Essential oils for beef cattle: how to improve ruminal fermentation and animal performance

Pietro Celi (DVM, PhD)

February 16, 2016
Presentation outline

• Overview
  - Essential oils
• Mode of Action
• Animal performances (Beef)
  - Higher daily weight gain
  - Feed efficiency
• Dosage - Recommendations
**Invited Review: Essential Oils as Modifiers of Rumen Microbial Fermentation**

S. Calsamiglia, M. Busquet, P. W. Cardozo, L. Castillejos, and A. Ferret

Grup de Recerca en Nutrició, Managí i Benestar Animal. Departament de Ciencia Animal i dels Aliments, Universitat Autònoma de Barcelona, 08193–Bellaterra, Spain

Table 1. Essential oils with antimicrobial activity, their main active components, and susceptible microorganisms

<table>
<thead>
<tr>
<th>Essential oil of</th>
<th>Name</th>
<th>Active components</th>
<th>Susceptible microorganisms</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allium sativum</td>
<td>Garlic</td>
<td>Allicin, diallyl sulfite</td>
<td>Enteropathogenic bacteria</td>
<td>Ross et al., 2001</td>
</tr>
<tr>
<td>Anethum graveolens</td>
<td>Dill</td>
<td>Limonene, carvone</td>
<td>Gram-positive and gram-negative bacteria</td>
<td>Deans and Ritchie, 1987</td>
</tr>
<tr>
<td>Capsicum annum</td>
<td>Paprika</td>
<td>Capsaicin</td>
<td>Gram-positive and gram-negative bacteria</td>
<td>Deans and Ritchie, 1987</td>
</tr>
<tr>
<td>Cinnamomum cassia</td>
<td>Cassia</td>
<td>Cinnamaldehyde</td>
<td><em>Escherichia coli, Staphylococcus aureus</em>, <em>Listeria monocytogenes</em>, <em>Salmonella enteritidis</em></td>
<td>Ouattara et al., 1997;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mahmoud, 1994;</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Smith-Palmer et al., 1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hammer et al., 1999</td>
</tr>
<tr>
<td>Juniperus oxycedrus</td>
<td>Juniper</td>
<td>Cadinene, pinene</td>
<td><em>Aeromonas sobria, Enterococcus fæcalis, Staph. aureus</em></td>
<td></td>
</tr>
<tr>
<td>Melaleuca alternifolia</td>
<td>Tea tree</td>
<td>Terpinen-4-ol</td>
<td><em>Staph. aureus, E. coli</em>, gram-positive and gram-negative bacteria</td>
<td>Chao and Young, 2000;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cox et al., 2001;</td>
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<td></td>
<td></td>
<td>Sivropoulou et al., 1996;</td>
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<td></td>
<td></td>
<td>Dorman and Deans, 2000;</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Deans and Ritchie, 1987</td>
</tr>
<tr>
<td>Origanum vulgare</td>
<td>Oregano</td>
<td>Carvacrol, thymol</td>
<td>Gram-positive and gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td>Pimpinella anisum</td>
<td>Anise</td>
<td>Anethol</td>
<td><em>Aeromonas hydrophila, Brevibacterium linens, Brochothrix thermosphacta</em></td>
<td></td>
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<tr>
<td>Rosmarinus officinalis</td>
<td>Rosemary</td>
<td>1,8-Cineole</td>
<td><em>Staph. aureus, L. monocytogenes, Campylobacter jejuni</em></td>
<td>Ouattara et al., 1997;</td>
</tr>
<tr>
<td>Syzygium aromaticum</td>
<td>Clove</td>
<td>Eugenol</td>
<td><em>E. coli, Staph. aureus, L. monocytogenes, S. enteritidis, C. jejuni</em></td>
<td>Smith-Palmer et al., 1998</td>
</tr>
<tr>
<td>Thymus vulgaris</td>
<td>Thyme</td>
<td>Thymol, carvacrol</td>
<td><em>Salmonella typhimurium, Staph. aureus, Aspergillus flavus</em></td>
<td>Juven et al., 1994;</td>
</tr>
<tr>
<td>Zingiber officinale</td>
<td>Ginger</td>
<td>Zingiberene, zingerone</td>
<td>Gram-positive and gram-negative bacteria</td>
<td>Ouattara et al., 1997;</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Chao and Young, 2000</td>
</tr>
</tbody>
</table>
Thymol: Reduction of N-ammonia, inhibited microboal population ...

Eugenol: Less acetate and more propionate in the rumen .... improved feed- and energy-efficiency ....

Vanillin, Limonene .......... Cinnamonaldehyde, Capsaicin ...
CRINA® Ruminants - a unique blend of essential oil compounds

Essential oils are

- Steam volatile secondary plant compounds
- Natural flavours and fragrances
- Natural plant defense systems
- Terpenes or phenols
- Antibacterial, antifungal, antimicrobial
- No fats, neither oils, nor indispensible!
Botanical: What’s the difference?

- **Plant extracts**
- **Essential Oils (EOs)**
- **Essential Oil Compounds**

**Plant extracts**
- Different and numerous molecules interacting
- (also including carbohydrates, fibre, protein,...)

**Essential Oils (EOs)**
- Mixtures of compounds obtained from plants
- (e.g. EOs of thyme)

**Essential Oil Compounds**
- Pure active compounds
- either extracted from plants
- or synthesized (nature identical)
- (e.g. Thymol)
Essential Oils (EOs)

- Natural vegetable products extracted by steam and / or water distillation

- Currently some 2,600 known EOs

- Mixtures of different chemical compounds (e.g. alcohol, esters, aldehydes, ketones) and small amounts of non-volatile residues (paraffins, waxes)

- Each compound having its own positive or negative properties

- Fluctuating compositions influenced by many factors e.g.:
  - Species
  - Soil
  - Climate
  - Harvesting
  - Storage
Influence of geographical origin on EOs profile

Rosemary from Spain

Rosemary from Tunisia

1. Alpha-Pinene
2. Camphene
3. Beta-Pinene
4. Eucalyptol
5. Camphor
Important Essential Oils Compounds

- **Eugenol**
  - Molecular formula: $C_{10}H_{12}O_2$
  - Chemical structure:
  - Characteristics/effects: analgesic, anaesthetic, antibacterial, antiherpetic, candicide, nematicide

- **2-Methoxyphenol (Guaiacol)**
  - Molecular formula: $C_7H_8O_2$
  - Chemical structure:
  - Natural occurrence: aromatic oil is derived from guaiacum or wood creosote (i.e. beech wood)
  - Characteristics/effects: expectorant, antiseptic, and local anaesthetic

- **3-Methylphenol**
  - Molecular formula: $C_7H_8O$
  - Chemical structure:
  - Natural occurrence: widely occurring in nature
  - Characteristics/effects: antiseptic
Important Essential Oils Compounds

- **Piperine**
  - Molecular formula: $C_{17}H_{19}NO_3$
  - Natural occurrence: ex. *Piper nigrum*
    (total content in black pepper: about 5% piperine)
  - Characteristics/effects: enhancing intestinal absorption, anti-inflammatory, anti-malarial, thermo genesis increasing

- **Thymol**
  - Molecular formula: $C_{10}H_{14}O$
  - Natural occurrence: *Monarda didyma*, L.
    (31% Thymol in essential oil)
  - Characteristics/effects: acaricide, anthelmintic, antibacterial, antiherpetic, antispasmodic, fungicide
Essential Oils Compounds Properties

- Many essential oil compounds have antimicrobial activities
- Thymol, eugenol, 2-methoxyphenol (guaiacol), 3-methylphenol,... develop their action against bacteria through interacting with the cell membrane
- This interaction causes conformational changes in the membrane structure, leading to the leakage of ions across the cell membrane. Bacteria can usually counterbalance these effects, but bacterial growth is slowed down.
- The spectrum of activity varies between compounds, with a main activity on Gram + bacteria, but some compounds have a wider spectrum and act as well on Gram - (i.e. thymol)
- Some essential oils stimulate the secretion of enzymes from the digestive glands (pancreas, salivary glands,...) and the intestinal wall
  - Piperine is a good example
Main Components of CRINA® Ruminants

All compounds are: food grade listed by the F.E.M.A. / G.R.A.S. all appear on EU Register of Feed Additive, (Reg.1831/2003)
Advantages of Nature Identical Compounds

- Selected and defined composition of essential oil compounds
- High potency and efficacy
- Standardized well defined product free of antagonistic substances
CRINA® products

Research & Development process

- *in vitro* evaluation
  - single compounds or in combination

*in vivo* validation
research stations

*in vivo* validation
commercial conditions

CRINA®
Ruminants
# Similarity between Ionophores and CRINA® Ruminants

<table>
<thead>
<tr>
<th>What is it</th>
<th>Hydrophobic</th>
<th>Attachment to bacterial cell membrane</th>
<th>Disturbs flow of nutrients</th>
<th>Effect mainly on gram positive bacteria</th>
<th>Effects in the rumen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionophores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C2/C3 ‾</td>
</tr>
<tr>
<td>Carboxylic Polyethers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Protein degradation ‾</td>
</tr>
<tr>
<td>Steam volatile plant compounds</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>NH₃ production ‾</td>
</tr>
<tr>
<td>Terpenes &amp; phenols</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control</th>
<th>CRINA® Ruminants</th>
<th>Rumensin®</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2 %</td>
<td>50.9</td>
<td>50.6</td>
</tr>
<tr>
<td>C3 %</td>
<td>28.5</td>
<td>33.8</td>
</tr>
<tr>
<td>C2/C3</td>
<td>1.8</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Meyer et al. 2009

<table>
<thead>
<tr>
<th>Control</th>
<th>Eugenol</th>
<th>Control</th>
<th>Monensin</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃ (mmol/l)</td>
<td>15.7</td>
<td>12.0</td>
<td>12.4</td>
</tr>
</tbody>
</table>

Castillejos et al 2006
Yang and Russell, 1993
Presentation outline

- Overview
  - Essential oils
- Mode of Action
- Animal performances (Beef)
  - Higher daily weight gain
  - Feed efficiency
- Dosage - Recommendations
Mode of action of CRINA® Ruminants

CRINA® Ruminants
Reduces the rate of degradation of some protein sources

CRINA® Ruminants
Reduces the deamination process

Rumen micro-organisms

Attachment
Colonisation

Feed particles

Protein
Peptides
AAs
NH₄⁺

Some rumen bacteria
e.g. Starch rich raw materials

High ammonia producing bacteria
e.g. Clostridium stricklandii

Some rumen bacteria
e.g. Starch rich raw materials
The essential oil compounds in CRINA® Ruminants modulate the rumen microflora. CRINA® Ruminants supports the synthesis of VFA and increases the production of microbial protein.
## CRINA® Ruminants

### Effect on bacteria degrading starch or amino acids (1)

<table>
<thead>
<tr>
<th>effect on growth of pure culture of rumen bacteria</th>
<th>IC(_{50}) Ino. (ppm) CRINA Ruminants (McIntosch et al., 2003)</th>
<th>Ruminal niche (Russell et al., 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clostridium sticklandii</strong></td>
<td>36.0</td>
<td>AA</td>
</tr>
<tr>
<td><strong>Peptostreptococcus anaerobius</strong></td>
<td>42.5</td>
<td>AA</td>
</tr>
<tr>
<td><strong>Selenomonas ruminantium</strong></td>
<td>57.0</td>
<td>ST, DX, SU, L, S</td>
</tr>
<tr>
<td><strong>Ruminococcus flavefaciens</strong></td>
<td>60.0</td>
<td>CU, HC</td>
</tr>
<tr>
<td><strong>Prevotella brevis</strong></td>
<td>57.5</td>
<td>ST, PC, XY, SU</td>
</tr>
<tr>
<td><strong>Prevotella albensis</strong></td>
<td>50.0</td>
<td>ST, PC, XY, SU</td>
</tr>
<tr>
<td><strong>Eubacterium ruminantium</strong></td>
<td>70.0</td>
<td>HC, DX, SU</td>
</tr>
<tr>
<td><strong>Anaerovibrio lipolytica</strong></td>
<td>73.8</td>
<td>GL, SU</td>
</tr>
<tr>
<td><strong>Veillonella parvula</strong></td>
<td>88.0</td>
<td></td>
</tr>
<tr>
<td><strong>Prevotella ruminicola</strong></td>
<td>33.8</td>
<td>ST, PC, XY, SU</td>
</tr>
<tr>
<td><strong>Fibrobacter succinogenes</strong></td>
<td>95.0</td>
<td>CU</td>
</tr>
<tr>
<td><strong>Butyrivibrio fibrisolvens</strong></td>
<td>56.2</td>
<td>ST, CU, HC, PC, SU</td>
</tr>
</tbody>
</table>

CU, cellulose  
HC, hemicellulose  
DX, dextrins  
SU, sugars  
St, starch  
PC, pectin  
XY, xylans  
L, lactate  
S, succinate  
GL, glycerol  
AA, amino acids

\(^a\)IC\(_{50}\) is the concentration of CRINA® Ruminants that led to a 50% in cell density at 24 h of incubation
CRINA® Ruminants
Effect on bacteria degrading starch or amino acids (2)

<table>
<thead>
<tr>
<th>effect on growth of pure culture of rumen bacteria</th>
<th>IC$_{50}$ Ino. (PPM) CRINA Ruminants (McIntosch et al., 2003)</th>
<th>Ruminal niche (Russell et al., 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Prevotella bryantii</em></td>
<td>54.0</td>
<td>ST, PC, XY, SU</td>
</tr>
<tr>
<td><em>Lachnospira multipara</em></td>
<td>112.5</td>
<td>PC, SU</td>
</tr>
<tr>
<td><em>Ruminococcus albus</em></td>
<td>49.0</td>
<td>CU, HC</td>
</tr>
<tr>
<td><em>Ruminobacter amylophilus</em></td>
<td>42.6</td>
<td>ST</td>
</tr>
<tr>
<td><em>Mitsuokella multiacidas</em></td>
<td>113.5</td>
<td></td>
</tr>
<tr>
<td><em>Megasphaera elsdenii</em></td>
<td>113.0</td>
<td>L, SU</td>
</tr>
<tr>
<td><em>Lactobacillus casei</em></td>
<td>56.2</td>
<td>ST, SU</td>
</tr>
<tr>
<td><em>Streptococcus bovis</em></td>
<td>127.5</td>
<td>AA</td>
</tr>
<tr>
<td><em>Clostridium aminophilum</em></td>
<td>94.2</td>
<td></td>
</tr>
</tbody>
</table>

involved in starch fermentation (Nagaraja, 2007)

IC$_{50}$ is the concentration of CRINA® Ruminants that led to a 50% in cell density at 24 h of incubation.

CU, cellulose  
PC, pectin  
HC, hemicellulose  
DX, dextrins  
SU, sugars  
St, starch  
XY, xylans  
L, lactate  
S, succinate  
GL, glycerol  
AA, amino acids
CRINA® Ruminants

Effect on the microbial attachment and colonisation

CRINA Ruminants reduces the attachment of rumen microbes on feed particles and their colonisation
CRINA® Ruminants

*reduced protease activity on some protein sources*

Effect of CRINA® Ruminants on the microbial attachment and colonisation
Impact on the attached protease activity on different protein sources

<table>
<thead>
<tr>
<th>Protein Source</th>
<th>Crina</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soya bean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish meal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rape seed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Attached protease activity (mg casein/ g wet weight/ hr)

Source: Rowett and Crina, 2001
CRINA® Ruminants

Effect on the degradability of soybean meal

Soybean meal

DM digestion (%)

Incubation time (h)

Control  Crina Ruminants

P < 0.07

P < 0.09

0h  2h 4h 6h 8h 16h 24h 48h

Soybean meal
## CRINA® Ruminants

**Influence on proteolysis to ammonia (NH₃)**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>CRINA® Ruminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>0.46</td>
<td>0.49</td>
</tr>
<tr>
<td>Oligopeptide</td>
<td>1.03</td>
<td>1.22</td>
</tr>
<tr>
<td>Dipeptide</td>
<td>0.60</td>
<td>0.69</td>
</tr>
<tr>
<td>Amino acids</td>
<td>410</td>
<td>372*</td>
</tr>
<tr>
<td>Ammonia (NH₃)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(nmol NH₃ / mg protein / min)</td>
<td></td>
</tr>
</tbody>
</table>

* P<0.05

Data from 4 dairy cows receiving concentrate: maize silage
CRINA Ruminants dosage at 1 g/d

Source: adapted from McIntosh F.M. et al., 2003
Getting more out of the feed

- By inhibiting hyperammonia-producing bacteria CRINA® Ruminants has a direct and beneficial effect on protein digestion by:
  - Slowing down the rate of protein digestion
  - Reducing protein degradability
  - Increasing the proportion of by-pass protein and boosting the value of lower grade protein sources
  - Reducing the amount of amino acids that are degraded to ammonia
CRINA® Ruminants Improves Propionate Concentration

### In vitro (dairy cows)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>CRINA® Ruminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCFA mmol/l</td>
<td>76.5^a</td>
<td>72.2^b</td>
</tr>
<tr>
<td>Acetate %</td>
<td>67.3^a</td>
<td>64.5^b</td>
</tr>
<tr>
<td>Propionate %</td>
<td>22.9^a</td>
<td>27.8^b</td>
</tr>
<tr>
<td>Butyrate %</td>
<td>5.5^a</td>
<td>4.9^b</td>
</tr>
</tbody>
</table>

Source: Kung et al., 2008, J. Dairy Sci, 91, 4793-4800

### In vivo (beef cattle)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>CRINA® Ruminants</th>
<th>Rumensin®</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCFA mmol/l</td>
<td>109.2^ab</td>
<td>125.2^c</td>
<td>104.7^a</td>
</tr>
<tr>
<td>Acetate %</td>
<td>50.9</td>
<td>50.6</td>
<td>50.1</td>
</tr>
<tr>
<td>Propionate %</td>
<td>28.5</td>
<td>33.8</td>
<td>32.8</td>
</tr>
<tr>
<td>Butyrate %</td>
<td>12.9</td>
<td>9.9</td>
<td>11.2</td>
</tr>
</tbody>
</table>

(Means without a common superscript are significantly different (P<0.05)

Source: Meyer et al., 2009, J. Anim. Science

More available energy for milk production and weight gain
Nutritional Benefits of CRINA® Ruminants

Rumen - degradation of

Protein ↓ → + 5 % more bypass protein!
Starch ↓ → + 3 % more bypass starch!
NDF ↑ → + 2 % more digestible!

Rumen - volatile fatty acids

Propionate concentration ↑ → more available energy
Presentation outline

• Overview
  - Essential oils
• Mode of Action
• Animal performances (Beef)
  - Higher daily weight gain
  - Feed efficiency
• Dosage - Recommendations
Effect of CRINA® Ruminants on weight gain and feed efficiency in beef cattle

Species: Beef Cattle
Country: USA, Nebraska

Objective
- To compare the effects of CRINA® Ruminants and Rumensin (monensin) with and without Tylan (tylosin phosphate) on performance of beef cattle

Trial details
- 376 crossbred yearling steers
- Treatments:
  - Control: 66% high moisture corn, 16.5% dry rolled corn, 7.5% alfalfa hay, 5% molasses, 5% concentrates
  - + CRINA® Ruminants 1g/hd/d
  - + CRINA® Ruminants 1g/hd/d + Tylan 90 mg/hd/d
  - + Rumensin 300 mg/hd/d + Tylan 90 mg/hd/d
- Parameters measured: Dry matter intake, body weight, average, daily gain, kg gain to kg feed, Liver abscesses, fermentation pattern

Results

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>CRINA®</th>
<th>CRINA® + Tylan®</th>
<th>Rumensin + Tylan®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW, kg</td>
<td>408</td>
<td>406</td>
<td>407</td>
<td>407</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>610</td>
<td>615</td>
<td>617</td>
<td>611</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>12.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.4&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.76</td>
<td>1.81</td>
<td>1.83</td>
<td>1.78</td>
</tr>
<tr>
<td>Gain : Feed</td>
<td>0.145&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.151&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.153&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.156&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total liver abscesses %</td>
<td>27.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.6&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>8.6&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>6.5&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Conclusions & Benefits

CRINA® Ruminants:
- Increased feed efficiency in finishing steers
- Decreased liver abscesses

Source: Meyer et al., 2009, J. Anim. Science
CRINA® improves propionate concentration in the rumen of beef cattle

<table>
<thead>
<tr>
<th>Mmol/L</th>
<th>Control</th>
<th>CRINA®</th>
<th>Rumensin®</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCFA</td>
<td>109&lt;sub&gt;ab&lt;/sub&gt;</td>
<td>125&lt;sup&gt;c&lt;/sup&gt;</td>
<td>105&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Acetate</td>
<td>55.5</td>
<td>63.3</td>
<td>52.6</td>
</tr>
<tr>
<td>Propionate</td>
<td>31.1</td>
<td>42.3</td>
<td>34.4</td>
</tr>
</tbody>
</table>

Source: Meyer et al., 2009, J. Anim. Science

More propionate = more glucose = more energy = higher weight gain
Effect of CRINA® Ruminants on weight gain and feed efficiency in beef cattle

Species: Beef Cattle
Country: USA, Nebraska

Objective
- To compare the effects of CRINA® Ruminants and Rumensin (monensin) with and without Tylan (tylosin phosphate) on performance of beef cattle

Trial details
- 376 crossbred yearling steers
- Treatments:
  - Control: 66% high moisture corn, 16.5% dry rolled corn, 7.5% alfalfa hay, 5% molasses, 5% concentrates
  - + CRINA® Ruminants 1g/hd/d
  - + CRINA® Ruminants 1g/hd/d + Tylan 90 mg/hd/d
  - Rumensin 300 mg/hd/d + Tylan 90 mg/hd/d
- Parameters measured: Dry matter intake, body weight, average, daily gain, kg gain to kg feed, Liver abscesses, fermentation pattern

Conclusions
CRINA Ruminants compared to untreated control, improved:
- ADG: +2.3%
- Feed Efficiency: -3.8%
- DMI: -1.2%
- Incidence liver abscesses was significantly reduced

CRINA Ruminants + Tylan = Rumensin + Tylan

Benefits
CRINA® Ruminants:
- Increased propionate concentration yielding more available energy for weight gain.
- ROI = 3:1 (Based on improved weight gain)

Source: Meyer et al., 2009, J. Anim. Science
Effect of CRINA® Ruminants & RONOZYME® RumiStar on Finishing Cattle

Species: Finishing Cattle
Country: Brazil

Objective

- To evaluate the combination of essential oils and exogenous enzymes on performance of Nellore bulls finished in a feedlot

Trial details

- Animals: 300 Nellore bulls (initial BW = 330 ± 33 kg)
- Basal Diet: 82.5% corn, 8.5% sugarcane bagasse, 5% SBM, 3% minerals, 1% urea
- Experimental: duration 90 days,
- Treatments:
  - T1- Monensin (Tortuga, 26mg/kg DM)
  - T2- CRINA® Ruminants (90 mg/kg DM)
  - T3- CRINA® Ruminants + Monensin (90 & 26 mg/kg DM, resp.)
  - T4- CRINA® Ruminants + RONOZYME® RumiStar (90 & 560 mg/kg DM resp.)

Conclusions & Benefits

- When a combination of RONOZYME® RumiStar + CRINA® Ruminants were supplemented;
  - Slaughter weight (HCW) was 5% heavier vs. Monensin
  - ADG was 12% higher compared to Monensin
  - Dry Matter Intake was 9% higher compared to Monensin

CRINA® improves weight gain and feed intake in Angus crossbreds in Australia

<table>
<thead>
<tr>
<th>Day 30</th>
<th>Control</th>
<th>Monensin</th>
<th>CRINA®</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, kg/d</td>
<td>1.75</td>
<td>1.58</td>
<td>1.83</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>7.3</td>
<td>6.5</td>
<td>7.2</td>
</tr>
<tr>
<td>FE, ADG:DMI</td>
<td>0.240</td>
<td>0.243</td>
<td>0.254</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 85</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, kg/d</td>
<td>1.57</td>
<td>1.54</td>
<td>1.68</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>7.8</td>
<td>7.2</td>
<td>7.9</td>
</tr>
<tr>
<td>FE, ADG:DMI</td>
<td>0.201</td>
<td>0.213</td>
<td>0.212</td>
</tr>
</tbody>
</table>

Queensland Department of Primary Industries & Fisheries, Brigalow Research Station Feedlot Research Facility, Theodore, Queensland, Australia, 2005)

Increase in DWG of up to 16% and of DMI of 11% compared to positive control.
Weight gain and feed intake in cattle during the first 28 days in feedlot in Brazil

<table>
<thead>
<tr>
<th></th>
<th>MONENSIN</th>
<th>Fosbovi CRINA®</th>
<th>Fosbovi CRINA® + RumiStar™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW (kg)</td>
<td>330.8</td>
<td>330.8</td>
<td>330.6</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>382.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>388.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>391.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>1.352&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.550&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.667&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>7.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.41&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>FE, ADG:DMI</td>
<td>0.177&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.190&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.199&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Increase in DWG of up to 23% and of DMI of 9% compared to positive control.
Weight gain and feed intake in cattle during the first 90 days in feedlot in Brazil

<table>
<thead>
<tr>
<th></th>
<th>MONENSIN</th>
<th>Fosbovi CRINA®</th>
<th>Fosbovi CRINA® + RumiStar™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW (kg)</td>
<td>330.8</td>
<td>330.8</td>
<td>330.6</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>476.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>486.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>494.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>1.615&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.722&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.812&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>8.64&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.24&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>9.45&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>FE, ADG:DMI</td>
<td>0.187</td>
<td>0.187</td>
<td>0.193</td>
</tr>
</tbody>
</table>

Advantage of the treatment groups remained until end of the fattening period.
Presentation outline

- Overview
  - Essential oils
- Mode of Action
- Animal performances (Beef)
  - Higher daily weight gain
  - Feed efficiency
- Dosage - Recommendations
## Supplementation Guidelines

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>100 kg BW</th>
<th>200 kg BW</th>
<th>400 kg BW</th>
<th>600 kg BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cows</td>
<td>1 g/hd/d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef cattle</td>
<td>150 - 200 mg/hd/d</td>
<td>300 - 400 mg/hd/d</td>
<td>600 - 800 mg/hd/d</td>
<td>900 - 1200 mg/hd/d</td>
</tr>
<tr>
<td>Sheep, goats</td>
<td>100 mg/hd/d</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>