What is Actisaf®?

- Actisaf® is a **specific strain of live yeast** of the species Saccharomyces cerevisiae
- Yeast are **single cell organisms** classified as fungi
- Yeast ferments carbohydrates, **respiring oxygen** and producing carbon dioxide

Key factors for a live yeast to be effective:

- **Strain** - Actisaf is a specific strain selected for performance as a feed additive
- **Stability** - Actisaf has a unique drying process that gives excellent stability
- **Dose** - Yeast must be administered at the correct dose to get the optimum response
Actisaf® is produced by Phileo Lesaffre Animal Care, part of Lesaffre, the world’s largest manufacturer of yeast.

Around 40% of the world’s yeast is made by Lesaffre!

Actisaf® is produced by a unique and patented fermentation process in the production plant in Lille.
Digestion in the rumen

The rumen is a large fermentation chamber packed full of microbes, which:

- Digest feed to make energy and protein available to the animal
- Require a low oxygen environment, and pH between 6.0-7.0, to optimise feed digestion

**Bacteria**
- ~300 species
- $10^{10}$ to $10^{11}$ cells/ml

**Methanogenic Archaea**
- ~6 species
- $10^6$ to $10^8$ cells/ml

**Ciliate Protozoa**
- ~40 species
- $<10^5$ cells/ml

**Anaerobic Fungi**
- ~30 species
- $<10^5$ cells/ml
Digestion in the rumen - “feed the bugs first”

1. Cattle consume feed
2. Microbes digest feed
3. Microbes grow
4. Microbes produce energy in the form of Volatile Fatty Acids (VFA)
5. Some microbes are washed out of the rumen and provide the majority of the cow’s protein requirements
Maximising returns

- Plan to achieve **maximum weight gain per kg of feed**

- Highest feed efficiency is realised in **young animals** and declines with age

- Focus on **protein first to growing cattle** to grow frame and avoid small, over-fat animals

- Focus on **energy first in finishing diets** to hit target slaughter weight and conformation
Common diet targets for growing & finishing cattle

<table>
<thead>
<tr>
<th>Growing cattle diet targets (Continuous frame growth)</th>
<th>Finishing cattle diet targets (short sharp period of max DLWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DMI</strong></td>
<td><strong>2.3% BW</strong></td>
</tr>
<tr>
<td><strong>DLWG (KG)</strong></td>
<td><strong>0.7-1.3kg</strong></td>
</tr>
<tr>
<td><strong>DM</strong></td>
<td><strong>30-60%</strong></td>
</tr>
<tr>
<td><strong>CP</strong></td>
<td><strong>15-16%</strong></td>
</tr>
<tr>
<td><strong>Mj ME</strong></td>
<td><strong>10.5-11.4</strong></td>
</tr>
<tr>
<td><strong>NDF</strong></td>
<td><strong>&gt;40%</strong></td>
</tr>
<tr>
<td><strong>Fat</strong></td>
<td><strong>&lt;3%</strong></td>
</tr>
<tr>
<td><strong>Starch &amp; Sugars</strong></td>
<td><strong>&gt;20%</strong></td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td><strong>0.80%</strong></td>
</tr>
</tbody>
</table>

(EBLEX, 2013)
Water - the forgotten nutrient

- Cattle require between 5-7 litres of water per kg dry matter consumed

- The water content of feed is very variable

- Cattle will drink together so water supply must cope with peak demand

- All stock must have an uninterrupted supply of fresh, clean and easily accessible water at all times

- Water troughs should ideally be inspected daily and, if contaminated with straw or faeces, they should be cleaned out
Challenges to rumen function

- Diet transition or changes in diet formulation
  - Finishing diets contain high sugar/starch
    - Rapidly fermented in rumen
      - Rapid decrease in rumen pH
        - Poor rumen function and acidosis
          - Reduced fibre digestion
          - Reduced energy output from rumen
          - Reduced intakes
          - Reduced weight gain
          - Increased acidity
            - Damage to rumen papillae - reduced nutrient absorption
              - Coriitis (previously known as laminitis) causing lameness (if acidosis is for a sustained period)
How does Actisaf® work in the rumen?

- The rumen is continually challenged by oxygen, which is toxic to rumen bacteria

- Actisaf® uses up oxygen, resulting in the growth of fibre-digesting bacteria and lactate-utilising bacteria, increasing feed digestion and stabilising rumen pH, which prevents acidosis from developing

- Actisaf® allows the microbes to convert lactate to propionate, a volatile fatty acid (VFA) that optimises growth rates, feed efficiency and lean meat production

- Five grams of Actisaf® has been proven to have the equivalent buffering effect of 150 grams of sodium bicarbonate, thereby stabilising rumen pH
Actisaf® vs Bicarbonate
Fermentation parameters & fibre degradation

How does Actisaf live yeast differ from sodium bicarbonate in stabilising ruminal pH in high yielding dairy cows?

<table>
<thead>
<tr>
<th>(mM)</th>
<th>Control</th>
<th>Actisaf*</th>
<th>Bicarbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total VFA</td>
<td>85.3a</td>
<td>99.4b</td>
<td>95.3b</td>
</tr>
<tr>
<td>Acetate</td>
<td>53.2a</td>
<td>59.1b</td>
<td>60.8b</td>
</tr>
<tr>
<td>Propionate</td>
<td>18.0a</td>
<td>25.8a</td>
<td>20.0a</td>
</tr>
<tr>
<td>Butyrate</td>
<td>10.6</td>
<td>10.2</td>
<td>10.1</td>
</tr>
<tr>
<td>Lactate</td>
<td>16.5b</td>
<td>5.4a</td>
<td>12.2b</td>
</tr>
</tbody>
</table>

*Trends at P <0.1 +41% +77% *Significant differences at P <0.05

Impact of Actisaf on lactate-utilising organisms

*Selenomonas ruminantium Megasphaera elsdenii

% relative abundance

Digestibility trial

Trends at P <0.1

<table>
<thead>
<tr>
<th>%</th>
<th>DM</th>
<th>OM</th>
<th>NDF</th>
<th>ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Control Actisaf Bicarbonate

*Note Actisaf delivers an increase in propionate (a glucose precursor essential for lean meat production) over control and over bicarbonate, and a reduction in lactate.
Actisaf stabilises rumen pH

Rumen pH drops after feeding. Actisaf® stabilises rumen pH, thereby avoiding the negative impact of low pH on the rumen microbes and associated negative health consequences:

Changes in rumen pH after feeding

<table>
<thead>
<tr>
<th>Time</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1h</td>
<td>6.6</td>
</tr>
<tr>
<td>0h</td>
<td>6.2</td>
</tr>
<tr>
<td>+1h</td>
<td>6.0</td>
</tr>
<tr>
<td>+2h</td>
<td>5.8</td>
</tr>
<tr>
<td>+3h</td>
<td>5.6</td>
</tr>
<tr>
<td>+4h</td>
<td>5.4</td>
</tr>
<tr>
<td>+5h</td>
<td>5.2</td>
</tr>
<tr>
<td>+6h</td>
<td>5.0</td>
</tr>
<tr>
<td>+7h</td>
<td>4.8</td>
</tr>
<tr>
<td>+8h</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Threshold
What are the benefits of Actisaf®?

Actisaf® creates a more favourable environment for the rumen microbes resulting in:

- Improved digestibility and feed utilisation
- More stable rumen pH
- Increased DM intakes
- Improved carcass classification
- Less ‘stalling’ of cattle on diet change
- Up to 9% improvement in DLWG
- Up to 4.3% improvement in FCE
Risk factors for poor rumen function

- Insufficient head space/ inconsistent feed mixing
- Abrupt pen moves
- Diet dry matter
- Poor storage of by-products resulting in spoilage
- Low levels of fibre/NDF
- Rapid increase in feed rates or rapid diet transition
- Stress
- Running out of feed for a period of time
- High starch and sugars
pH fluctuation after feeding ad lib diet

Ruminal pH over a 48 hour period of a steer adapted to a 92.5% concentrate diet based on dry-rolled corn fed once daily at 0 and 24 hours. Ruminal pH was monitored with a submersible pH electrode suspended through the plug of the ruminal cannula and was recorded every minute:

<table>
<thead>
<tr>
<th>Hour</th>
<th>Ruminal pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>4.5</td>
</tr>
<tr>
<td>24</td>
<td>5.5</td>
</tr>
<tr>
<td>36</td>
<td>5.0</td>
</tr>
<tr>
<td>48</td>
<td>6.5</td>
</tr>
<tr>
<td>60</td>
<td>6.0</td>
</tr>
</tbody>
</table>

E18 Nagaraja and Titgemeyer (Cooper et al., 1998)

Affect of low rumen pH on rumen microbes?

Ruminal ciliated protozoal population and ruminal pH in cattle with experimentally induced acute acidosis and subacute acidosis:

Reduced ciliated protozoa is indicative of reduced fibre digestion
Schwaiger et al (2014). This research showed that cattle exposed for a short time (8 days) to concentrates before an induced acidosis challenge recovered more slowly than cattle exposed for longer (34 days) (recovery from acidosis at -369min/day rather than -588min/day, P = 0.019). This indicates that greater time allows better adaption of the rumen, resulting in more stable rumen pH.

Holtshausen et al (2013). 16 animals were transitioned from a high-forage diet to a finishing diet in three steps. Mean daily ruminal pH declined (from pH 6.26 to pH 5.81) and mean duration of time below pH 5.5 increased from 2.58hr/day to 8.31hr/day by the end of step 3. In addition DMI declined and meal size and duration were reduced. The study concluded that a more gradual change to a finishing ration could reduce the incidence and severity of acidosis.

Castillo-Lopez et al (2014). This study showed that animals in the last 50 days of the finishing period had lower mean rumen pH (6.0) and more time/day when rumen pH was below 5.5 (194 mins/day). This increase in ruminal acidosis risk was attributed to days on feed and dry matter intake in the finishing period.
Cereal choice and level of processing

Factors that increase the rumen degradability of starchy feeds:

(Morris & Chalcombe., 2014)
Warning signs

- Unexplained diarrhoea
- Loose dung
- Variable dung consistency (can indicate diet sorting)
- Soft, grey or foamy dung
- Mucin/fibrin casts in the dung
- Gas bubbles in dung
- Reduced feed intake
- Weight loss
- Lethargy
- Rapid breathing
- Poor ruminantion rates/cud chewing
- Poor feed digestion - undigested fibre/grains in dung
- Tail swishing in absence of flies
Acidosis damages rumen pappillae

Pappillae are finger-like projections in the rumen that are vital for nutrient absorption.
Summary

- Focus - **maximum weight gain per kg of feed**, which is reliant on balanced nutrients, good management and **optimum rumen function**

- High starch and sugar diets and diet transition can cause **rumen acidosis**, limiting performance

- **Actisaf creates a more favourable environment for rumen microbes**, improving feed conversion efficiency, intake, daily liveweight gain and carcass classification

- Feeding Actisaf delivers an average return on investment of €39 (£36) per animal
Supplementary information
Challenges to rumen function

- Ruminal acidosis is a digestive disorder that occurs in all ruminants
- When cattle consume feed, microbes ferment feed that feed and produce mainly acid (volatile fatty acids as well as some other short chain fatty acids CO2, methane, etc.)
- These VFAs are the dominant energy source for ruminants
- Problems occur when too much acid is produced and cattle are not able to neutralise the acid which lowers the rumen pH (acidity)
- When pH gets too low we see:
  - Reduced fibre digesting microbes
  - Increased numbers of microbes that ferment feeds into a strong acid called lactic acid (moving into acute acidosis)
  - Production of toxins from dying microbes which can induce inflammation (endotoxins, ethanol, amines & histamines)
  - Damage to the epithelium/lining of the stomach reducing the amount of nutrient that can be absorbed and potentially allowing microbes & toxins to enter the blood stream
  - Liver damage
  - Laminitis
- Any change in diet requires the rumen microbes to adapt
- This generally takes around 3 weeks
- However, if too much starch/sugar in the form of cereals or byproducts are fed often the bugs cannot adapt quickly enough
  - Leading to a drop in the pH (acidity of the rumen)
  - Leading to a condition known as subclinical ruminal acidosis
  - As the pH drops fibre digesting microbes cannot function
  - When the pH drops even further the bugs that normally produce propionate (key source of glucose for lean meat gain) switch to producing lactic acid (10x more acidic) making the problem, even worse leading to a condition known as acidosis
Energy - brief explanation

- Carbohydrates, such as fibre, starch and sugars, are mainly broken down into volatile fatty acids (VFAs) by the rumen microbes - mainly acetate, propionate and butyrate - with some being digested further down the digestive tract to glucose. Dietary fat is also essential and supplies a small amount of the animal’s energy requirements. Excess amounts of certain kinds of fat in the diet can inhibit the rumen microbes, and ruminants can only attain a small proportion of their dietary requirements from dietary fat sources
- Volatile Fatty Acids (VFAs) are absorbed across the rumen wall to provide energy for the animal
- Problems arise when VFAs accumulate faster than the animal can absorb them
- Leading to a condition known as sub-acute ruminal acidosis

Protein - brief explanation

- Protein comes in two forms depending on whether it can be degraded by the microflora in the rumen or not
- Degradable protein is broken down by the microflora into amino acids, or synthesised from non-protein nitrogen if adequate energy (carbon) is present
- These amino acids are used by the microflora themselves for growth and reproduction
- Microbes are constantly washed out of the rumen, where they provide amino acids which are digested and absorbed in the stomach and small intestine. Amino acids are the building blocks of protein and muscle as well as other vital body functions
- Rumen undegradable protein is not broken down directly and it provides amino acids directly to the small intestines
- Microbial protein should be maximised first, as it supplies most of the animal’s protein requirements. It is important to ensure the right conditions are present in the rumen - rumen degradable energy in balance with rumen degradable protein - and correct rumen pH, a low oxygen rumen environment and adequate water intakes
# Ruminal acidosis in beef cattle

## Comparison of acute and subacute acidosis in beef cattle

<table>
<thead>
<tr>
<th>Item</th>
<th>Acute&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Subacute&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical signs</strong></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Mortality</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

## Ruminal Changes

### Fermentation products
- **Ruminal pH**
  - <5.0
  - 5.0 to 5.5
- **Total organic acids**
  - Increased
- **Lactic acid**
  - High [50 to 120 mM]
  - Normal [0 to 5 mM]
- **VFA**
  - Below normal [<100 mM]
  - High [150 to 225 mM]

### Microbes
- **Gram-negative bacteria**
  - Decreased
  - No change
- **Gram-positive bacteria**
  - Increased
  - No change
- **Streptococcus bovis**
  - Increased initially
  - No change
- **Lactobacillus spp.**
  - Increased
  - Increased
- **Lactic acid-producers**
  - Increased
  - Increased
- **Lactic acid-utilizers**
  - Decreased
  - Increased
- **Ciliated protozoa**
  - Absent or decreased
  - Absent or decreased

## Microbial “toxic” products

<table>
<thead>
<tr>
<th>Item</th>
<th>Acute&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Subacute&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>Increased</td>
<td>ND&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Amines</td>
<td>Increased</td>
<td>ND</td>
</tr>
<tr>
<td>Endotoxins</td>
<td>Increased</td>
<td>Increased</td>
</tr>
</tbody>
</table>

## Blood changes

<table>
<thead>
<tr>
<th>Item</th>
<th>Acute&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Subacute&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Decreased (&lt;7.350)</td>
<td>Normal to slightly decreased</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>Increased, particularly D(-)</td>
<td>Normal</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>Marked reduction [&lt;20 mEq/L]</td>
<td>Normal to transient reduction</td>
</tr>
<tr>
<td>Base status</td>
<td>Base deficit</td>
<td>Base excess</td>
</tr>
<tr>
<td>Packed cell volume</td>
<td>Increased (&gt;40%)</td>
<td>Normal (30 to 35%)</td>
</tr>
<tr>
<td>Endotoxins</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Inflammatory mediators</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

## Sequelae

<table>
<thead>
<tr>
<th>Item</th>
<th>Acute&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Subacute&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumenitis</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Laminitis</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Polioencephalomalacia</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Liver abscesses</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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<sup>1</sup>Data from Nagaraja et al. (1998)

<sup>2</sup>Changes in response variables are in relation to forage-adapted animal

<sup>3</sup>Changes in response variables are in relation to grain-adapted animal

<sup>4</sup>ND = not determined
The Role of Actisaf®

↗ BENEFICIAL ORGANISMS (Fibre digesters & lactate utilisers)

↗ Fibre digestion (NDF & ADF)

↗ Rate of fibre breakdown

↗ Rate of disappearance

↗ Nutrient absorption

↗ DMI

↗ Improved performance

Reduced lactate levels increased propionate

Microbial protein

Improved performance