XXXI Reunión Científica Anual de la
Asociación Peruana de Producción Animal
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Manipulacion del ecosistema ruminal

¿Qué perspectivas?

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ALIMENTACIÓN
AGRICULTURA
MEDIO AMBIENTE

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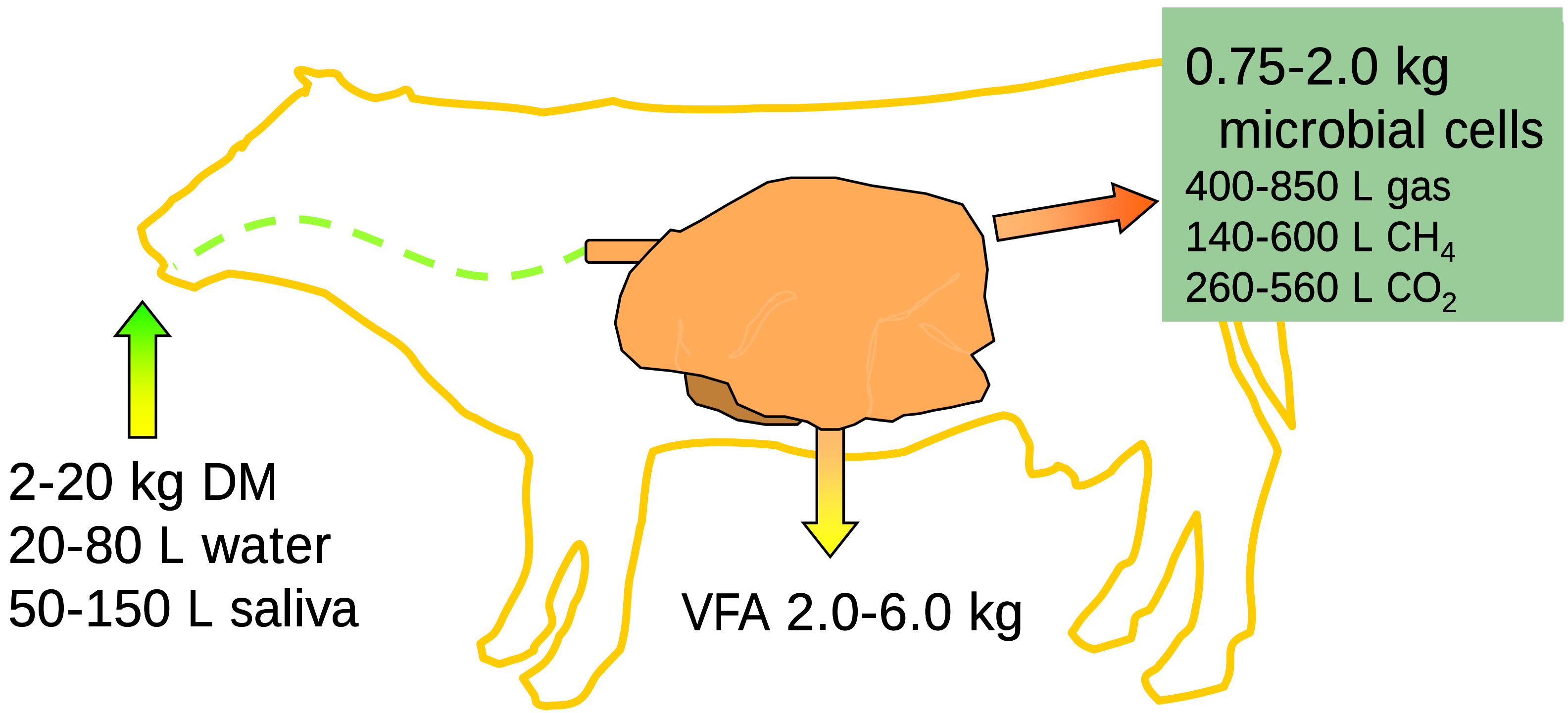
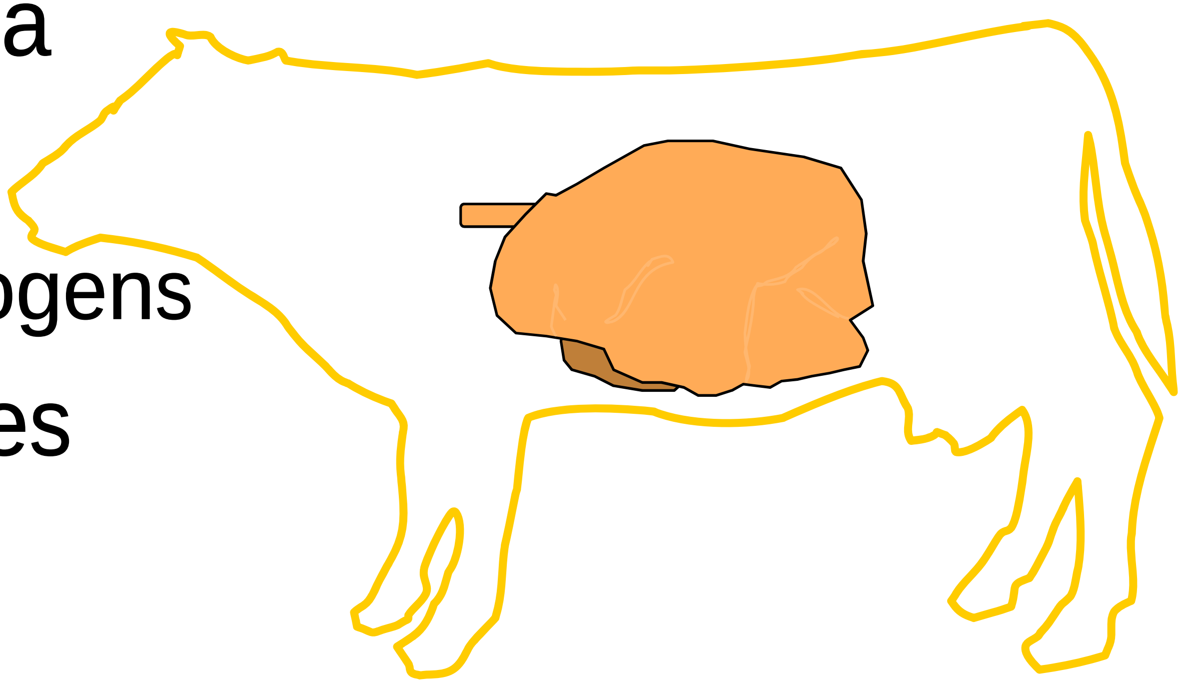


0.75-2.0 kg microbial cells
400-850 L gas
140-600 L CH_4
260-560 L CO_2
2-20 kg DM
20-80 L water
50-150 L saliva
VFA 2.0-6.0 kg

Microbial Groups in the Rumen

- Eubacteria
- Archaea
  - Methanogens
- Eukaryotes
  - Protists
  - Fungi



Gastrointestinal symbionts

PROVIDE

- Energy
  VFA can provide up to 80% of the energy needs
- Protein
  microbes convert NPN into high quality protein
- Vitamins
  synthesis of B-complex and K vitamins
- Detoxifying functions

Why do we want to modify the rumen microbiota?

- To enhance beneficial processes
- To reduce or eliminate inefficient processes
- To reduce or suppress processes detrimental to the host
- To restore the normal microbiota

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Objetivos tradicionales

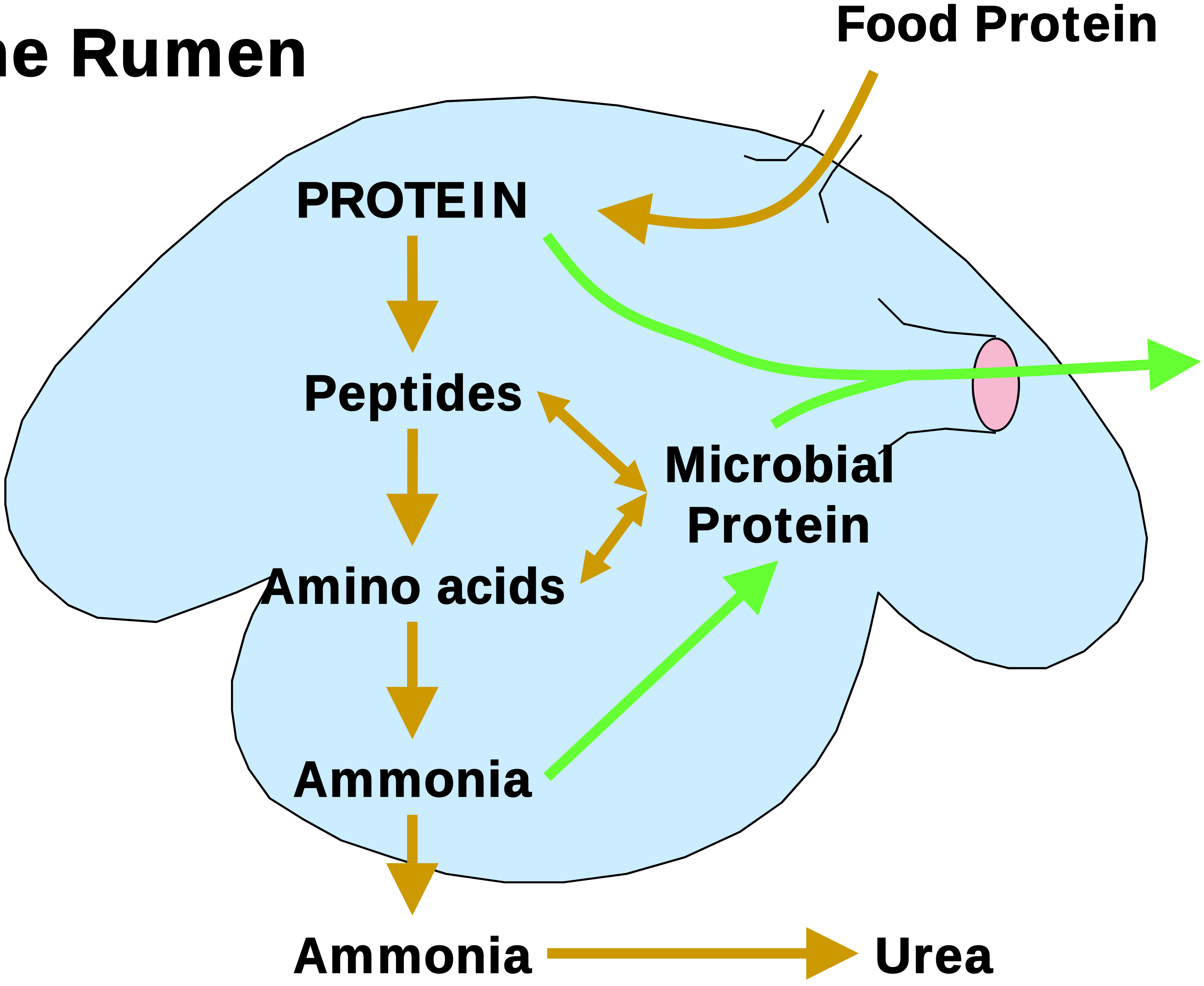
- ↑ digestion de fibras
- ↓ velocidad de degradacion

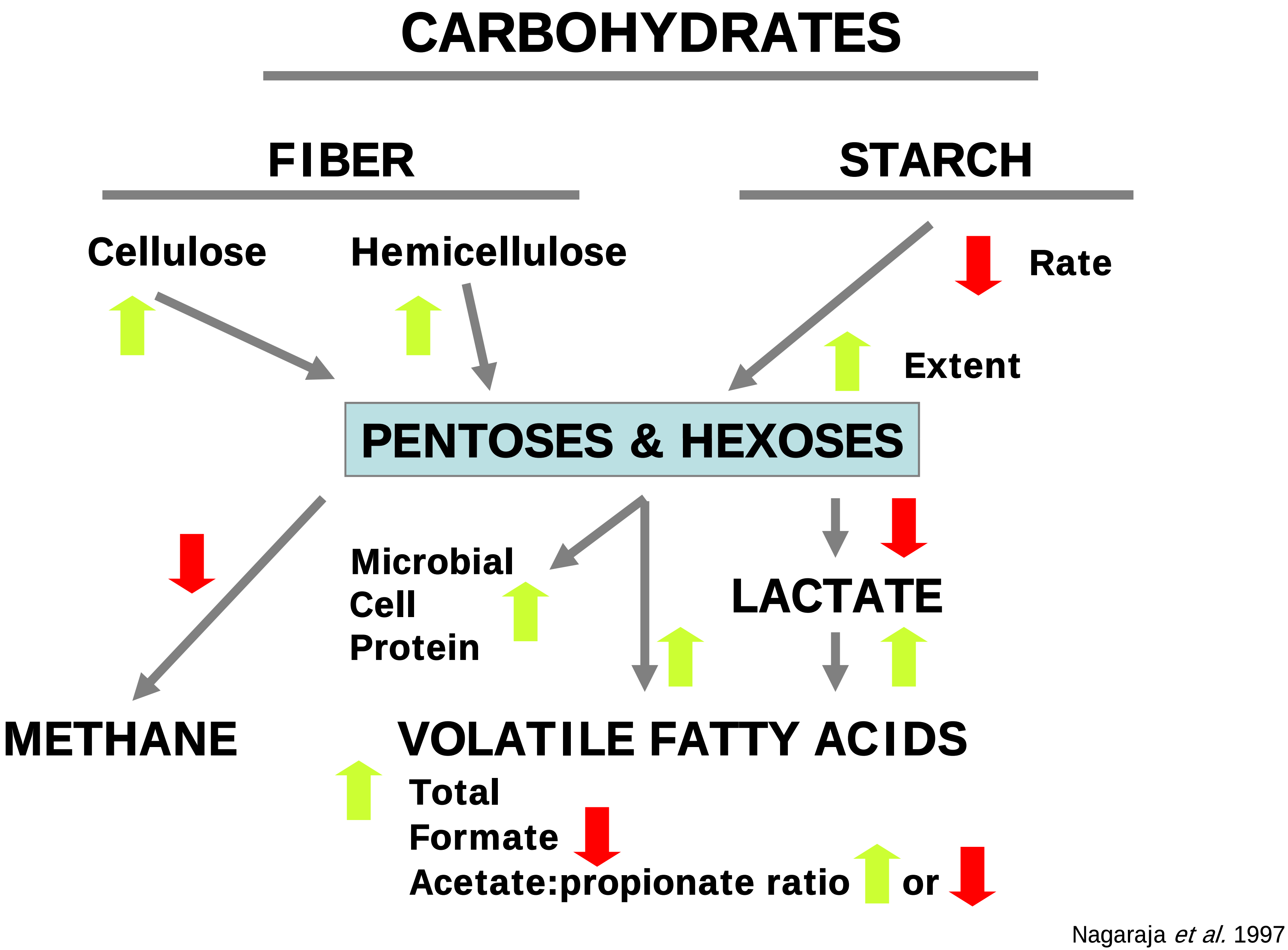
  carbohidratos fermentescibles (rumen)
- ↓ degradacion de proteinas (rumen)
- ↑ balance de energia
  - C2:C3
  - CH_4

Nuevos Objetivos

- ↓ eliminacion NH_3
- ↓ emision de CH_4
- ↑ calidad de productos
  - Valor sanitario
  - Valor nutricional

Protein Metabolism in the Rumen




CARBOHYDRATES
FIBER
STARCH
Cellulose
Hemicellulose
Rate
Extent
PENTOSES & HEXOSES
Microbial
Cell
Protein
LACTATE
METHANE
VOLATILE FATTY ACIDS
Total
Formate
Acetate:propionate ratio
or
Nagaraja et al. 1997

Approaches to Modify Rumen Fermentation

Types of interventions

- Dietary
- Animal
- Microbial

Dietary Intervention

↑ Digestibility of plant fiber

↓ Feed protein degradation

Feeding management

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Animal Intervention

- Feed intake
- Saliva production
- Gut functionality

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Microbial Intervention

- Buffers
- Growth factors
  - Vitamins
  - Minerals
- Fat supplementation
- Ionophore antibiotics
- Other antibiotics
- Probiotics
- Enzymes
- Plants & plant extracts
  - Tannins
  - Saponins
  - Essential oils
- …

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PROBIOTICS

"Viable microbes used as dietary supplements having potential for improving health or nutrition of the host upon ingestion"

Probiotics for Ruminants

Bacterial

- Lactobacilli
- Bifidobacteria
- Propionibacteria
- Streptococci
- Enterococci
- (*E. coli*)

Yeast

- *Saccharomyces cerevisiae*
- *Aspergillus oryzae*

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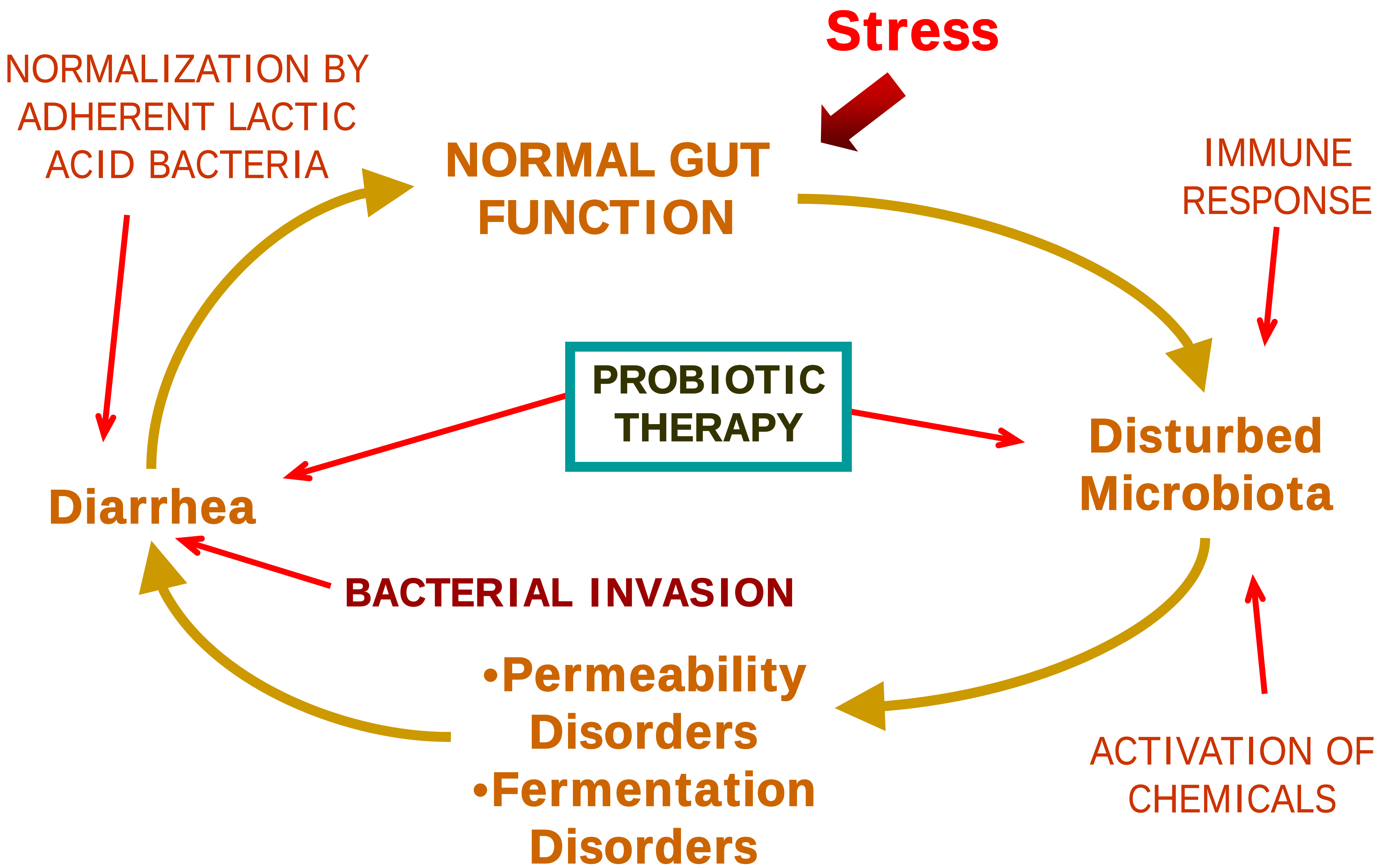
Mode of Action of Probiotics

Stress

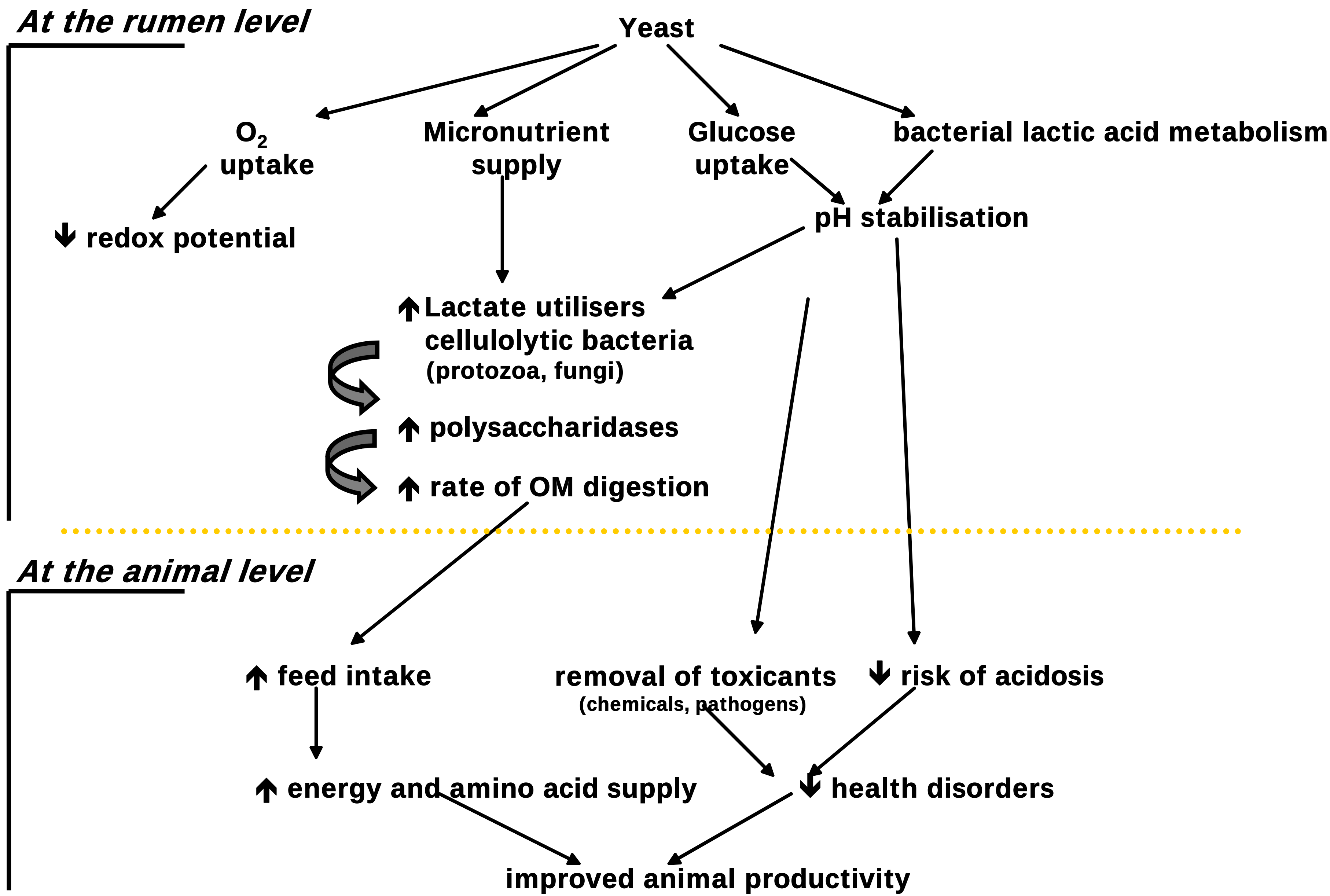
NORMAL GUT FUNCTION

- Transportation
- Change of feed
- Weather
- Antibiotic treatment
- Infection
- Toxins

Mode of Action of Probiotics



Mode of Action of Yeast Probiotics



Jouany & Morgavi, 2007

Yeast probiotics

- Common feed additive in ruminants
- Data from 122 in vivo trials
(meta-analysis, Sauvant 2005)

↑ Milk yield 1.3 kg/d

↑ ADF digestibility 2.8%

- Increases
  - Total & cellulolytic bacteria
  - Microbial protein synthesis & microbial growth
  - NDF degradability

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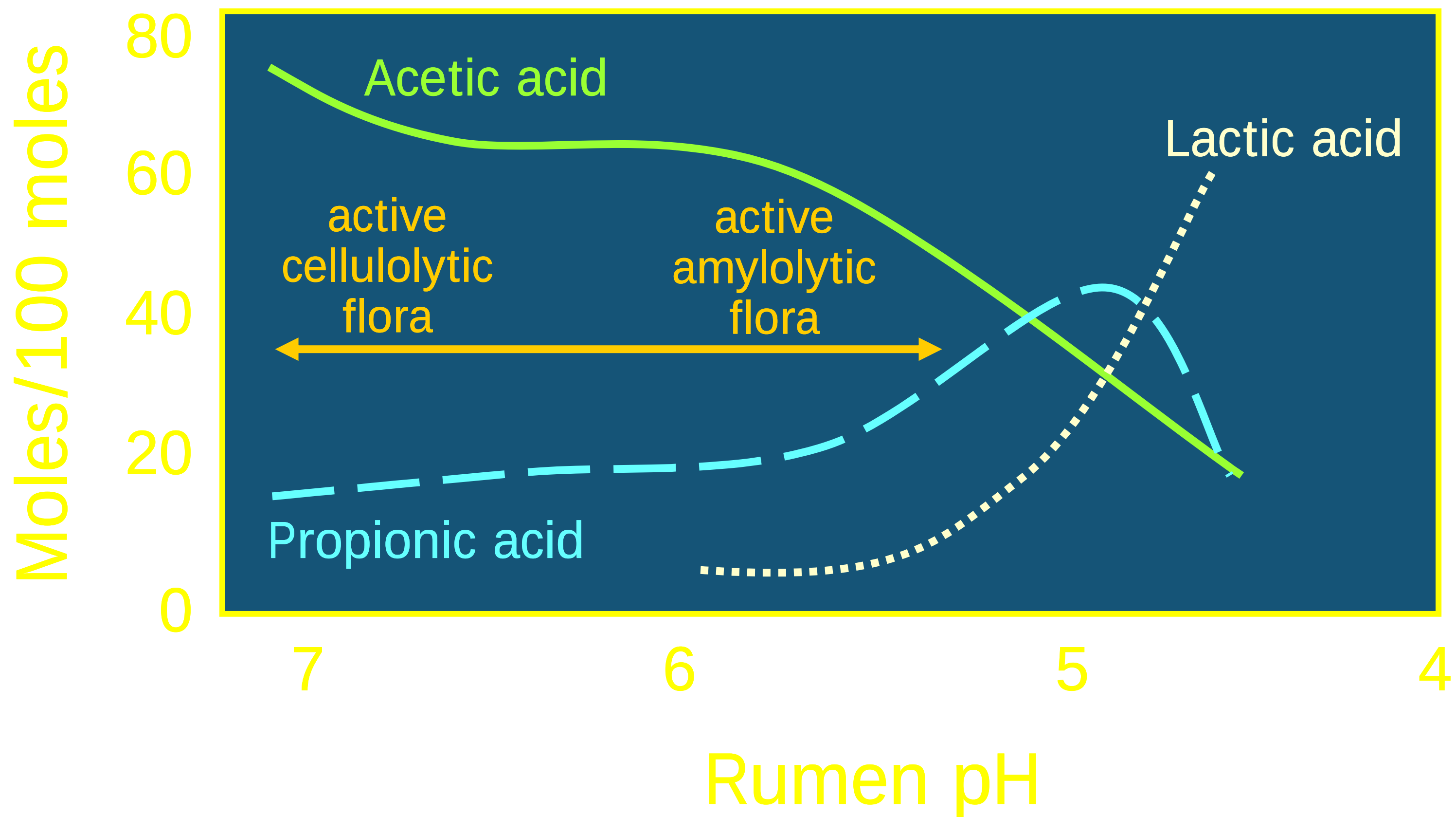
[redacted]



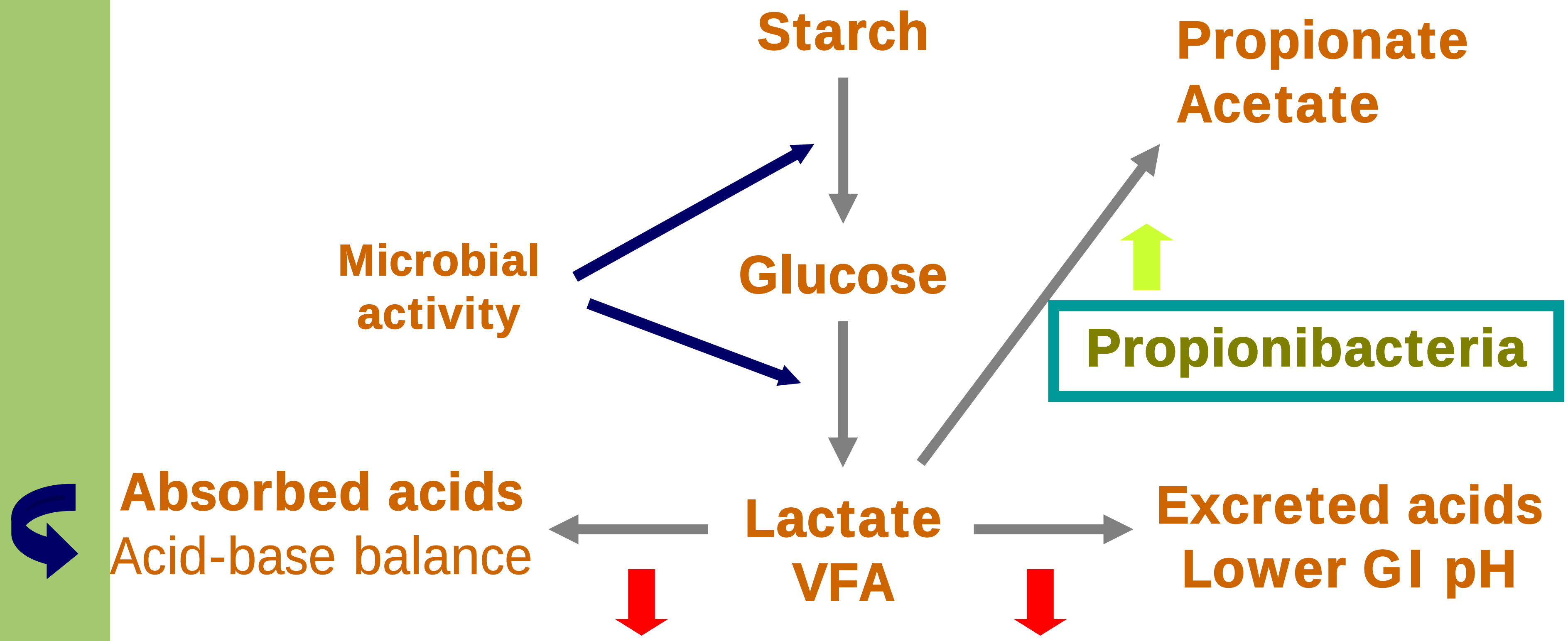
Moles/100 moles
80
60
40
20
0
Acetic acid
Lactic acid
active
cellulolytic
flora
active
amylolytic
flora
Propionic acid
7
6
5
4
Rumen pH

Propionibacteria

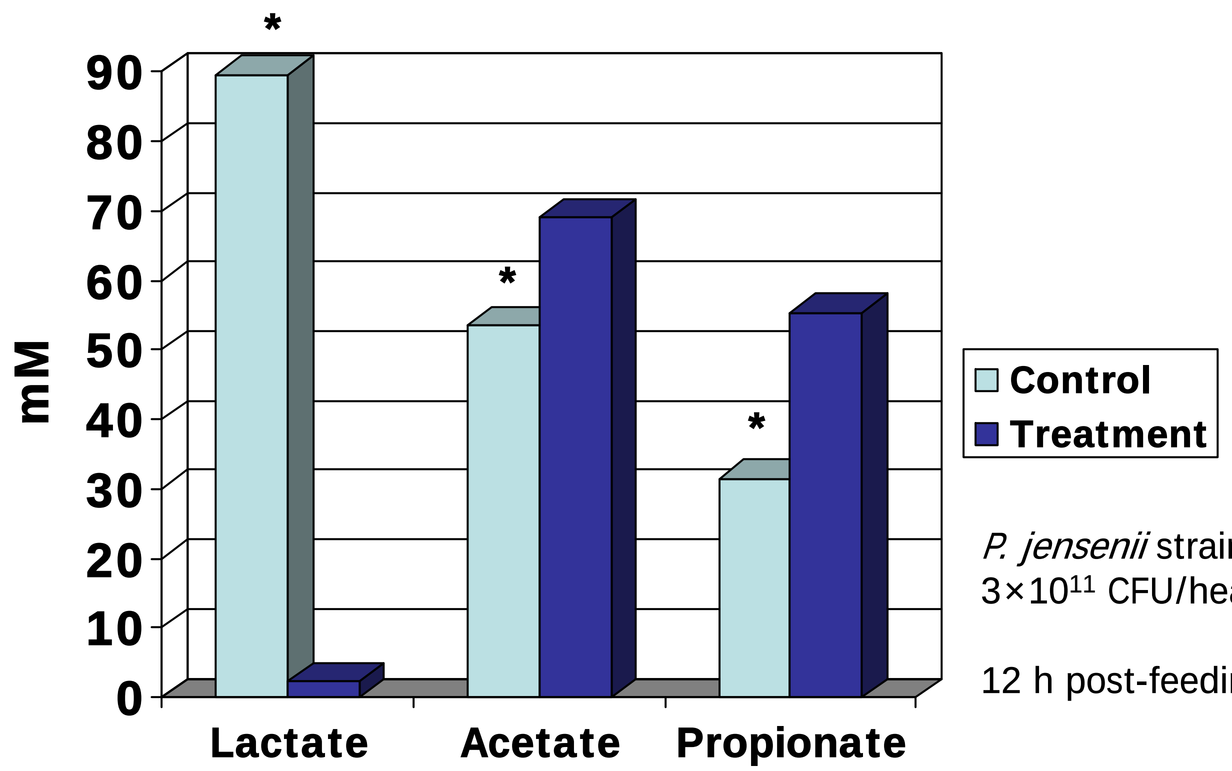
Biochemical properties

- Produce propionic and acetic acid
- Utilize lactic acid
- Reduce nitrates and nitrites to N_2
- Produce broad spectrum antimicrobials
- Produce agglutinating factors

Proposed Role of Propionibacteria



Effects of *Propionibacterium jensenii* on ruminal metabolism during acute acidosis



P. jensenii strain P-63
3×10^{11} CFU/head/day

12 h post-feeding

Swinney-Floyd, 1997

Summary of Effects of Propionibacteria

- Propionate ↑
- Average daily gain ↑
- Dry matter intake ↓ or ↑
- Feed conversion efficiency ↑
- Carcass weight ↑

But not always!

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Other bacterial probiotics and uses

- Lactate producers (Lactobacilli, Enterococci)
- Rumen strains
- To reduce pathogens loads and shedding

  Most effective against *E. coli* O157

  Lactobacillus acidophilus NP51 (NPC 747) and *Propionibacterium freudenreichii*

review Sargeant et al. 2007

Exogenous enzymes

- Milk production
  ↑ 1.05 ± 1.41 kg/d

  Avg 49 treatments (Beauchemin et al.)

- Beef production
  fewer studies, increases of up to 9% ADG reported

High producing animals

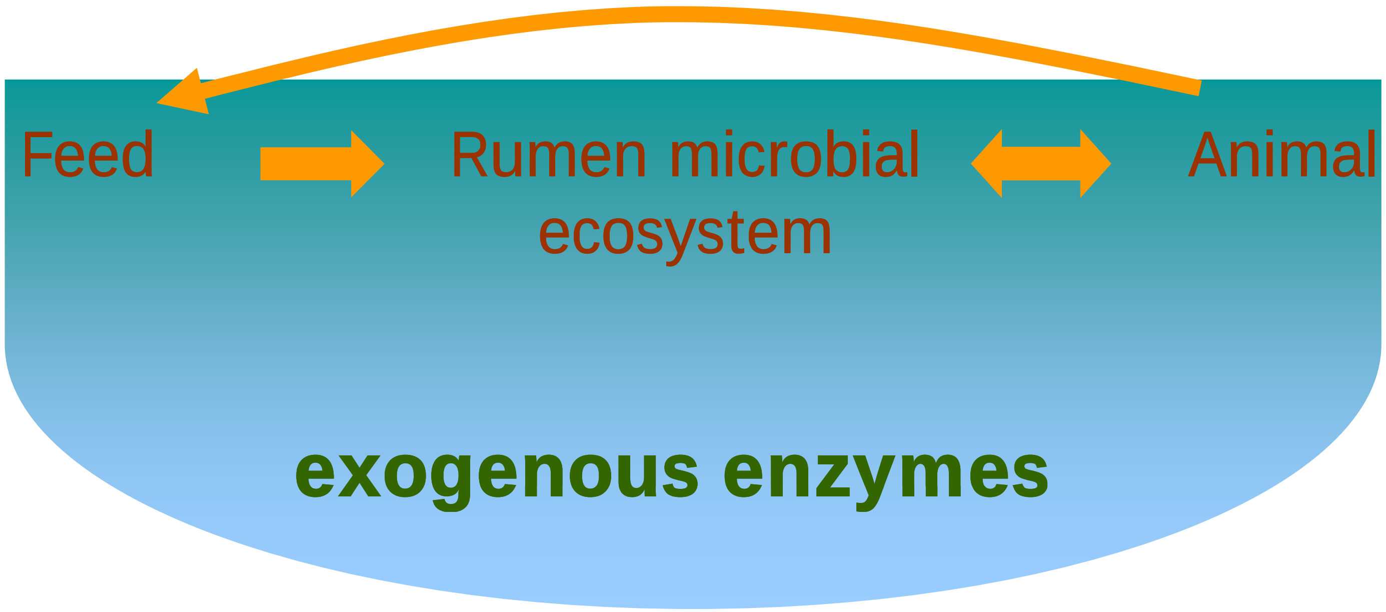
Change in diet

↑ Intake

↑ Rate of passage

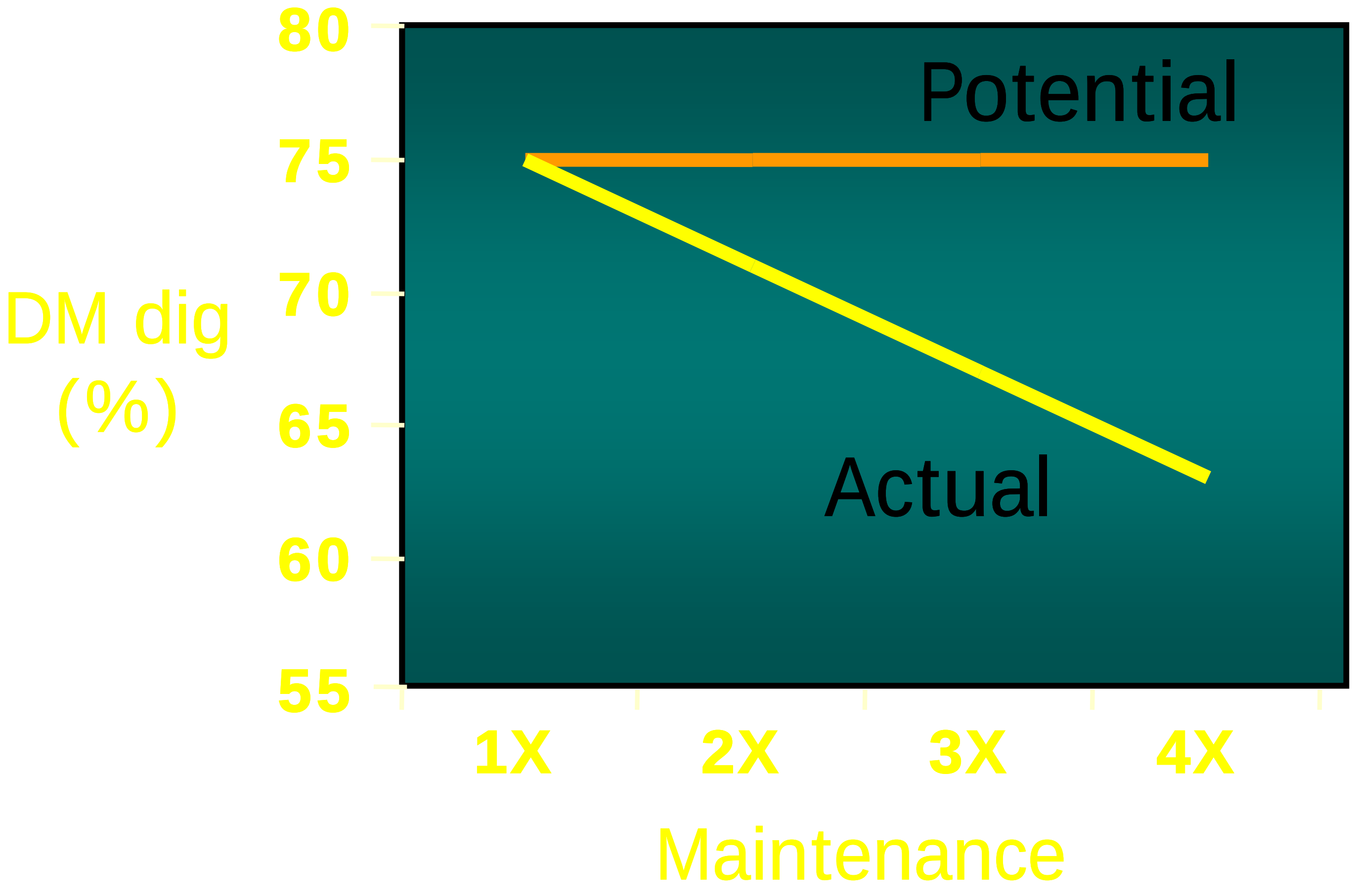
Altered homeostasis

Nutrient deficiencies



“Stress situation”

Expected depression in digestibility (NRC)



Factors affecting feed enzymes efficacy

- Enzyme product
- Diet composition
- Rumen microbial ecosystem
- Level and method of supplementation
- Production level

}

Mode of action

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Plants and Plant extracts

- Plant secondary compounds
- Defense mechanism
- Antimicrobial activity
- Used in animal nutrition
  - Flavoring
  - Influence digestion

Plants and Plant Extracts

- Tannins
- Saponins
- Essential oils

Limitations for adoption

- Product variability
- Loss of some properties during storage
- Toxicity

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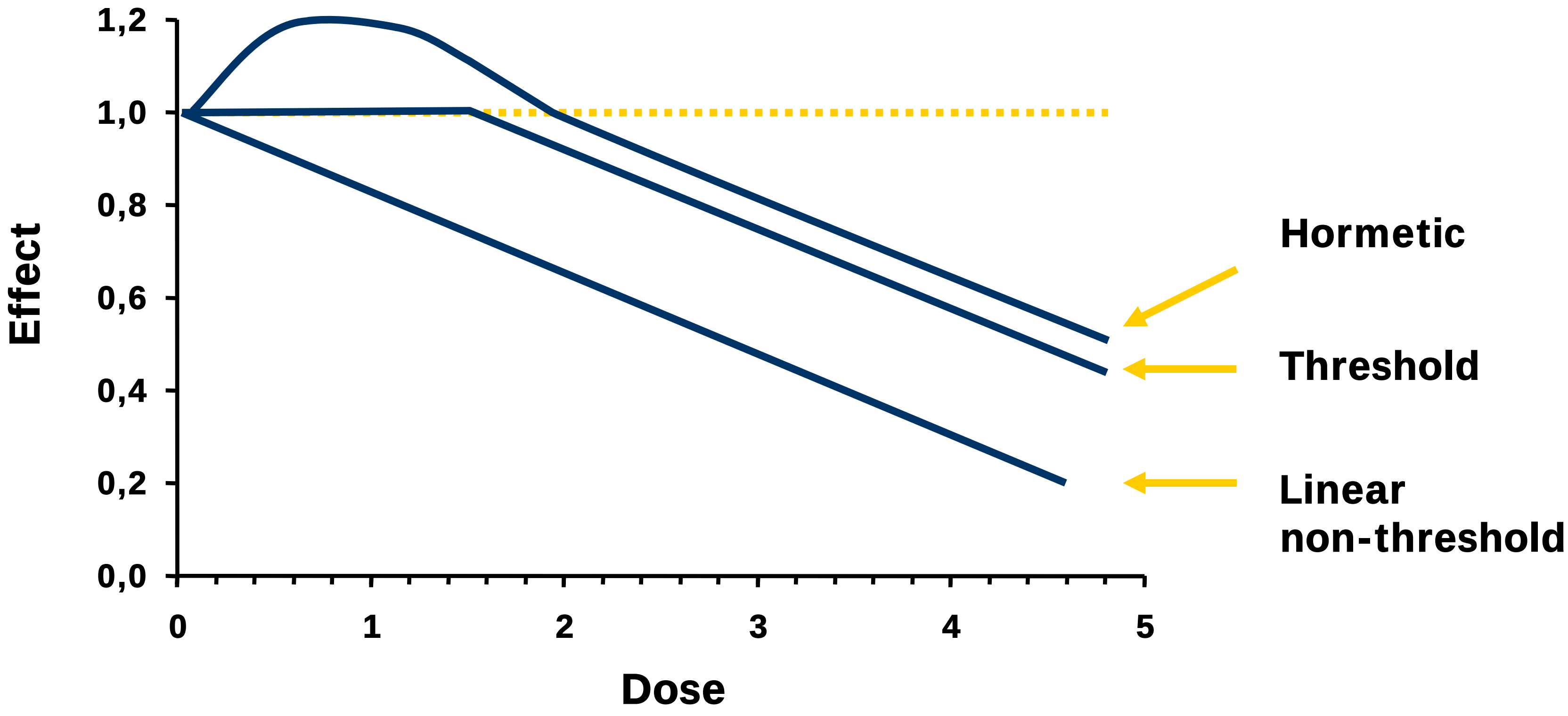
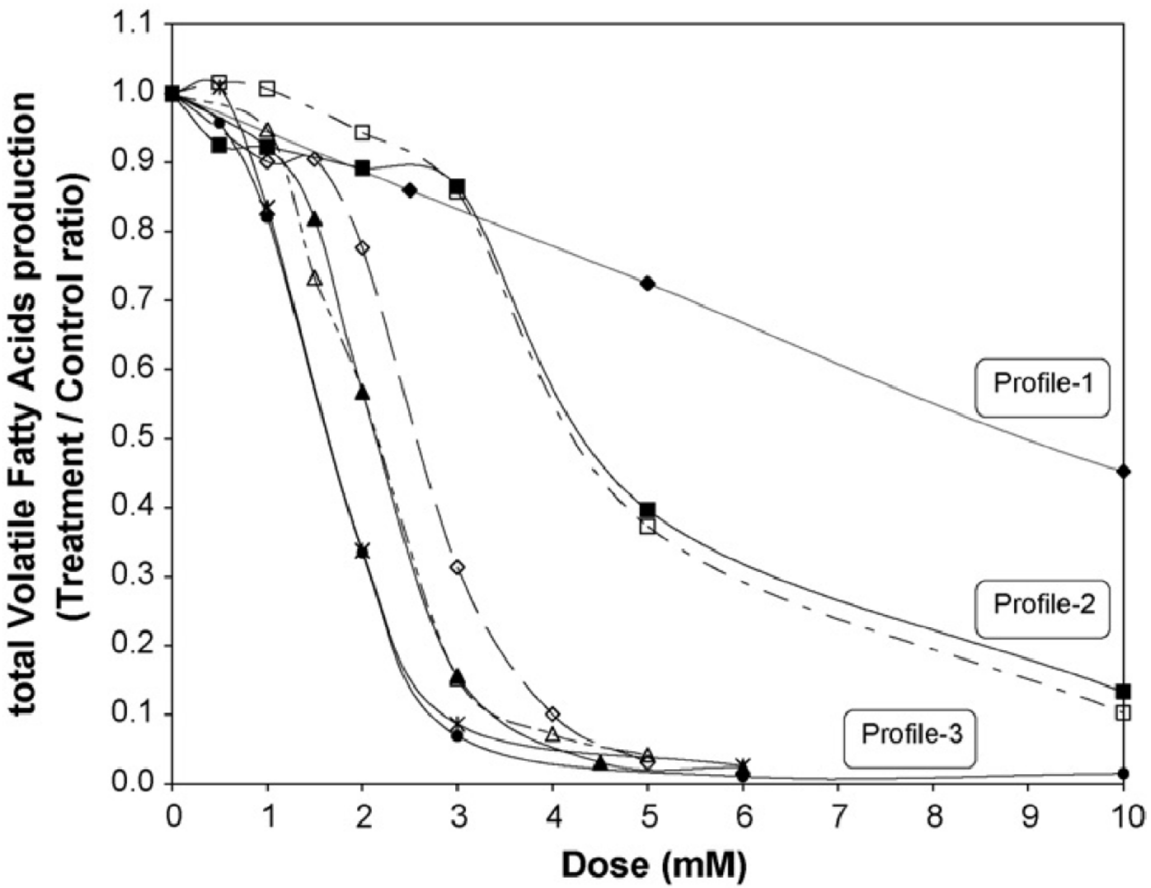
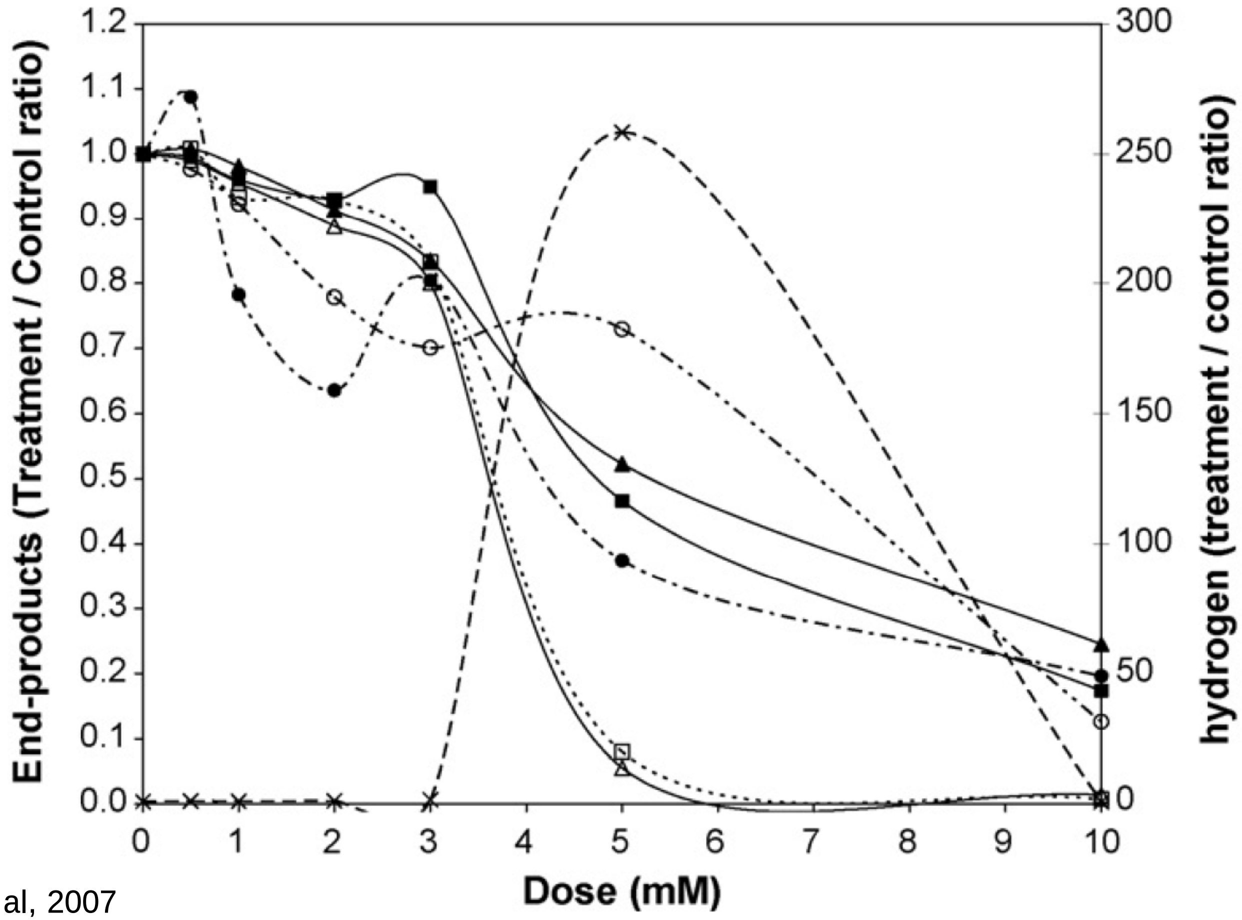
Toxic effect



Adapted from Calabrese & Baldwin, 2003



Macheboeuf et al, 2007



Macheboeuf et al, 2007

Nuevos Objetivos

- ↓ eliminacion NH_3
- ↓ emision de CH_4
- ↑ calidad de productos
  - Valor sanitario
  - Valor nutricional

Why methane?

- Loss of energy

~ 6-8% intake

- Environmental problem

Enteric methane is the most important component of greenhouse gas emissions in ruminant production

  - Beef cattle 60~70 kg/yr
  - Dairy cattle 110~145 kg/yr
  - Sheep 8 kg/yr

Livestock and the Environment

- Grazing - 26% earth's surface
  - – 70% dry areas degraded by overgrazing
- Feed crops - 33% arable land
- Consumes 8% water
  - – Contributes to contamination
- 18% GHG emissions
  - – 37% methane

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Some proposed tactics …

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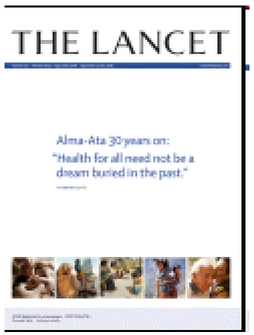
  UN: eat less meat to curb global warming

  R. Pachauri
  Chairman IPCC

- 

  McMichael et al. Lancet 2007

  Food, livestock production, energy, climate change, and health .

  "To prevent increased greenhouse-gas emissions from this production sector, both the average worldwide **consumption** level of animal products and the **intensity** of emissions from livestock production must be reduced."

… contrast with the reality

- World Animal Production

Previsions 2050:

+ 50% meat and milk production

- To consider:
  - Capacity to use forage feeds by ruminants
  - Social, cultural and economic role of ruminants
  - Landscape preservation

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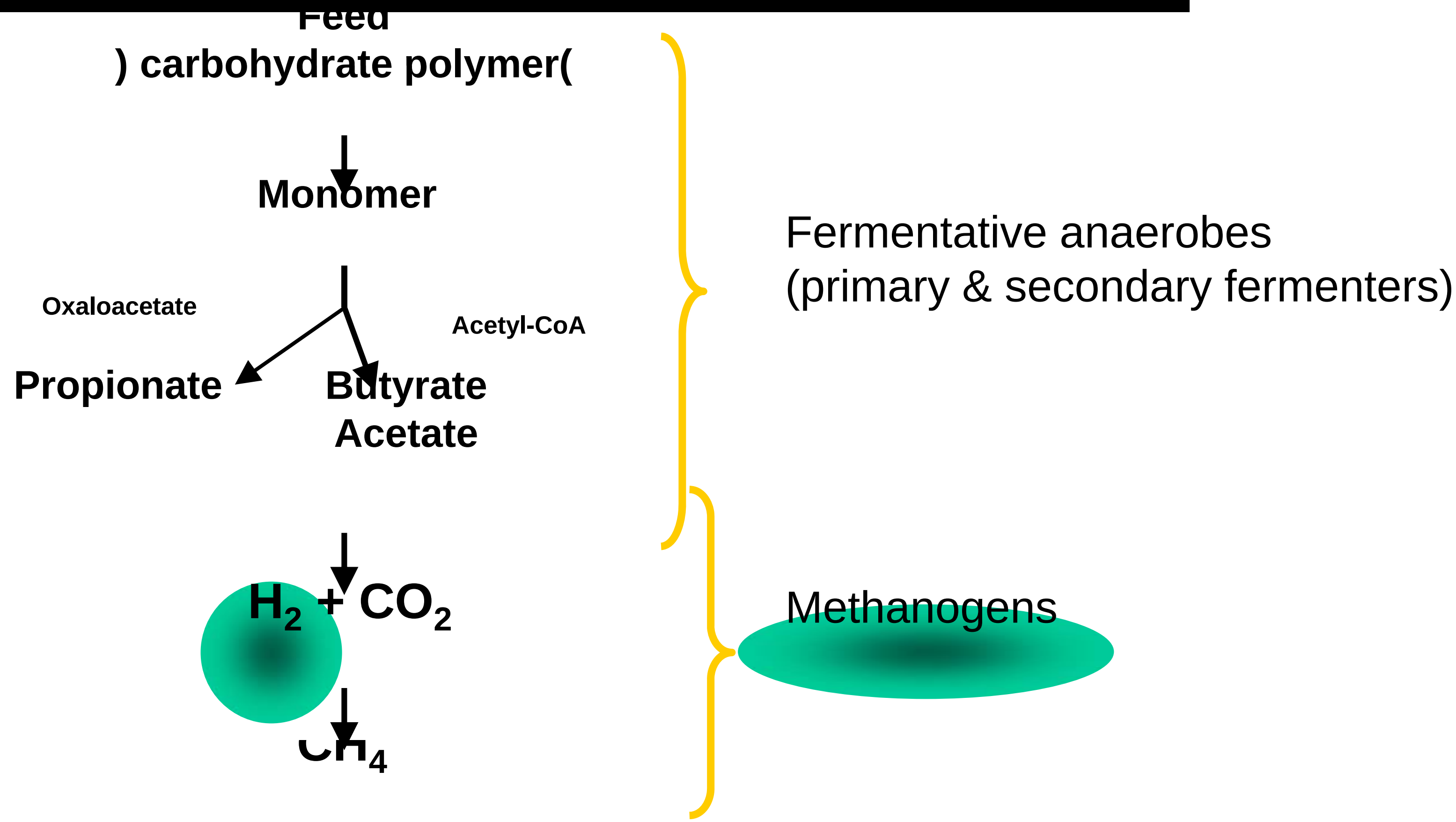
Livestock and Environment

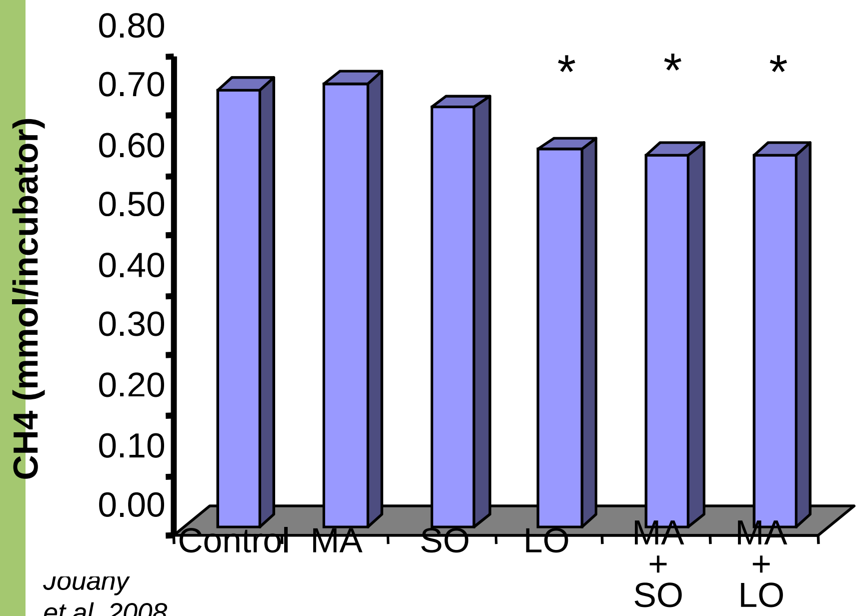
Animal products

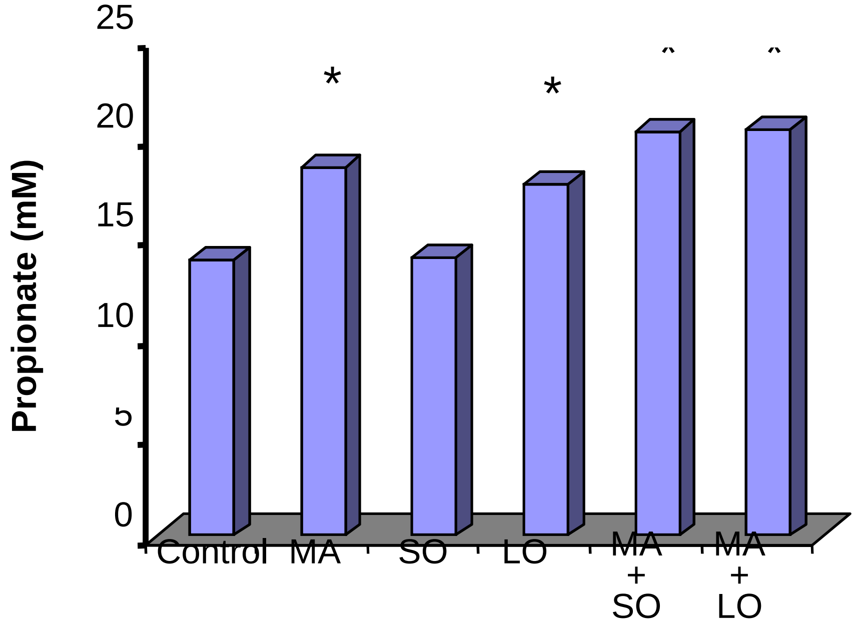
Environmental (dis)services

Methanogenesis



Effect of malic acid, sunflower oil, linseed oil and their combinations on rumen metabolite production



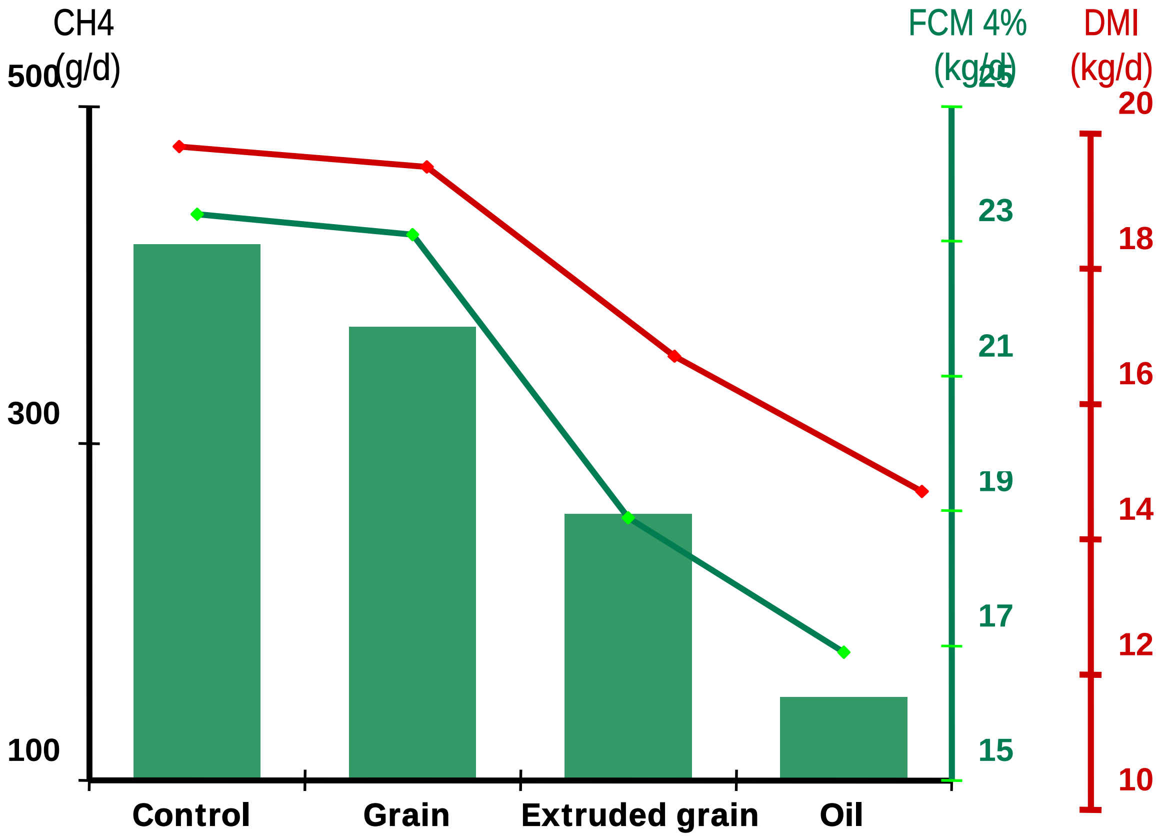


Jouany et al, 2008

- Linseed oil reduced in vitro rumen methanogenesis by 14% without a negative effect on fermentations.

Effect of linseed lipid preparations

- Maize silage:concentrate diet (65:35)
- Supplement eq. 6% lipid in diet

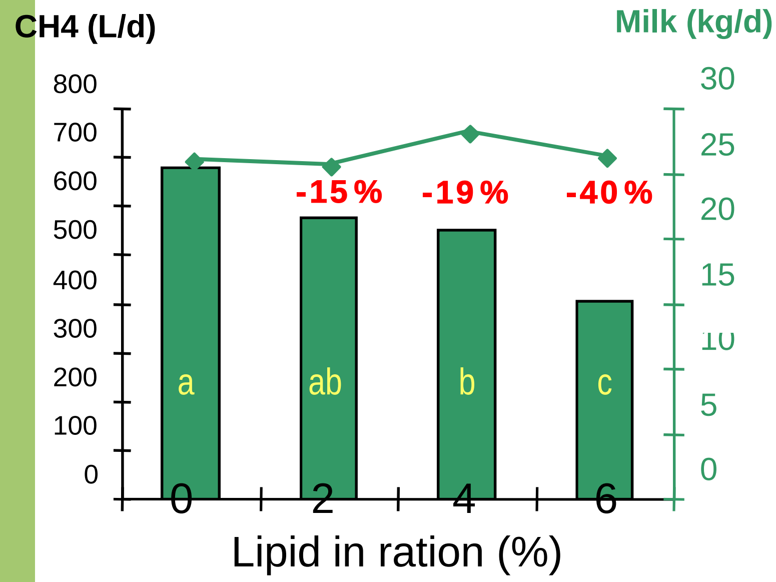


CH4 g/kg FCM 4%	19.3a	16.4ab	14.8b	9.3c

Martin et al, 2007

Effect of extruded linseed concentration

[redacted]



Martin et al, 2007

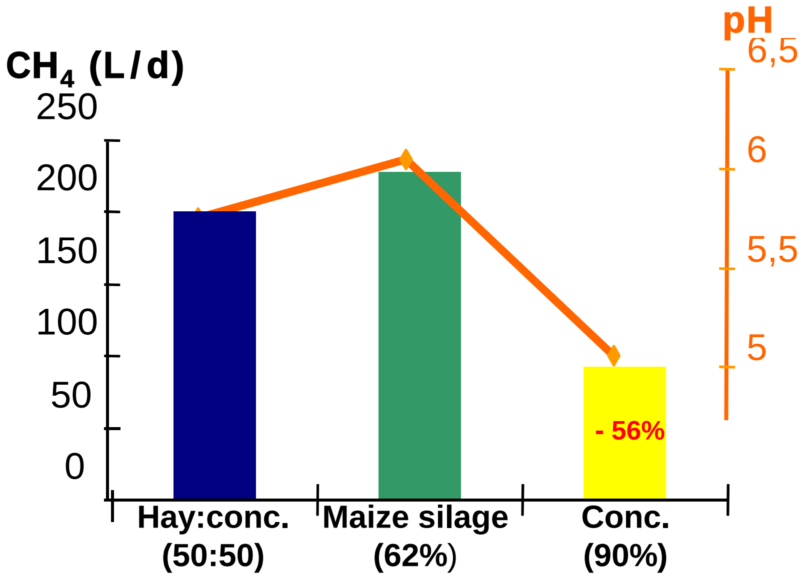
Microbial numbers and VFA

	H2-producers		H2-utilizers	VFA
	Protozoa	Cellulolytic bacteria	Archaea Methanogens	C3
1h pre feeding	→ (P<0.1)	→	→	→
3h post feeding	↘	ND	ND	→

Mosoni et al, 2008

Linear decrease of methanogenesis

Effect of high-concentrate diets



CH_4 (% E intake)

Martin et al, 2007

Hay:conc. (50:50)	Maize silage (62%)	Conc. (90%)
7.2	6.6	2.5

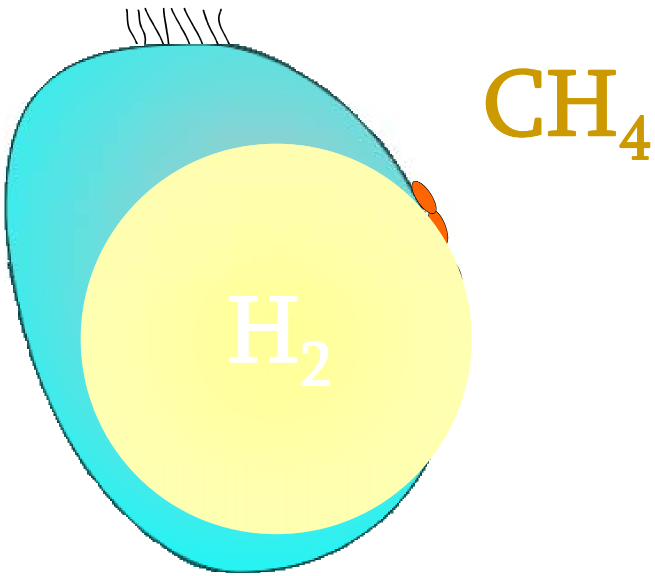
- High-concentrate diets decrease methanogenesis

➔ propionate

↓ protozoa

Role of protozoa in ruminal methanogenesis

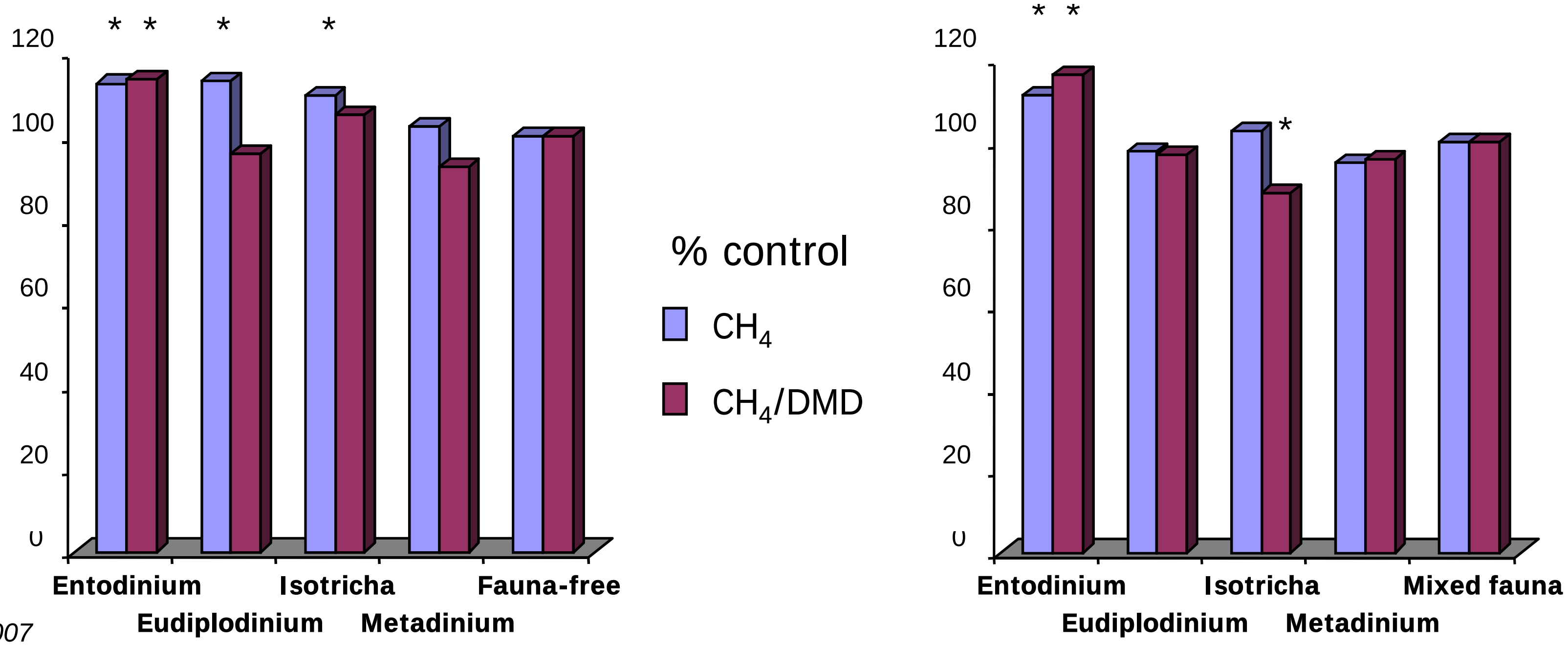
Many diets, feed supplements and additives that reduce methane emissions affect protozoa



10 to 25 % of CH_4 produced by ruminants comes from the association ciliate-archaea

Rumen protozoa and methane production

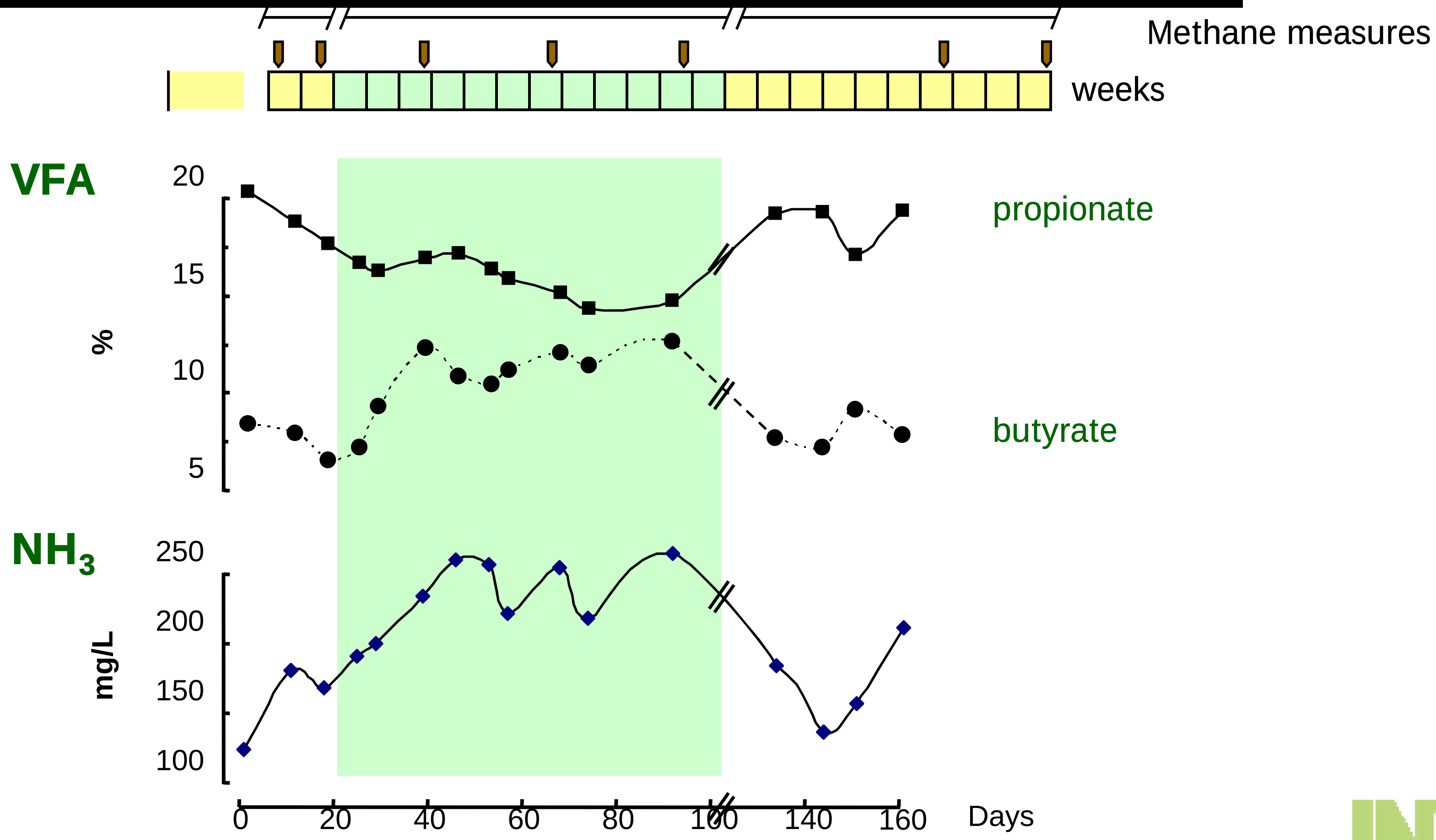
[redacted]



Ranilla et al, 2007

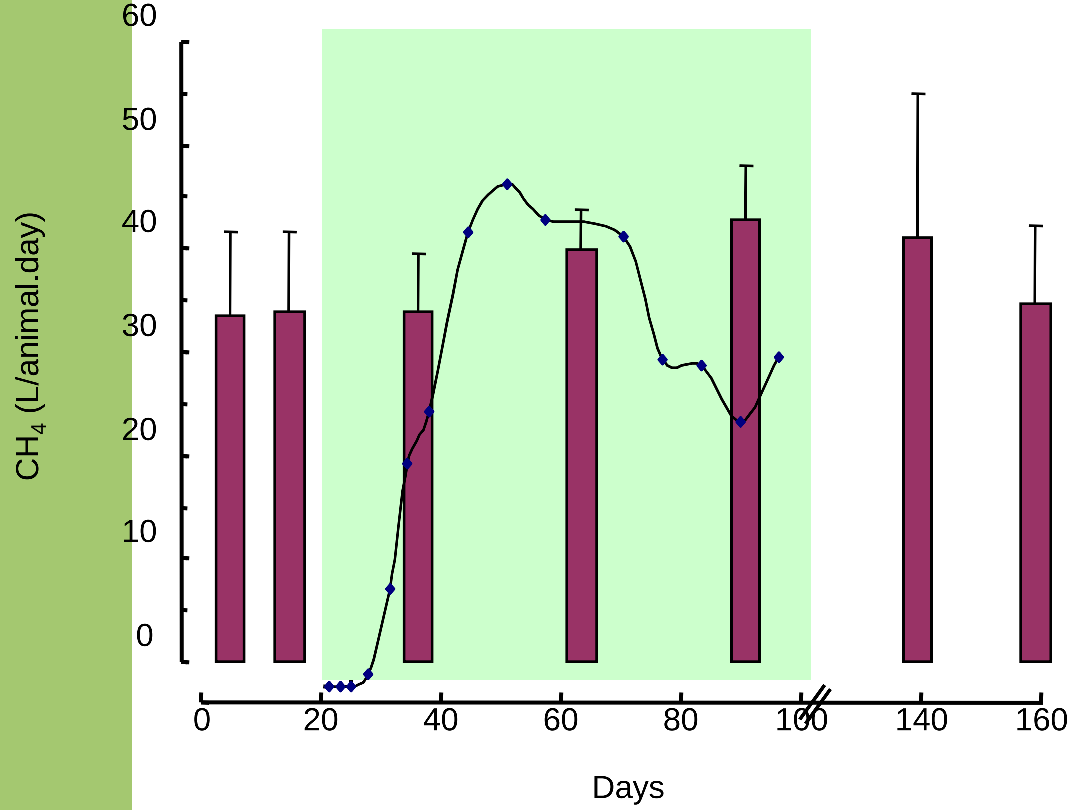
- Only *E. caudatum* increased the production of methane
- Other negative effects were ↑ NH_3 & ↘ substrate degradation

Defaunation assay



Morgavi et al, 2008

Methane emissions



	L/d	L/kg $LW^{0.75}$
Defaunated 1	33.5 b	1.40 b
Refaunated	41.1 a	1.69 a
Defaunated 2	36.9 ab	1.49 b

Defaunation has a long-term effect on methane emissions

↙ 20%

Future

- Increase use of biological alternatives to antibiotics and chemicals as animal feed additives
- Due to:
  - An increased awareness that antibiotics derange the normal protective flora
  - An increase in antibiotic resistant strains
  - Public (consumer) concerns

Future

- Increase efficacy
- Consider the whole system of production
- Additional objectives addressing specific problems:
  - Environmental (CH_4 emissions, NH_3 pollution, ...)
  - Emerging diseases
  - Product quality

Gracias por la atención

INRA Clermont-Ferrand/Theix
Research Centre