, Mottram 2016) have shown that the reticulum is less dynamic than the ventral sac but that for practical purposes we can use an offset of +0.25 pH units for the reticulum to estimate the ventral sac pH value. This conclusion needs testing in field conditions as other authors (Sato, 2015) propose an offset of 1 pH unit. This is only of importance when comparing prior publications which used 5.5 pH in the ventral sac as the threshold for SARA. In future, a reticulum threshold value of 5.8 will probably displace the previous values which can only be monitored by invasive procedures. We monitor data coming from the research users when they share this data so that we can help them manage the life of their boluses. We tend to see well regulated pHs with meals offered at the same time every day and pHs which rarely extend outside a range of 5.8 to 6.5 pH.

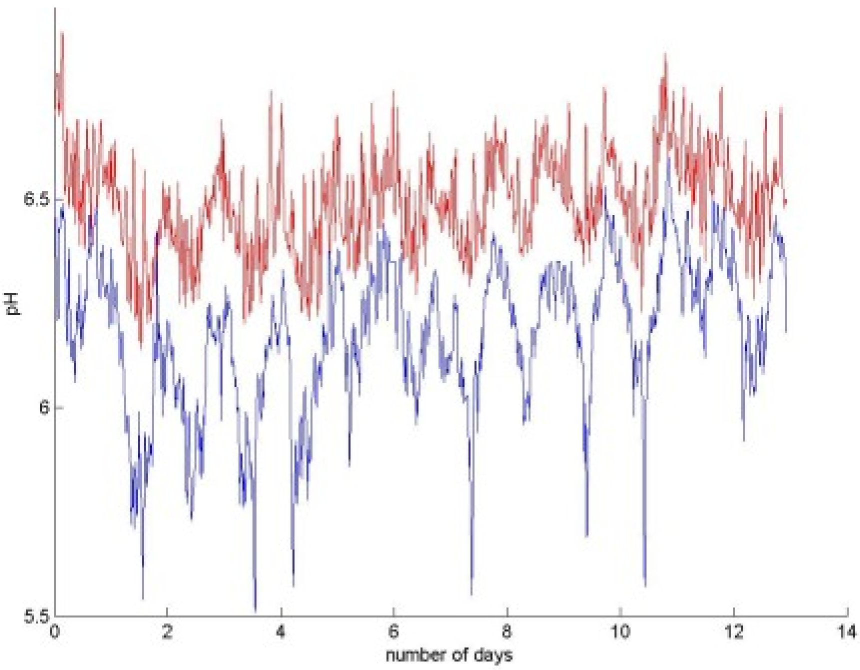

Figure 1 The difference between reticulo-rumen (red) and ventral sac pH (blue) can for herd management purposes be regarded as 0.25 pH units although there are dynamic differences

Results from commercial herds

The data we see from commercial operations is much more varied with wide ranges of pH both daily and seasonally. The mean rumen pH does not vary much across a range of mean annual milk yields of 7-12000 l (Mottram, 2015) and husbandry system has a far greater effect on rumen pH parameters. What the rumen pH data and clinical analysis has shown is that the daily routines to which cows are subjected have a major effect on cow health. The rumen pH data answers the question as to what the cow is eating and when she is eating and ruminating.

In grazed animals we have seen huge disruptions to rumen pH profiles caused by weather effects and grass variety. In the unstructured environment of the grazing herd, it is more difficult to maintain a stable range of pH and some investment in research is needed to develop management strategies if the societal drive to encourage grazing becomes mandatory. Modern dairy cows may not be suited to the "traditional" systems favoured by consumer groups.

A major benefit of continuous monitoring of rumen pH is that it highlights differences among batches of feed and the immediate effect that a sudden change of feed has on rumen pH. In well managed herds with stable feed supplies and management not pushing for high levels of milk output, rumen pH profiles are of great value for establishing a base line but are probably not essential for routine monitoring.

The conclusion of Atkinson (2013) from a veterinary field study was that 30% of cows in the UK suffer from SARA and our challenge has recently been to see how that matches our large data set of rumen pH data. If we use an offset of 0.25 pH units, we also find that about 31% of the time, the cows (4000 cow days) have reticulum pH values below 5.8 pH.

Discussion

After five years of making and shipping boluses, I am now of the opinion that rumen pH is a vital indicator of nutrient management in commercial dairy herds. It can be deployed in two ways.

1. A short term veterinary/nutritionist intervention to identify a problem in nutrient management and to observe the effect of correcting an imbalance in feeding. This is particularly important where mycotoxicosis, which has the same clinical symptoms as SARA, is suspected. Most herds will correct the problem and not see a recurrence for months or years, usually when there is a change in bulk forage or grazing area.
2. A continuous monitoring tool to manage constantly changing food sources particularly for herds pushing for high milk yields or precise milk solids targets and using variable quality nutrients (grass and by-products).

These two different strategies require adapting our base technology. I can foresee a need for cheaper short life boluses that can be applied immediately by a veterinarian diagnosing a problem and using a mobile phone to collect data. For the second scenario, we need longer life boluses and a fixed infrastructure to continuously download data throughout the year. Both of these approaches pose engineering challenges for us in the future. Wireless rumen telemetry has shown up the limitations of our previous techniques to detect and manage SARA and has given us a new tool to improve dairy cow nutritional management.

References

Atkinson, O., 2013, Prevalence of subacute ruminal acidosis (SARA) on UK dairy farms, Proc.BCVA.
Gasteiner, J.M., Fallast, S., Rosenkranz, J., Häusler, K., Schneider, T. & Guggenberger, 2010. Measuring rumen pH and temperature by an indwelling and wireless data transmitting unit and application under different feeding conditions. Berliner und Münchner Tierärztliche Wochenschrift 123, 406-412.
Mottram, T.T.F., 2015. The effect of husbandry system on rumen pH in dairy cows. Proc. 66th Conf. EAAP, Warsaw, 09/2015.
Mottram T.T.F., 2016. Redefining SARA in dairy cows with reticulum pH measurements, Proc. First Int. Precision Dairy Conf., Leeuwarden, NL (in press).
Sato, S., 2016, REVIEW ARTICLE, Pathophysiological evaluation of subacute ruminal acidosis (SARA) by continuous ruminal pH monitoring, Animal Sci. J. 87, 168–177. doi:10.1111/asj.12415
Tajik, J. & Nazifi, S., 2011. Diagnosis of subacute ruminal acidosis: A Review. Asian J. Anim. Sci. 5, 80-90.