RUMEN HEALTH

A well functioning, healthy rumen is the cornerstone of dairy cow health and performance. Discover why in this series of short articles.

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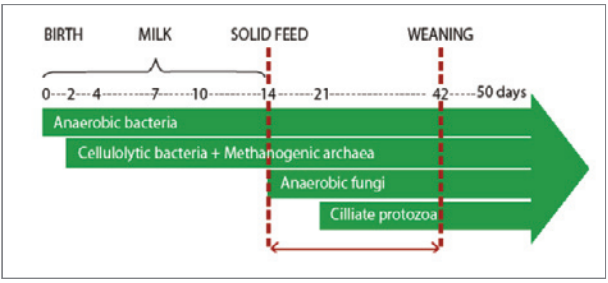
Rumen Development

When a young ruminant is born, its rumen is considered a sterile environment that contains no bacteria or other microbial life. The young ruminant is naturally exposed to different microbes through the dam's birth canal and vagina, saliva, skin and faeces.

- Anaerobic bacteria appear a few hours after birth.
- Cellulolytic bacteria and methanogenic archaea appear at 2-4 days of age.
- Anaerobic fungi colonise the rumen during the second week.
- Ciliate protozoa begin to be established only during the third week.

Pre-ruminant colonisation sequence of rumen microflora (lamb model).



The separation from the dam may occur early; the newborn ruminant naturally undergoes stress, suppressing immunity and delaying rumen development.

The transition from milk to solids can also occur when microbial colonisation is incomplete and result in frequent digestive disorders in the young animal.

Diversity of microbial communities in the rumen depends largely on diet composition.

The development of the rumen (weight, wall thickness and papillae number, integrity and length) is highly dependent on the level of complexity of its microbiota. Grain feeding increases the concentration of butyric acid in the rumen, which stimulates papillae growth.

A mature microbial ecosystem is necessary to ensure the full capacity to digest solid feed. Optimal animal growth and performance relies on:

- Rapid establishment of microbial populations.
- Development of an abundant and functional microbiota.
- Stimulation of intake and digestive activity.
- Maximising the absorptive capacity of the rumen wall.

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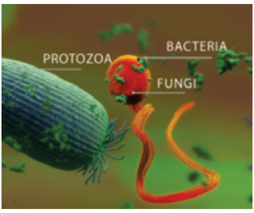
Meet the Microbes



The rumen hosts a very diverse community called the microbiota (bacteria, protozoa, fungi). Ruminant animals would not be able to digest feedstuffs, especially forages, without these microbial populations. Thanks to this unique symbiotic relationship, ruminants can convert plant materials into milk, meat or wool.

Here is an overview of these and their role in the rumen:

• Bacteria

Rumen bacteria account for 10^{10} organisms/ml of rumen fluid and several hundred species have been characterised. By volume, they comprise up to 50% of the total microbial biomass. Bacteria species are an important source of microbial protein, which supply the ruminant with 75-80% of its metabolisable protein. Bacteria are also important for producing enzymes that digest fibre (cellulose, hemicellulose), starch and sugars.

• Protozoa:

Ciliate protozoa are larger than bacteria and account for 10^6 organisms/ml of rumen fluid, however they still make up to 50% of the total microbial biomass. They have various activities:

- Cellulolytic and hemicellulolytic protozoa can digest plant particles.
- Different protozoa have a positive role, digesting starch (more slowly than bacteria).
- Other protozoa can consume lactic acid, thereby limiting the risk of acidosis.

Some types of protozoa are able to remove oxygen.

Most of them degrade proteins very efficiently and release ammonia. These proteins represent around 25% of the microbial protein available for the animal. A single protozoal cell can swallow up to several thousand bacteria in an hour so they play a very important role in rumen microbial population stability.

• Fungi:

Rumen fungi comprise up to 8-10% of microbial biomass and are strictly anaerobic. They play an essential role in fibre digestion due to the production of filamentous rhizoids which invade plant tissues, and their efficient enzymatic activities. This physical action can facilitate access to more digestible tissues and help release polysaccharides, which are linked to lignin increasing the pool of digestible energy for the rumen microflora.

Digestive comfort is directly linked to the balance of the different microbial communities in the digestive tract.

These communities are changed in their function and activity according to dietary factors, but also to management and environmental conditions. It has been demonstrated that when the rumen microbiota is challenged, a ruminal microbial imbalance occurs which impairs fibre digestion, increases acidosis risk, and may trigger inflammation which negatively impacts digestive comfort and well-being.

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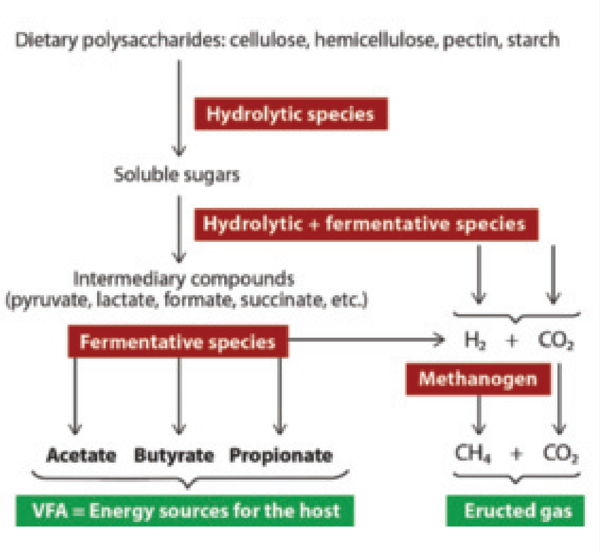
Rumen Fermentation

Rumen fermentation is a process that converts ingested feed into energy sources for the host. Fibre scratches the rumen wall to start a series of contractions.

These contractions lead to rumination, which is the process that physically breaks down the fibre source. Feed is then regurgitated, chewed and swallowed usually 50-70 times during rumination before passing through to the next compartment of the stomach.

Microbial populations ferment feed and water into volatile fatty acids (VFA) and gases (methane and carbon dioxide). When fermentable carbohydrate in the diet is digested too rapidly, the bacteria will increase the production of both VFA and lactic acid.

Rumen fermentation pathways.



To sustain growth and the activity of fibrolytic microbes, it is crucial to maintain ruminal pH above 5.8, which will prevent the decline of fibre digestion and subsequent problems.

Strategies that limit acid load, notably by competing with lactate producing bacteria, help to optimise fibre digestion.

Frequent changes in management or diet can alter the balance of the microbes and consequently, the profile of the fermentation end products.

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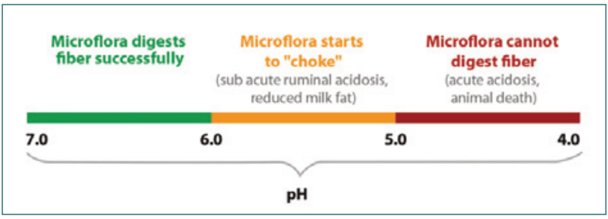
Rumen Challenges: Poor Fibre Degradation

Ruminants depend on microbial fermentation within the rumen to acquire energy from plant material. The different fractions from plant cells walls are not entirely physically accessible and achieve various degrees of digestibility in the rumen.

To improve animal productivity, a portion of the forage diet is increasingly substituted with readily-fermentable carbohydrates. However, the supplementation of diets with readily-fermentable carbohydrates is known to depress rumen fibre degradation. Additionally, the major fibre-degrading bacterial species *Fibrobacter succinogenes, Ruminococcus albus* and *R. flavefaciens*, as well as rumen fibrolytic fungi, are particularly vulnerable to rumen pH at 5.8 or lower.

Fibre degradation depends on rumen pH.



The challenge for ruminant nutritionists is to **maximise a balanced nutrient intake and availability, digestion and ultimately the efficiency of this process** to convert to milk, meat or wool.

Indicators and risk parameters of poor fibre degradation include:

- Decreased animal performance.
Low milk production, milk fat and a reduced fat/protein ratio may be due to impaired rumen fermentation in lactating dairy cattle.

- Liquid manure and presence of undigested grain.
Undigested processed grains in the faeces because of poor rumen efficiency may be due to an increased passage rate due to an imbalanced or low diet digestibility.

- Lower body condition.

- Heat stress.
(high temperature and/or humidity) also increases the risks of acidosis and low fibre degradation.

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Clinical and Subclinical Dimensions of Rumen Acidosis

Different degrees of acidosis appear when the fermentation profile of the rumen is unbalanced by high levels of lactic acid or butyric acid:

• Sub acute ruminal acidosis (SARA)

- More common, results from excessive volatile fatty acid (VFA) production that exceeds the ability of the rumen to neutralise and it exceeds the absorption capacity of the ruminal papillae.
- Rumen pH drops below 5.8 and remains below this threshold for three or more hours within a 24-hour period.
- Animals generally have mild diarrhoea, lowered dry matter intake and laminitis.
- Can develop into acute acidosis if the pH is never able to recover.

• Acute ruminal acidosis

- Less common, more severe, usually occurs when pH falls below 5.5.
- Usually associated with a drastic diet change.
- Animals have depressed productivity, go off feed, have elevated heart-rate, diarrhoea and may die.
- Severe lactic acidosis may cause irregular feeding behaviour and gorging, which creates more spikes of acid production.

• Financial impacts

One study estimates the overall impact to the US dairy industry is between $500million and $1billion per year. Another study estimates SARA costs $34,750 per 100 cows. In lactating cows, economic loss can be attributed to: lower milk fat content (-0.76%), depressed milk production (-10%), poor reproductive performance and increased risk of secondary metabolic disorders.

Indicators and risk parameters of rumen acidosis include:

- Decreased animal performance:
  Low milk production, milk fat and a reduced fat/protein ratio may be due to impaired rumen fermentation.
- Decreased rumination activity.
- Locomotion issues:
  Lame animals can indicate high levels of rumen histamine production and bacteria endotoxin release.
- Poor rumen fill.
- Liquid manure.
- Presence of undigested grains in the faeces.
- Heat stress:
  Heat stress (temperature and/or humidity) increases the risks of acidosis and low fibre degradation.

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Health Issues Linked to Rumen Challenges

When the rumen microbiota is challenged due to internal or external stress factors (diet, heat stress, transitions), a ruminal microbial imbalance occurs which impairs fibre digestion, increases acidosis and may trigger inflammation which negatively impacts well-being, such as:

• Laminitis

Laminitis, an inflammatory status of the hoof wall, is due to histamine produced by some rumen bacteria under low pH. The initial activation of laminitis starts with the low rumen pH, lysis or death of Gram-negative bacteria, which leads to the release of lipopolysaccharide (LPS), a very potent stimulator of inflammation. Histamine is also produced by an animal under stress. Histamine production leads to an inflammatory condition in the animal that can weaken the laminar structure in the hoof wall, thus leading to laminitis.

Poor locomotion in a dairy cow is a visible signal of lameness

• Bloat

Bloat is an over distention of the rumen with the gases of fermentation. Intensively fed cattle typically have a high proportion of cereals in their diet, which quickly produces gas during digestion. Cattle on these diets are not able to expel gas fast enough during rumination, due to the small quantity of long fibre in the diet.

• Liver abscess

Liver abscesses are formed by pathogenic toxins that have escaped the rumen. When the rumen wall is damaged by the effects of acidosis, bacteria can enter the bloodstream and proliferate throughout the liver. Toxins produced by certain bacteria lead to a coagulative necrosis that can develop into encapsulated abscesses over time.

The cornerstone of digestion and performance is the rumen, where forage and feed are converted into energy and microbial protein thanks to the activity of the rumen microflora: bacteria, protozoa and fungi.

Good rumen efficiency (healthy rumen and good microbial balance) is key for optimal feed efficiency, reproductive performance, overall productivity, longevity and health of dairy cows.

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