Alternatives to the Use of Antibiotic Growth Promotores in Ruminants

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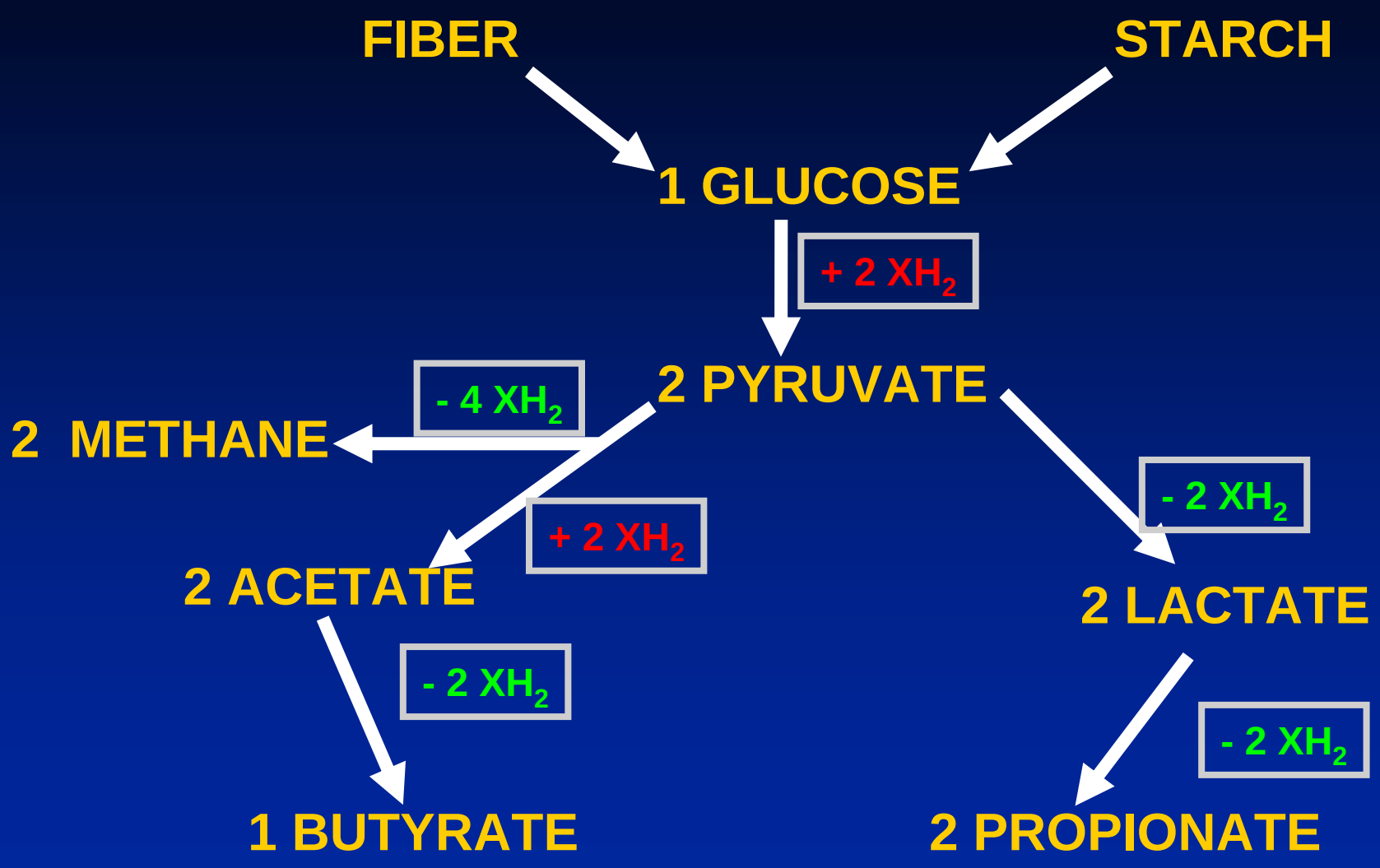
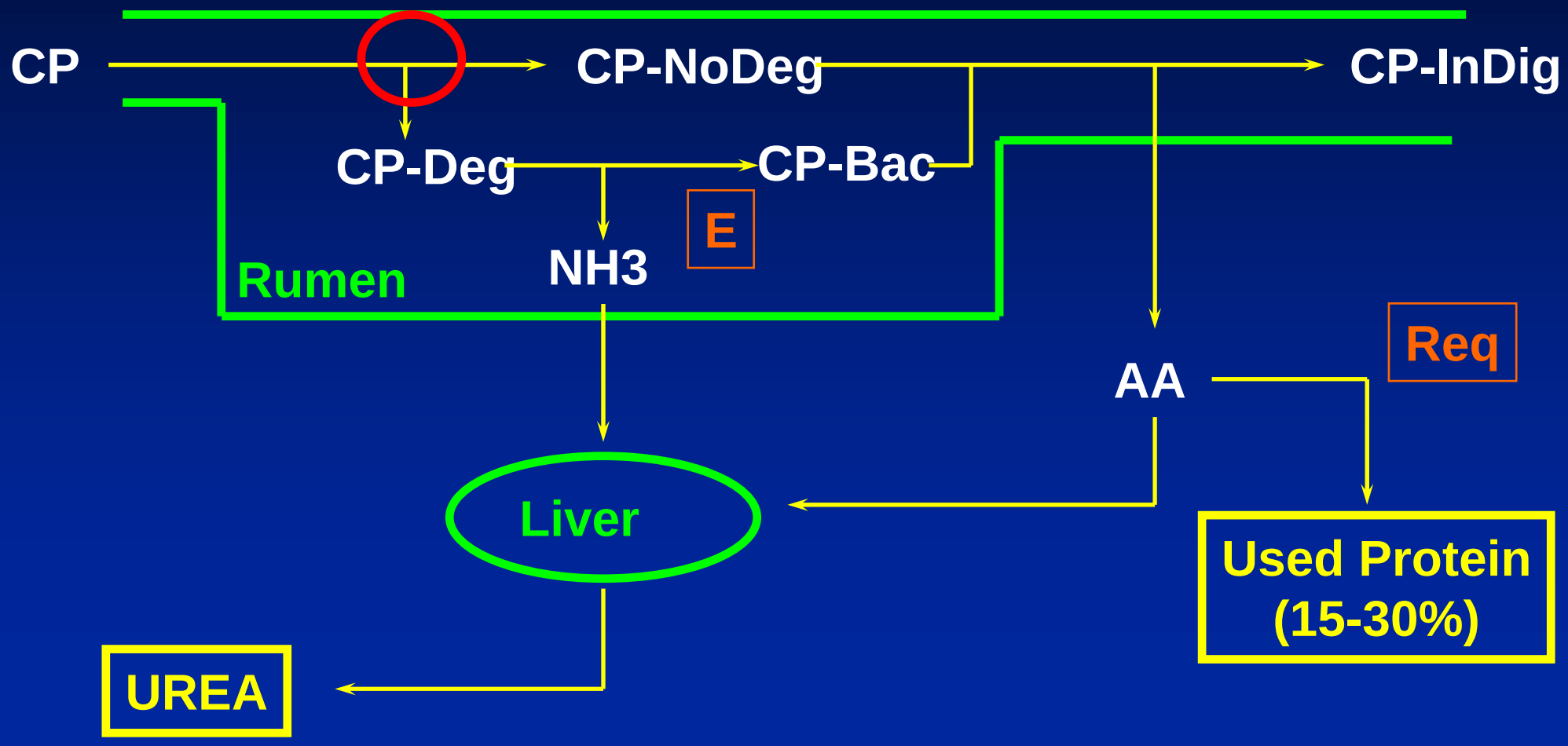

FIBER
STARCH
1 GLUCOSE
+ 2 XH2
2 PYRUVATE
- 4 XH2
2 METHANE
+ 2 XH2
2 ACETATE
- 2 XH2
1 BUTYRATE
- 2 XH2
2 LACTATE
- 2 XH2
2 PROPIONATE

N Metabolism in the Rumen



Monensin
⇓ Gram +
⇑ Gram -

⇑ Propionate
⇓ Acetate
⇓ Butyrate

⇓ CH_4

⇓ Catabolism Pep & AA

⇓ NH_3

Ban of antibiotics 2006 Regulation 1831/2003 ⇒
⇒ search of alternatives

Objectives

Fermentation and inefficiencies

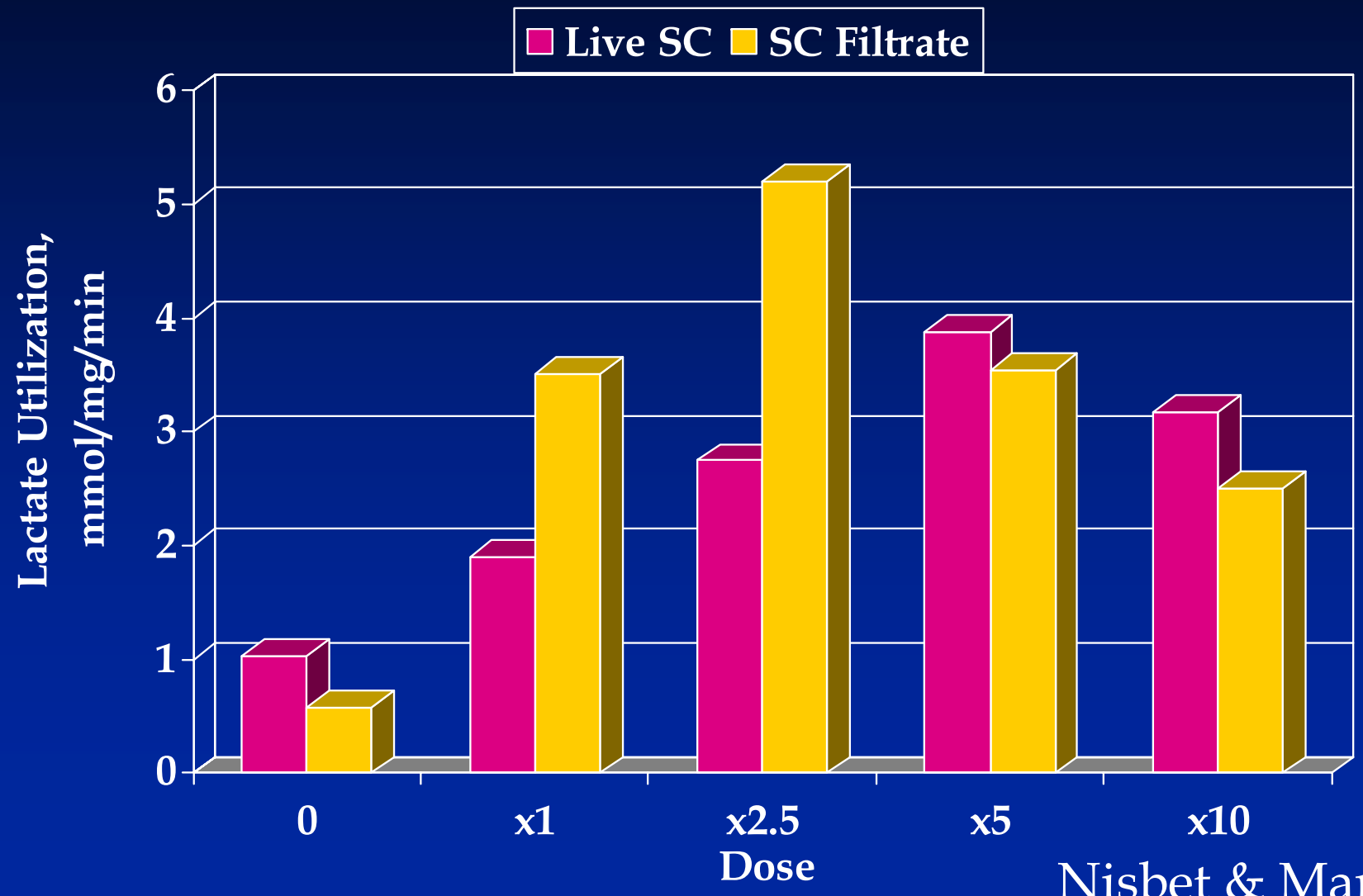
Modulation

Enhance
Microbial Activities

Inhibit
Microbial Activities

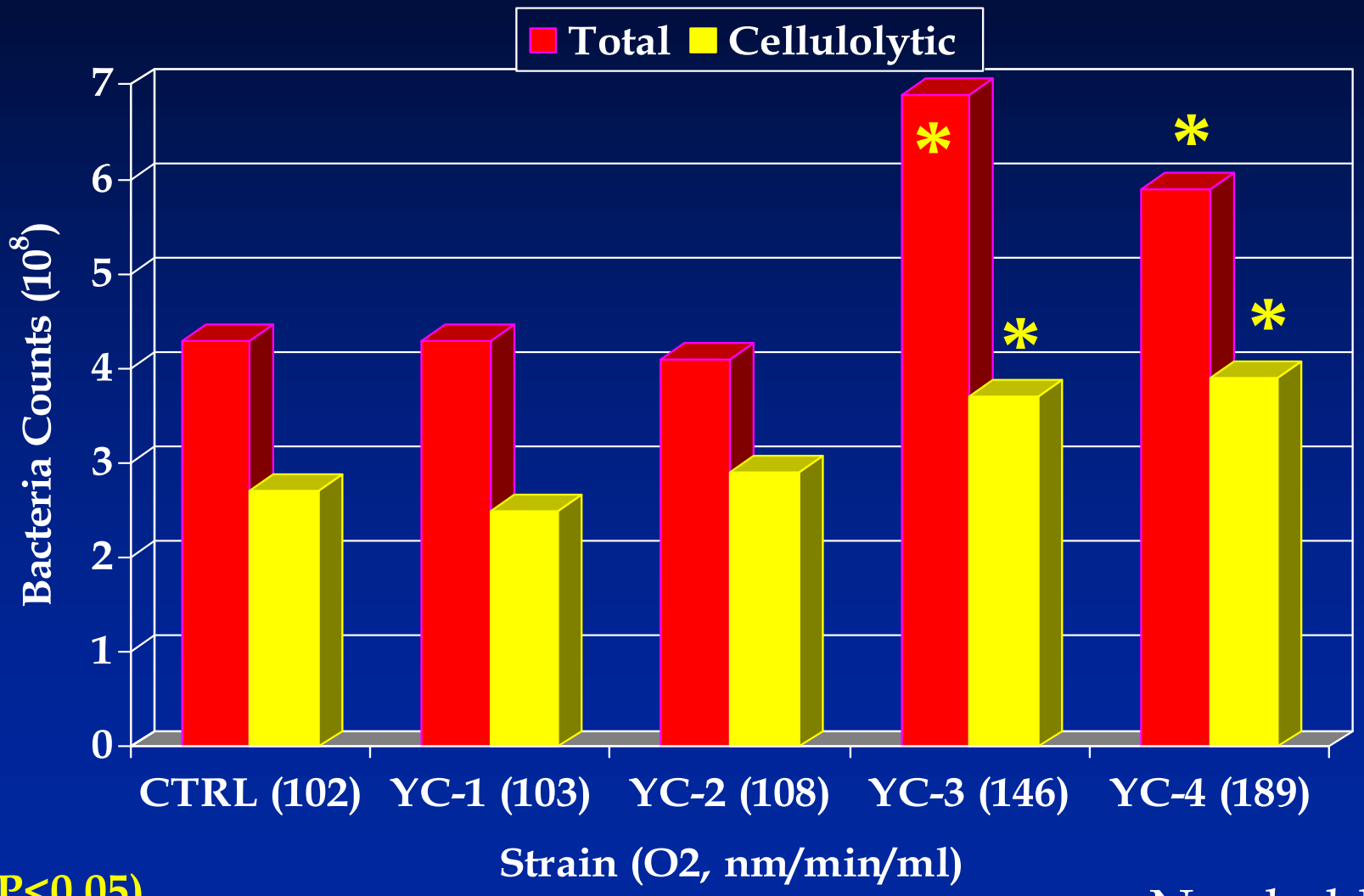
- Yeast/Fungi

Lactate Utilization by *S. ruminantium* in Live vs Dead *S. cerevesiae*



Nisbet & Martin (1991)

YC Strain, Oxygen Consumption and Microbial Counts

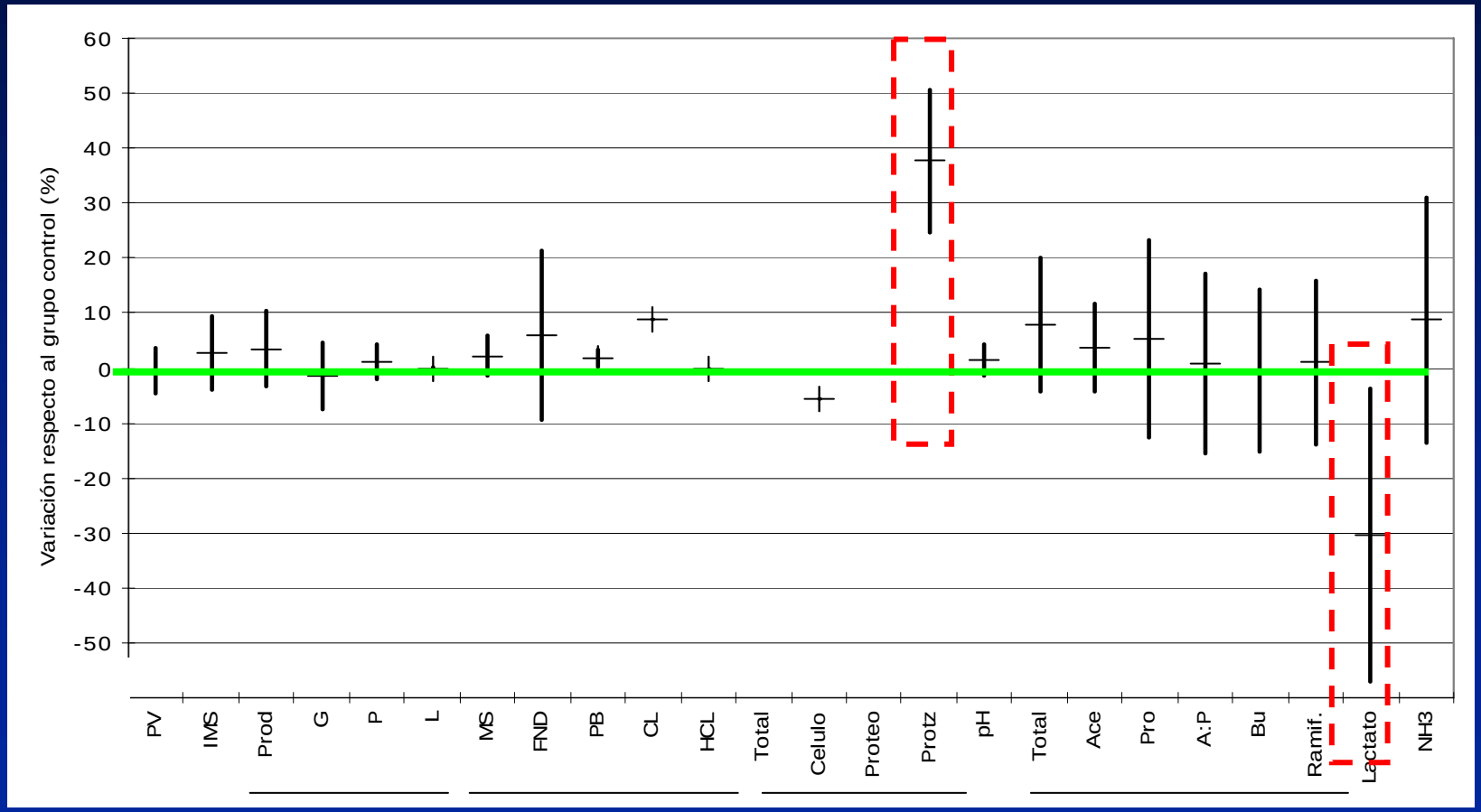


* (P<0,05)

Newbold et al. (1996)

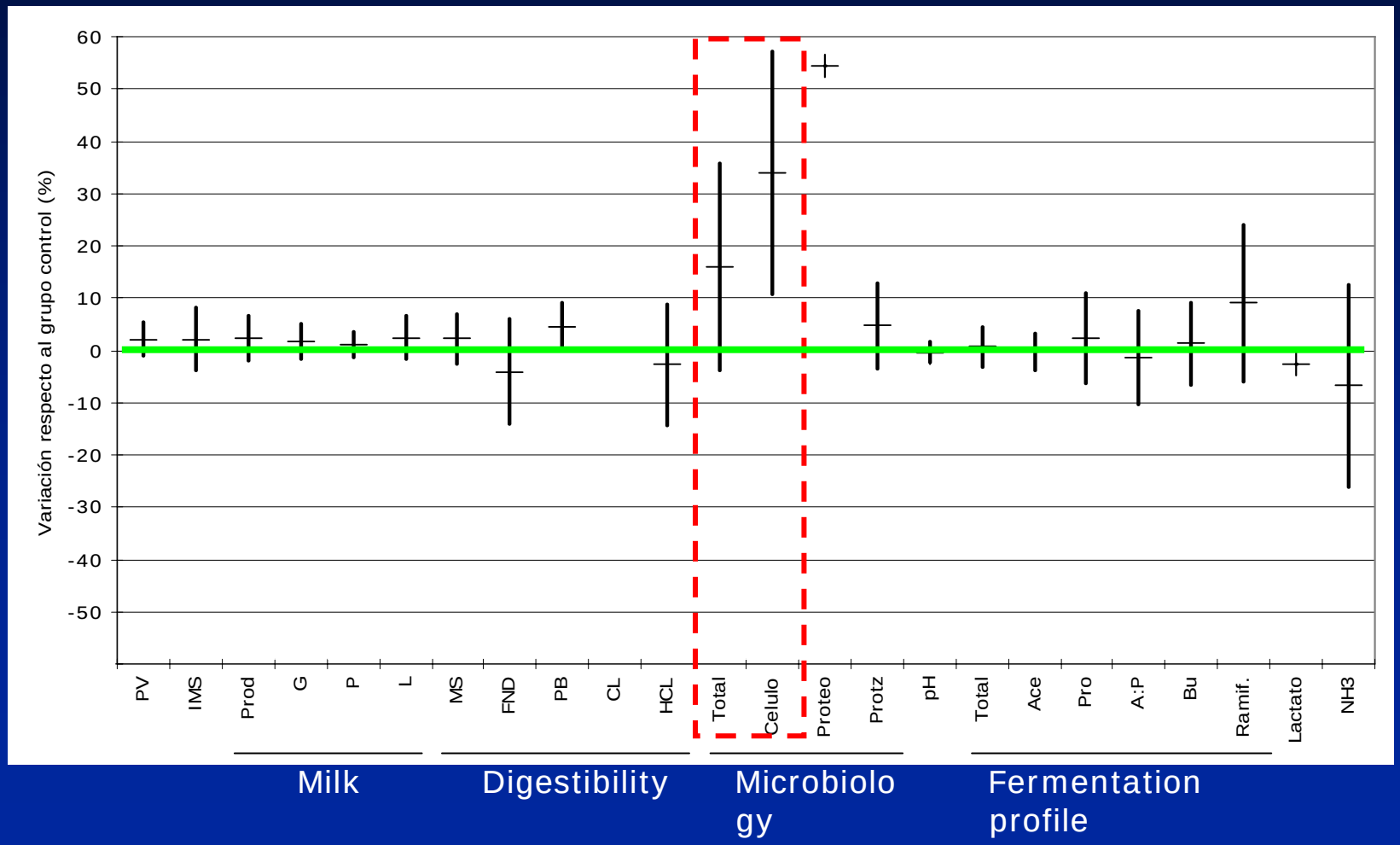
Live Yeast

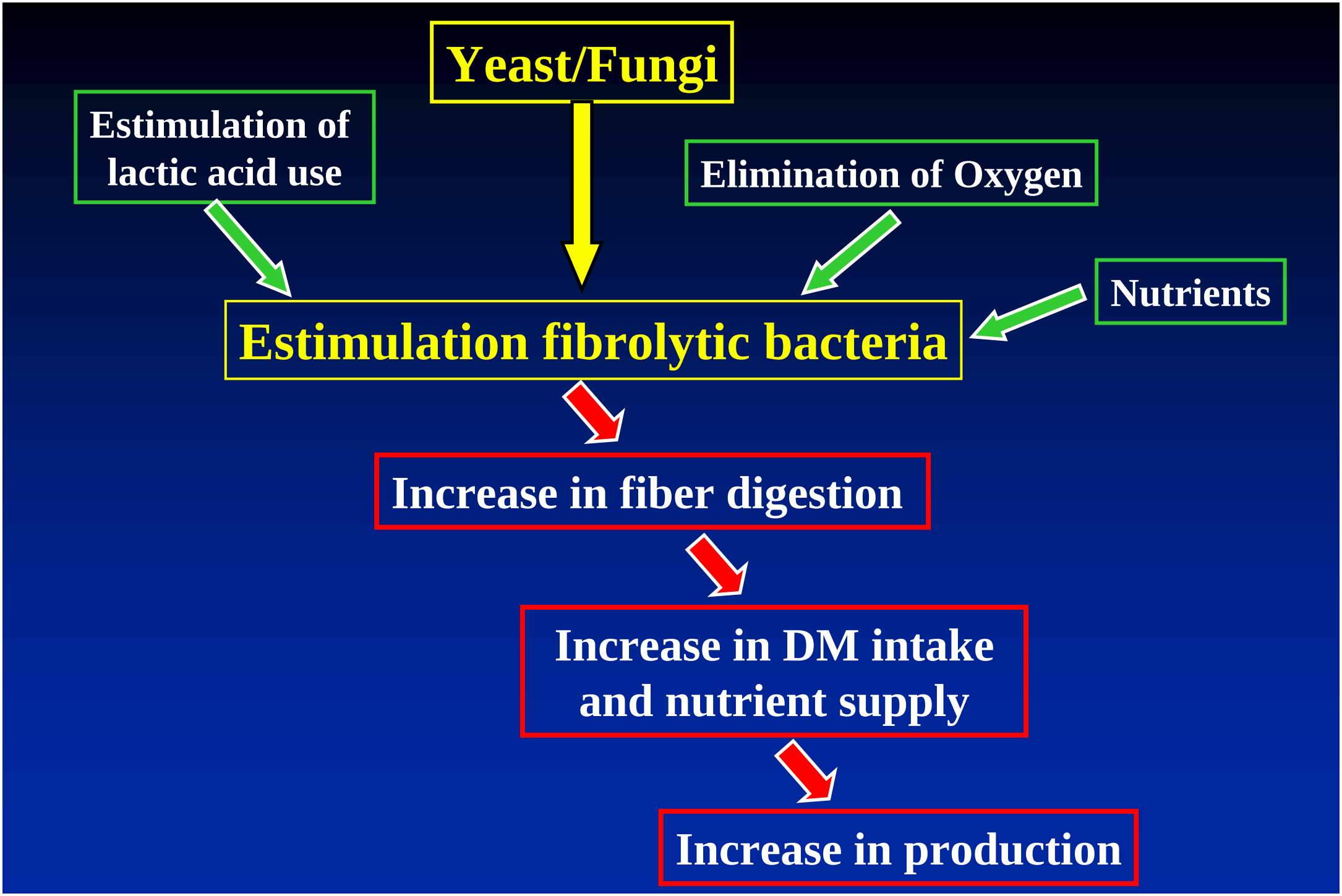
- Summary of 25 studies



Yeast Culture

- Summary of 21 studies




Yeast/Fungi
Estimulation of lactic acid use
Elimination of Oxygen
Nutrients
Estimulation fibrolytic bacteria
Increase in fiber digestion
Increase in DM intake and nutrient supply
Increase in production

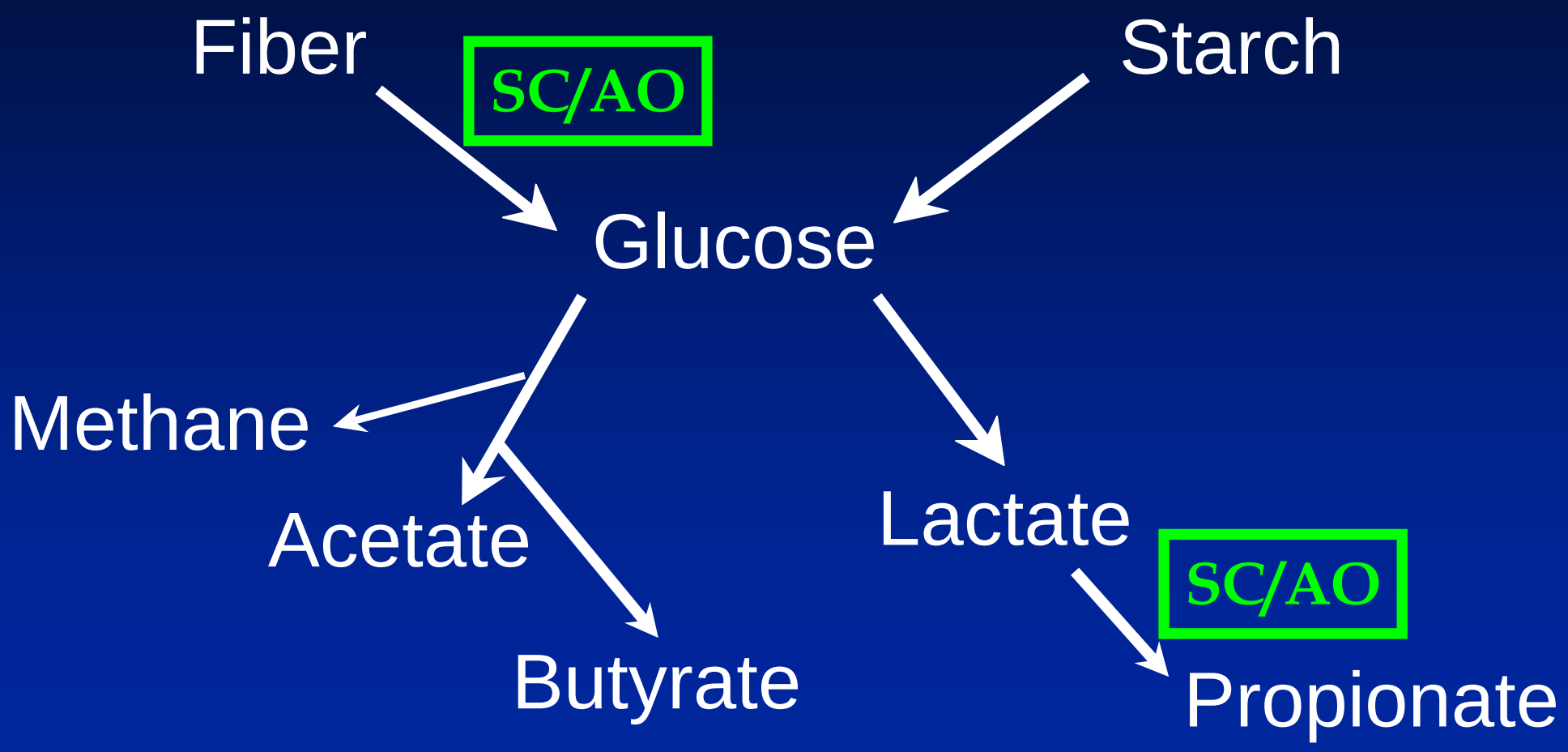
Effects of *S. cerevisae* and *A. oryzae* on Performance (Yoon & Stern, 1995)

- *S. cerevisae*: Summary 12 studies:
  - Average increase in fat corrected milk (4%): 0.58 L
  - Average increase in DM intake: 0.32 kg
  - The increase in DM intake justifies the improvement in milk production.
- *A. Oryzae*: Summary of 14 studies
  - Average increase in fat corrected milk (4%): 0.79 L
  - Average increase in DM intake: 0.36 kg
  - The increase in DM intake justifies the improvement in milk production.

Effects of live vs culture of *S. cerevisae* (Robinson & Erasmus, 2008)

- *Live*:
  - DM Intake: +4.3%
  - Milk yield: 2.7%
  - Milk energy output: +3.4%
- *Culture*
  - DM Intake: +1.8%
  - Milk yield: 3.6%
  - Milk energy output: +3.0%

Direct Fed Microbials: Energy



Objectives

Fermentation and inefficiencies

Modulation

Enhance Microbial Activities

- Yeast/Fungi

Inhibit Microbial Activities

- Plant extracts
- Antibodies

Essential Oils

1960

1970

1980

1990

2000

➔ Borcher et al., 1965; ➔ Oh et al., 1967

➔ Oh et al., 1968; ➔Nagy & Tengerdy, 1968

Legal use of Monensin (1971-1975)

➔ Broderick & Balthrop, 1979

Ban on Antibiotic Use Anounced

➔ Ismael et al., 1990; ➔ Sivropoulou et al., 1995

➔ Sivropoulou et al., 1996; ➔ Helander et al., 1998

➔ 2000-2012: More than 65 papers and 4 reviews

Nitrogen Metabolism

	CTR	MON	CIN	GAR
LPep N	6.8	5.4	6.4	5.5
SPep + AA N	1.9	4.4†	2.5	4.6*
Ammonia N	19.2	13.0*	16.0 †	17.0†

* $P < 0.05$ † $P < 0.10$

Busquet et al., 2005a

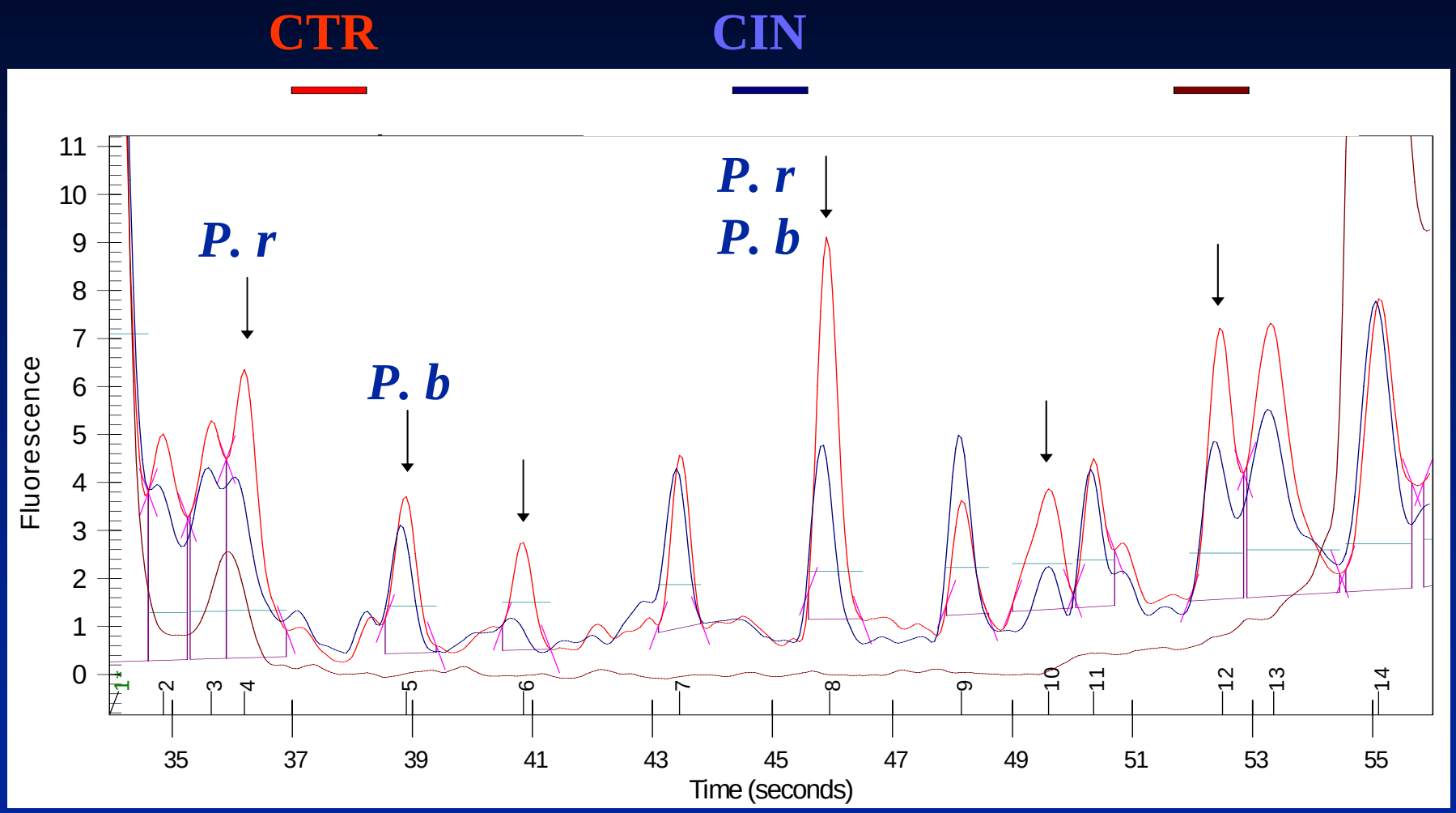
Nitrogen Metabolism

	CTR	FEN	CAD	TEA	DIL	GIN	CLO
LPep N	3.8	4.5	6.1	4.3	5.0	4.8	6.9 *
SPep + AA N	5.2	5.0	5.0	4.5	4.7	4.0	2.8 †
Ammonia N	7.5	8.7	7.4	8.0	8.5	7.1	6.4

* $P < 0.05$ † $P < 0.10$

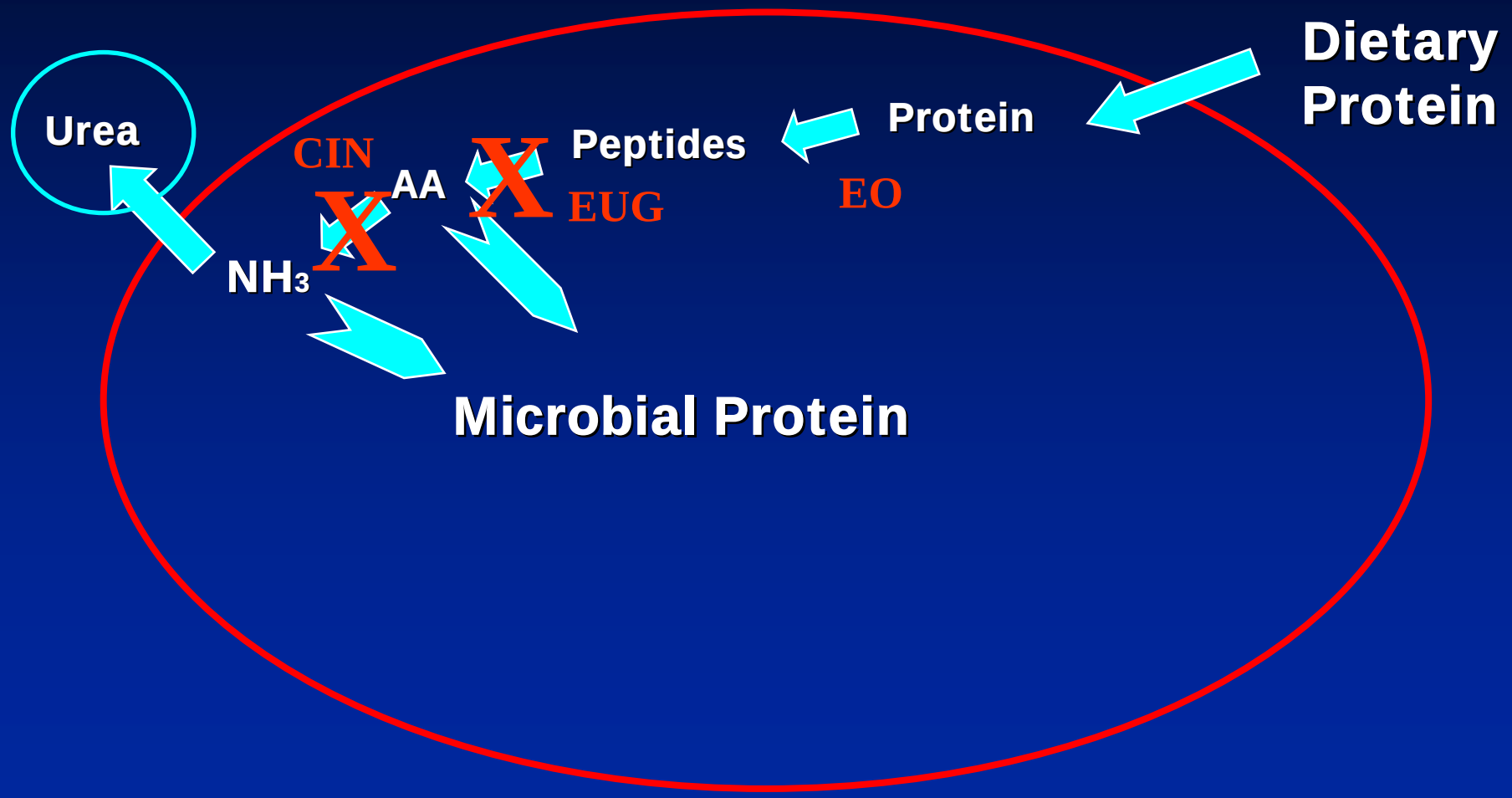
Busquet et al., 2005c

Mechanism of Action: *(Prevotella)*

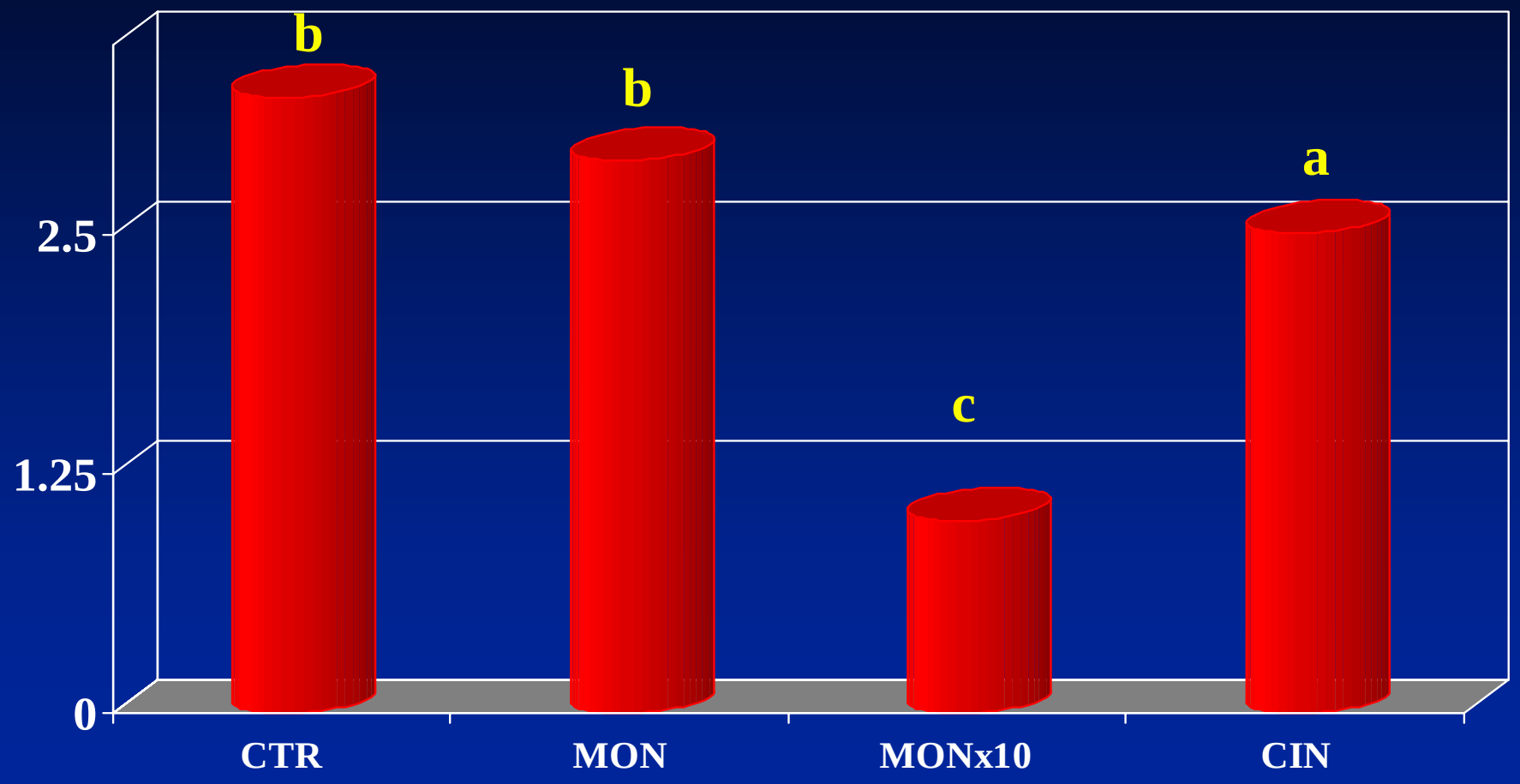


(Ferme et al, 2004)

Essential Oils: Protein



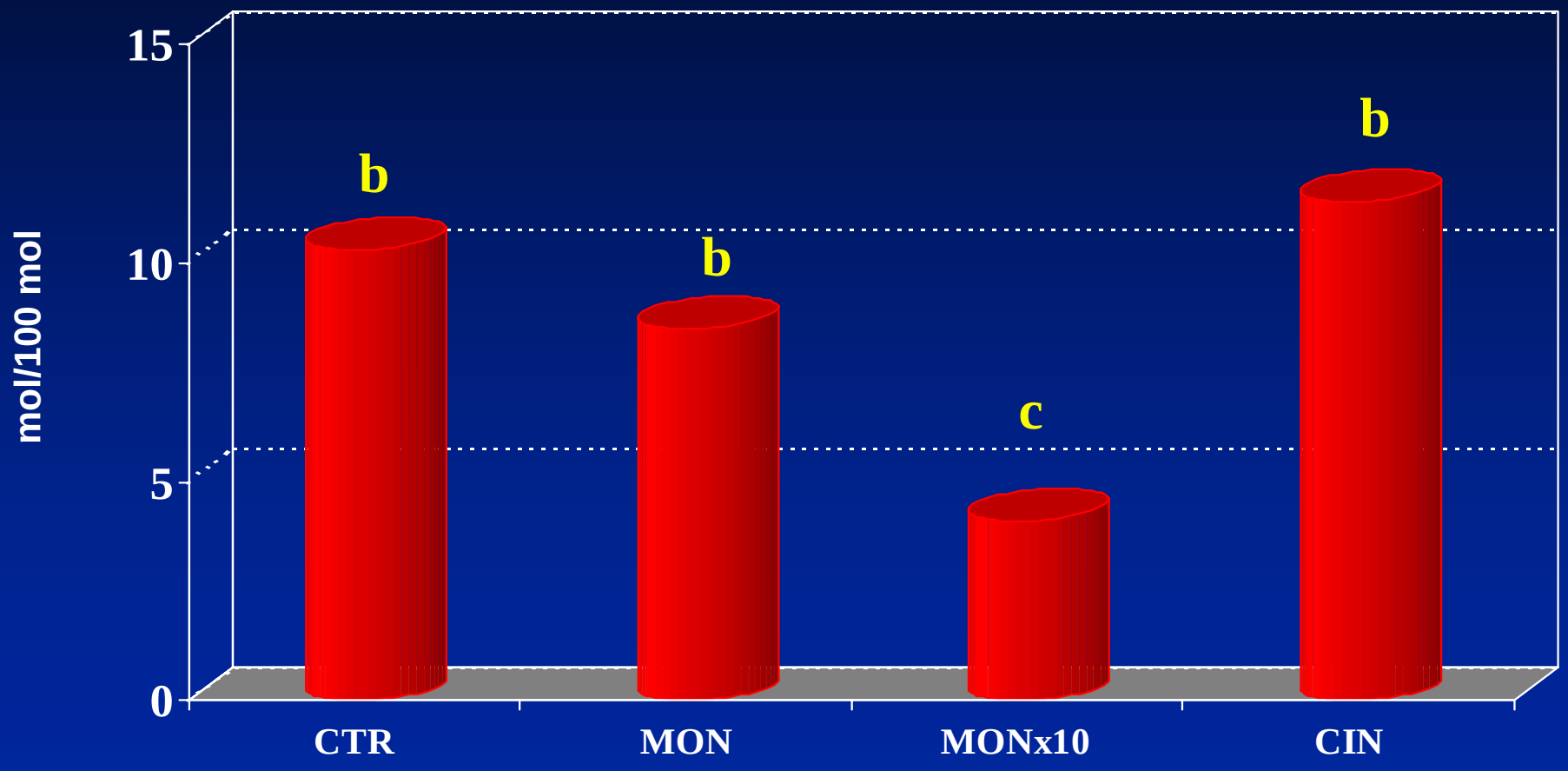
Acetate to Propionate Ratio



abc (P<0,05)

Busquet et al., 2005 (J. Dairy Sci.)

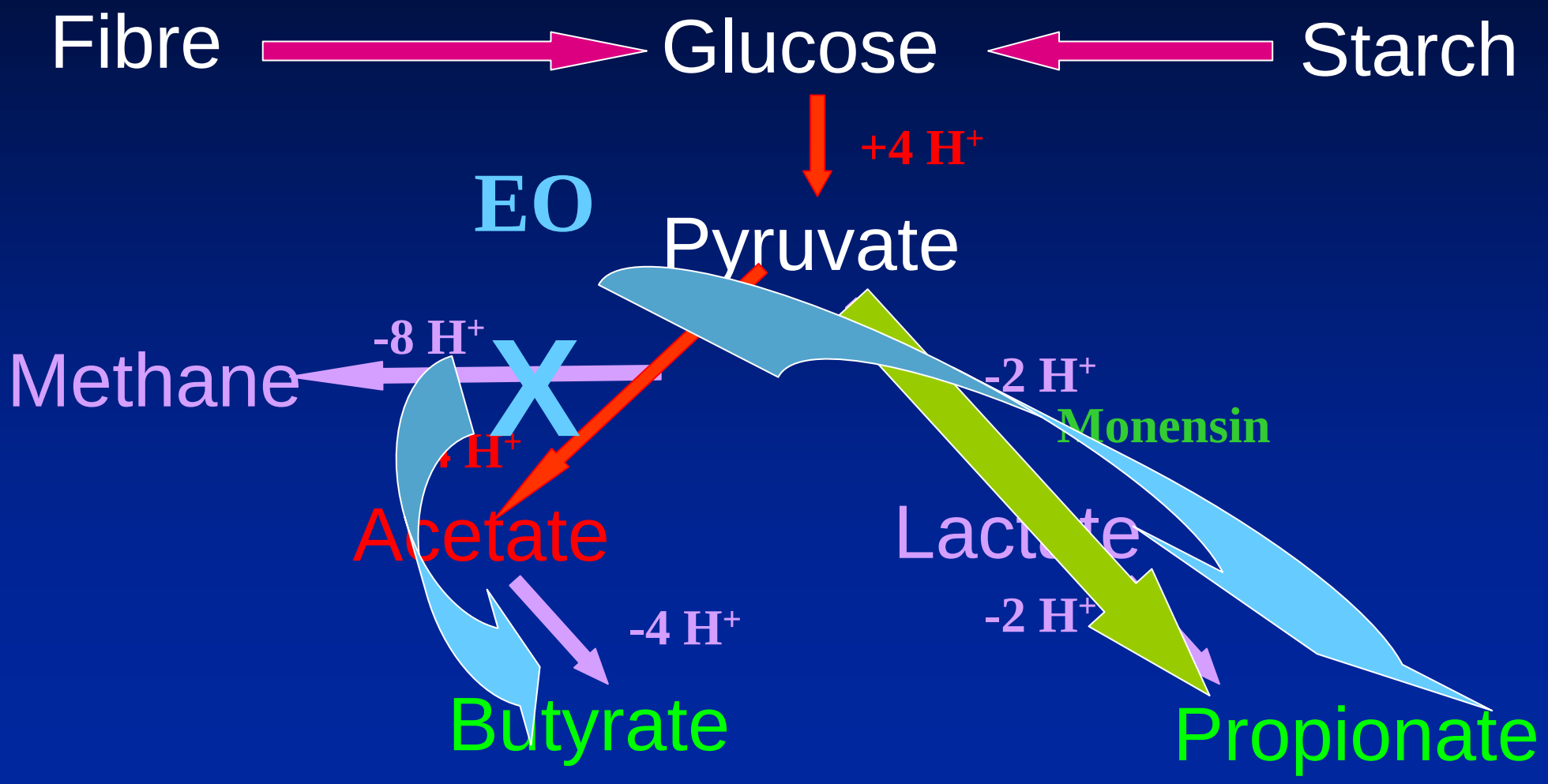
Molar Proportion of Butyrate



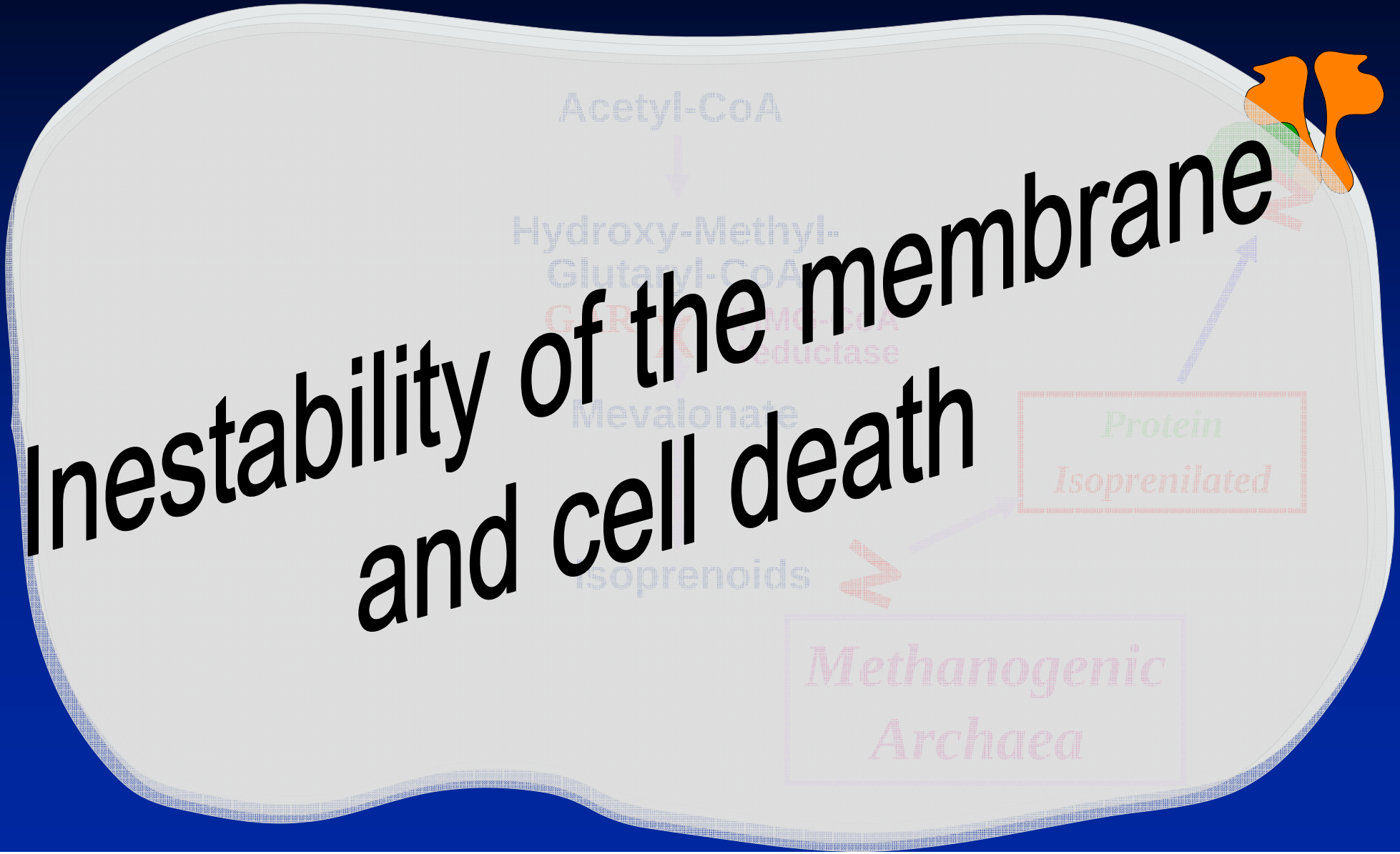
abc (P<0,05)

Busquet et al., 2005a (J. Dairy Sci.)

Hipothesis: Inhibition of Methanogenesis



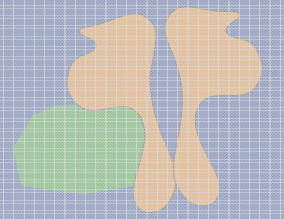
Hipothesis: Inhibition of methanogenesis



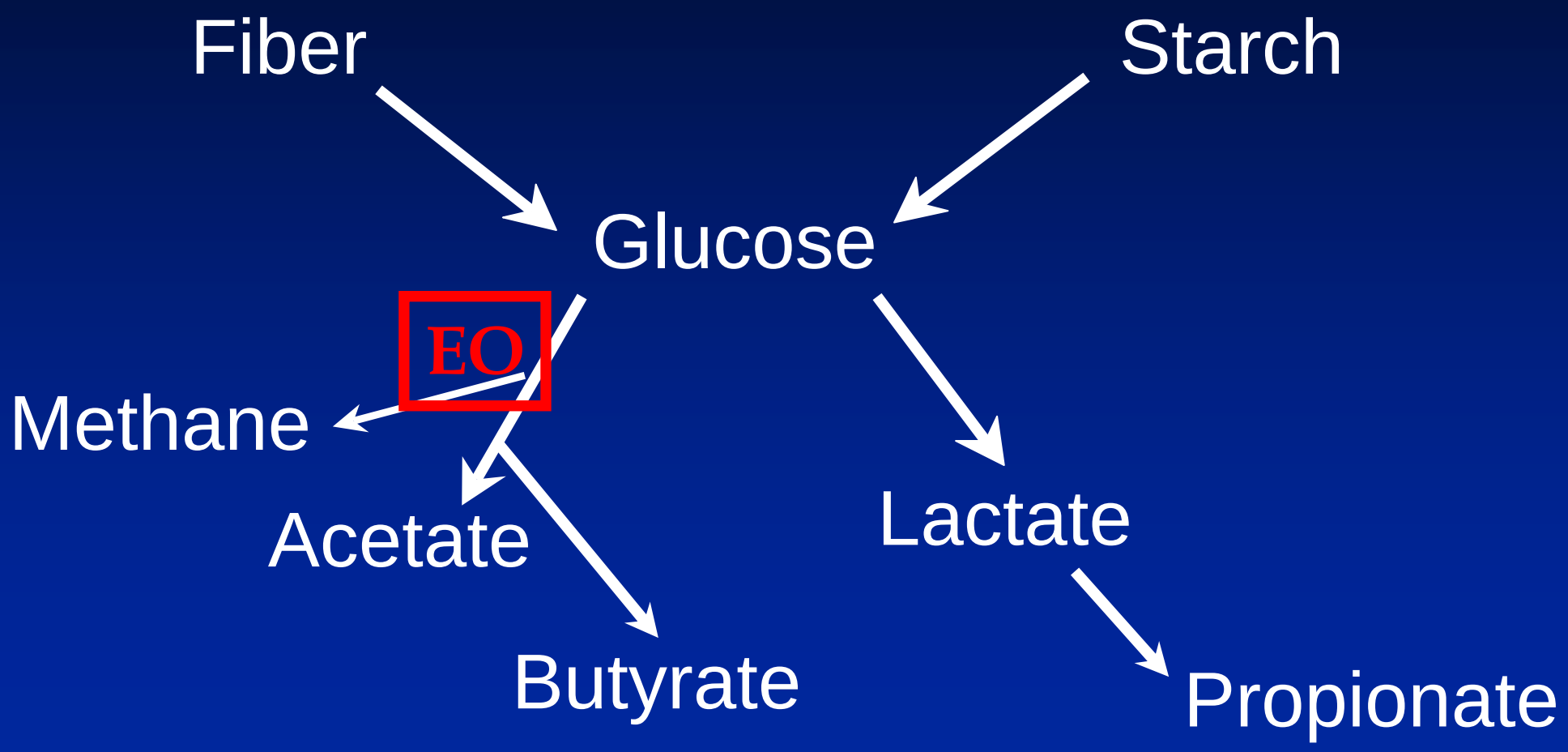
Inestability of the membrane and cell death

Hipothesis: Inhibition of methanogenesis

- The **methanogenic *Archaea*** are the **only** rumen microorganisms that require the isoprenoid untis in the cell membrane.
- Garlic extract and their active components may be very selective agaist this group of microbes



Essential Oils: Energy

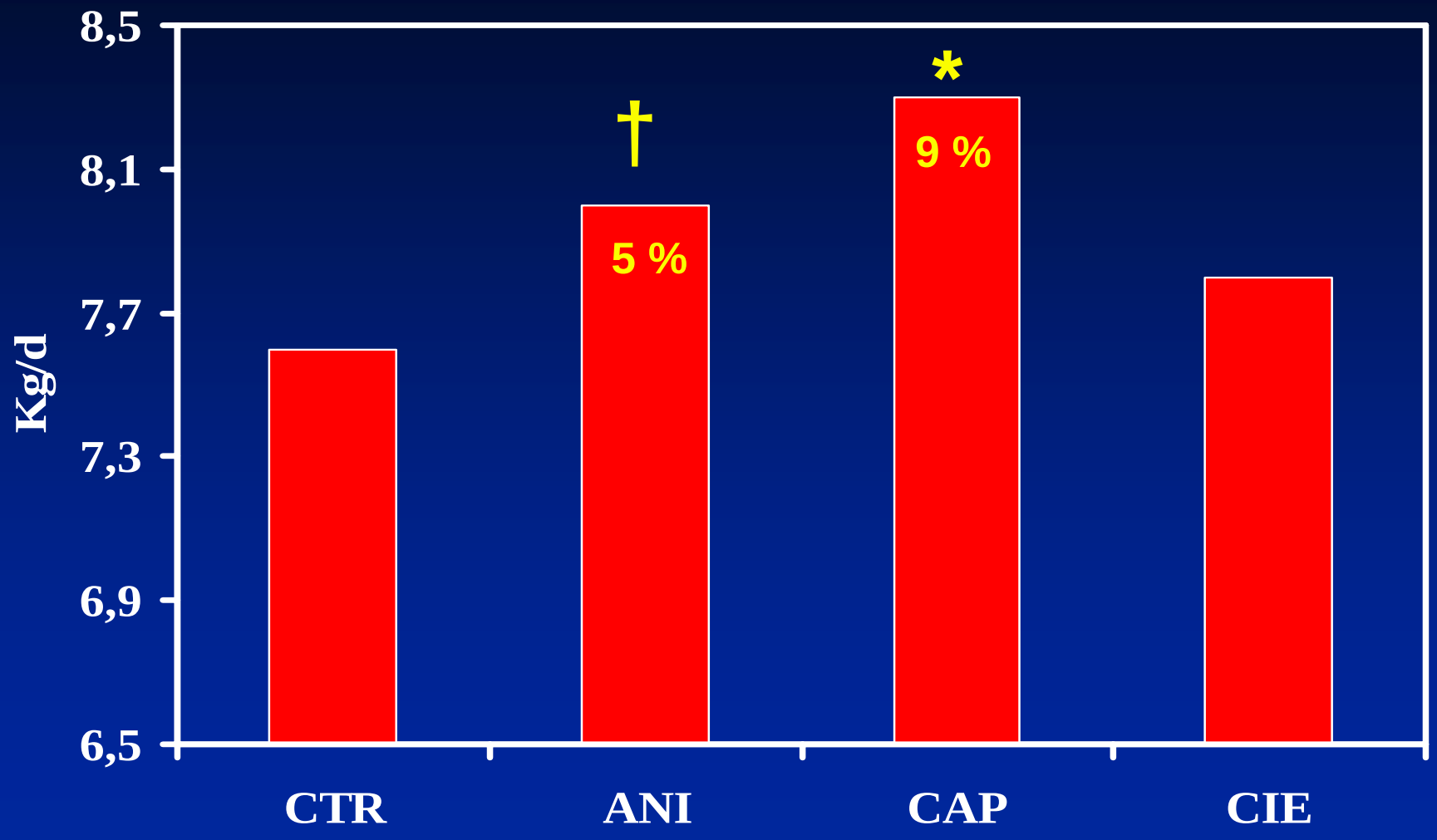


Beef: Fermentation Profile

	CTR	ANI	CAP	CIE	SEM
pH	6.1	6.07	6.14	6.05	0.07
VFA total, mM	155.1	155.5	154.5	152.9	3.15
VFA individual,%					
- Acetate	56.8	53.9*	53.9*	52.9*	0.61
- Propionate	26.7	31.2*	29.8	30.5*	1.05
- Butyrate	11.6	10.7	12.1	12.1	0.85
BC-VFA, mM	4.5	3.8*	4.0*	4.1*	0.16
C_2:C_3	2.1	1.7*	1,81†	1,7*	0.19
L-lactic, mM	0.33	0.27†	0.29	0.25*	0.04

* P< 0.05; † P< 0.10

Beef: Dry Matter Intake



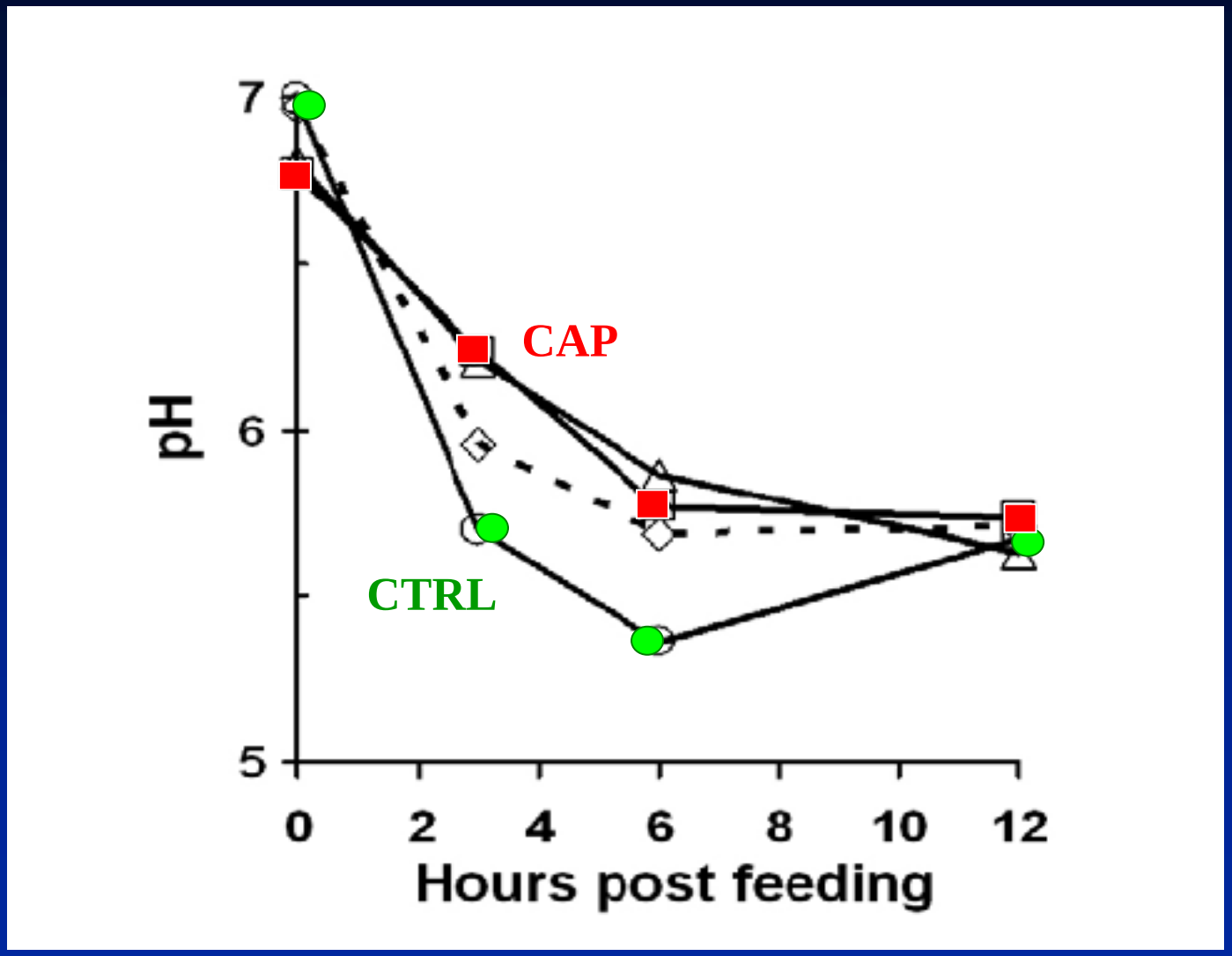
* P< 0.05; † P< 0.10

UAB

Hypothesis

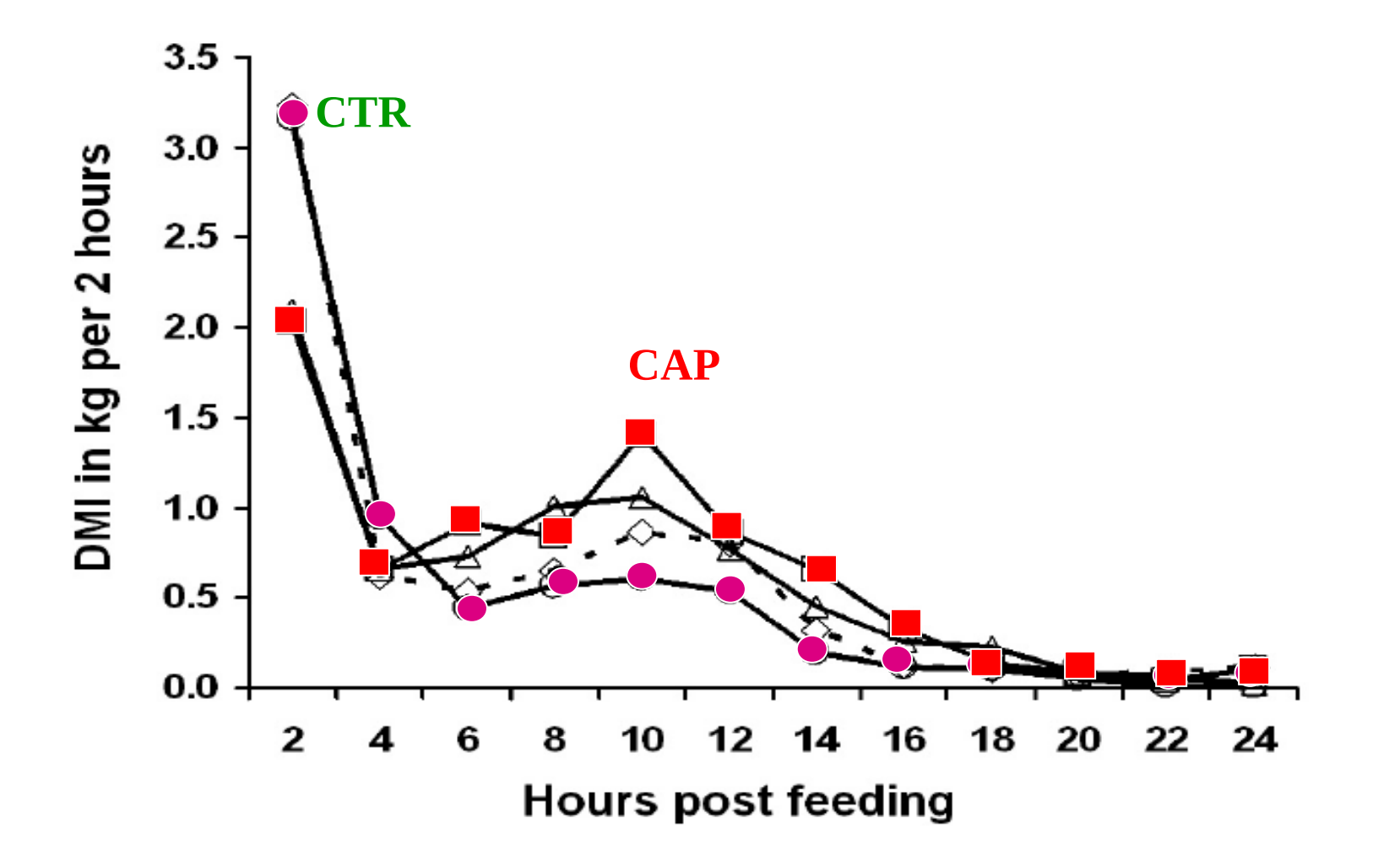
- How can we increase intake and maintain pH?
- Rumen fermentation, pH and DM intake patterns

Pattern of DMI and pH



(Rodriguez et al., un published)

Modifying the Pattern of DMI with Additives



(Rodriguez et al., unpublished)

Essential Oils

- Antimicrobial activity: no search for the most antimicrobial, but for the optimal product/dose.
- High diversity of substances (and effects).
- Some have proven effects in vivo
- Performance data limited, incosistent and urgently needed

Objectives

Fermentation and inefficiencies

Modulation

Enhance Microbial Activities

- Yeast/Fungi

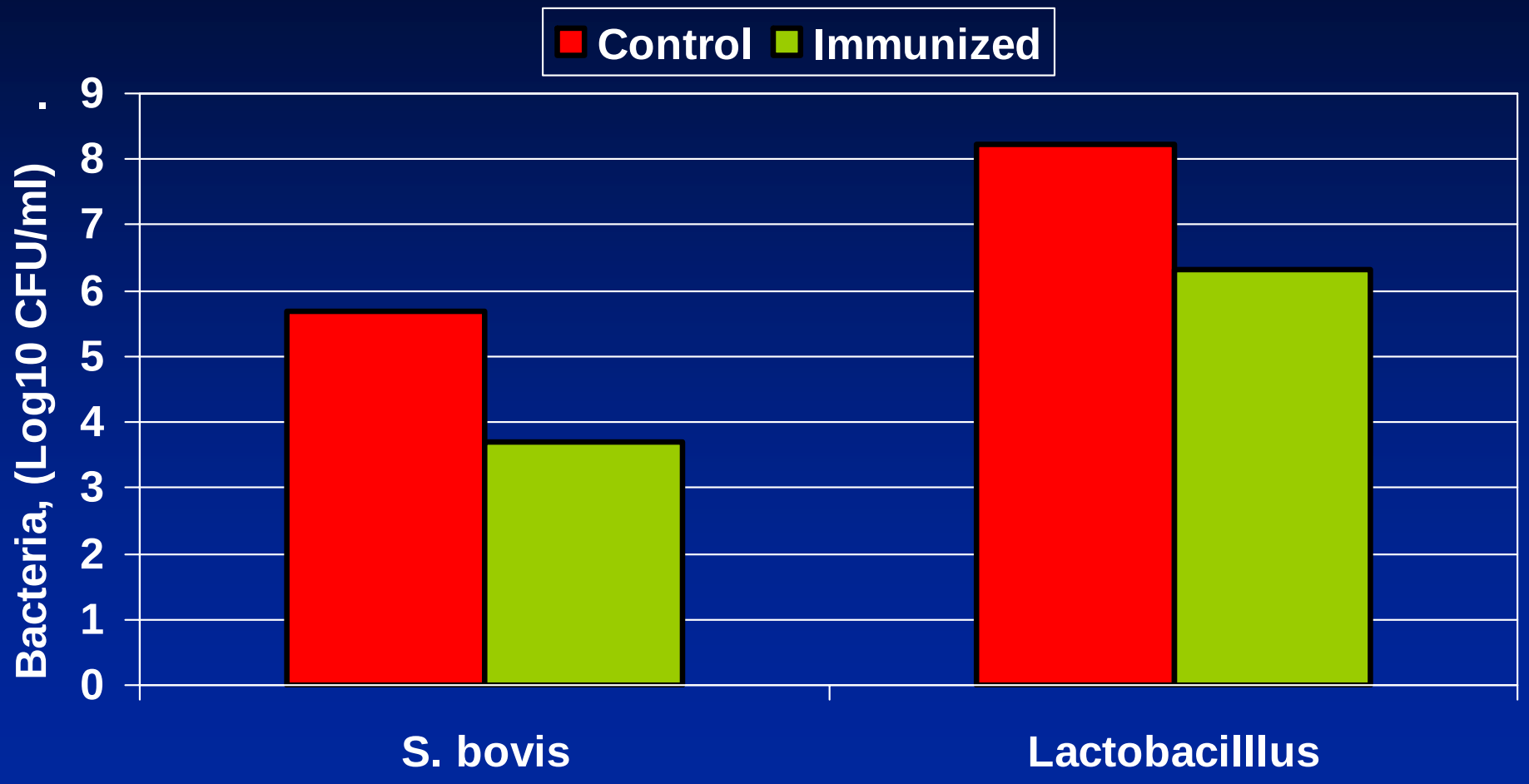
Inhibit Microbial Activities

- Plant extracts
- Antibodies

Inhibition of Specific Microbial Groups: Antibodies

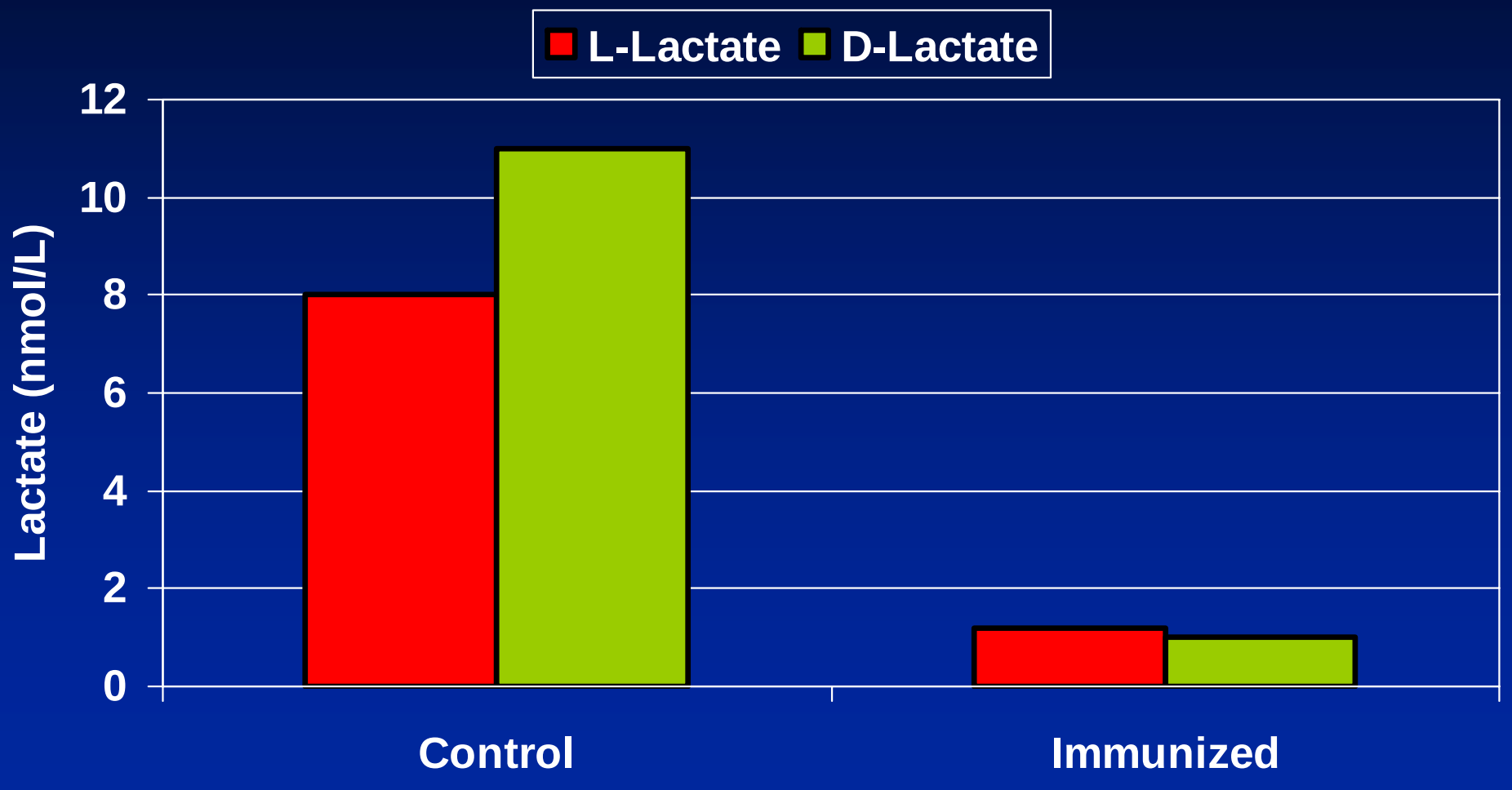
- Immunization
  - Immunization → Antibodies to the rumen through saliva → Reduction of specific microbial groups

Bacterial Counts after Immunization



Shu et al. (1999)

Lactate Concentrations after Immunization

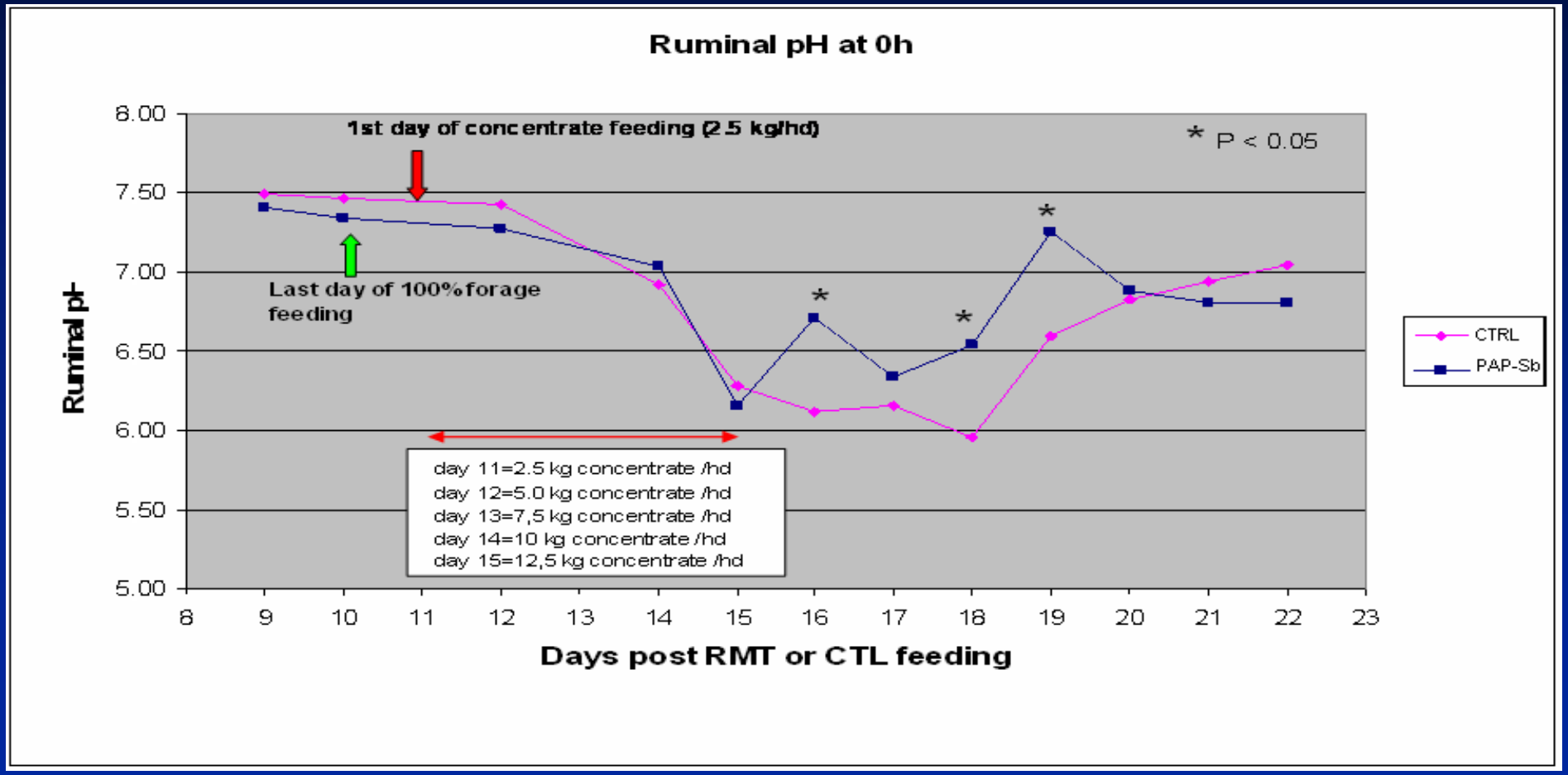


Shu et al. (1999)

Inhibition of Specific Microbial Groups: Antibodies

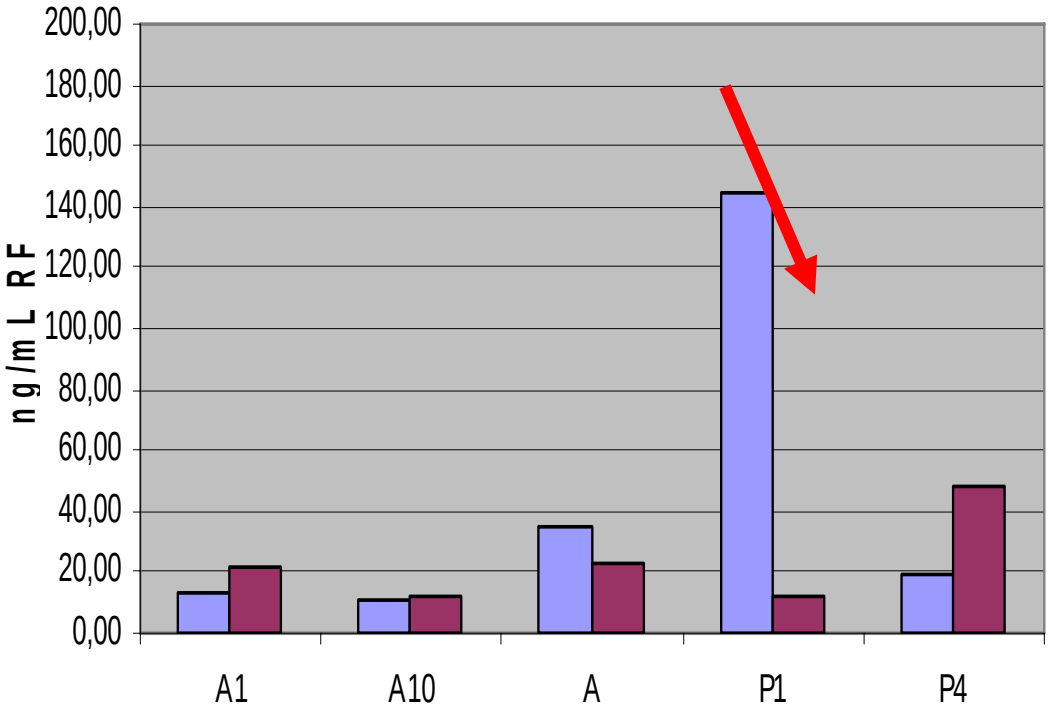
- Immunization
  - Immunization → Antibodies to the rumen through saliva → Reduction of specific microbial groups
- Polyclonal antibodies
  - Immunization of chickens → Polyclonal antibodies → Oral dose → Reduction of specific microbial groups

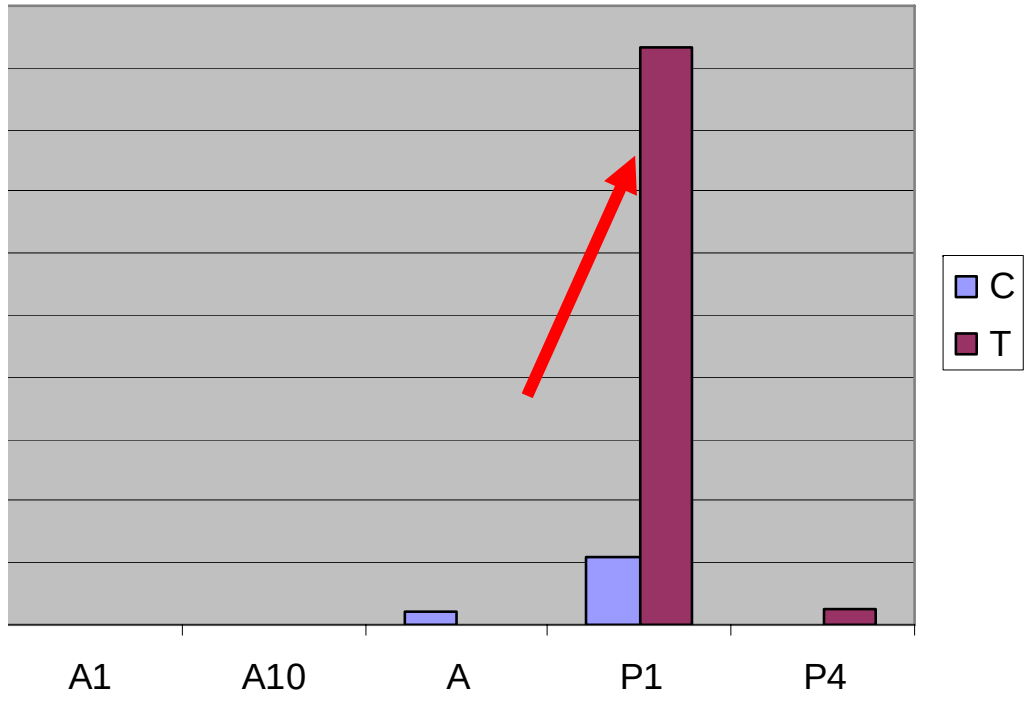
Antibodies against *S. bovis* and pH:



(Blanch et al., 2006)

Antibodies and *S. bovis* and *M. elsdenii*



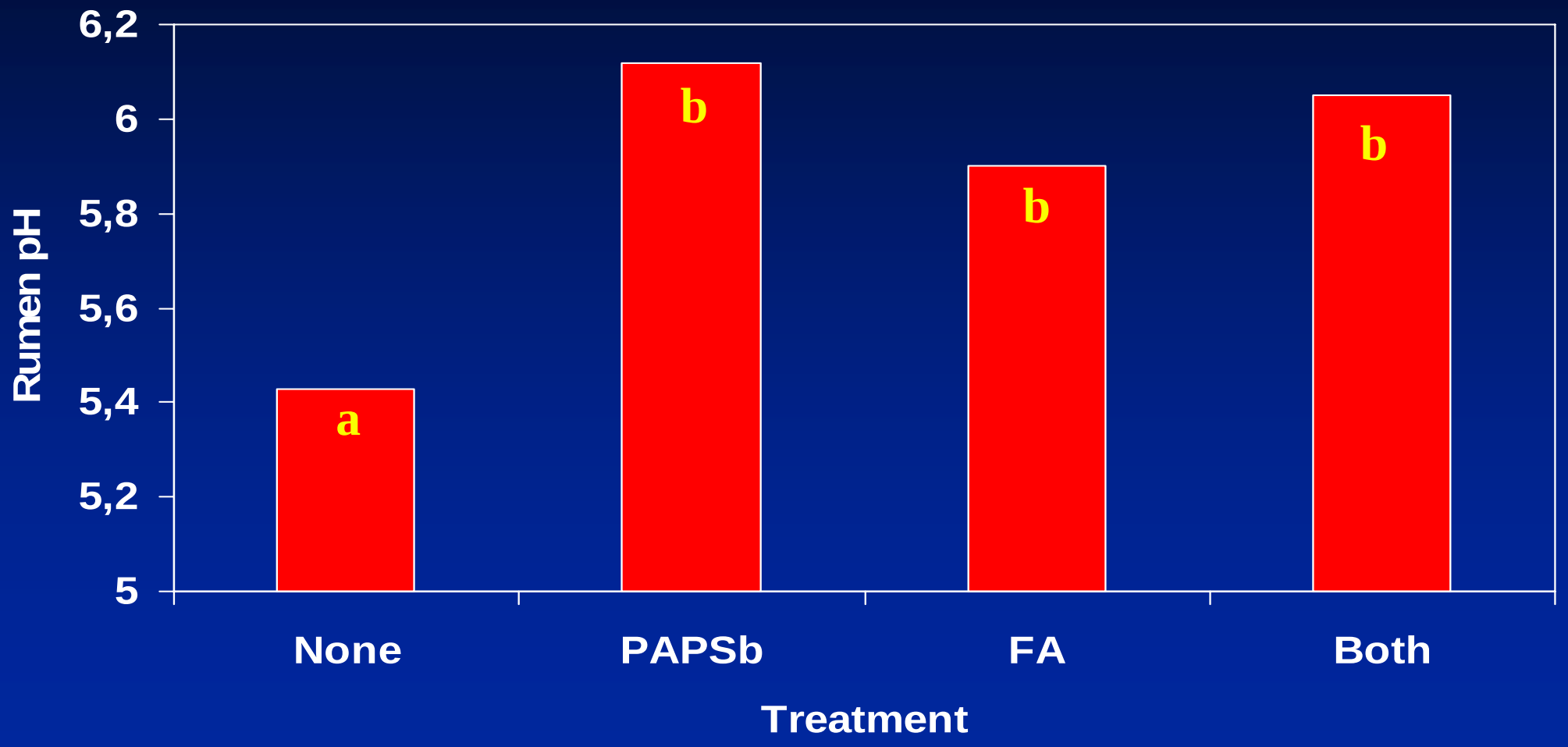


DAY: $P < 0.10$

S. bovis ***M. elsdenii***

(Blanch et al., 2006)

Effect of S.b. and F.n. Antibodies on Ruminal pH



[a, b] (P < 0.05).

DiLorenzo et al. (2005)

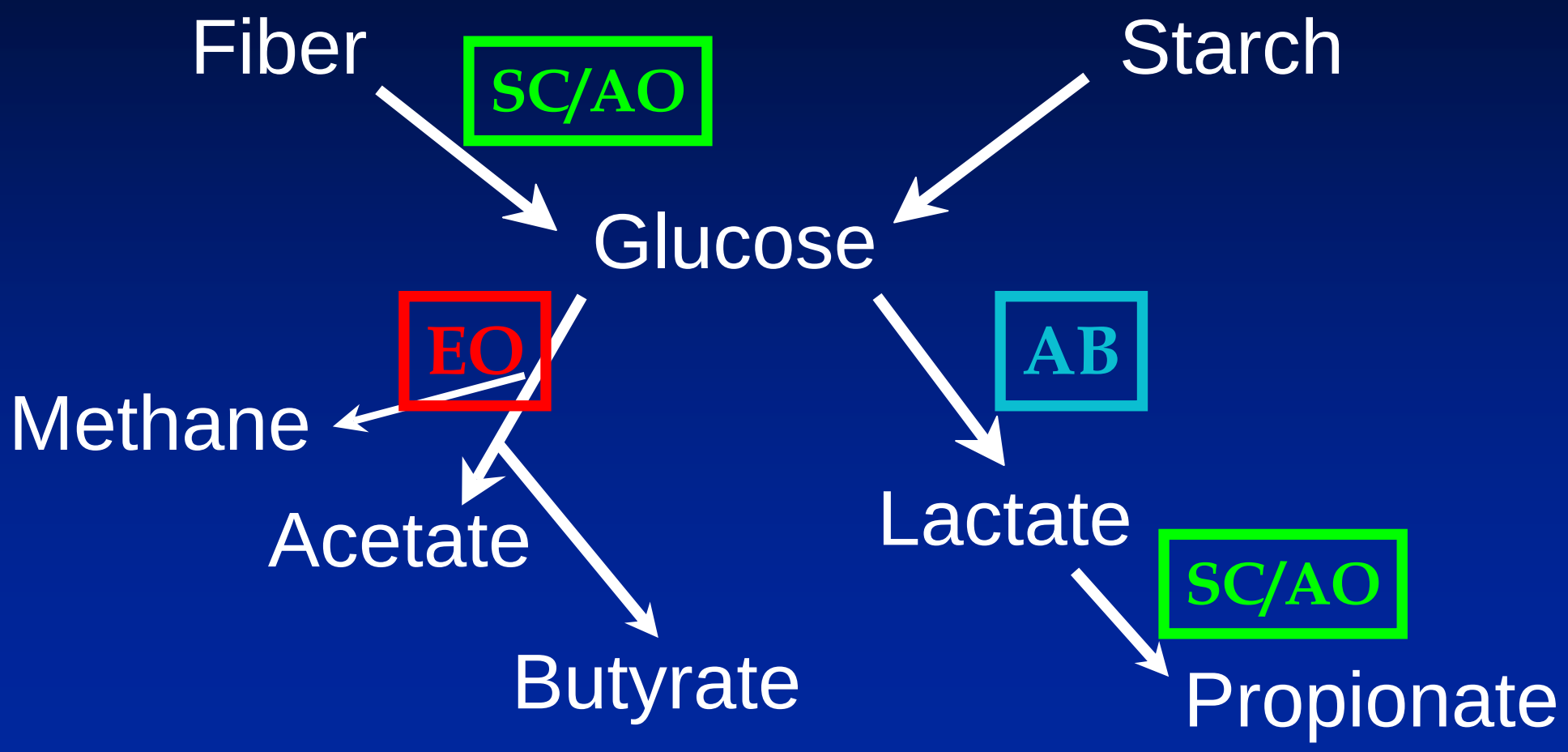
Effect of Antibodies on Feedlot Performance

	CTR	Fn	Sb	Both	SE
Initial BW, kg	265	267	266	267	0.72
Final BW, kg	539	545	544	543	2.76
ADG, kg	1.70	1.74	1.74	1.73	0.02
DMI, kg/d	9.46	9.40	9.32	9.37	0.10
Gain/Feed	0.179[a]	0.185[b]	0.186[b]	0.184[ab]	0.002

[a,b] ($P < 0.05$)

DiLorenzo et al. (2005)

Summary: Energy



Conclusions

- The objectives of modulating ruminal fermentation should be clearly defined for each production system.
- The careful selection and combination of additives with specific effects and synergies may help in optimising ruminal fermentation.
- Data on benefits of these combinations is not available.
- The use rumen modifiers can only be justified if animal performance and economic benefits are obtained. However, this information is very limited and urgently needed.