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Direction and practice in response to banned use of antibiotics as feed additives in beef cattle feeding

应对抗生素添加剂禁用的肉牛生产方向与策略

Wenzhu Yang & Karen Beauchemin

Agriculture and Agri-Food Canada, 加拿大农业与农业食品部列桥研究中心

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Presentation outlines 报告提纲

- Antibiotic use in beef cattle 肉牛用抗生素
- Alternatives to in-feed antibiotics 饲用抗生素替代物
- Probiotics or direct-fed microbials (bacteria, yeast) 益生菌或直接饲喂微生物（细菌、酵母菌）
- Plant bioactive 植物提取物
- Feed enzymes 饲用酶制剂
- Other products 其它产品
- Conclusion 结论

Antibiotic use in livestock 抗生素在家畜中的应用

- Therapeutic: cure a disease 用于治疗：治愈疾病
- Prophylactic: prevent a disease 用于预防：预防疾病
- Growth promoters: subtherapeutic to increase growth rates and improve feed efficiency

生长促进剂：使用亚治疗剂量以增加生长速度并改善饲料转化效率

Antibiotics approved for animal feed
动物饲料中批准使用的抗生素

- In-feed antibiotics 饲用抗生素
  - Ionophores (Monensin, Lasalocid) 离子载体类（莫能菌素、拉沙里菌素）
  - Tylosin (Tylan®) 泰乐菌素

SWINE FEED

Antibiotic	Rank
Virginiamycin	II
Lincomycin	II
Tilmicosin	II
Tylosin phosphate	II
Chlortetracycline , sulfamethazine and procaine penicillin	II/III
Lincomycin and Spectinomycin	II/III
Tylosin phosphate and Sulfamethazine	II/III
Zinc bacitracin and procaine penicillin	II/III
Bacitracin methylene disalicylate	III
Bacitracins	III
Chlortetracycline	III
Oxytetracycline	III
Ionophores	IV

POULTRY FEED

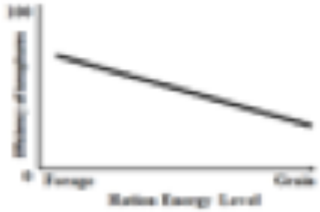
Antibiotic	Rank
Virginiamycin	II
Erythromycin thiocyanate	II
Hygromycin B	II
Penicillin from Procaine penicillin	II
Zinc bacitracin and Procaine Penicillin	II
Bacitracins	III
Chlortetracycline	III
Oxytetracycline	III
Bambermycins	IV
Ionophores	IV

CATTLE FEED

Antibiotic	Rank
Tylosin phosphate	II
Oxytetracycline hydrochloride and Neomycin sulphate	II/III
Bacitracins	III
Chlortetracycline	III
Chlortetracycline and Sulfamethazine	III
Oxytetracycline	III
Ionophores	IV

Efficiency of Ionophores 离子载体的作用效率

- Beef Cattle Nutrient Research Model肉牛营养研究模型(2016):
  - 3% reduction in dry matter intake 干物质采食量降低3%
  - Improved gain:feed (high forage > high grain)
    改善增重饲料比（高粗料日粮>高谷物日粮）
  - increased ME availability (2.3% for monensin)
    提高代谢能利用率（莫能菌素可提高2.3%）
- More propionate and less acetate 乙酸降低而丙酸增多
- Inhibit proteolytic bacteria – less protein degradation
  抑制蛋白分解菌-蛋白质降解较少
- Reduces eating rate (smaller, more frequent meals)
  采食速率降低（少量多次采食）
- Less digestive problem 消化问题较少
- Monensin levels now > 40 mg/kg because high concentrate diets are less responsive to monensin (DiLorenzo and Galyean 2010).
  由于高精料日粮对莫能菌素不敏感，因此目前莫能菌素添加水平高于40mg/kg



Duffield et al. 2012

Prevalence of liver abscesses in tylosin-fed cattle
饲喂泰乐菌素的牛的肝脏脓肿发病率

- Reduction in liver abscesses 肝脓肿发病率下降
- 2.1 % increase in growth rate 生长速度增加2.1%
- 2.6 % increase in feed efficiency 饲料效率增加2.6%
- 0.24% increase in dressing percentage

屠宰率增加0.24%

- Extra $5 to $14/hd

每头牛利润额外增加5-14美元

Source 来源: Elanco Animal Health

	No. Livers examined 参评肝脏数量	Abscessed livers (%) 脓肿发病率
Study 1		
Control	266	31[a]
Vaccine	271	16[b]
Tylosin	283	9[b]
Study 2		
Control	279	48[a]
Vaccine	263	30[b]
Tylosin	275	12[b]

Control :对照组；Vaccine：疫苗组；Tylosin：泰乐菌素组

Source 来源: Nagaraja and Lechtenberg (2007)

Pressure to decrease use of in-feed antibiotics in beef production 减少肉牛生产中饲用抗生素使用的压力

- In 2006, the EU had already banned the use of antibiotics as growth promotion

  2006年，欧盟已经禁止将抗生素用作生长促进剂

- U.S. FDA banned the use of antibiotics as feed supplements to help livestock and poultry grow faster in January 2017

  2017年1月，美国FDA禁止将抗生素用于促进家畜和家禽生长速度的饲料补充料中国2020年底全面禁止饲用抗生素的使用

- In Canada, livestock producers need a prescription from a licenced veterinarian to buy a medically important antibiotic for therapeutic use in livestock production since December 2018

  自2018年12月起，加拿大的畜牧生产者在购买用于治疗目的的药用抗生素时，必须要从执业兽医师那里拿到处方

- Are there alternative feed additives that could be used to promote growth?

  是否有能够用于促进动物生长的新型饲料添加剂呢？

What alternatives to use？ 使用哪种抗生素替代物呢

- Probiotics (live microorganisms, yeast, fungi, and bacteria)
  益生菌(活体微生物，如酵母菌、真菌和细菌等)
- Prebiotics(益生素)
- Phytochemicals or plant-derived compounds (saponin, tannins, essential oils)
  植物来源的化合物或植物提取物(皂苷、单宁、精油)
- In-feed enzymes (饲用酶制剂)
- Antimicrobial peptides (抗菌肽)
- Immune modulators (免疫调节剂)
- Organic acids (citric or acetic acids...) 有机酸(柠檬酸或乙酸)
- Phage therapy (噬菌体疗法)
- Vaccines (疫苗)
- Buffers(缓冲剂

- Do they work? 它们会有效吗
- When do they work?它们何时起效
- Are they cost effective? 他们具有成本优势吗
- What does the research say? 目前研究结果

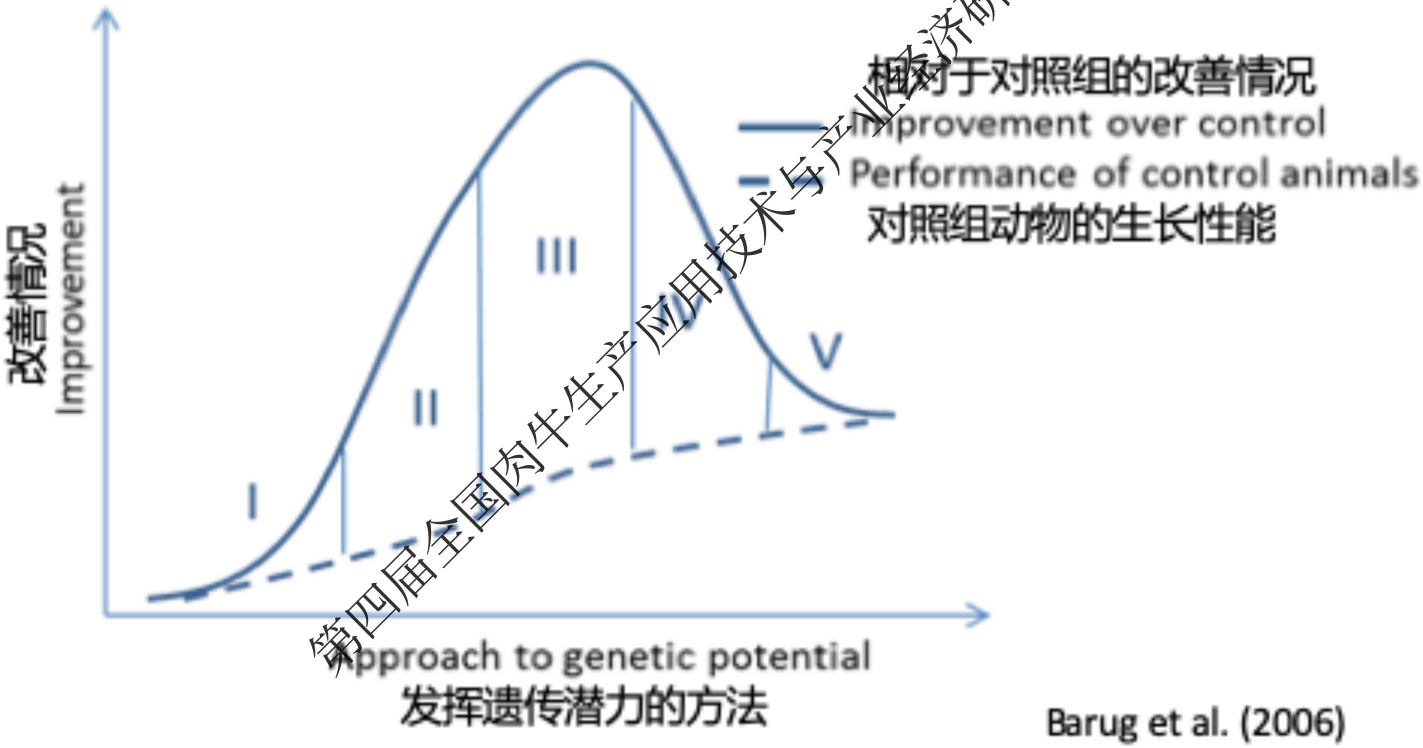
When to use feed additives? 何时使用饲料添加剂

Cost 成本 : Benefit 效益

$$$$$ → Measurable performance benefit expected 预期可衡量的性能效益 (MORE DATA)

$ → Preventative insurance 预防性保障 (LESS DATA)

When to use feed additives?何时使用饲料添加剂



Barug et al. (2006)

Why use of feed additives 为什么使用饲料添加剂

Animal Performance
动物生产性能

- Improve growth rate 提高生长速率
- Feed efficiency饲料效率
- Rumen fermentation瘤胃发酵
- Acidosis protection 亚瘤胃酸中毒保护
- Improve fiber digestion 改善纤维消化

Environmental Impact
环境效应

- Lower methane emissions 减少甲烷排放
- Reduce N losses 降低氮损失

Health & Food Safety
健康&食品安全

- Immune response 免疫反应
- Decrease pathogen shedding减少病原体排泄

Probiotics or direct-fed microbials (DFM)
益生菌或直接饲喂微生物（DFM）

- Probiotic: A live microbial feed supplement beneficially affects the host animal by improving its intestinal microbial balance" (Fuller 1989)

  益生菌：一种活性微生物饲料补充料，可以通过改善宿主肠道微生物平衡而对其产生有益影响

- DFM: Alive, naturally occurring microorganisms that have been used to improve digestive function of livestock (Krehbiel et al. 2003)；

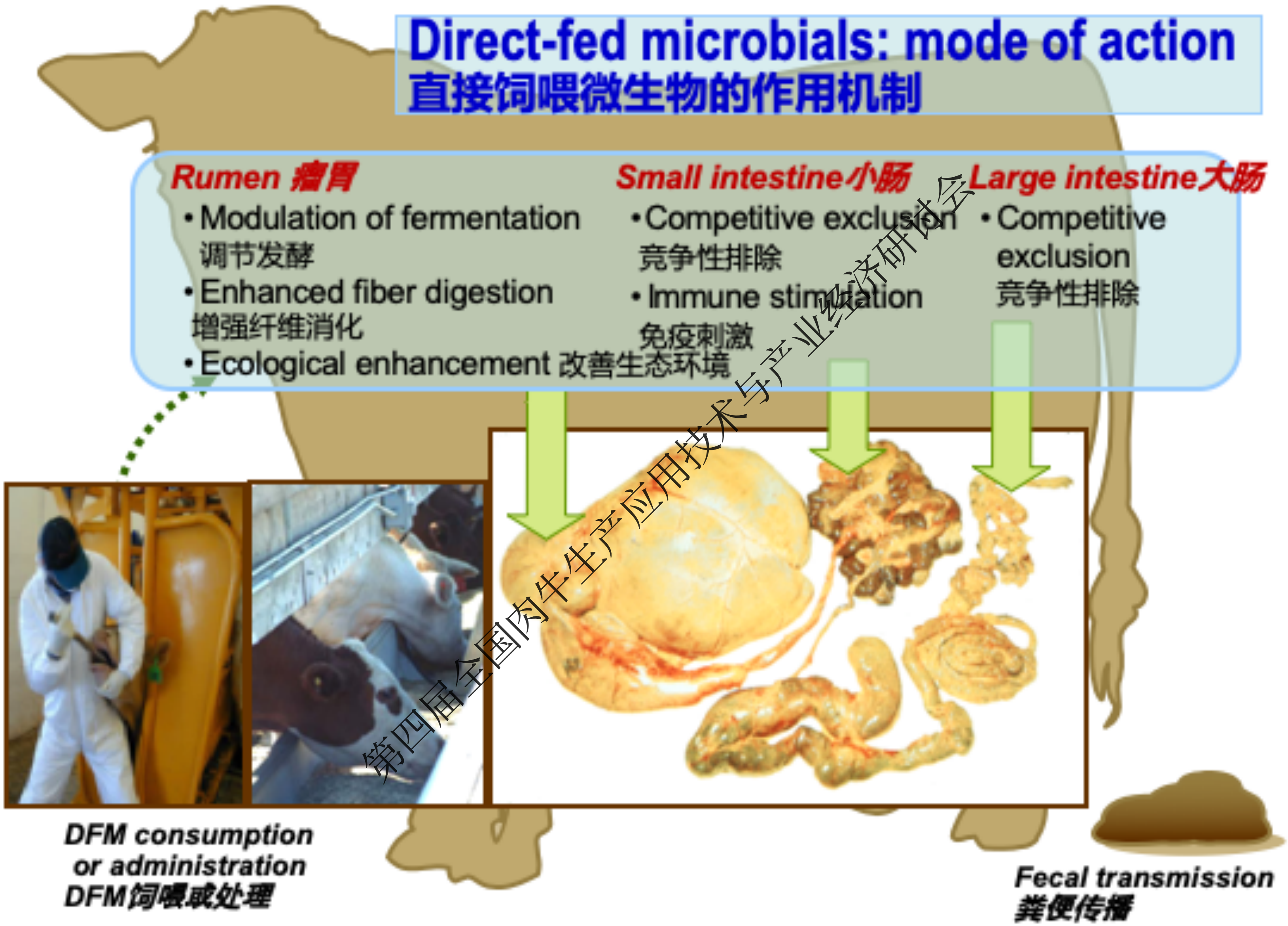
  DFM：活的、天然存在的用于改善家畜消化功能的微生物

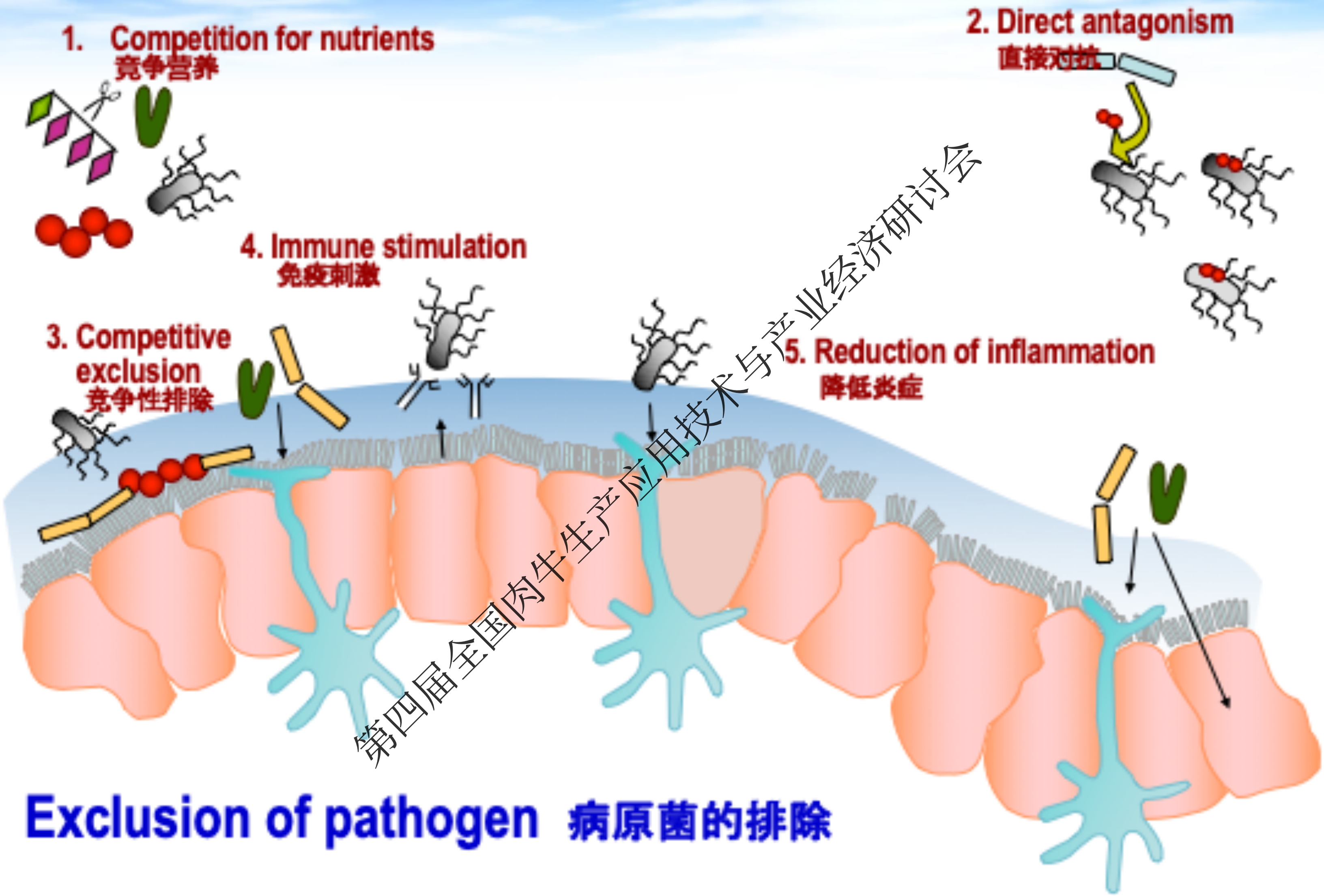
- DFM: bacteria and yeast (live yeast and yeast culture)；

  DFM：细菌和酵母菌（包括活酵母和酵母培养物）

- Prebiotic: substrate is selectively utilized by host microorganisms conferring a health benefit. Non-digestible carbohydrates (oligosaccharides and polysaccharides), peptides, proteins, lipids, limited for cattle, use in calves?

  益生素：可以选择性的被宿主微生物利用并有益于宿主健康的物质，如不可消化碳水化合物（寡糖和多糖）、小肽、蛋白质、脂质等，对成年牛效果有限，但可否用于犊牛？


Direct-fed microbials: mode of action
直接饲喂微生物的作用机制
Rumen 瘤胃
• Modulation of fermentation
调节发酵
• Enhanced fiber digestion
增强纤维消化
• Ecological enhancement 改善生态环境
Small intestine小肠
• Competitive exclusion
竞争性排除
• Immune stimulation
免疫刺激
Large intestine大肠
• Competitive exclusion
竞争性排除
DFM consumption
or administration
DFM饲喂或处理
Fecal transmission
粪便传播



Exclusion of pathogen 病原菌的排除

Bacterial DFM 直饲型细菌

- Ruminant bacterial DFM commercially available；

目前已存在商业型反刍动物直饲型细菌

- The original concept of feeding bacterial DFM to livestock is based on potential intestinal effects；

饲喂家畜细菌性DFM的最初理念是基于其潜在的肠道效应

- Potential modifiers of rumen fermentation and productivity of ruminants；

  反刍动物瘤胃发酵和生产效率的潜在调节剂

- May play a role in enhancing intestinal function in young calves (Krehbiel et al., 2003)；

  可能在改善犊牛肠道功能中起重要作用

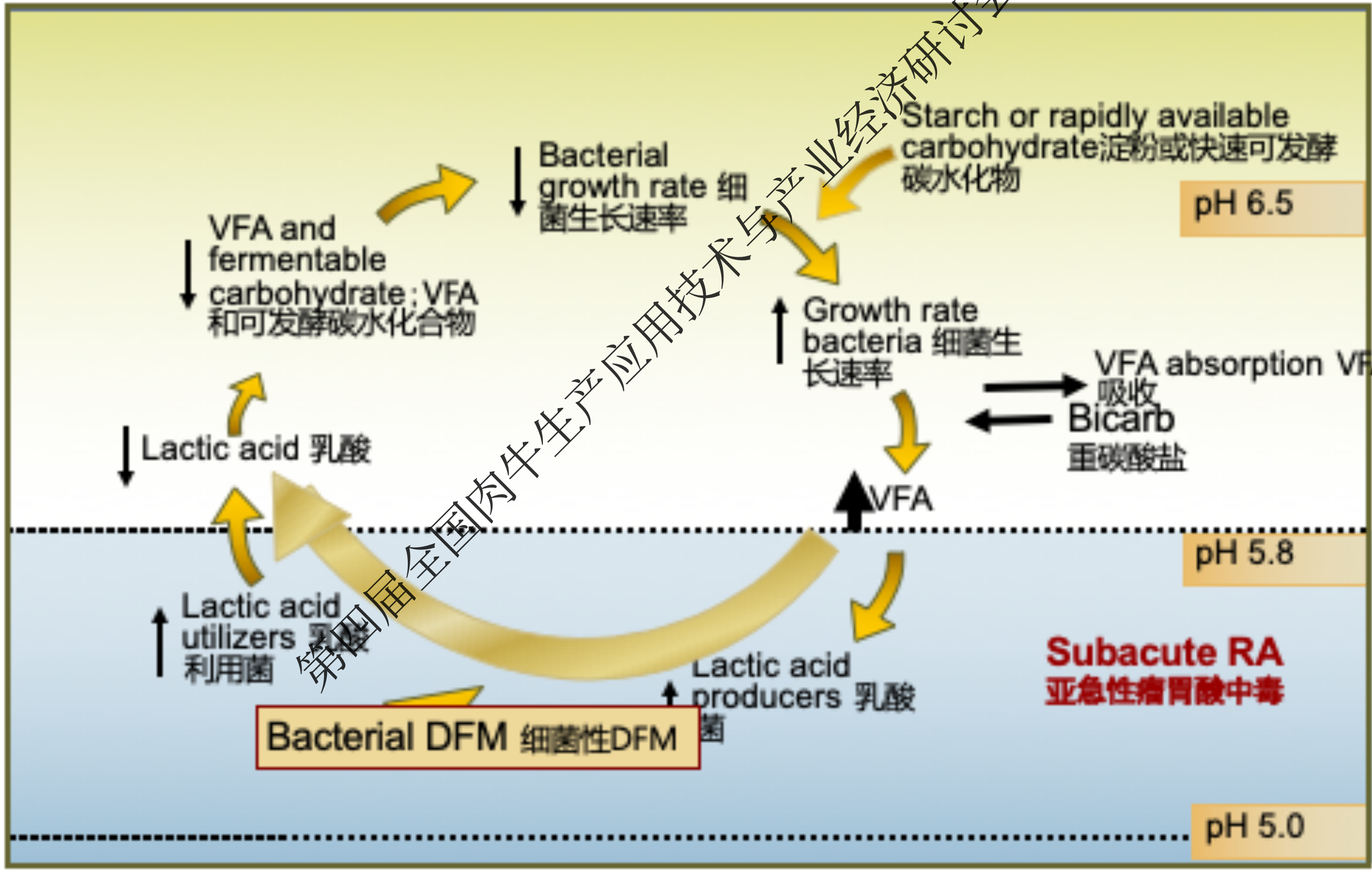
- Some evidence for reduced fecal shedding of harmful pathogens, E. coli; not substantiated in recent studies (Luedtke et al. 2016; Wilson et al. 2016)；

  一些证据表明，它可以降低粪便中有害病原菌如大肠杆菌的排放，但没有在近期研究中得到证实

Main bacterial species used in DFM
DFM中使用的主要的细菌物种

Category分类	Organism 细菌物种
Lactic acid producers	*Enterococcus faecium* 粪肠球菌
乳酸生产菌	*Lactobacillus planetarium* 植物乳杆菌
	Lactobacillus acidophilus 嗜酸乳杆菌
Propionate producers (Lactic acid utilizers)	*Propionibacterium freudenreichii* 费氏丙酸杆菌
丙酸生产菌（乳酸利用菌）	*Megasphaera elsdenii* 埃氏巨型球菌
	Prevotella bryantii 布氏普雷沃氏菌

Changes occurring in the rumen: subacute ruminal acidosis
瘤胃中产生的变化：亚急性瘤胃酸中毒



Rumen fermentation in steers fed enterococcus faecium (EF)
饲喂粪肠球菌(EF)的阉牛的瘤胃发酵

- EF stimulate LA-utilizing bacteria that produce propionate
  EF刺激生产丙酸的乳酸利用菌的生长
- 8:92 forage:concentrate, **short-term study** 精粗比8:92，短期研究
- Control vs *Enterococcus faecium* EF212 (6×10^9 cfu/d)
  对照组vs粪肠球菌EF212组（添加量$6X10^9$ cfu/d）

	Control	EF
Lactate-utilizing bacteria (10^7), cfu/mL 乳酸利用细菌	4.3	6.8
Propionate, mmol/100 mmol 丙酸	25.4^b	33.1^a
Mean rumen pH 平均瘤胃pH	5.56	5.50
Minimum rumen pH 最低瘤胃pH	5.15^a	5.03^b

Beauchemin et al. 2003. JAS 81:1628

Feedlot cattle inoculated with propionibacterium strains
饲喂丙酸菌属菌株的育肥场肉牛

	Control	P169	P5	P54	P-value
Backgrounding diet 后备牛日粮					
Min. pH 最低pH	5.34	5.27	5.19	5.32	NS
pH<5.8, min/d	7.1	9.8	11.7	9.2	NS
Ac:Pr 乙丙比	1.44	1.69	1.50	1.96	NS
Finishing diet 育肥牛日粮					
Min. pH 最低pH	5.87	5.86	5.74	5.92	NS
pH<5.8, min/d	1.2	0.5	3.0	0.7	NS
ADG, kg/day 平均日增重	1.3	1.3	1.5	1.3	NS

Vyas et al., 2014; JAS 92: 2192-2201

Vyas et al., 2014; Animal 8: 1807-1815

Bacterial DFM on growth response
细菌性DFM对生长性能的影响

Study 1: LAB = L. acidophilus and E. faecium（嗜酸乳杆菌和粪肠球菌）; LAB/LU = L. acidophilus and P. freudenreichii（嗜酸乳酸菌和F乳杆菌）, Days 156; F:G=10:90 (Kenney et al. 2015 JAS 93:2336)

Item	Treatments			SEM	*P* <
	Control	LAB	LAB/LU		
Initial BW 初始体重, kg	355	356	355	1.0	0.99
Final BW 终末体重, kg	634ab	644a	625b	6.3	0.05
DMI 干物质采食量, kg/d	9.57	9.57	9.50	0.16	0.77
ADG 平均日增重, kg/d	1.82a	1.87a	1.75b	0.04	0.05
Feed conversion 饲料转化率	5.26	5.09	5.41	0.12	0.07

Study 2: LAB = L. acidophilus and E. faecium, Days 56; F:G=20:80; (Kenney et al. 2015 CJAS 95:93)

Item	Control	LAB	SEM	*P* <
Initial BW 初始体重, kg	280	280	1.1	0.98
DMI 干物质采食量, kg/d	9.0	9.2	0.30	0.25
ADG 平均日增重, kg/d	1.54	1.57	0.08	0.21
Feed conversion 饲料转化率	5.78	5.85	0.19	0.41

Bacterial DFM – Calves 细菌性DFM-犊牛

- DFM can inhibit or prevent pathogen like E. coli establishment attached to the intestinal mucosa

  DFM可以抑制或预防病原菌（如大肠杆菌）在肠黏膜上附着

- Greatest performance response to bacterial DFM occurred within first 14 d of the receiving period (Crawford et al. 1980)

  细菌性DFM的最大性能响应发生在接收期的前14天

- Morbidity was reduced by 28% in cattle receiving the bacterial DFM vs. control cattle

  与对照组牛相比，接受细菌性DFM处理的牛的发病率下降28%

- DFM improved recovery of morbid newly received feedlot calves with reduced need of antimicrobial treatment (Krehbiel et al. 2003).

  DFM改善了育肥场新接收牛的应激恢复过程，同时减少了对抗生素的需求

- Growth performance response to bacterial DFM is not consistent (Krehbiel et al. 2003)

  细菌性DFM对牛生长性能影响的结果不一致

Summary – Bacterial DFM 总结-细菌性DFM

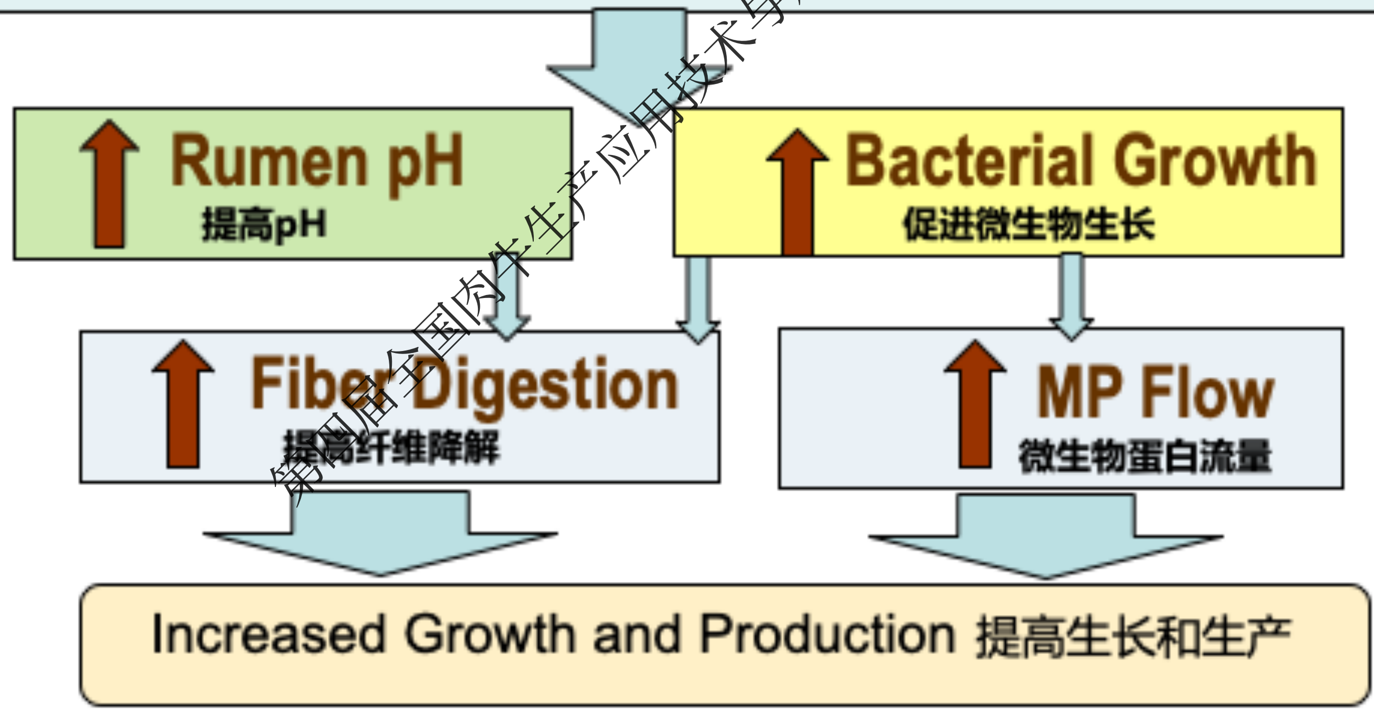
- Many commercial products available
  许多可用的商业化产品
- Limited number of scientific long term studies in beef cattle
  在肉牛上的长期科学研究有限
- Inconsistent results, very few studies with improvements in gain or feed efficiency
  研究结果不一致，改善增重或饲料效率的结果极少

Commercial yeast (Saccharomyces cerevisiae) products used in ruminant diets
用于反刍料中的商品化酵母产物 (酿酒酵母)

Yeast 酵母菌	Contains 含量
Active dry yeast 活性干酵母(ADY)	• Viable yeast cells (>10 billion colony forming units per gram [cfu/g]) 有活力的酵母细胞 (>10^{11}cfu/g) • Fermentation process 发酵过程 ⇨ cell mass separated from the spent liquid, filtered and dried into instant dry yeast 从发酵液中分离、过滤并即时干燥的酵母细胞数量
Yeast culture 酵母培养物 (YC)	• Yeast plus culture medium 酵母菌+培养基 • Fermentation process 发酵过程 ⇨ entire culture-media dried onto carrier (e.g., wheat middlings) 在载体（如麦麸）上干燥整个培养基 • Cells are not viable 细胞无活性

Proposed mode of action of yeast in the rumen
酵母菌在瘤胃中可能的作用机制

- Oxygen scavenging (ADY), lower redox potential in the rumen **除氧，降低瘤胃中氧化还原能力**
- Increased rate of colonization of feed particles **增加饲料颗粒黏附**
- Growth factors (B vitamins, organic acids, peptides and AA) for microbes **微生物生长因子（VB等）**
- Stimulation of lactic acid utilizers, enhanced lactic acid utilization **刺激乳酸菌生长，增强乳酸利用**
- Increased ciliate protozoa **增加纤毛原虫数量**
- Reduced *Strep. bovis*, **乳酸产气菌（牛链球菌）减少，降低乳酸产量**



How important is yeast viability 酵母活力有多重要?

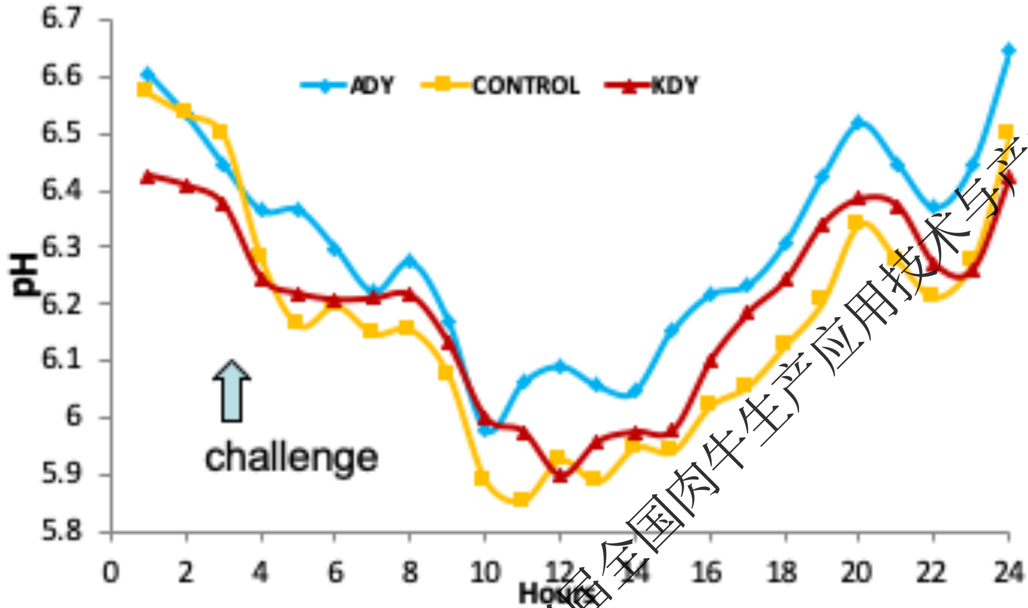
- Growing beef cattle生长肉牛
- 50:50 (forage : concentrate) diet
  精粗比50:50日粮
- Treatments 处理:
  - Control (no yeast) 对照组（无酵母）
  - ADY - 4 g/d (AB Vista), 6 x 10^{10} cfu/d
  - KDY - 4 g/d (autoclaved ADY，高压灭菌处理ADY)

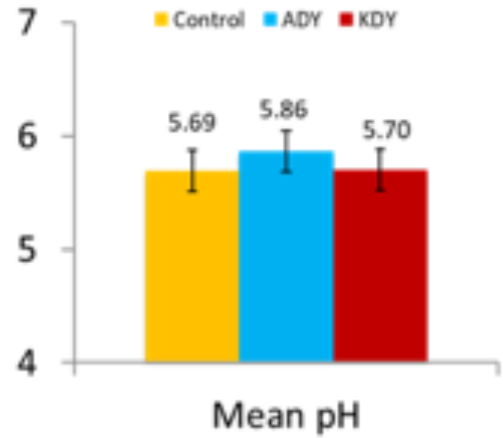
Continuous measurements of pH
连续测定pH

Adaptation 适应期	Baseline measurements 基线测定	Restricted feed 50% 限饲50%	Acidosis challenge 人为介导酸中毒	Recovery 恢复
d 1 – 14	d 15 – 20	d 21	d 22	d 23 – 28

Vyas et al. 2014 JAS 92:724; Vyas et al. 2014 AFST 197:103

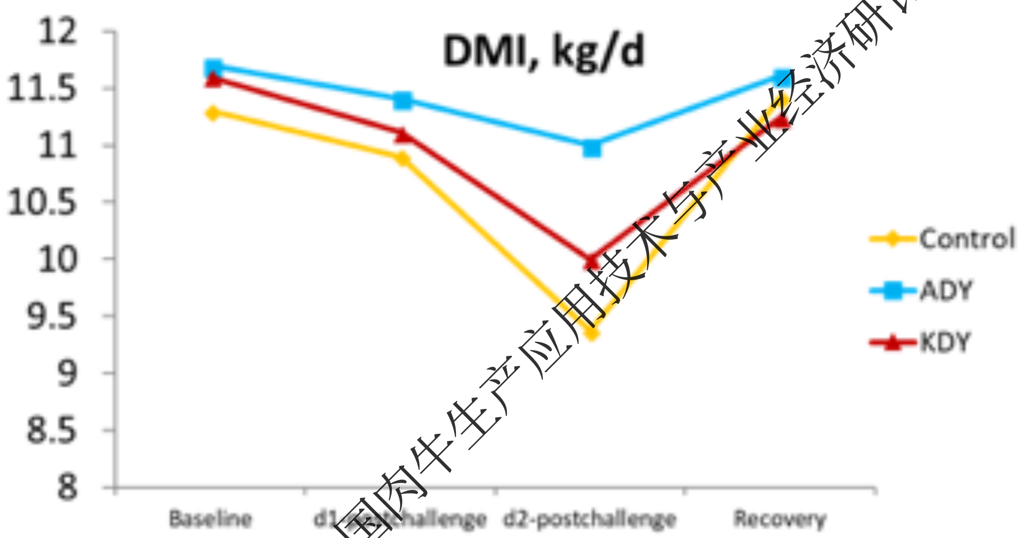
Average hourly ruminal pH (after challenge)
每小时平均瘤胃pH（介导酸中毒后）





- Mean ruminal pH on d1 post-challenge was numerically higher with viable yeast ($P = 0.13$)
  经活性酵母处理的牛在人工介导酸中毒后1d内瘤胃pH数值上较高
- pH recovery tended to be quicker with ADY
  经ADY（活性干酵母）处理的牛的瘤胃pH有较快的恢复趋势

Effects of ADY and killed yeast (KDY) on dry matter intake
（活性或灭活干酵母对干物质采食量的影响）



❖ ADY helped maintained dry matter intake during and post grain challenge

活性干酵母有助于维持人为介导酸中毒后肉牛的DMI水平

Rumen protected and non-protected ADY
瘤胃保护或不保护型ADY

- Animals 动物: rumen cannulated beef heifers 装有瘤胃瘘管的青年母牛
- Design 设计: a 5 × 5 Latin square 一个5X5的拉丁方试验
- Diet日粮: 10% barley silage and 90% barley
  10%大麦青贮+90%的大麦
- Treatments 处理:

1. Control (no additives) 对照组（无添加剂）
2. Antibiotics (ANT; monensin+tylosin)
   抗生素组（ANT；莫能菌素+泰乐菌素）
3. Active dried yeast (ADY) 活性干酵母（ADY）
4. Encapsulated ADY (EDY) 胶囊化的ADY（EDY）
5. Mixture of ADY and EDY ADY+EDY

Jiao et al. 2017. AFST 228:13-22

Encapsulation of ADY to improve post-ruminal digestion in beef cattle

EDY对肉牛瘤胃后消化的改善作用

	Control	ANT	ADY	EDY	ADY + EDY
Intake of DM, kg/d；DMI	11.8	12.1	11.9	11.5	11.9
Digestibility, % intake 消化率					
Rumen 瘤胃					
OM (true) 有机物（真）	66.4	68.1	63.8	62.4	62.9
NDF 中性洗涤纤维	42.4	41.8	43.0	46.5	46.0
Postruminal 瘤胃后					
OM 有机物	24.0[bc]	21.6[c]	28.8[ab]	29.9[a]	31.9[a]
NDF 中性洗涤纤维	9.3[bc]	6.5[c]	11.8[ab]	16.4[ab]	19.2[a]
Total tract, % 全消化道					
OM 有机物	77.6[cd]	76.4[d]	79.2[bc]	80.3[ab]	81.9[a]
NDF 中性洗涤纤维	51.7[bc]	48.3[c]	54.7[b]	62.9[a]	65.2[a]

Jiao et al. 2017. AFST 228: 13-22

Effect of ADY on growth performance in beef steers
ADY对阉牛生长性能的影响

	Control	ANT	ADY	EDY	ADY + EDY
Initial BW, kg 初始体重	448	448	448	448	448
Final BW, kg 终末体重	627	623	628	625	631
Intake of DM, kg/d DMI	11.0[ab]	10.5[b]	11.4[a]	11.3[a]	11.5[a]
ADG, kg/d 平均日增重	1.59	1.57	1.61	1.57	1.63
F:G, kg/kg 饲料转化率	6.82	6.66	7.02	7.08	6.93
Severely abscessed liver, % 严重肝脓肿	26.7[a]	26.7[a]	6.7[b]	20.0[a]	6.7[b]
Blood glucose, mg/dL 血糖	85.4[b]	82.7[b]	79.4[b]	87.8[ab]	95.2[a]
Haptoglobin, μg/mL 触珠蛋白	202[b]	164[b]	356[a]	359[a]	372[a]
Serum amyloid A, μg/mL 血清淀粉样蛋白A	6.66[a]	4.36[bc]	5.60[ab]	4.06[c]	4.03[c]
Fecal IgA, μg/g 粪IgA	0.17	0.16	0.17	0.14	0.18
Fecal E. coli, $\times 10^7$ 粪中大肠杆菌	8.5	10.1	4.0	3.3	2.5

Ran et al. 2018 JAS, 96:4385-4397

Use of yeast culture (YC) in beef cattle
酵母培养物（YC）在肉牛中的应用

Design 设计: **5 × 5 Latin Square 拉丁方试验**

28

21 | 7

Adaptation 适应期 | Sampling采样期

Treatments 处理:

1）Control (CON; no YC, no antibiotics);

对照组（CON；无YC，无抗生素）

2）330 mg monensin + 110 mg tylosin/d (ANT)

每天使用330 mg莫能菌素+110mg 泰乐菌素（ANT）

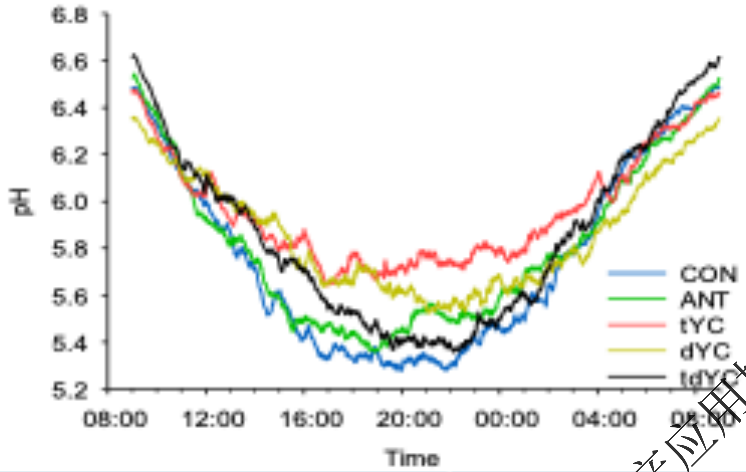
3）Top dressed YC (tYC; 18 g/d) **口服YC（tYC；18g/d）**

4）Duodenally delivered YC (dYC; 18 g/d)

十二指肠投放YC（dYC；18g/d）

5）Mixture of #3 & 4 (tdYC, 36 g/d); **3+4（tdYC，36g/d）**

Effect of yeast culture on rumen pH
酵母培养物对瘤胃pH的影响



Item 项目	Treatments 处理					P <
	Control	ANT	tYC	dYC	tdYC	
pH Value pH值						
Mean pH 平均pH	5.77	5.81	5.96	5.87	5.87	0.58
Minimum pH 最小pH	5.02^{c}	5.13^{bc}	5.30^{a}	5.21^{ab}	5.05^{c}	0.03
Maximum pH 最大pH	6.74	6.69	6.70	6.60	6.77	0.65
pH < 5.6, h/d	11.6	10.4	5.6	8.6	8.7	0.09
Fecal IgA, μg/g 粪便IgA	59.7^{b}	85.5^{a}	45.1^{bc}	72.6^{ab}	79.4^{ab}	0.03

Shen et al. 2018, 96:3916-3927

Use of YC in finishing beef steers
YC在育肥阉牛中的应用

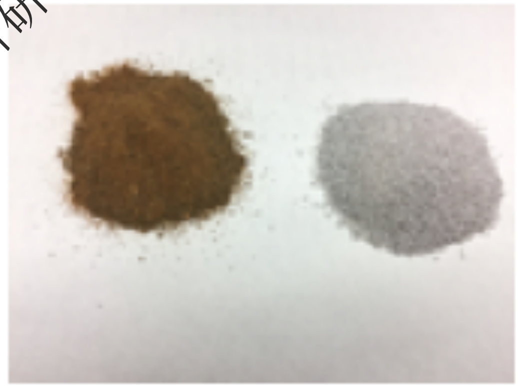
Treatments 处理:

1) Control (no YC, no antibiotics)；**对照组**
2) YC, 12 g/d
3) YC, 15 g/d
4) YC, 18 g/d
5) Encapsulated YC, 7 g/d；**包被YC，7g/d**
6) Monensin + tylosin；**莫能菌素+泰乐菌素**

Diet: F:G = 10:90%；日**粮精粗比10:90**

120 days on feed；**饲喂120 d**

Non- or encapsulated YC
非包被或包被YC



Effects of YC on growth and carcass of finishing steers
酵母培养物对育肥阉牛生长性能和胴体特性的影响

Item	YC, g/d 0	YC, g/d 12	YC, g/d 15	YC, g/d 18	E-YC	ANT	SEM	*P* < Treat	*P* < L
No of steers 阉牛数量	15	15	15	15	15	15			
Growth 生长性能									
Initial BW, kg 初始体重	533	533	533	533	533	533	9.8	1.00	0.99
Final BW, kg 终末体重	703	719	721	709	722	716	13.4	0.36	0.59
DMI, kg/d 干物质采食量	11.8	12.2	11.9	11.6	12.5	11.9	0.36	0.84	0.95
ADG, kg/d 平均日增重	1.62	1.77	1.79	1.68	1.80	1.75	0.08	0.49	0.26
F:G, kg/kg 料重比	7.3	6.9	6.7	6.8	6.9	6.8	0.21	0.54	0.09
Carcass traits 胴体特性									
HCW, kg 热胴体重	414	423	420	417	421	421	8.4	0.97	0.64
Dressing, % 屠宰率	58.9	58.8	58.2	58.8	58.5	59.0	0.37	0.73	0.56
Back fat, mm 背膘厚	20.4	22.0	20.8	20.1	19.3	20.8	1.71	0.92	0.97
LM area, cm^2 眼肌面积	80.3	80.3	81.1	78.5	80.2	77.1	2.64	0.75	0.74
Marbling score 大理石花纹	5.51	6.33	5.96	6.00	5.96	5.75	0.22	0.29	0.10
Liver score, % 肝脏评分									
Abscessed 肝脓肿	66.7	60.0	53.3	60.0	53.3	60.0	--	0.97	
Severely 严重肝脓肿	53.3	33.3	20.0	20.0	20.0	6.7	--	0.10	

No quadratic effect; Abscessed = % liver with at least 3 small abscesses; severely = at least 1 abscess with diameter > 2.5 cm

无二次曲线效应：肝脓肿=至少三个小脓肿的肝脏比例；严重肝脓肿：至少一个囊肿直径>2.5 cm

Shen et al. unpublished

YC on fecal and blood metabolites in finishing steers

酵母培养物对育肥阉牛粪便和血液代谢物的影响

Item 项目	Yeast culture, g/d 酵母培养物				eXPC	ANT	P <	
	0	12	15	18			Treat	L
No of steers 阉牛数量	10	10	10	10	10	10		
Feces 粪便								
Fecal pH 粪便pH	6.22[b]	6.37[b]	6.22[b]	6.63[a]	6.49[ab]	6.74[a]	0.01	0.04
IgA, μg/g	3.78[ab]	4.42[a]	3.28[ab]	4.56[a]	1.82[b]	5.12[a]	0.05	0.71
E. coli counts 大肠杆菌数量	7.50	7.14	7.15	7.17	7.18	7.31	0.23	0.02
Blood 血液								
Glucose, mg/dl 葡萄糖	108	92	97	105	95	100	0.62	0.43
NEFA, μ*M* *非酯化脂肪酸*	125	[illegible]	152	132	137	136	0.93	0.50
BUN, mg/dl 尿素氮	22.5[b]	27.4[ab]	26.7[ab]	30.8[a]	30.2[a]	30.8[a]	0.01	0.01
APP, μg/mL 急性相蛋白								
Hp 触珠蛋白	124[bc]	126[bc]	128[b]	146[a]	113[c]	126[bc]	0.01	0.04
LBP 脂多糖结合蛋白	[illegible]	83	103	112	87	103	0.35	0.09
SAA 血清淀粉样蛋白A	13.2	19.4	28.6	29.5	22.2	22.4	0.14	0.01

No quadratic effect; APP = acute phase protein; Hp = haptoglobin; SAA = serum amyloid A; LBP = lipopolysaccharide binding protein

Shen et al. unpublished

Meta-analysis: ADY and monensin for feedlot cattle
荟萃分析：活性干酵母和莫能菌素对肉牛的影响

15 studies；15项研究

	Control	ADY*	Monensin	ADY + Monensin
ADG, kg/d 平均日增重	1.45^a	1.54^b	1.54^b	1.57^b
Kg DMI/kg gain 料重比	6.61^a	6.40^b	6.32^b	6.13^b

* S. cerevisiae CNCM I-1077

Erasmus et al. 2009

Yeast vs beef cattle performance?
酵母菌vs肉牛生长性能？

- Meta-analysis for beef cattle (12 papers, 22 studies)
  基于肉牛实验研究的荟萃分析（12篇文章，22项研究）
- Mixed results 结果比较复杂
- Overall, no effects of ADG 总体上，对平均日增重无影响
  - Animals receiving a diet containing 30 to 50% forage with yeast had greatest response in ADG (similar to dairy diet)
  日粮包含30-50%粗饲料（与奶牛日粮相似）同时饲喂酵母，动物具有最高的ADG
- Overall, decreased DMI in feedlot cattle (-1 kg/d)
  总体上，降低了育肥牛的干物质采食量（-1kg/d）
- Mixed effects on feed:gain ratio 对料重比的影响比较复杂
- Results depend on diet composition, strain used and dose
  结果取决于日粮成分、使用的酵母菌菌株和剂量

Sartori et al. (2017) Journal of Agricultural Science; Vol. 9, No. 4; 2017

Summary of Meta-Analyses in dairy cows
有关奶牛的研究荟萃分析总结

	Desnoyers et al. 2009	deOndarza et al. 2010	Robinson and Erasmus 2009	Poppy et al 2012
Yeast type 酵母菌类型	ADY	ADY	ADY & YC	YC
	------% change from control------			kg/d change
DMI, kg/d 干物质采食量	1.2	---	1.8	0.6 (early lactation)
Milk yield, kg/d 产奶量	2.6	2.6	3.0	1.6
Milk fat, kg/d 乳脂	NS	2.5	4.4	0.06
Milk protein, kg/d 乳蛋白	NS	2.0	2.0	0.03

Other emerging uses of yeast for ruminants: pathogen control 酵母菌在反刍动物中的其他新用途：控制病原体

- ADY and yeast cell wall can influence the ability of certain microbes to colonize the gut (esp. non-ruminants) **ADY和酵母细胞壁可以影响某些微生物在肠道中定植的能力（尤其是非反刍动物）**
- Can bind pathogens and mycotoxins **可以结合病原体和霉菌毒素**
- *S. cerevisiae* subspecies *boulardii* (ADY) in humans, horses and pigs decreased antibiotic-associated diarrhea and restore the natural microbiota in large and small intestine **在人、马和猪中，酿酒酵母的亚种boulardii能够减少抗生素引起的腹泻，并恢复大肠和小肠的天然微生物种群**
- Few ruminant studies (e.g., Keyser et al. 2007 - receiving feedlot cattle; Galvao et al. 2005 - calves)

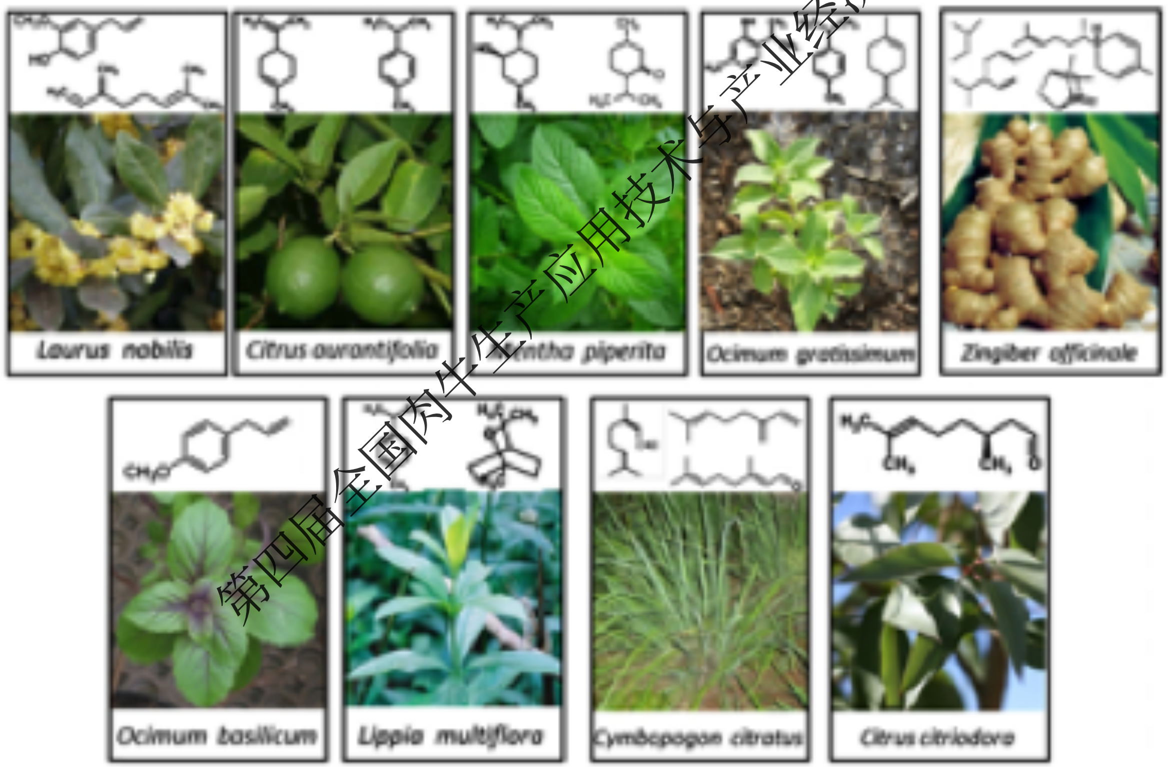
  有关反刍动物的研究很少
- Premature to draw conclusions **下结论尚过早**
  - Resistant to ruminal digestion? Metabolically active in the intestine?
  是否抗瘤胃消化？在肠道中是否有代谢活性

Summary总结 – Yeast 酵母菌

- Both ADY and YC help improve rumen pH and reduce liver abscess
  活性酵母和酵母培养物均可以改善瘤胃pH，降低肝脓肿发病率
- Viable yeast more effective than non-viable yeast during acidosis
  活酵母比失活酵母在缓解瘤胃酸中毒方面更为有效
- YC improve growth performance at high or low forage diets, but ADY appears to be effective at high-forage?
  酵母培养物可以在高或低粗料日粮条件下改善动物生长性能，而活性干酵母似乎在高粗料环境下更为有效?
- Both ADY and YC improve immune response and alter blood metabolites
  活性干酵母和酵母培养物均可以提高免疫反应并改变血液代谢物浓度
- Not clear whether gain and feed:gain ratio is consistently increased, but yeast might help reduce morbidity
  增重和料重比能够稳定提高尚不清楚，但酵母菌可能有助于降低发病率
- Most beneficial: 1) transition and starter period; 2) when ionophore is not fed
  在以下情况下饲喂酵母菌非常有益（1）过渡期和开食期；（2）不使用离子载体
- Rumen protected yeast may be beneficial 瘤胃保护酵母可能是有益的

Plant essential oils 植物精油 (EO)

- Volatile components produced by plants 植物产生的挥发性组分
- Give the characteristic smell, taste 赋予它们独特的气味和味道

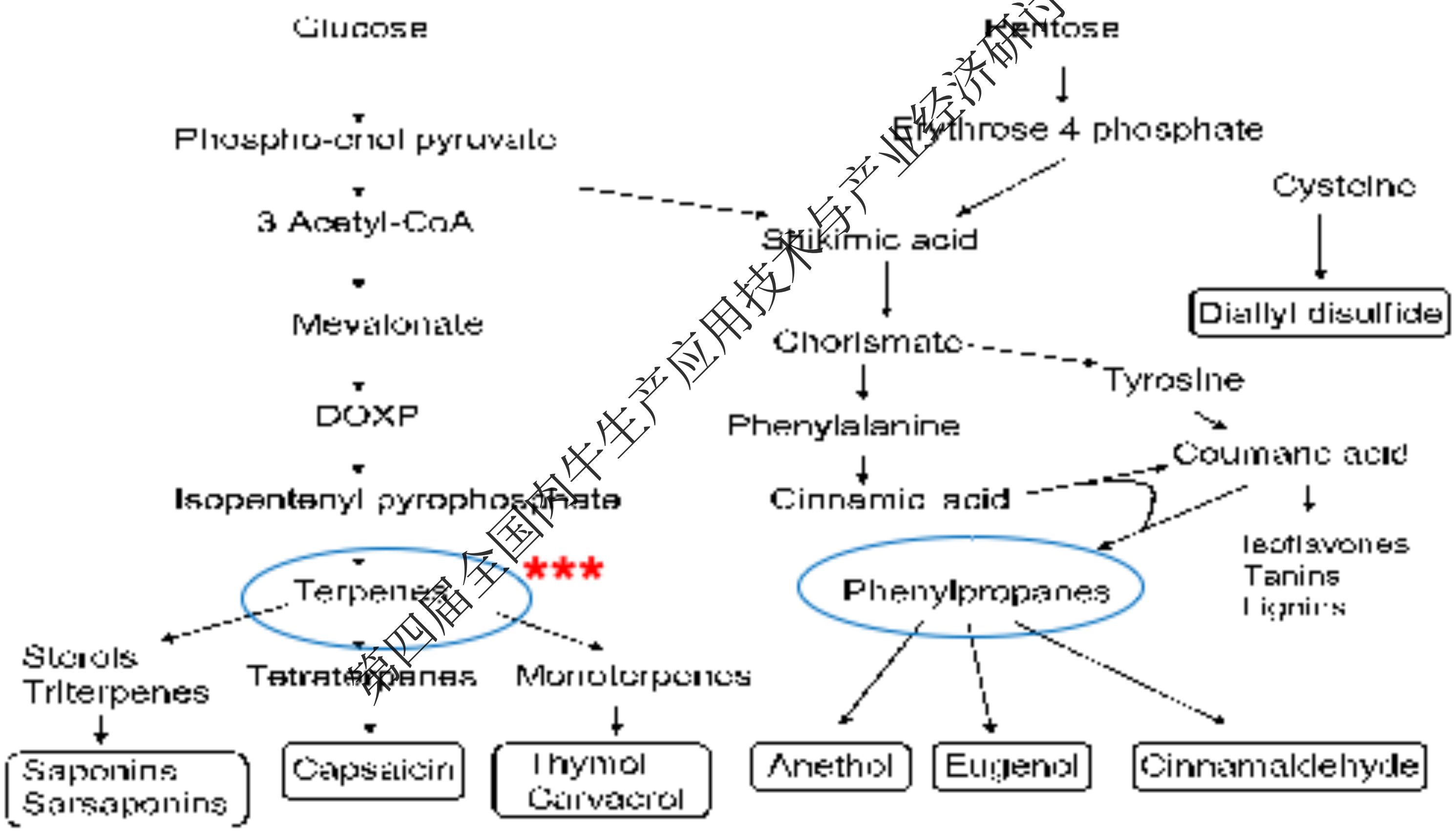


Some sources of essential oils 一些精油的来源 (EO)

Plant 植物	Main components	% total	Plant	Main components	% total
Angelica root 当归根	α-Pinene	24·7	Pepper 胡椒	α-Pinene	9·0
	α-3-Carene	10·5		β-Pinene	10·4
	α-hellandrene+myrcene	10·8		Sabinene	19·4
	Limonene	12·9		δ-3-Carene	5·4
	β-Phellandrene	10·4		Limonene	17·5
	p-Cymene	7·7		β-Caryophyllene	14·7
Bergamot 柠檬	β-Pinene	7·7	Nutmeg 肉豆蔻	α-Pinene	26·0
	Limonene+β-phellandrene	39·4		β-Pinene	15·0
	γ-Terpinene	8·6		Sabinene	27·1
	Linalool	11·1		Myristicin	5·9
	Linalyl acetate	28·0			
Cinnamon bark 肉桂皮	(E)-Cinnamaldehyde	77·1	Orange 橙子	Limonene	91·5
	Eugenol	7·2			
Coriander 香菜	*p*-Cymene	6·1	Mandarine 柑橘	Limonene	79·5
	Linalool	72·0		γ-Terpinene	9·7

Chao et al. 2000

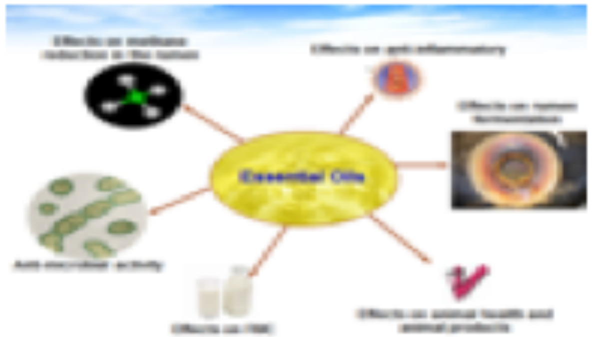
EOs are broadly classified as Terpenes and Phenylpropanes based on the pathway of biosynthesis 根据生物合成途径，EOs可大致分为萜烯类和苯基丙烷类物质



***Most prevalent types of EOs

Plant essential oils 植物精油

- Many are inhibitory to fungi, bacteria and protozoa 许多植物精油对真菌、细菌和原虫都有抑制作用
  - Gram-positive bacteria most susceptible (similar to monensin)
    格兰氏阳性细菌尤其敏感（与莫能菌素相似）
- Most studied for beef: thyme (thymol), oregano (carvacrol), clove (eugenol), cinnamon (cinnamaldehyde) and garlic (allicin)
  许多研究涉及肉牛：百里香（百里香酚），牛至（香芹酚）、三叶草（丁子香酚）、肉桂（肉桂醛）和大蒜（大蒜素）
- Various mechanisms of action identified 确定了多种作用机制
  - Lipophilic, disrupt cell wall function (terpenes) 亲脂性的，破坏细胞壁功能（萜烯类）
  - Disrupt ion gradient across plasma membrane, cause cell death (carvacrol)
    破坏细胞膜上的离子梯度，导致细胞死亡（香芹酚）



Effects of EO on in vitro rumen fermentation
EO对体外瘤胃发酵的影响

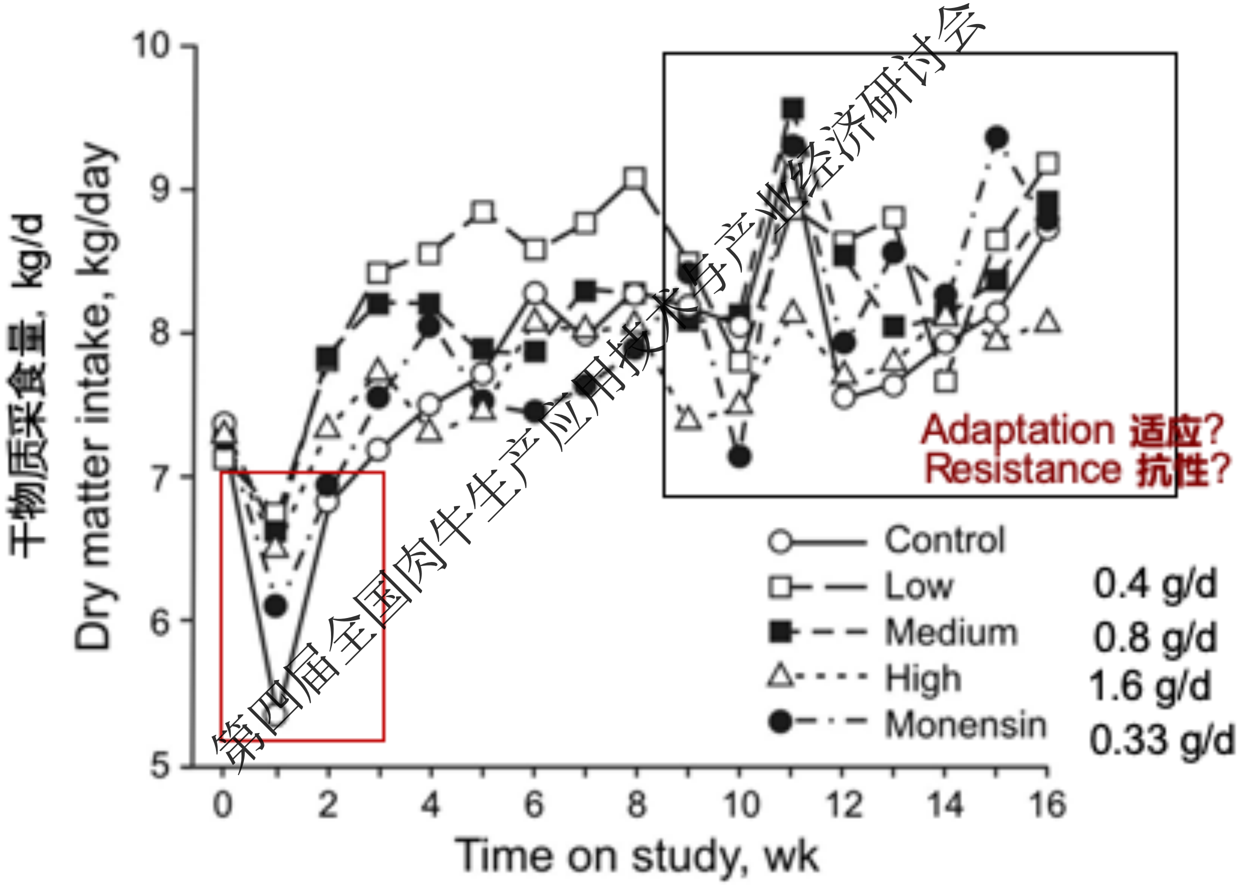
	EO 精油							Active component		
	Blend*	Garlic	Thy	CIN	Oreg	Anise	Caps	CIN	Eug	Anethol
Total bacteria 细菌	-	-	-	-	-	-	-	-	-	-
Cellulolytic 纤维分解菌	-	=	↓	-	-	-	-	-	-	-
Protozoa 原虫	=	-	-	-	-	-	-	-	-	-
Deaminase 脱氨酶	↓	-	-	-	-	-	-	-	-	-
DM dig.干物质消化率	=	=	↓	-	-	-	-	-	-	-
pH	=	-	↑	-	-	-	-	-	↑	-
Total VFA 总挥发酸	=	↓	↓	-	-	-	↓	↓	↓	↓
Acetate 乙酸	=	↓	-	↓	↓	↓	-	↓	↓	↓
Propionate 丙酸	=	↑	-	↑	↑	↑	-	↑	↑	↑
Butyrate 丁酸	=	↑	-	-	-	-	-	↑	-	-
BVFA	=	↓	-	-	-	-	-	↓	↓	-
CH_4 甲烷	=	↓	-	-	-	-	-	-	-	-
NH_3 N 氨态氮		=↓	↓	↓	↓	↓↑	↓	↓	↓↑	↑

*Commercial blend of EO (CRINA); Thy, thyme; oreg, oregano; art, Artenisia; Caps, Capsidium; Eug, eugenol; All, allicine; =, no effect; ↑, increased (P<0.05); ↓, decreased (P<0.05); -, no data.

Essential oils for beef cattle: Cinnamaldehyde
可用于肉牛的精油：肉桂醛

Dose (g/d) 剂量	Experiment conditions 试验条件	Major effects 主效应	Reference
0.4 to 1.6	Long term, high grain diet 长期，高谷物	No effect on intake or gain (increased intake in first 6-8 weeks). 对采食量或增重没有影响（采食量在前6-8周内增加）	Yang et al. 2010a
0.4 to 1.6	Short term, high grain diet 短期，高谷物	No major effect on rumen fermentation. Digestibility of NDF decreased with high dose. 对瘤胃发酵没有显著影响，随着剂量增加，NDF消化率下降	Yang et al. 2010b
5	45 d, high grain diet 45天，高谷物	No effect on intake or gain, rumen pH, rumen ammonia N and total VFA. **Acetate decreased, propionate increased**. 对采食量、增重、瘤胃pH、瘤胃氨态氮和总VFA含量无影响，但乙酸降低，丙酸增加	Vakili et al. 2013

Weekly change in feed intake of steers supplemented with cinnamaldehyde or monensin 补饲肉桂醛或莫能菌素的阉牛的采食量的变化趋势（每周）



Yang et al. 2010 JAS 88:1082

Essential oils for beef cattle: thymol, eugenol
肉牛用精油：百里香酚，丁子香酚

EO product 精油产品	Dose (g/d) 剂量	Experiment condition 试验条件	Major Effects 主要影响	Reference
Thymol (thyme) 百里香酚	5	45 d, high grain diet 45d，高谷物日粮	No effect on intake or gain. **Acetate decreased, propionate increased.** 对采食量和增重无影响，乙酸降低，丙酸升高	Vakili et al. 2013
Eugenol (cloves) 丁子香酚	0.4 to 1.6	Short term, high grain diet 短期，高谷物日粮	Lowered protein degradation in the rumen. **Acetate decreased, propionate increased.** 减少瘤胃内蛋白质降解，乙酸降低，丙酸升高	Yang et al. 2010c

Essential oils for beef cattle, anise, capsicum
肉牛用精油：茴香，辣椒

EO product 精油产品	Dose (g/d)剂量	Experiment conditions 试验条件	Major Effects 主要影响	Reference
Anise 茴香	0.5	Short term, high grain diet短期，高谷物日粮	Reduced VFA, NH_3-N, acetate, increased propionate 挥发酸、氨态氮、乙酸降低，丙酸升高	Fandiño et al. 2008
Capsicum 辣椒	0.5	Short term, high grain diet短期，高谷物日粮	Increased DMI, increased butyrate and reduced acetate DMI和丁酸升高乙酸降低	Fandiño et al. 2008
Activo Premium, Grasp (4 EO)	1 to 1.5	Long term high forage & high grain diets 长期，高粗料&高谷物日粮	No effects on DMI, gain or methane 对DMI、增重或甲烷产量无影响	Beauchemin, unpublished

Phytogenic Compounds 植物源性化合物

- A group of natural growth promoters used as feed additives, derived from herbs, species or other plants (Digestarom®).
  一类从草药、树种或其他植物中提取的、可用作饲料添加剂的天然生长促进剂
- Ingredients: licorice, caraway, vanilla, essential oil of clove, salt and silicon dioxide
  原料：甘草、葛缕子、香草、三叶草精油、盐和二氧化硅
- Antimicrobial, anti-inflammatory, antioxidant activities
  具有抗菌、抗炎和抗氧化活性
- Potential replacement for growth promoting antibiotics?
  生长促进性抗生素的潜在替代物

Phytogenic compounds (PC) - finishing steers
植物源性化合物（PC）-育肥阉牛

Item 项目	PC, g/d 0	0.5	1.0	SEM	P < Linear
Initial BW, kg 初始体重	468	469	468	4.1	0.99
Final BW, kg 终末体重	664	669	675	7.1	0.27
DMI, kg/d 干物质采食量	9.04	9.53	9.45	0.30	0.36
ADG, kg/d 平均日增重	1.82	1.87	1.95	0.05	0.09
F:G, kg/kg 料重比	4.97	5.10	4.85	0.25	0.49
Liver scores, % 肝脏评分					
Abscessed 肝脓肿	55.0	59.0	55.0	…	0.92
Severely 严重肝脓肿	50.0	30.8	42.5	…	0.23

Diet = 10% silage and 90% barley, monensin included, 110 d finishing, 40 steers/treatment
Abscessed = % liver with at least 3 small abscesses;
Severely = at least 1 abscess with diameter > 2.5 cm

Brand et al. unpublished

Summary 小结 - essential oils 精油

- Show promise 应用前景广阔
- Responses highly variable depending upon the EO 作用效果随EO类型不同高度变化
  - Increase intake (short term), increase propionate, decrease protein degradation
    增加采食量（短期），提高丙酸含量，降低蛋白质降解
  - Antimicrobial action of EO is an ionophore-like mechanism
    EO的抗菌基质类似于离子载体类抗生素
- More likely to work when ionophore is not fed 在不饲喂离子载体时可能更有效
- A lot of in vitro work or short term in vivo study 体外或短期体内研究较多
- Need more feeding studies (long term) 需要更多的（长期）饲养试验加以验证

Essential oils 精油 – issues 问题?

- Variable composition, and no standard for any of the commercial EO products

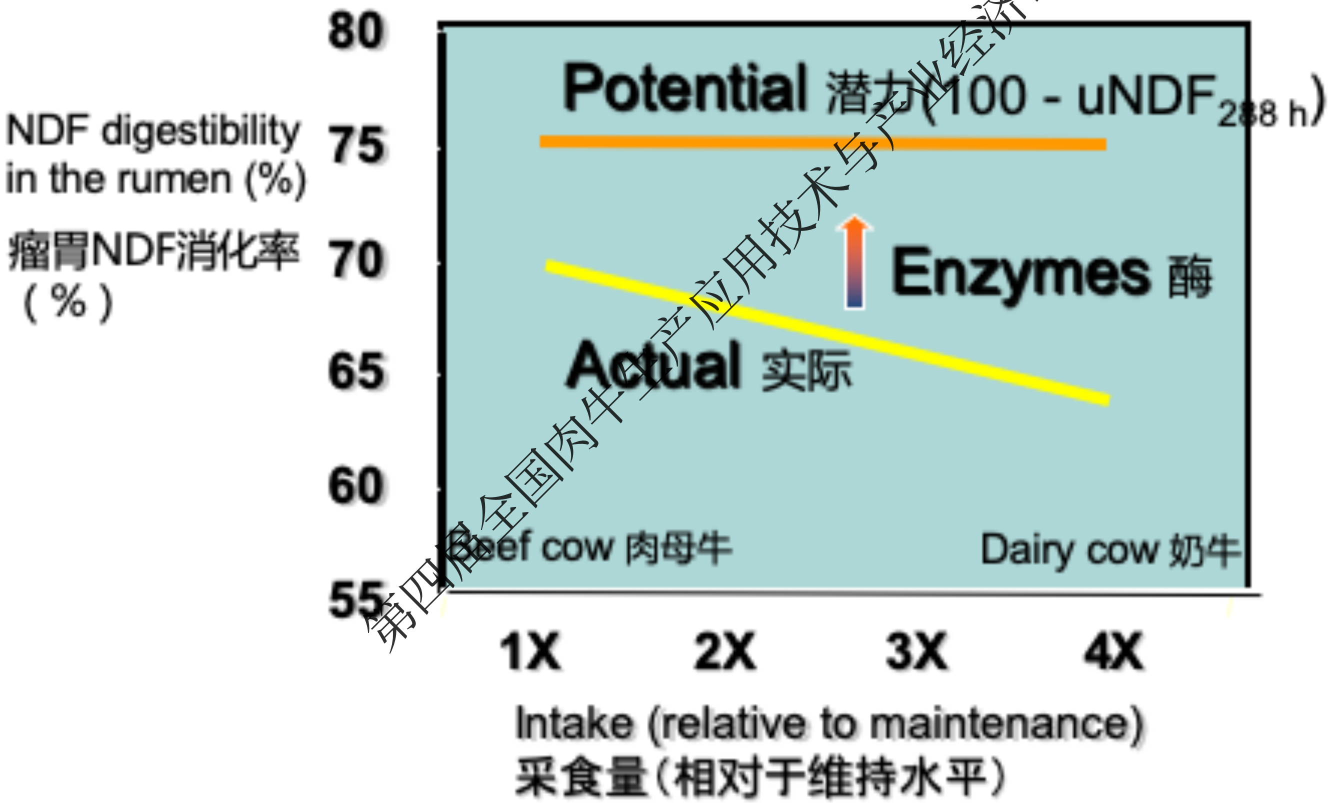
  成分高度变异，且所有商业EO产品均无质量标准
- Low chemical stability and high volatility 化学稳定性低而挥发性高
- Aromatic compounds, taste and smell, reducing palatability and feed intake

  芳香类化合物，具有独特气味和味道，可能降低适口性和采食量
- Residue transfer to animal products? 动物产品中是否有残留

Ruminant feed enzymes 反刍动物饲用酶制剂

- Objective is to improve fiber digestion 目的是改善纤维消化
- Increase animal performance (results highly variable)
  提高动物性能（结果高度变异）
- Allow greater use of forages and low quality forage/byproducts in diets
  可在日粮中更多地使用牧草和低质量的粗饲料/副产品
- Products of microbial fermentation (mostly fungal origin, Trichoderma)
  微生物发酵产品（大部分是真菌如木霉属来源）
- "Non-viable" (source organisms removed) 失活的（移除来源有机物）
- Concentrated enzymic activities 高度浓缩的酶活性
  - Polysaccharidases (cellulases and xylanases)
    多糖酶（纤维素酶和木聚糖酶）

Theoretical digestibility 理论消化率

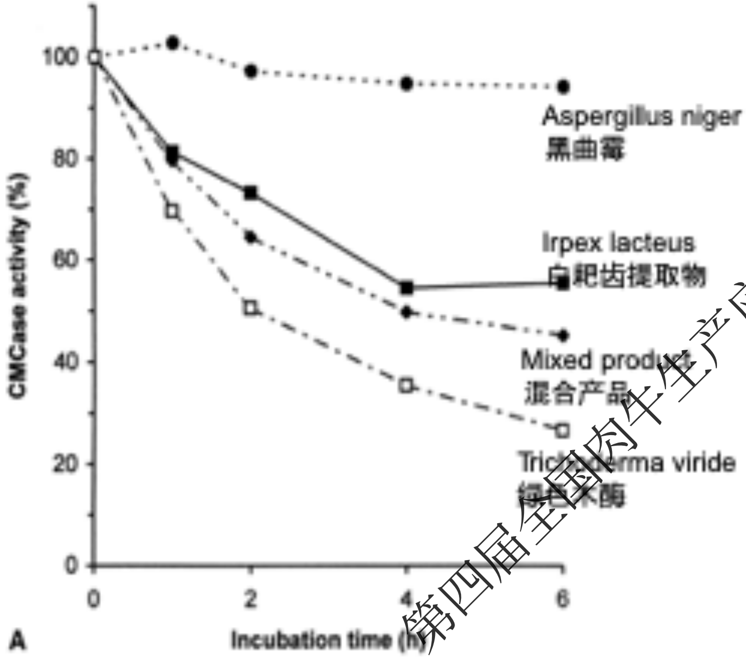


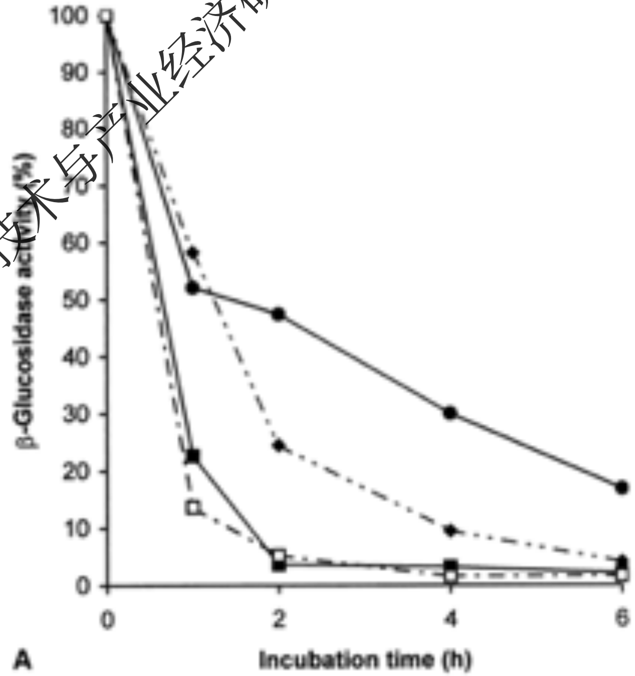
Variable in vivo responses with enzyme additives of ruminants
酶制剂在反刍动物的体内试验研究结果变异较大

WHY 为什么?

- Are feed enzymes stable in the rumen
饲用酶制剂在瘤胃内是否稳定?
- What enzyme activities are needed 需要什么样的酶活性?
- Is pretreatment of feed needed 是否需要对饲料进行预处理 ?
- How do enzymes increase fiber digestion
酶是如何增加纤维消化的?
  - Accessibility of substrate and microbial attachment limit fiber digestion by microbes
  底物和微生物附着的难易程度限制了微生物对纤维的消化
  - Is enzyme activity rate-limiting in the rumen
  酶活性在瘤胃内是否受限?

Stability of enzyme activities in rumen fluid
瘤胃液内酶活性的稳定性





Enzymes are subject to degradation in the highly proteolytic environment
酶在高蛋白水解环境中易降解
Some activities last only several hours
一些酶的活性仅能持续数小时

(Morgavi et al., 1999)

What enzymic activities are needed?
需要什么样活性的酶？

Activity 活性	ENZ1	ENZ2	ENZ3
Endoglucanase	332	324	351
Exoglucanase	74	38	81
Xylanase	0.8	58	542
β-glucanase	351	264	315
Arabinoxylanase	22	79	359
Lichenase	560	639	807
Arabinofuranosidase	0.3	0.3	17
β-glucosidase	6.0	3.1	3.8
β-xylosidase	0.3	0.3	29

Units = nmol sugar released/mg product/min.

由上到下依次是：内切葡聚糖酶、外切葡聚糖酶、木聚糖酶、 β-葡聚糖酶、阿拉伯木聚糖酶、地衣聚糖酶、阿拉伯呋喃糖酶、 β-葡糖苷酶、 β-木糖苷酶

Effects of recombinant enzyme and ammonia-fiber expansion (AFEX) treatment of wheat straw on DM digestibility in situ

重组酶和氨化处理（AFEX）对小麦秸原位干物质消化率的影响

	Wheat Straw		AFEX Wheat Straw		P <		
	E-	E+	E-	E+	AFEX	Enz	E × A
Soluble (A), % 可溶性组分	7.1	7.0	16.4	16.8	0.01	0.74	0.40
Slowly Digestible(B), % 慢速降解组分	51.5	51.8	64.6	63.9	0.01	0.70	0.26
Rate (kd), /h 降解速率	2.88	2.88	3.21b	3.86a	0.01	0.01	0.01
Eff Deg, % 有效降解率	28.4	28.5	44.9b	48.0a	0.01	0.01	0.01

A = soluble and washout fraction 可溶性或可洗脱组分; B = potentially digestible fraction 潜在可消化组分; kd = rate of disappearance of fraction B 组分B的消失速率; Eff Deg = effective rumen degradability estimated with a passage rate of 4%/h 基于4%的瘤胃通过率估算的瘤胃有效降解率.

Beauchemin et al. (unpublished)

Effects of recombinant enzyme and AFEX treatment on growth of lambs and digestibility of beef heifers 重组酶和氨化处理（AFEX）对羔羊生长速率和青年肉母牛消化率的影响

	Straw		AFEX Straw		P <		
	E-	E+	E-	E+	AFEX	ENZ	E × A
Lambs 羔羊							
Initial BW, kg 初始体重	25.4	24.0	24.3	25.3	0.91	0.86	0.20
Final BW, kg 终末体重	53.0	51.7	51.4	52.0	0.58	0.74	0.43
DMI, kg/d 干物质消化率	1.52	1.47	1.58	1.63	0.01	0.92	0.13
ADG, g/d 平均日增重	301	295	309	300	0.51	0.45	0.90
D28 ADG, g/d 28天ADG	302	318	325	368	0.01	0.02	0.27
F:G 料重比	5.1	5.0	5.2	5.5	0.04	0.45	0.21
Beef heifers 青年肉母牛							
DMI, kg/d 干物质采食量	8.95	8.82	...	...	...	0.66	...
DM dig, % 干物质消化率	65.7	65.3	...	...	...	0.61	...

Ribeiro et al. and Ran et al. (unpublished)

Summary 小结 - ruminant feed enzyme 反刍动物酶制剂

- Increasing fiber digestibility will be increasing important in the future (limited land and feed)

  提高纤维消化率将会越来越重要
- Enzymes feed additive for ruminants are still experimental

  反刍动物饲用酶制剂仍处于试验阶段
- Cost of enzymes relatively high 酶的成本相对较高
- Need to design enzymes for ruminants (most commercial enzymes are not ruminant specific)

  需要为反刍动物设计专用酶（大多数商品酶并非针对反刍动物消化特点的）
- May need to combine enzymes with pretreatment (low quality feeds)

  可能需要将酶和预处理相结合（低质饲料）

Other alternative products
其它替代产品

Blend of feed additives 混合饲料添加剂

<u>Product A 产品A</u>

- Probiotic (LAB), plant based enzymes and prebiotics
  益生菌（LAB），植物基础的酶和益生素
- Replacement to antibiotics or to assist with antibiotics
  替代抗生素或与抗生素配合使用

<u>Product B 产品B</u>

- Probiotic, plant enzymes, selenium and immune boosting and vitamin, trace minerals
  益生菌、植物酶、硒和免疫增强剂及维生素、微量元素
- A supplement for dairy cattle, beef cattle & sheep
  作为奶牛、肉牛和绵羊的补充料

Growing trial 生长试验

Treatments 处理:

1. Control 对照组
2. Implant (**IM**) 埋植剂组
3. Implant + Antibiotics (**ANT**; monensin, tetracycline) 埋植剂+抗生素（ANT；莫能菌素，四环素）
4. Implant + Product A 埋植剂+产品A
5. Product B 产品B组

Growth performance of steers – Growing (diet; F:G = 60:40, DM basis)
阉牛的生长性能 – 生长（日粮：精粗比40:60，DM基础）

	Treatments 处理					
Item 项目	Control	Implant	IM+Ant	IM+A	B	P <
Initial BW, kg 初始体重	279	279	279	279	279	1.00
Final BW, kg 终末体重	388^{b}	420^{a}	41[illegible]	417^{a}	400^{ab}	0.02
DMI, kg/d 干物质采食量	7.93	8.09	7.88	8.35	8.11	0.37
F:G 料重比	8.10^{a}	6.40^{c}	6.56^{c}	6.69^{c}	7.43^{b}	0.01
ADG, kg/d 平均日增重						
D0-28 0-28天	0.82^{c}	1.11^{b}	1.21^{ab}	1.39^{a}	0.93^{bc}	0.05
D29-56 29-56天	0.98^{b}	1.33^{a}	1.03^{b}	1.14^{ab}	0.96^{b}	0.05
D57-84 57-84天	1.05^{b}	1.39^{a}	1.35^{a}	1.31^{a}	1.35^{a}	0.05
D85-112 85-112天	0.99^{b}	1.18^{ab}	1.22^{a}	1.06^{ab}	1.06^{ab}	0.05
Overall 总体	0.99^{b}	1.28^{a}	1.23^{a}	1.25^{a}	1.11^{a}	0.01
Drug treatments 药物治疗						
#steers (/15) 阉牛数量	8	2	3	0	2	…
% 百分比	53.3^{a}	13.3^{bc}	20.0^{b}	0^{c}	13.3^{bc}	0.05

Growth performance of steers – Finishing

阉牛生长性能 – 育肥

Item项目	Treatments 处理					SEM	$P <$
	Control	Implant	IM+Ant	BLac+IM	Boviglo		
Initial BW	428^{b}	459^{a}	448^{ab}	457^{a}	433^{b}	7.7	0.02
Final BW	606	636	633	630	617	12.0	0.56
DMI, kg/d	10.6	10.6	10.5	10.7	10.9	0.39	0.94
ADG, kg/d	1.58	1.56	1.65	1.54	1.65	0.07	0.43
F:G, kg/kg	6.71	6.90	6.41	6.90	6.67	0.21	0.35

Diet: F:G = 10:90, DM basis，日粮精粗比=90:10，干物质基础;
Initial BW=初始体重; Final BW=终末体重; DMI=物质采食量; ADG=平均日增重;
F:G=料重比

Buffers (sodium bicarbonate) 缓冲剂（小苏打）

- Fed at 0.5 to 1% of diet DM 以日粮干物质的0.5-1%进行饲喂
- Commonly used in dairy diets 常用于奶牛日粮中
- Small increase ruminal pH (~ 0.2 pH units), can be important for fiber digestion

  小幅度增加瘤胃pH值(~ 0.2 pH单位)，对纤维消化有重要作用
- Minimal/variable responses in beef cattle 对肉牛的影响极小或变异很大
- Increase osmotic pressure of the rumen 增加瘤胃内渗透压
- Not widely adopted by the beef cattle industry 未被肉牛行业广泛使用
- Mix into diet, not free-choice 混合于日粮中，不要自由采食

Protected vitamin B 保护性维生素B

- B-vitamins include biotin, B12, folic acid (B9), niacin (B3), Pantothenic acid, pyridoxine (B6), riboflavin (B2), thiamin (B1) B族维生素包括生物素（B7），B12，叶酸（B9），盐酸（B3），泛酸（B5），吡哆醇（B6），核黄素（B2），硫胺素（B1）
- Many B vitamins are involved in the energy and protein metabolic efficiency 许多B族维生素与能量和蛋白质代谢效率直接相关
- Most of the vitamins are required for normal immune function and can enhance immunity under certain circumstances 大部分B族维生素是正常免疫功能所必需的，在某些情况下可以增强免疫力
- Rumen microbes normally synthesize B-vitamins in sufficient quantities to meet requirements 正常情况下瘤胃微生物可以合成足够数量的的B族维生素来满足宿主需求
- One of the primary factors affecting vitamin requirements in cattle is physiologic stress 影响牛对维生素需求量的主要因素之一是生理应激
- Stress increases the requirement of some B vitamins due to higher metabolic needs, shift in metabolic priority and lower rumen activity. 应激会增加一些B族维生素的需要量，这是由于该状态下较高的代谢需求，改变代谢优先级并减少瘤胃活动

Role of B vitamins in energy metabolism
B族维生素在能量代谢中的作用

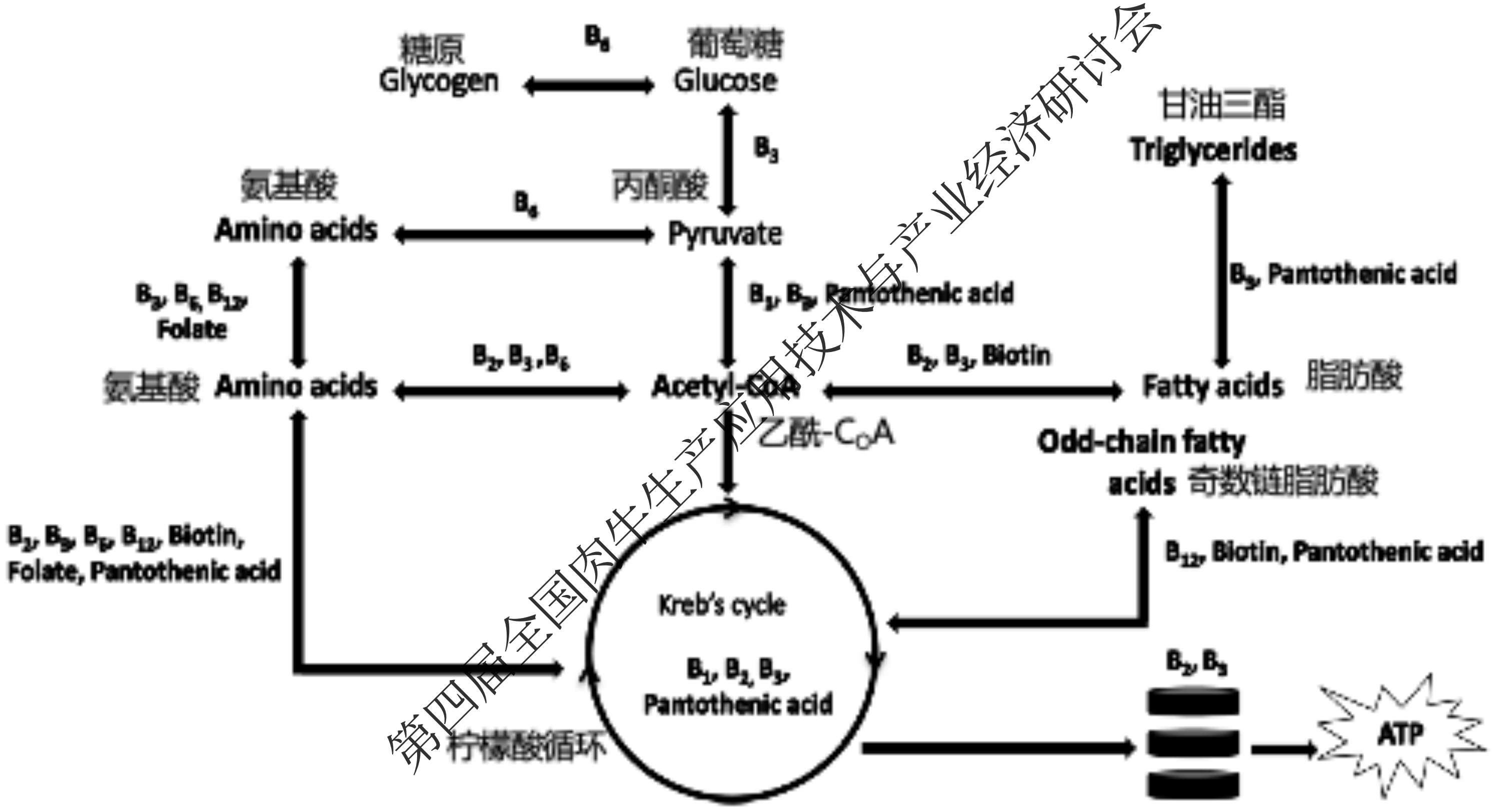


Figure 1.1 Role of B complex vitamins in energy metabolism

Protected vitamin B 保护性维生素B

- Only vitamins A and E are routinely provided to feedlot cattle upon entry into the feedlot, but there are indications that B vitamins would be of benefit 在育肥牛进入育肥场时通常只饲喂其维生素A和E，但有研究显示补充VB也是有益的
- A number of B vitamins are important in managing stress in feedlot cattle 一些B族维生素在缓解育肥牛应激方面非常重要
- High degradation rate of the B vitamins by rumen microbes 瘤胃微生物降解B族维生素的速率非常快
- Most of the B vitamins would need to either be injected or ruminally protected to insure that they bypass rumen destruction. 大多数B族维生素需要通过注射或过瘤胃保护以避免在瘤胃中被降解
- Microencapsulation permits the delivery of B vitamins in the intestine, allowing beef to take advantage of their properties 微胶囊可以将B族维生素运送至小肠，进而使肉牛从它们的特性中获益

B vitamins B族维生素	Rumen degradation 瘤胃降解率, %
Folic acid **B7**	97
Riboflavin **B2**	99
Pyridoxine **B6**	41
Thiamin **B1**	68
Biotin **B7**	45-60
B12	80

Protected vitamin B– animal trial
保护性维生素B – 动物试验

Supplementation of vitamin B may be required when tress is high such as weaning, the receiving
当牛的应激很高例如断奶、新接收阶段，可能需要补充维生素B

- A study was conducted in Mexico (Leclerc et al., 2015) 一项在墨西哥开展的研究
- 899 beef cattle (15 pens/treatment) 899头肉牛（每个处理15个圈）
- Control vs rumen protected B vitamins blend (2g/head/d) 对照组vs过瘤胃VB混合物
- A 21-day receiving period 21天的新接收期
- Rumen protected B vitamins (folic acid, pyridoxine, pantothenic acid and biotin; Jefo Nutrition, St-Hyacinthe, Canada) 瘤胃保护性VB（叶酸、吡哆醇、泛酸和生物素）
- Improved ADG and feed efficiency 提高ADG和饲料效率

	Control 对照组	Protected B vitamins VB处理组
Number of cattle 牛头数	448	451
Days on feed 饲喂时间	21	21
Initial Weight, Kg 初始体重	265	259
Final Weight, Kg 终末体重	306	306
ADG, Kg 平均日增重	2.01^{a}	2.20^{b}
Feed Intake, Kg 饲料采食量	8.53	8.35
Feed Efficiency 饲料效率	4.33^{a}	3.90^{b}

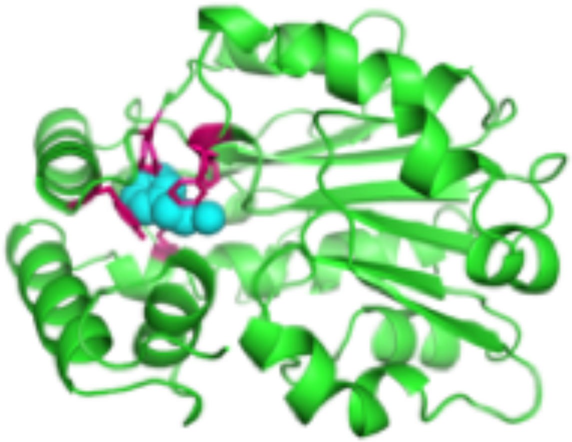
Methane Inhibitor: 3-Nitrooxypropanol (NOP)
甲烷抑制剂：3-硝基氧丙醇（NOP）

- Experimental compound 试验性化合物 (DSM Nutritional Products, Switzerland)
- Inhibits the last step of methanogenesis in the rumen

  抑制瘤胃甲烷生成最后一步
- Degraded in the GIT to propanediol, (propylene glycol), nitrate, nitrite

  在消化道中被降解为丙二醇、硝酸亚和亚硝酸盐
- Low safety risk (not carcinogenic or mutagenic)

  安全风险低（无致癌或致畸作用）



Mode of Action 作用机制:

▪Structural analog of Methyl-coenzyme M

甲基辅酶M的模拟结构

▪Binds to the active site of the enzyme (methyl-coenzyme M reductase) involved in the last step of methane synthesis and oxidizes its active site Ni(I) (Duin et al. 2016. PNAS.1600298113)

与甲烷生成过程最后一步的甲基辅酶M还原酶的活性位点结合，并氧化其活性微店Ni

Effects of feeding 3-Nitrooxypropanol (NOP, 200 mg/kg) and monensin (MON, 33 mg/kg) to feedlot cattle NOP和莫能菌素（MON）对育肥场肉牛的影响

Backgrounding phase 后备期 – 105 days

	-MON		+MON		Significance	
	-NOP	+NOP	-NOP	+NOP	MON	NOP
Initial BW, kg 初始体重	308	308	308	310	0.86	0.69
Final BW, kg 终末体重	462	459	464	464	0.31	0.71
DM intake, kg/d	8.41	7.64	8.08	7.64	0.12	<0.01
Feed:gain 料重比	5.81	5.43	5.46	5.29	<0.01 (+4%)	<0.01 (+5%)
ADG, kg/d 平均日增重	1.45	1.43	1.47	1.46	0.21	0.41
CH_4, g/kg DM intake	28.2	15.7	28.1	17.1	0.65	<0.01 (-42%)

No significant interactions between MON and NOP
MON和NOP之间没有显著地交互作用

240 steers, 6 pens/trt
240头阉牛，每个处理6个围栏

Vyas et al. 2018 JAS

Effects of feeding 3-Nitrooxypropanol (NOP, 125 mg/kg) and monensin (MON, 33 mg/kg) to feedlot cattle
NOP和莫能菌素（MON）对育肥场肉牛的影响

Finishing phase 育肥期 – 105 days

	-MON		+MON		Significance	
	-NOP	+NOP	-NOP	+NOP	MON	NOP
Initial BW, kg 初始体重	507	504	512	513	0.06	0.81
Final BW, kg 终末体重	698	692	694	697	0.97	0.82
DM intake, kg/d DMI	12.1	11.4	11.4	11.0	0.06	0.06
Feed:gain 料重比	6.67	6.58	6.58	6.29	0.58	<0.01
ADG, kg/d 平均日增重	1.80	1.79	1.73	1.74	0.08	0.98
CH_4, g/kg DM intake	15.9	8.32	19.1	13.8	0.06	<0.01

+3%
-37%

No significant interactions between MON and NOP
MON和NOP之间没有显著地交互作用

240 steers, 6 pens/trt
240头阉牛，每个处理6个围栏

Vyas et al. 2018 JAS

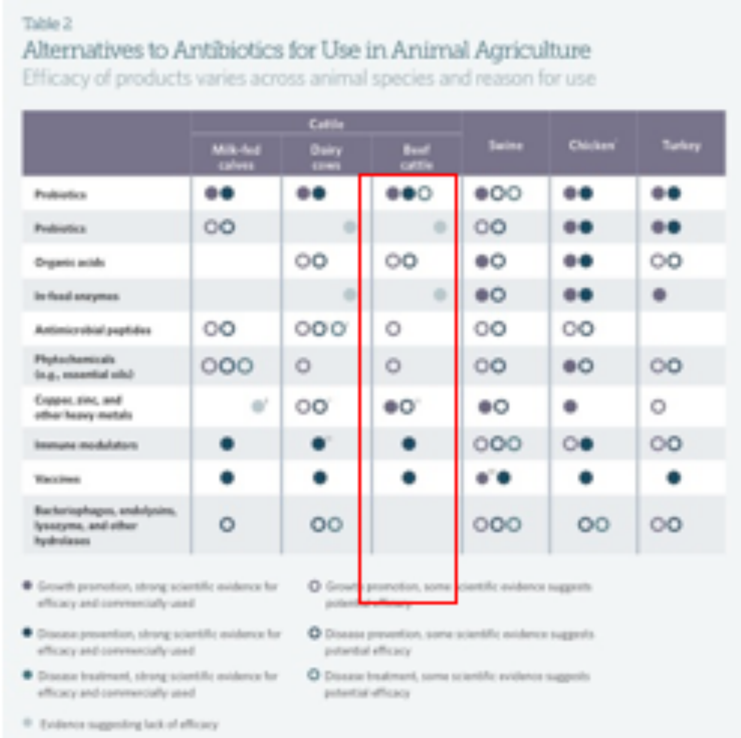
Nitrate as an alternative H_2 sink in the rumen
硝酸盐作为瘤胃中一种替代性氢气吸收池

- Nitrate is reduced to nitrite and then ammonia
  硝酸盐被还原为亚硝酸盐在被还原为氨
- Nitrate acts as an alternative H sink, competes with methanogenesis and lowers methane emissions
  硝酸盐作为一种替代性的H吸收池，可与产甲烷过程竞争，进而降低甲烷排放
- Source of dietary non-protein nitrogen 日粮非蛋白氮来源
- Potential for nitrite toxicity 具有潜在地亚硝酸盐毒性
  - Animal adaptation needed 需要动物适应
  - Encapsulation slows release of nitrate 封装以减缓硝酸盐释放

Lee and Beauchemin (2014) Can J Anim Sci 94:557-570 (review)

Summary - available evidence for efficacy of each alternative
小结 – 每种替代物有效性的现有证据

- Probiotics **益生菌**: growth promotion (**GP**) and disease prevention (**DP**), strong scientific evidence；促生长（**GP**）和预防疾病（**DP**），强有力的科学证据
- Prebiotics **益生素**: lack of efficacy 缺乏有效性
- Organic acids **有机酸**: **GP** and **DP**, some evidence 有些证据
- In-feed enzymes **饲用酶**: lack of efficacy 缺乏证据
- Antimicrobial peptides **抗菌肽**: **GP**, some evidence 有些证据
- Phytochemicals **植物性化合物**: **GP**, some evidence 有些证据
- Copper, zinc **铜锌**: **GP**, strong evidence 强有力, **DP**, some evidence有些证据
- Immune modulators**免疫调节剂**: **DP**, strong scientific evidence 强有力的证据
- Vaccines**疫苗**: **DP**, strong evidence 强有力证据



Talkington et al. 2017, PEW

Conclusions 结论

- Many feed additives available, many more in development

  许多饲料添加剂可用，更多的在开发中
- With ban use of in-feed antibiotics, producers need to prepare use alternatives

  随着饲用抗生素的禁止使用，生产者需要准备使用替代品
- Many factors may affect the efficiency of feed additives 许多因素可能影响饲料添加剂的效率
- When is the effect of feed additive higher? 什么时候饲料添加剂更有效果？
- DFM may be a useful tool to promote health and reduce current use of antibiotics in cattle
  DFM可能是促进牛健康和减少当前抗生素使用的有效添加剂
- Need a science based approach 需要一种基于科学的方法
- Need long-term studies for beef cattle 需要在肉牛上进行长期研究
- Combination of different technologies may be best option for future?

  不同技术结合应用在未来可能是最佳选择

Thank You!

感谢聆听！

Questions?

欢迎提问