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ACIDOSIS OF THE RUMEN IN DAIRY COWS

Definition & causes

Consequences for the health and productivity of dairy cows

Prevention & detection

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Progress beyond

What is ruminal acidosis?

AN ESSENTIAL INDICATOR: RUMEN PH

In dairy cows, the pH of the rumen can vary physiologically between pH 6 and pH 7. A ruminal pH below 6.0 reduces the growth of bacteria that digest fibres, with a harmful impact on the animal's health and productivity.

So this is a critical limit: below pH 6, it's ruminal acidosis.
The rumen's productivity is undermined by poor digestion of fodder, which deteriorates the cow's production and health.

10%-26% OF DAIRY COWS ARE AFFECTED BY SUBACUTE RUMINAL ACIDOSIS.

Subacute ruminal acidosis (SARA) is a rumen condition characterised by low pH values over a significant period of time.

Surveys show that its incidence varies from 10% to 26%.

The subacute acidosis thresholds vary somewhat, depending on the authors, while remaining consistent:

- pH below 5.8 (Zebeli et al., 2008)
- more than 3 h/d where the pH is less than 5.6 (Plaizier et al., 2008)
- more than 5 to 6 h/d where the pH is less than 5.8 (Zebeli et al., 2008)
- more than 4 h/d where the pH is less than 6 (Sauvant, 2010)
- mean rumen pH below 6.16 (Zebeli et al., 2008)
- mean rumen pH below 6.2 (Sauvant, 2010)

Origin of acidosis

ACCUMULATION OF ACIDS IN RUMEN

The pH falls in the rumen due to the accumulation of acids, mainly volatile fatty acids (VFA), also known as short-chain fatty acids (SCFA), and lactic acid.

This accumulation is due to several phenomena that can combine:

- Excessive acid production in the rumen due to surplus or too rapid ingestion of **highly fermentable feed** (cereals, co-products, young grass) or in excessive quantities
- **Excessively quick transitions:** feed changes should ideally be spread over 3-6 weeks
- **Insufficient rumination and salivation**, which reduces regurgitation of the cud, due to a lack of effective fibre and their sifting by the animals
- **Environmental factors** negatively affecting the pH of the rumen: lack of time spent ruminating, discomfort, heat and stress
- Ingestion of **excessively large meals in too little time**

PRIMIPARES, ABOUT 25%-45% OF HERDS, ARE MORE SENSITIVE TO ACIDOSIS THAN ADULTS. THE FIRST WEEK OF LACTATION IS A HIGH-RISK PERIOD.

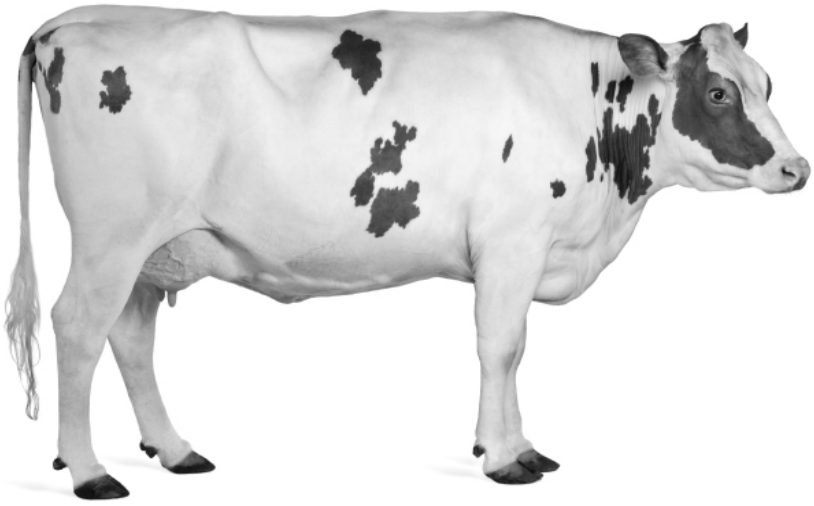
Fibre intake

NUTRITIONAL BALANCE AND CORRECT RUMEN FUNCTION

An adequate level of physically effective fibres is needed to stimulate chewing activity, regurgitation of the cud, rumen motility and mixing of its contents.

This fibre level maintains correct function of the rumen's ecosystem and therefore its pH. Furthermore, the quantity of degradable starch must adapt.

Many parameters are also involved in the development of subacute ruminal acidosis: sifting to favour fine particles, speed of ingestion, space at the trough, duration of feed transitions.



It should be remembered that the nutritional effects of particle size and peNDF (physically effective NDF) are complex and contribute to:

- Ingestion
- Sifting
- Ruminal mattress formation
- Rumination and salivation
- Ruminal mobility;
- Ruminal fermentations
- The passage of digesta
- Absorption of nutrients

In conclusion, fibre intake must be optimised by avoiding both too little fibre, and therefore acidosis, as well as an excess, which bulks out the feed and reduces the animal's energy intake.

Consequences of acidosis

DOUBLE INFLAMMATION

Acidosis will cause a change in the microbial population (microbiome) in the rumen, leading to a greater proportion of Gram– bacteria.

These bacteria release various toxic molecules, including LPS (LipoPolySaccharide), which directly or indirectly cause a **local inflammatory and infectious condition** (ruminitis) **and a systemic state** characterised by the acute phase proteins (SAA, Haptoglobin, LPS binding protein).

The consequences for the animal are varied and significant:

- Decreased and irregular appetite, milk production and feed effectiveness
- Reduced milk fat, measured by the Butyraceous Level (BL), and the ratio of milk fat/ protein in the milk
- Decreased rumination (less than 50% of cows ruminate at rest)
- Intestinal acidosis, with fibrin in the cow pats
- Undigested cow pats containing long fibres, related to the reduced digestibility of the fibres
- Infections: liver abscesses and septic consequences
- Laminitis
- Reproductive disorders
- Poor general condition, weight loss, urine- and wall-licking

ONE CASE OF ACIDOSIS CAN RESULT IN A FINANCIAL LOSS OF ABOUT $400 (Plaizier 2009).

Inflammations and oxidative stress

CONSEQUENCES OF THE FEED

High-production dairy cows receive rich feed to support nutrient and energy needs during lactation. This type of diet, due to the rapid accumulation of short-chain fatty acids (SCFA or VFA) in the rumen, leads to an increased risk of subacute ruminal acidosis.

Systemic inflammation is triggered by lysis and proliferation of Gram– bacteria in the rumen that release endotoxins such as LPS, lipopolysaccharide, from the microbial cell wall, into the environment of the rumen.

Bacterial LPS is a highly pro-inflammatory substance able to pass across damaged digestive barriers and enter the bloodstream, causing systemic inflammation. LPS and certain biogenic amines (histamine, ethanolamine, pyrrolidine, isopropylamine, putrescine, cadaverine, tyramine and spermidine) are metabolic markers of SARA.

BACTERIAL LPS IS A HIGHLY PRO-INFLAMMATORY COMPOUND CAPABLE OF PASSING THROUGH DAMAGED DIGESTIVE BARRIERS AND ENTERING THE BLOODSTREAM LEADING TO SYSTEMIC INFLAMMATION.

Research has suggested that LPS could be absorbed through the intestinal mucosa and not just through the rumen wall. In fact, the wall of ruminants' intestinal mucosa is relatively thin compared to that of the thick-walled rumen. This would mean that starch not digested in the rumen ('by-pass') and fermented in the intestine would be a source of LPS.

Following the presence of microbial toxins, local macrophages, the first-line of defence, secrete a wide range of pro-inflammatory cytokines. In subacute ruminal acidosis, there is a positive correlation between the level of concentrate in the diet, particularly above 45% concentrate in the feed, and serum amyloid A (SAA), which is an acute phase protein and an inflammatory marker used in cattle studies.

OXIDATIVE STRESS IS A MAJOR FACTOR IN IMPAIRED IMMUNE RESPONSES, EXPOSING THE DAIRY COW TO MULTIPLE HEALTH DISORDERS.

LPS is largely responsible for most of the inflammatory reactions caused by ROS (Reactive Oxygen Species) and nitrogen derivatives. High LPS levels may induce Kupffer cells and neutrophils to produce ROS in response to additional stimuli. Recruiting phagocytic cells results in surplus ROS or altered antioxidant status. The inability to control ROS accumulation adequately in metabolically active tissues will lead to oxidative stress.

The balance between free radicals and antioxidants is known to be disrupted in many diseases and can be attributed to numerous factors, such as excessive ROS production, an inability of cells to produce adequate quantities of antioxidants and nutritional mineral or vitamin deficiencies.

Several studies have recently described oxidative stress as an important factor responsible for impaired immune and inflammatory responses, resulting in dairy cattle being highly sensitive to various health disorders, including mastitis, placental retention, laminitis and poor reproductive performance, particularly during the transition period.

Prolonged ruminal acidosis causes an inflammatory condition and oxidative stress that severely disturbs the health and production of dairy cows.

Transition period

IMPORTANCE OF FEED

The transition period (i.e. the period between 3 weeks before and 3 weeks after birth) is strategic for the health, fertility and productivity of dairy cows.

75% of diseases occur during the first 3 weeks of lactation. Since the 1980s, numerous publications have shown the correlations between high blood levels of plasma free fatty acids and ketone bodies, and the incidence of diseases such as post-partum hypocalcaemia, retained placenta, metritis, displaced abomasum, mastitis.

This period is characterised by drastic metabolic, immune and endocrine changes, making cows extremely susceptible to disease. Energy requirements at the start of lactation are considerable: 72 g of glucose are required to produce 1 kg of milk. The various tissues and organs coordinate to attempt to compensate for glucose deficiency by becoming insulin-resistant, limiting glucose uptake into the cells and allowing catabolism and mobilisation of tissues, releasing amino acids and glycerol from skeletal muscle and adipose tissue.

The major nutritional challenge during this period is to meet the increasing energy and key nutrient requirements while cows' ingestion potential is limited. This mechanism results in a negative energy balance and deficiencies of key nutrients at the beginning of the post-partum period.

To reduce this gap between energy and nutrient intake and requirements, the are fed large quantities of concentrates, often replacing fibre-rich fodder, causing subacute ruminal acidosis. This is aggravated by the rumen not being sufficiently adapted to lactation feed: the rations for spent dairy cows are very fibrous, so the change of feed at calving is drastic.

Inflammation has been commonly observed during the transition period in cows, one cause of which is ruminal acidosis.

PRODUCING 1 kg OF MILK DEMANDS 72 g OF GLUCOSE AT THE START OF LACTATION: A CONSIDERABLE ENERGY REQUIREMENT.

The transition period entails a high risk of acidosis due to the rapid increase in high-energy nutrients while rumen is not fully adjusted to it.

Detection of ruminal acidosis

DELICATE MEASUREMENTS TO BE MADE

Measuring the rumen pH is not easy on a farm:

Ruminal puncture is a veterinary procedure to be used for **clinical practice only**. It gives a single and not the pH kinetics.

Recording using ruminal bolus samples is used to plot a graph of daily pH variations; unfortunately this noteworthy technique is expensive and complex to use, **so it is reserved for trials and experiments.**

In practice, the following indicators allow subacute ruminal acidosis in a herd to be detected correctly:

— Feed criteria:

- Degradable starch level in the rumen above 20%
- NDF level below 28%-32%
- Inadequate peNDF level
- Lack of physical fibres highlighted by feed sifting, by reference to the Penn State criteria

— Criteria observed on animals:

- Significant screening by animals, large quantity of fibres refused
- Irregular ingestion, rumen filling score below 3
- Decreased and irregular milk production
- Decreased butyraceous level (BL)
- Reduced rumination, either by measurement with a recorder collar, or by observing fewer than 50% of cows at rest ruminating
- Undigested cow pats, with fibres of more than 0.5–1 cm and sometimes with fibrin present, indicating intestinal acidosis
- Laminitis

Prevention of sub-clinical acidosis

DIET AND ENVIRONMENT

DISTRIBUTE 250 GRAMS OF SODIUM BICARBONATE PER DAY, IN ORDER TO OBTAIN A BACA OF 250 TO 400 mEq/kg DRY MATTER

- **Maintain a BACA of 250 – 400 mEq/kg of dry matter.** Sodium Bicarbonate fed up to 1% of the dry feed matter, or 250 grams per day, is one of the effective methods to achieve this objective
- **Physical fibre intake** following the usual recommendations: opt for well-consumed short fibres
- **Non-physical fibre intake**: 28%-32% NDF, 75% of which in fodder, 15%-18% peNDF > 8 when starch content is between 20% and 25%
- Aim for an **adequate proportion of resistant starch** in the rumen:
  - Limit the total starch content to 22%-25% of dry matter ingested in complete feed in a single batch
  - when batches are possible, 22% to 25% total starch for the first 3 weeks of lactation (mainly on grain maize) and then 25% to 30% up to a status score of 3, then 18%-22% in the middle and at the end of lactation
- **Live yeasts**
- **Sufficient mineral intake**, especially phosphorus, cobalt and sulphur
- **Transitions of 3 to 6 weeks** when making major feed changes
- Ensure an **adequate supply of clean water**
- **Freely-available feed, regular distributions**
- **Comfort**
- **Prevention of heat stress**
- **Adequate management of spent dairy cows**

CONCLUSION

Ruminal acidosis is frequent, insidious and disturbs the well-being, health and productivity of dairy cows.

Subacute ruminal acidosis is characterised not only by a low ruminal pH, abnormal fermentation and dysbiosis, but also by **a systemic inflammatory condition and oxidative stress, which are both highly damaging to the animal**.

Feeding criteria are essential for detecting and preventing ruminal abnormalities leading to acidosis. Nonetheless, variations in quality of the feed, the feeding behaviour of cattle, **individual factors and unexpected climatic events sometimes make the onset of acidosis unpredictable.**

The preventive measures described in this document must be implemented continuously in productive dairy farms to ensure healthy dairy cows, production and longevity.

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