Optimizing Gastrointestinal Microbial Ecology to Improve Health and Productivity in Beef Cattle
通过优化胃肠道微生物生态来提高肉牛健康和生产率

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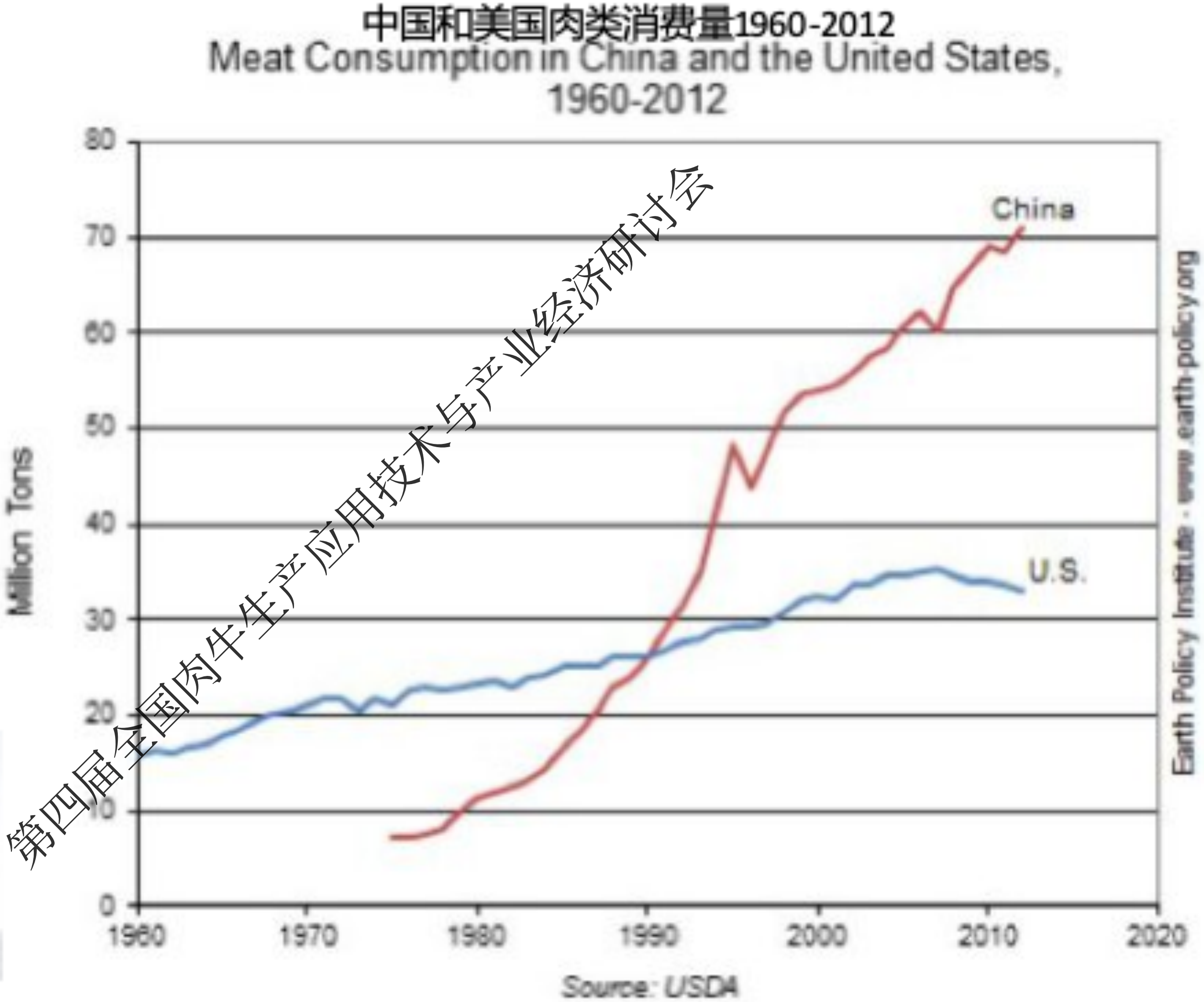
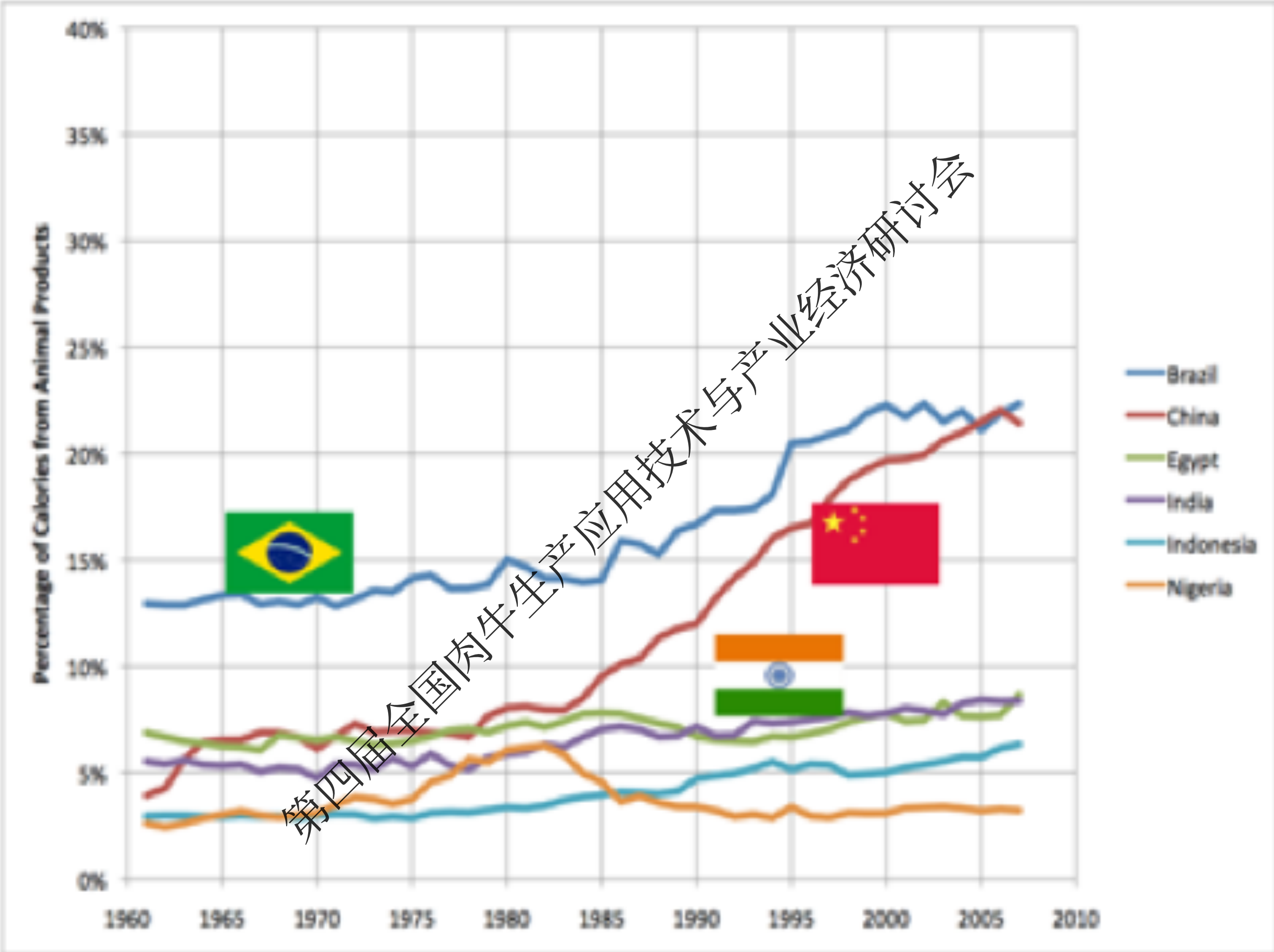
Total meat consumption has increased sharply in China.

中国肉类总消费量快速升高。

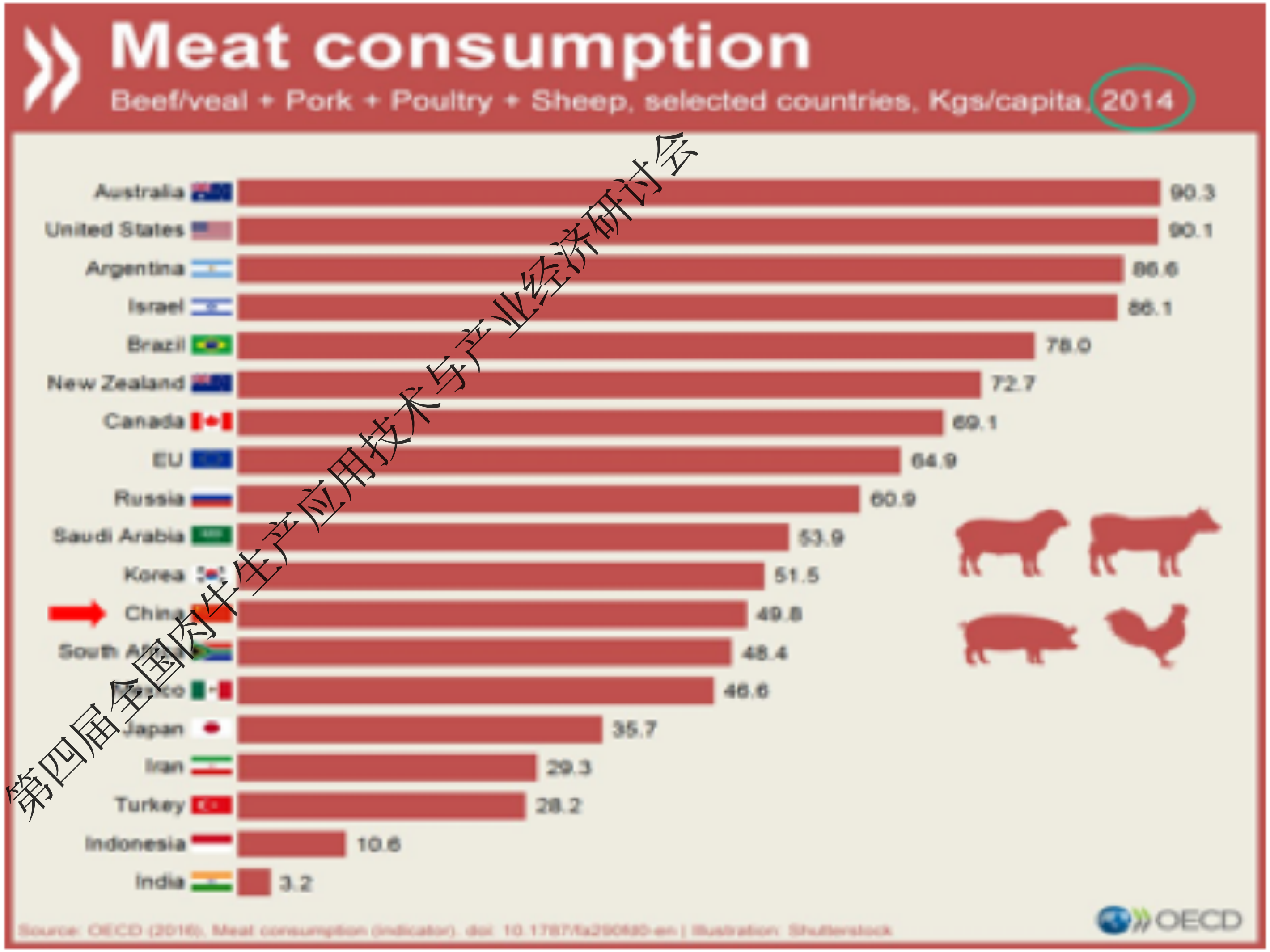


从动物产品中获得热量的比例



巴西
中国
埃及
印度
印尼
尼日利亚

肉类消费量：牛肉/小牛肉+猪肉+家禽肉+羊肉，入选国，人均kg 2014



But, meat consumption per capita remains low!

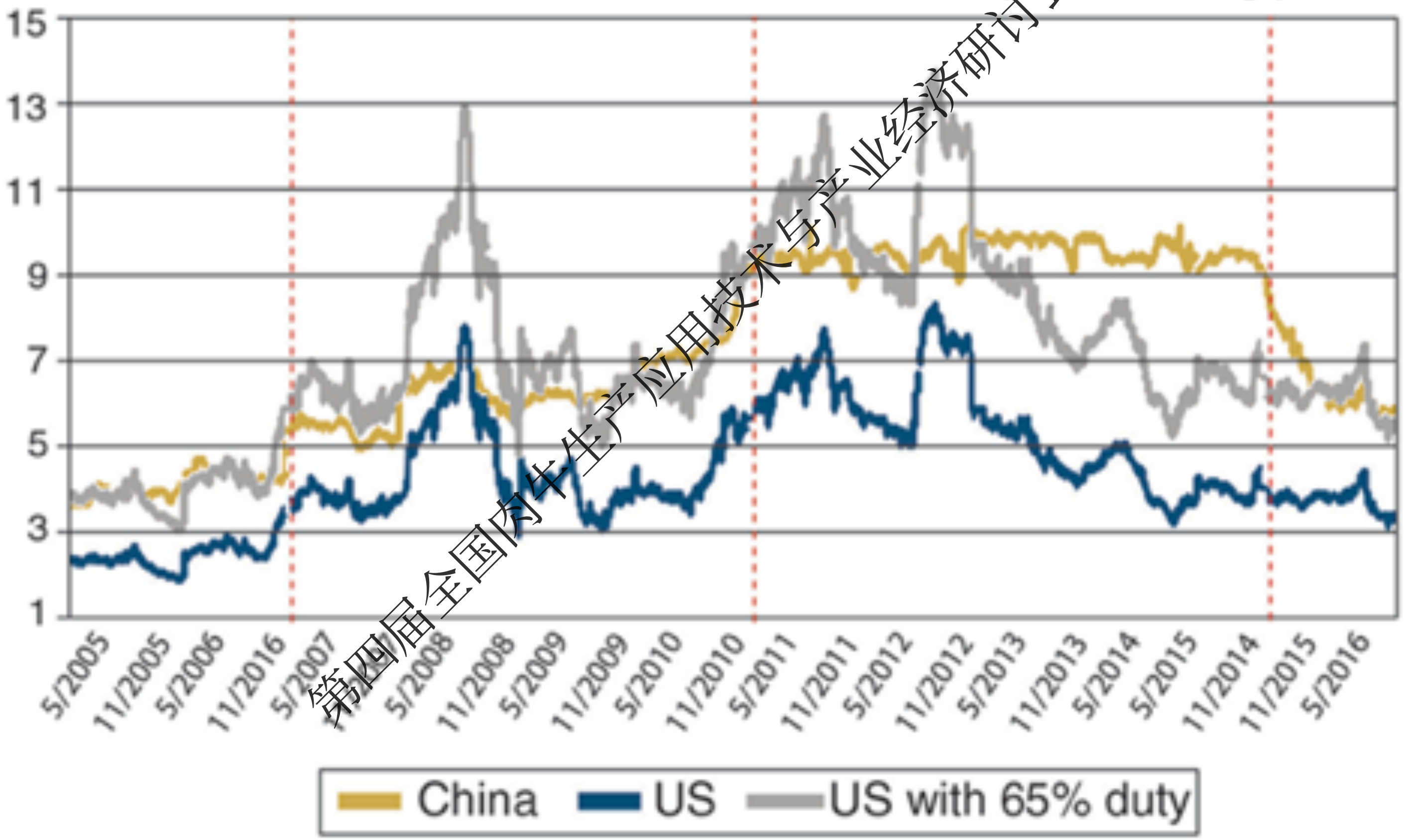
但人均肉类消费量仍然很低

Negative correlation between beef price and consumption
牛肉价格和消费量之间负相关

- Cost and profitability 成本和收益
- Productivity 生产率
- Health 健康

Feed is expensive in China
中国饲料价格昂贵

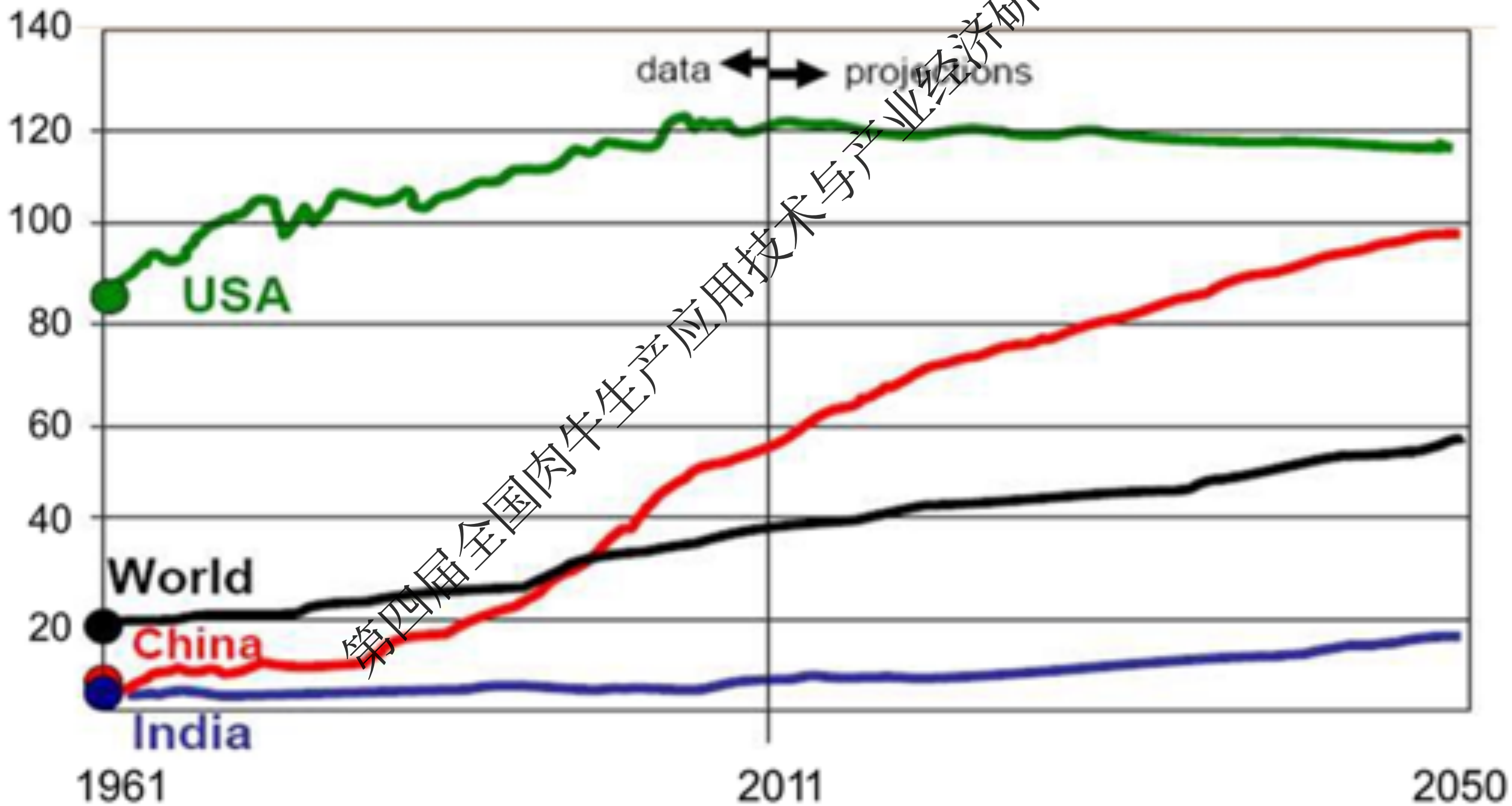
Dollars per bushels（1 bushel = 25 kg） 美元/蒲式耳（1蒲式耳=25kg）



Source: http://www.quandl.com 中国 美国 美国增加65%关税

Demand for beef projected to increase in China
中国牛肉需求量预计上涨

Meat consumption (kg/cap/yr) 肉类消费量（千克/人/年）

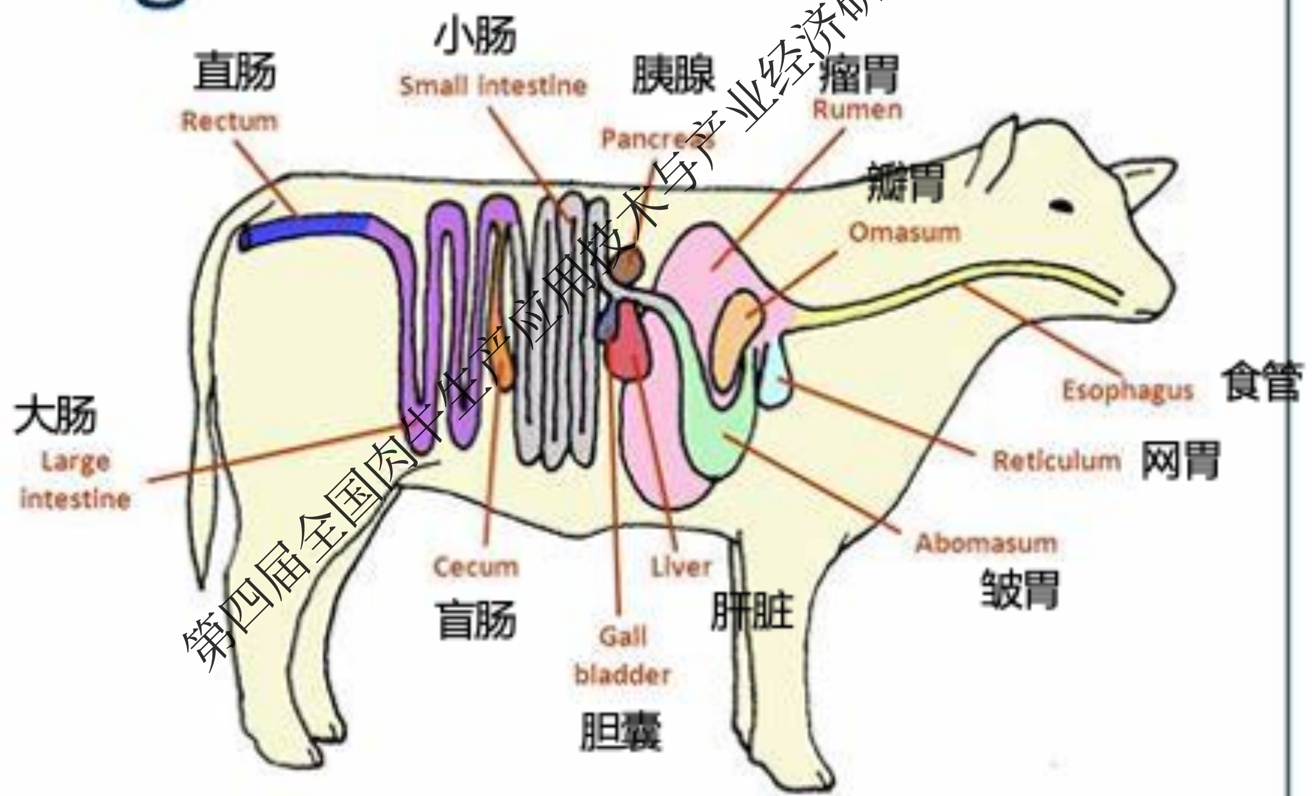


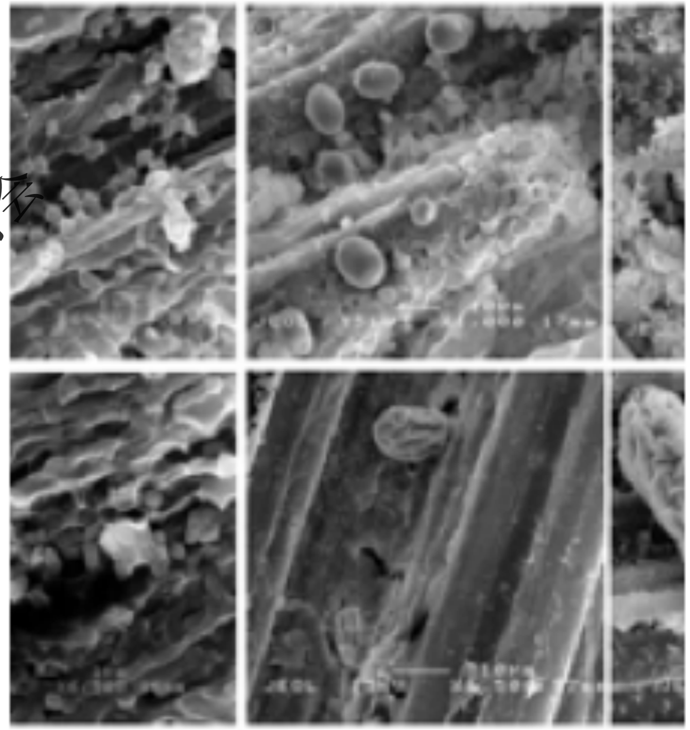
The four pillars of high-producing cows
高产母牛的四个支柱

GI tract and the gut microbial ecology
胃肠道和肠道微生物生态学

Digestive Tract - Cattle

消化道-牛

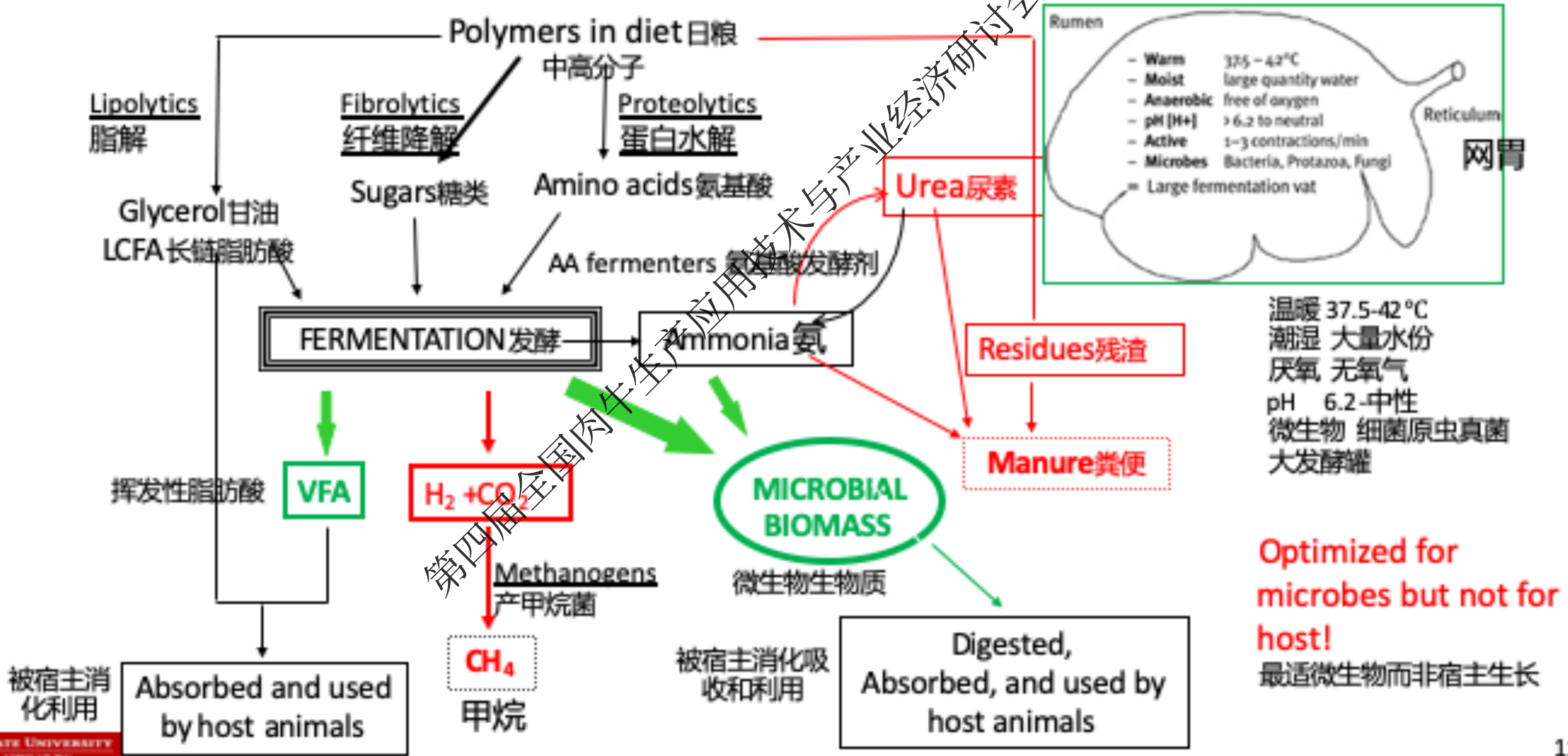




Beef is the king, but GI microbial ecology is the queen

牛肉是王那么为肠道微生物生态就是皇后

Feed efficiency is primarily determined by the rumen functions of rumen microbiome
饲料效率主要取决于瘤胃微生物的功能



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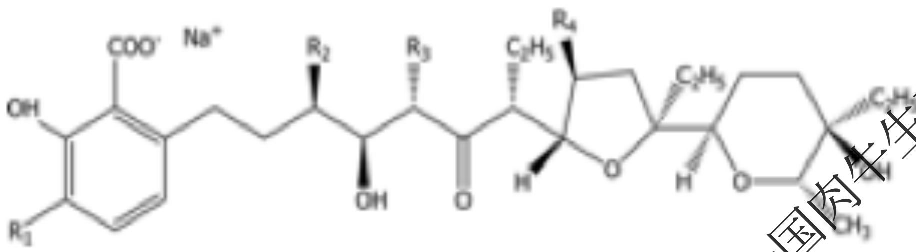
Optimizing rumen microbial ecology for enhanced feed digestion and utilization
通过优化瘤胃微生物生态学来增强饲料消化和利用

1. Ionophores 离子载体
2. Antibiotics (not including ionophores, banned)
   抗生素（不包括离子载体，禁用）
1. Direct fed microbials (DFMs) 直接饲用微生物
2. Phytochemicals 植物源化合物
3. New strategies for targeted control of gastrointestinal ecology
   胃肠道生态学的靶向调控新策略

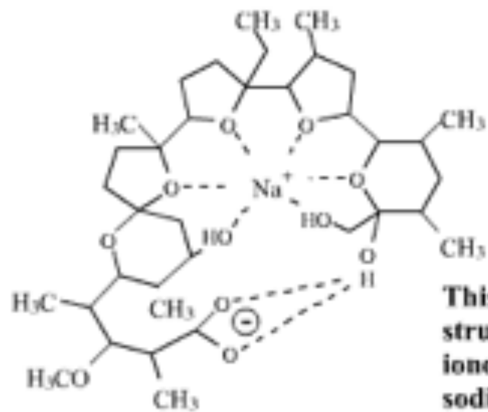
Ionophores 离子载体

- Small molecules typically lipid-soluble and transport ions across cell membrane 脂溶性小分子和跨细胞膜转运离子
- Produced by certain bacteria 特定细菌产生
- Commonly used ones: monensin, lasalocid, salinomycin, narasin, maduramicin, semduramicin 常用的：莫能菌素，拉沙里菌素，盐霉素，甲基盐霉素，马杜霉素，赛杜霉素



	R₁	R₂	R₃	R₄
Lasalocid A	CH_3	CH_3	CH_3	CH_3
Lasalocid B	C_2H_5	CH_3	CH_3	[illegible]
Lasalocid C	CH_3	C_2H_5	CH_3	CH_3
Lasalocid D	CH_3	CH_3	C_2H_5	CH_3
Lasalocid E	CH_3	CH_3	CH_3	C_2H_5

Lasalocid拉沙里菌素



This screen shows the structure of the polyether ionophore Monensin as a sodium salt with a central pore containing the sodium ion.

Monensin莫能菌素

Ionophores 离子载体

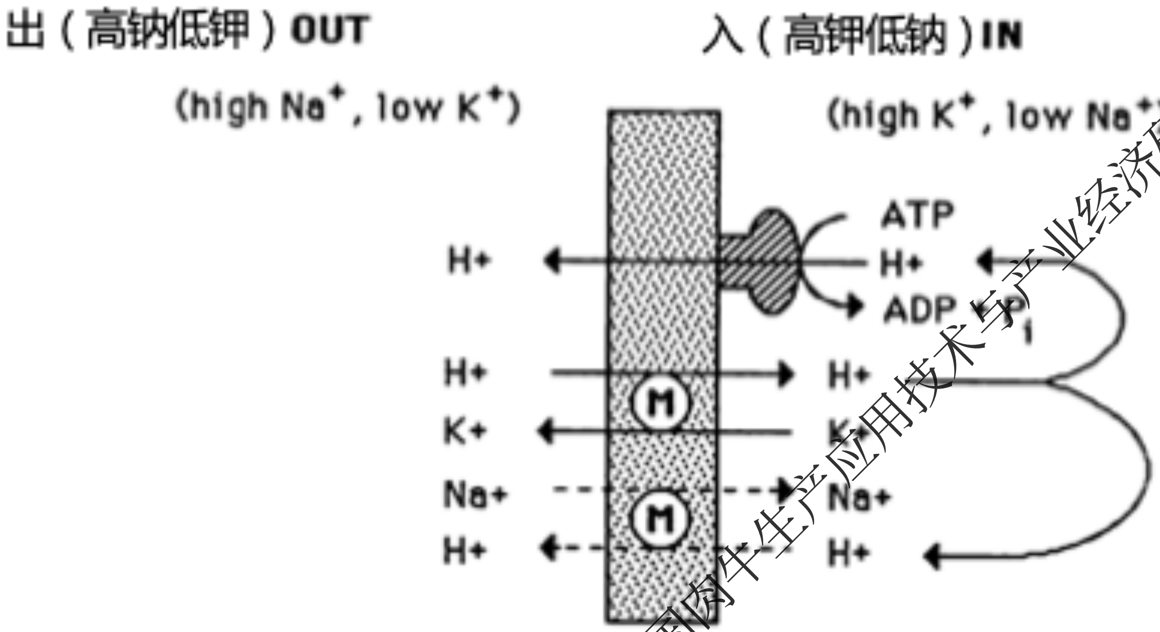


FIG. 2. Schematic diagram showing hypothetical effects of monensin (M) on ion flux in S. bovis (redrawn from reference 41).

图2. 莫能菌素对牛链球菌离子流示意图

Mode of action:

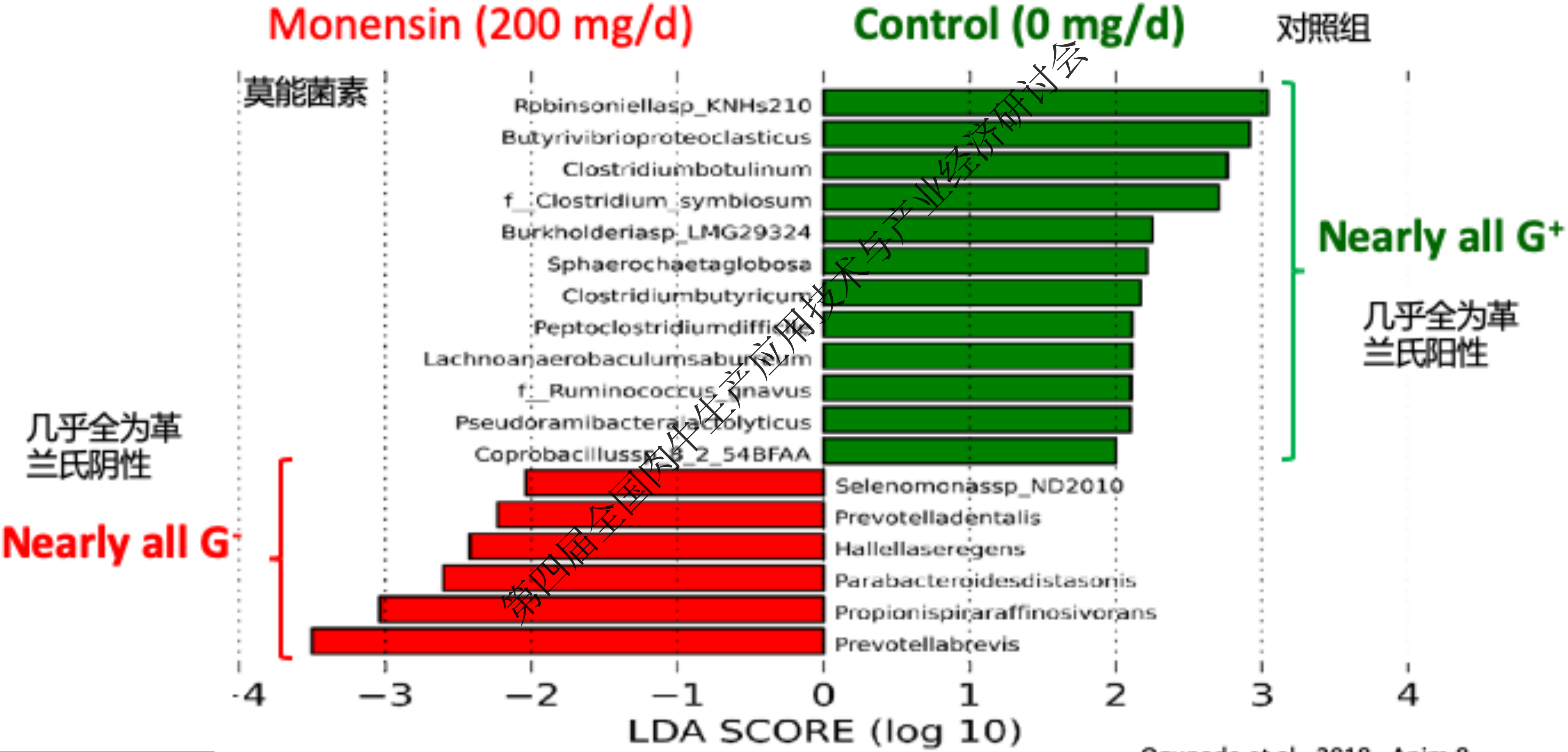
Creates pores in cell membranes and functions as Na^+/H^+ and K^+/H^+antiporter

作用模式：

在细胞膜中打孔并以Na+/H+和K+/ H+反向转运体发挥功能

- Sensitivity to ionophores: G^+ bacteria > G^- bacteria
- 对离子载体敏感性：革兰氏阳性菌>革兰氏阴性菌

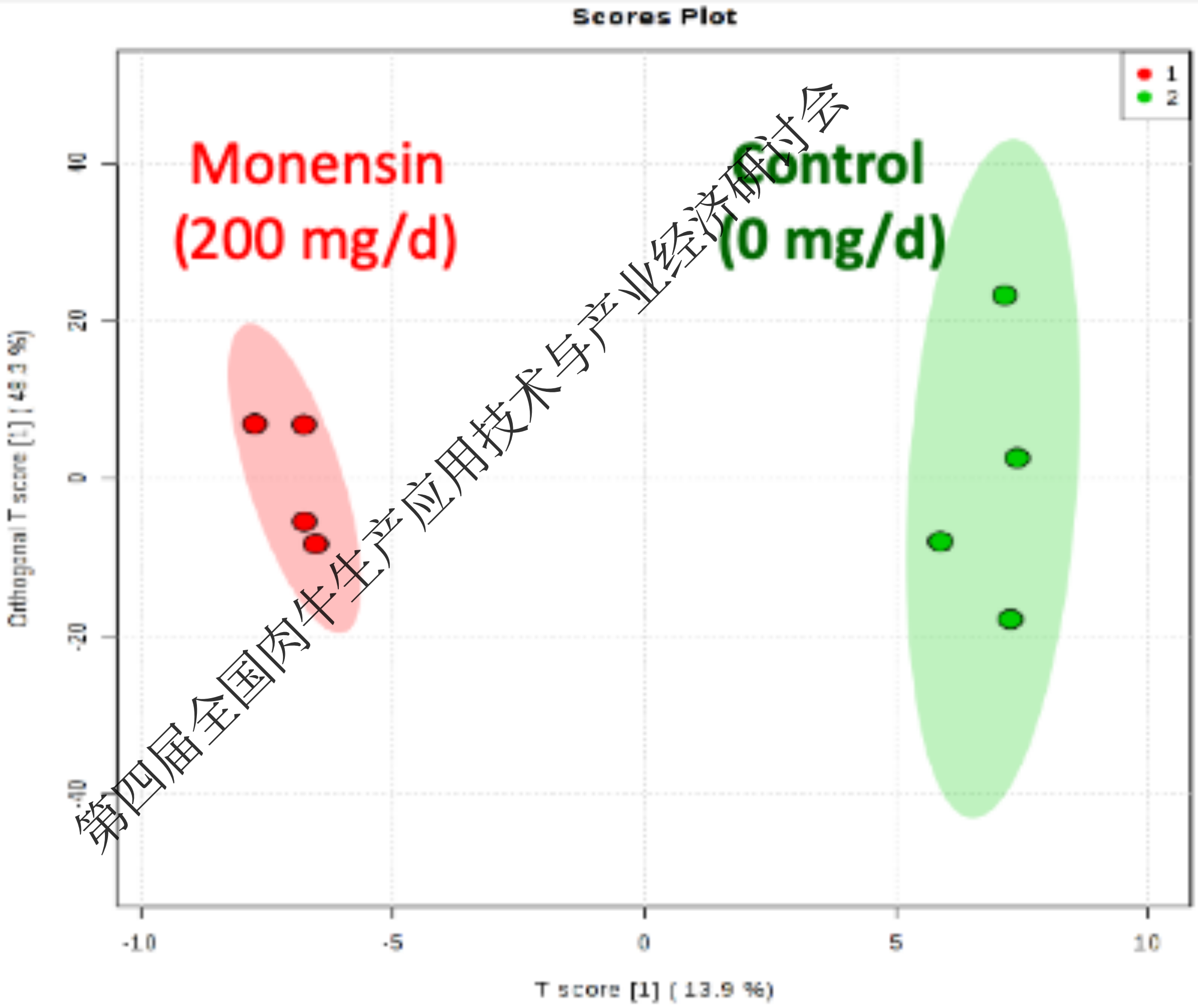
Ionophores – Monensin 离子载体-莫能菌素



Ogunade et al., 2018, Anim 8

Ionophores – Monensin离子载体-莫能菌素

Monensin affects the metabolome of the rumen microbiome
莫能菌素影响瘤胃微生物群代谢组学.



Ogunade et al., 2018, Anim 8

Ionophores – Monensin 离子载体-莫能菌素

- ↓ DMI (by 6.4%), feed required for 100 kg BW gain (by 7.5%)
  干物质采食量下降（6.4%）,100kg增重所需饲料下降（7.5%）
- ↑ rumen pH, ↓ risk or SARA 瘤胃pH升高，亚急性酸中毒风险下降
- ↑ ADG (by 1.6%), feed efficiency 平均日增重升高（1.6%），饲料效率升高

Table 3
Meta-analysis outcome summary of the effects of monensin on production parameters

Variable	Direction of Effect	Comments	P Value
Milk yield	↑	Consistent	<.001
DMI	↓	Consistent	.001
Efficiency	↑	Consistent	.066
Milk fat percentage[a]	↓	Heterogeneous	<.001
Milk protein percentage[b]	↓	Heterogeneous	<.001
Milk lactose percentage	—	No effect	.540
Body condition score	↑	Heterogeneous	.006
Body weight change	↑	Heterogeneous	<.001

Table 2
Meta-analysis outcome summary of the effects of monensin on serum/blood metabolic parameters

Variable	Direction of Effect	Percent Change	Significance (P)
BHBA	↓	13.4	.0001
Acetoacetate	↓	14.4	.003
Glucose	↑	3.2	.0001
NEFA	↓	7.1	.006
Urea	↑	6.2	.0001
AST	↓	Not calculated	.02
Cholesterol	↑	2.6	.076
Insulin	—	17.3	NS
Calcium	—	0.44	NS

Ionophores – Lasalocid 离子载体-拉沙里菌素

A meta-analysis of lasalocid effects on rumen measures, beef and dairy performance, and carcass traits in cattle[1]

拉沙里菌素对瘤胃指标，肉牛和奶牛生产性能和胴体特征影响的荟萃分析

H. M. Golder[2] **and I. J. Lean**

Scibus, Camden, NSW, 2570, Australia

J Anim Sci 2016, 94: 306-26.

- **10 studies 10个研究：**

  ↑ VFA (by 6.46 mM), NH_3 (by 1.44 mM), propionate (by 4.62 mM)

  升高：挥发性脂肪酸（6.46 mmol/L），氨气（1.44mmol/L），丙酸盐(4.62 mM)
- ↓ acetate (by 3.18 mM), butyrate % (0.83%, linearly with duration)

  下降：乙酸盐（3.18mM），丁酸盐（0.83%，与持续时间呈线性）
- At >200 mg/d, ↑ propionate % and valerate %, ↓acetate %

  当大于200mg/d时，丙酸和戊酸百分比升高，乙酸百分比下降

- **31 studies 31个试验**
- No effect on DMI

对干物质采食量无影响

- ↑ ADG (by 40 g/d), F:G ratio (by 410 g/kg), feed efficiency

平均日增重升高（40g/d）,料重比升高（410g/d），饲料效率升高

- **14 studies 14个试验**
- ↑ Hot carcass weight (by 4.73 kg)

  热胴体重增加 4.73kg
- No effect on dressing percentage, mean fat cover, or marbling score

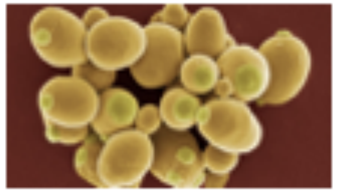
  对屠宰率，平均脂肪覆盖，或大理石花纹评分无影响

✓ Starting BW, dose, duration affect the outcomes
起始体重，剂量，持续时间影响结果

Yeast 酵母

- Yeast, *S. cerevisiae* is probably the best direct fed microbials

  酿酒酵母很可能是最好的直接饲用微生物



食母生 🔒锁定

本词条由"科普中国"百科科学词条编写与应用工作项目 审核。

食母生为麦酒酵母菌的干燥菌体，具有补充维生素及帮助消化，提高食欲之功效，适用于治疗各种类型的营养不良等，无副作用 [1] 。

药品名称	食母生	用法用量	口服：1g~4g/次，3次/日，嚼碎服
别　名	酵母；酿母；干酵母；	主要用药...	剂量过大可引起腹泻
外文名称	Dried Yeast；Dry Yeast；Saccharomyces Siccum	剂　型	片剂
		运动员慎用	非慎用
主要适用症	消化不良的辅助治疗，防治维生素B族缺乏症		

Yeast 酵母

- *S. cerevisiae* is probably the best direct fed microbials
  酿酒酵母很可能是最好的直接饲用微生物
- Benefits of feeding yeast to cattle: 牛饲喂酵母好处：
  - ↑ DMI 干物质采食量
  - ↑ DMD干物质消化率
  - ↑ fiber digestion纤维消化
  - ↑ ruminal VFA 瘤胃挥发性脂肪酸
  - Stabilizes ruminal pH稳定瘤胃pH
  - ↑ average daily gain 平均日增重

- Viable, non-viable yeast dried yeast cells
  活性，非活性酵母，干酵母细胞
- Yeast fermentation products
  酵母发酵产物
- Modes of action: not definitively determined
  作用模式：无最终定论

Yeast 酵母

Live yeast活酵母

清除氧气

Scavenges oxygen

与细菌竞争糖类

Competes with bacteria for sugars

产生的代谢物可作为小营养素

Produces metabolites as minor nutrients

改善瘤胃微生物区系和发酵

Improves rumen microbiome and fermentation

增强纤维消化

Increases fiber digestion

提高&稳定瘤胃pH

Increases & stabilizes rumen pH

增强微生物蛋白合成

Increases microbial protein synthesis

Yeast

Table 2. Relative abundance of the dominant ruminal bacterial genera (>0.1% of total sequences) of beef steers fed no or 15 g/d of live yeast product. 饲喂活酵母产品阉公牛优势瘤胃菌群属水平相对丰度

Item	Treatment [1]		SEM	*p*-Value
	CON	YEA		
Ruminococcaceae NK4A214 group	3.27	4.99	0.40	0.01
Candidatus_Saccharimonas	3.35	5.81	0.61	0.01
Christensenellaceae R-7 group	4.80	7.29	0.68	0.03
Bacteroidales BS11 gut group *	1.11	2.36	0.21	0.01
Ruminococcaceae UCG-010	0.67	1.00	0.16	0.01
Ruminococcus 2	1.53	4.01	0.93	0.03
Anaerovorax	0.44	0.72	0.08	0.01
Lachnoclostridium	0.22	0.00	0.09	0.04
Lachnoclostridium 5	0.35	0.02	0.11	0.04
Lachnospiraceae UCG-008	0.10	0.21	0.01	0.02
Ruminococcaceae UCG-005	0.21	0.30	0.02	0.02
Bacillus	0.22	0.00	0.09	0.03

[1] CON = no yeast treatment; YEA = 15 g/d of live yeast fermentation product (PMI, Arden Hills, MN, USA).
* Uncultured bacteria belonging to *Bacteroidales BS11* gut group. 对照：无处理；YEA：15g/d活酵母发酵产品

Ogunade et al., 2019, Animal 9(1)

Yeast

Table 4. Ruminal pH profile of beef heifers fed a diet supplemented with a strain of *Saccharomyces cerevisiae* as active dried yeast (ADY) or killed dried yeast (KDY)

Variable	Treatment: Control[1]	Treatment: ADY	Treatment: KDY	SEM	*P*-value
Mean pH	6.06[b]	6.28[a]	6.26[a]	0.121	0.02
Minimum pH	5.48[b]	5.65[a]	5.67[a]	0.103	<0.01
Maximum pH	6.74	6.84	6.77	0.054	0.12
Range in pH[2]	1.27[a]	1.19[ab]	1.10[b]	0.062	0.02
Ruminal pH < 5.8					
Duration of day,[3] h/d	7.03[a]	3.55[b]	3.66[b]	2.161	<0.01
AUC,[4] pH × min/d	110	71	47	52.9	0.19
Bout frequency, no./d	9.2[a]	4.9[b]	6.3[b]	1.58	0.05
Long bout (>3 h) frequency, no./d	0.69[a]	0.25[b]	0.33[b]	0.298	0.01
Ruminal pH < 5.6					
Duration of day, h/d	4.41[a]	2.47[b]	1.91[b]	1.399	<0.01
AUC, pH × min/d	42	37	14	13.5	0.09
Bout frequency, no./d	7.3	4.2	4.4	1.72	0.07
Long bout (>3 h) frequency, no./d	0.44	0.13	0.11	0.224	0.12

日粮中补充一株酿酒酵母活酵母或灭活酵母对青年母牛pH参数的影响

Vyas et al., J Anim Sci 92(2): 724-32

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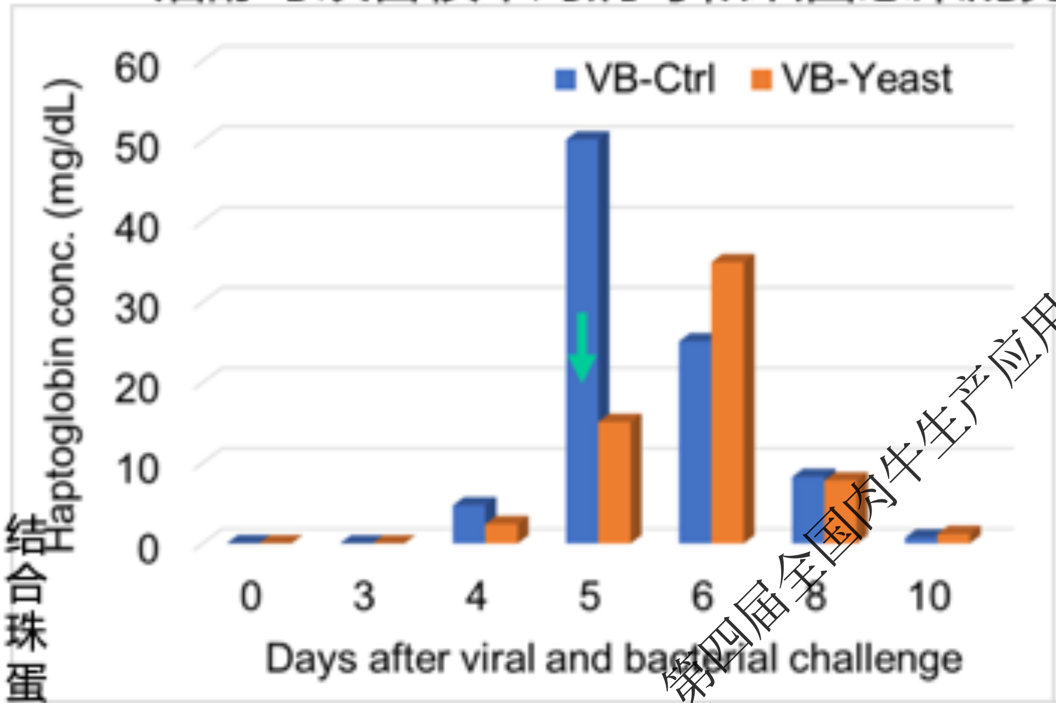
Bovine respiratory disease (BRD) complex BRD综合征

- An economically important and sometimes fatal disease of cattle, particularly in young calves and recently weaned cattle worldwide
  全世界范围内一种经济上十分重要且某些时候致命的疾病，特别是在幼犊牛和刚断奶牛
- Common in the US, over 50% of feedlot deaths are attributable to BRD
  在美国很常见，超过50%的肥育场病死牛的死因是BRD
- Approximately 40% deaths are attributable to BRD in calves aged 1 to 5 months
  大约40%的1-5月龄犊牛死因是BRD
- Complex, multifactorial etiology - infectious agents, compromised host immunity, environmental and management factors and stressors
  复杂多因素的病因 - 感染因子，宿主免疫受损，环境和管理因素和应激源
- Primary viral infection increases secondary bacterial infection 原发性病毒感染会继发细菌性感染
- Many bovine viruses 很多种牛病毒
- Bacteria: Mannheimia haemolytica, Pasteurella multocida, Histophilus somni, and Mycoplasma bovis
  细菌：溶血性曼氏杆菌，多杀性巴斯德菌，睡眠嗜血杆菌，牛支原体

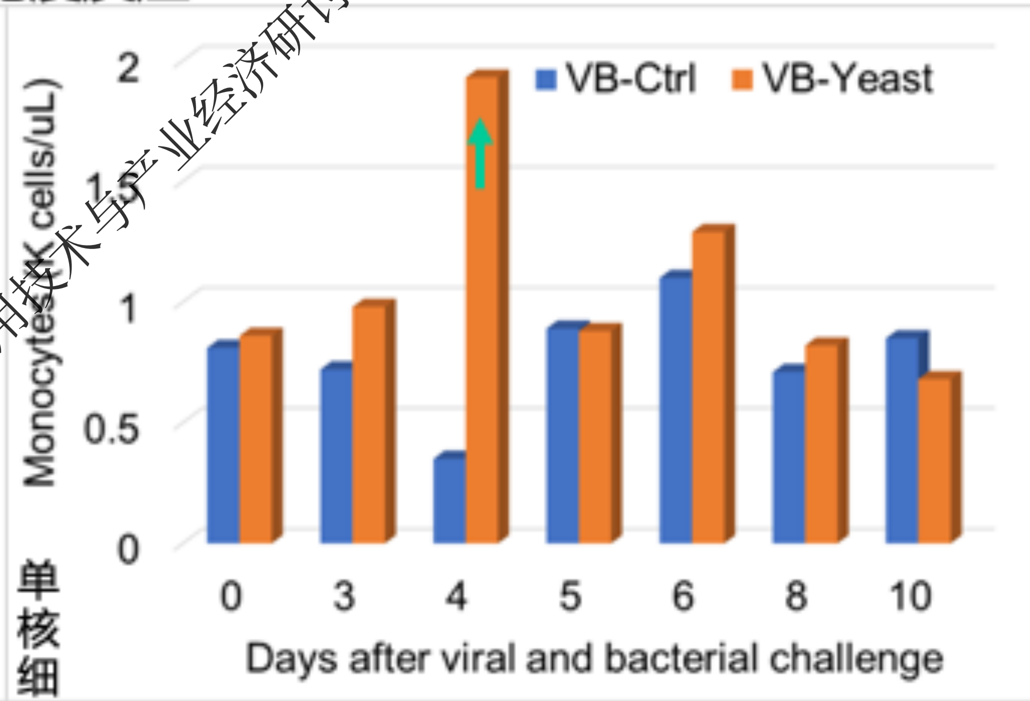
Yeast 酵母

- Live yeast improved immune response to viral and bacterial infection in calves
  活酵母改善犊牛对病毒和细菌感染的免疫反应



结合珠蛋白

病毒和细菌攻毒后天数



单核细胞

病毒和细菌攻毒后天数

Kayser et al., 2019, J Anim Sci 97: 1171-84

Yeast 酵母

Celmanax, a yeast product, improve steer health post weaning (d 4-31)
Celmanax，一种酵母产品，改善断奶后阉公牛健康

	Item	CONPC	CELM	SEM	*P*=
生长参数	Growth parameters[1]				
起始体重（d4）	Initial BW (day 4; kg)	230	232	3	0.60
运输后体重（d31）	Post-transport BW (day 31; kg)	242	245	3	0.52
平均日增重	ADG (day 4 to 31; kg/day)	0.46	0.52	0.05	0.41
采食量参数	DM intake parameters[2]				
干草	Hay (kg/day)	5.27	5.41	0.10	0.27
精料	Concentrate (kg/day)	0.44	0.50	0.04	0.26
总计	Total (kg/day)	5.55	5.77	0.11	0.20
健康参数	Health parameters[3]				
发病率	Morbidity (%)	16.0	0.0	4.9	0.03
膨气	Bloat (%)	0.0	0.0	-	-
呼吸道	Respiratory (%)	16.0	0.0	4.9	0.03
死亡率	Mortality (%)	0.0	0.0	-	-

No effect when yeast was fed day 31 after weaning
断奶后饲喂酵母无影响

Silva et al., 2018, Animal 12: 1576-83

Yeast
酵母

- ✓ Yeast/fermentation products function in the rumen.
- ✓ 酵母/发酵产物在瘤胃的功能

Shen et al., JAS, 2018, 96: 3916-27

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表3. 补充酿酒酵母发酵产物对育肥母牛采食量，十二指肠流，位点和消化程度的影响

Table 3. Effect of *Saccharomyces cerevisiae* fermentation product (SCFP) supplementation on feed intake, duodenal flow, site, and extent of digestion in finishing beef heifers

		Treatments[1]						
	Item	Control	ANT	rSCFP	dSCFP	rdSCFP	SEM	*P*-value
	Intake, kg/d							
干物质	DM	12.2	11.8	11.8	12.6	13.0	0.66	0.09
有机物	OM	11.2	10.8	[illegible]	11.6	11.9	0.58	0.10
NDF	NDF	3.9	3.8	3.8	4.0	4.2	0.23	0.07
淀粉	Starch	6.6	6.4	6.3	6.8	7.1	0.54	0.08
平均体重	Average BW, kg	685	677	675	681	689	32.6	0.21
十二指肠流量	Duodenal Flow, kg/d							
有机物	OM	6.42	5.81	5.04	6.07	5.33	0.585	0.20
微生物有机物	Microbial OM	1.48	1.52	1.22	1.25	1.43	0.167	0.20
NDF	NDF	1.68	1.63	1.47	1.60	1.54	0.158	0.65
淀粉	Starch	1.50	1.37	1.08	1.42	1.08	0.181	0.24
瘤胃可发酵有机物	RFOM[2]	[illegible]	5.73^{b}	6.20^{ab}	6.18^{b}	7.19^{a}	0.366	0.03
消化率	Digestibility coefficient							
瘤胃	Rumen							
有机物（真实）	OM (truly)[3]	53.1^{c}	57.3^{bc}	62.7^{ab}	56.3^{bc}	64.8^{a}	2.84	0.03
NDF	NDF	41.3^{b}	39.3^{b}	52.9^{a}	46.6^{ab}	52.9^{a}	3.29	0.01
淀粉	Starch	75.4	77.5	81.4	77.8	83.3	2.68	0.14
小肠	Intestinal							
有机物	OM	38.1	35.2	30.2	34.8	29.8	3.23	0.19
NDF	NDF	14.9	15.8	14.9	15.8	13.7	3.49	0.99
淀粉	Starch	20.8	18.7	16.1	18.8	13.6	2.59	0.21
总体	Total							
有机物	OM	77.2	77.4	80.7	79.8	81.7	1.23	0.07
NDF	NDF	56.2^{bc}	55.1^{c}	67.7^{a}	62.4^{ab}	66.1^{a}	2.55	0.01
淀粉	Starch	96.3	96.2	97.5	96.6	96.9	0.55	0.35

Yeast

Table 2. Effect of *Saccharomyces cerevisiae* fermentation product (SCFP) supplementation on ruminal pH and fermentation in finishing heifers 补充酿酒酵母发酵产物对育肥母牛瘤胃pH和发酵的影响

Item	Treatments[1]						
	Control	ANT	rSCFP	dSCFP	rdSCFP	SEM	*P*-value
Ruminal pH							
Mean	5.77	5.81	5.96	5.87	5.87	0.085	0.58
Minimum 最小值	5.02[c]	5.13[bc]	5.30[a]	5.21[ab]	5.05[c]	0.070	0.03
Maximum	6.74	6.69	6.70	6.60	6.77	0.083	0.65
pH < 5.8, h/d	12.7	12.2	[illegible]	11.7	11.6	1.81	0.48
pH < 5.6, h/d	11.6	10.4	[illegible]	8.6	8.7	1.80	0.09
pH < 5.2, h/d	4.3	2.2	0.3	2.1	2.4	1.35	0.30
Volatile fatty acids (VFA)							
Total, m*M*	141.9	136.6	132.6	141.6	134.5	6.54	0.56
Acetate (A), mol/100 mol	47.2	47.2	51.8	47.3	45.1	2.32	0.06
Propionate (P), mol/100 mol	28.5	31.4	29.4	30.0	26.8	5.54	0.68
Butyrate, mol/100 mol 丁酸	18.6[ab]	15.4[bc]	13.4[c]	16.8[bc]	22.3[a]	3.40	0.01
A:P ratio	[illegible]	1.74	2.10	1.76	1.88	0.367	0.58
Lactic acid, m*M*	[illegible]	0.11	0.12	0.08	0.08	0.060	0.38
NH_3-N, m*M*	[illegible]	9.40	11.80	7.46	9.19	2.591	0.43
Protozoa, ×10[5]/mL	3.53[b]	2.83[b]	9.93[a]	2.78[b]	4.35[b]	1.55	0.03

✓ Yeast/fermentation products function in the rumen.
酵母/发酵产物在瘤胃起作用

Shen et al., JAS, 2018, 96: 3916-27

The Ohio State University
College of Food, Agricultural, and Environmental Sciences

Yeast 酵母

	Measurement	Control	Yeast	P value
干物质采食量	DMI (g/kg BW)	34.6	35.0	<0.05
瘤胃pH	Rumen pH	6.31	6.34	<0.05
挥发性脂肪酸	VFA (mM)	95.2	97.3	<0.01
乳酸	Lactate (mg/L)	1.21	1.13	<0.10
有机物消化率	OMD (%)	70.2	71.0	<0.05
产奶量	Milk yield (g/kg BW)	46.5	47.7	<0.001
乳脂肪	Milk fat (%)	3.80	3.85	<0.10
乳蛋白	Milk protein (%)	3.20	3.19	>0.05

Adapted from Desnoyers, et al, 2009, JDS, 92:1620.

- Live yeast is more effective than dead yeast or yeast products.
  活酵母比死酵母或酵母产品更有效
- Limited energy source for yeast, thus limited metabolic activities.
  酵母的能量来源有限，因此代谢活动有限

DFMs affect *E. coli* O157 shedding from beef steers.

直接饲用微生物影响阉公牛大肠杆菌排出

Wisener et al., Zoonoses Public Health 62: 75-89

Table 1. Summary of results for field trials evaluating the use of direct-fed microbials to reduce prevalence of *Escherichia coli* O157 faecal shedding in beef cattle

DFM-*E. coli* O157-ruminants

Trial (lead author and publication year)	Intervention used in each comparison within the trial	Dose (CFU/animal/day)	Duration of DFM (days)
Ohya et al. (2001)	*Streptococcus bovis* LCB6 + *L. gallinarum* LCB12	40×10^{13}	14
Brashears et al. (2003)	*Lactobacillus acidophilus* (NP51)[a]	10^9	70
	L. crispatus (NP35)[b]	10^9	70
Folmer et al. (2003) Exp. #1	NP51	10^9	90
	NP45	10^9	90
Folmer et al. (2003) Exp. #2	NP51	10^9	104
	NP45	10^9	104
Smith et al. (2003)	NP51	10^9	128
	NP51 + *E. coli* vaccine	10^9	128
Elam et al. (2003)	*L. acidophilus* (NP51) + *L. acidophilus* (NP45) + *Propionibacterium freudenreichii* (NP24)	$10^9 + 10^6 - 10^6$ respectively	120
	NP51 + NP24	$10^9 + 10^6$	120
	NP51 + NP45 – NP24	$10^9 + 10^6 - 10^6$	120
Younts-Dahl et al. (2004)	NP51 + NP24	$10^9 + 10^6$	Unknown
	NP51 + NP45 – NP24	$10^9 + 10^9 - 10^9$	Unknown
	NP51 + NP45 – NP24	$10^9 + 10^6 - 10^9$	Unknown
Younts-Dahl et al. (2005)	NP51 + NP24	$10^7 + 10^9$	28
	NP51 + NP24	$10^8 + 10^9$	28
	NP51 + NP24	$10^9 + 10^9$	28
	NP51 + NP45 – NP24	$10^9 + 10^9 - 10^9$	28
Wisener et al. (2006)	NP51 + NP24	2×10^{10} of each	60
	NP51 + NP24 – *E. coli* vaccine	2×10^{10} of each	60
	NP51 + NP24 – neomycin	2×10^{10} of each	60
	NP51 + NP24 – *E. coli* vaccine	2×10^{10} of each	60
[illegible] et al. (2007)	NP51	10^9	125
Stephens et al. (2007a)	NP51 + NP24	$10^7 + 10^9$	137
	NP51 + NP24	$10^8 + 10^9$	137
	NP51 + NP24	$10^9 + 10^9$	137
Stephens et al. (2007b)	*L. acidophilus* (NP35) + NP24	$10^9 + 10^9$	Unknown
	L. acidophilus (NP28) + NP24	$10^9 + 10^9$	Unknown
	NP51 + NP24	$10^9 + 10^9$	Unknown
	NP35 + NP51 – NP24	$10^9 + 10^6 - 10^6$	Unknown
Tabe et al. (2008)	NP51 + NP24	$10^9 + 10^9$/g feed daily	84
Arthur et al. (2010)	*Bacillus subtilis*	2.5×10^9	84
Cernicchiaro et al. (2010)	*Aspergillus oryzae*	3.0 g	154
	Saccharomyces cerevisiae	0.5 g	154
Stephens et al. (2010)	*L. acidophilus* + *Saccharomyces cerevisiae*	$5 \times 10^9 + 8 \times 10^{12}$	167
Cull et al. (2012)	NP51 + NP24	$10^9 + 10^9$	87

[a]*Lactobacillus acidophilus* (NP51) formerly known as NPC 747.
[b]*Lactobacillus crispatus* (NP35) formerly known as NPC 750.

DFMs affect *E. coli* O157 shedding from beef steers.

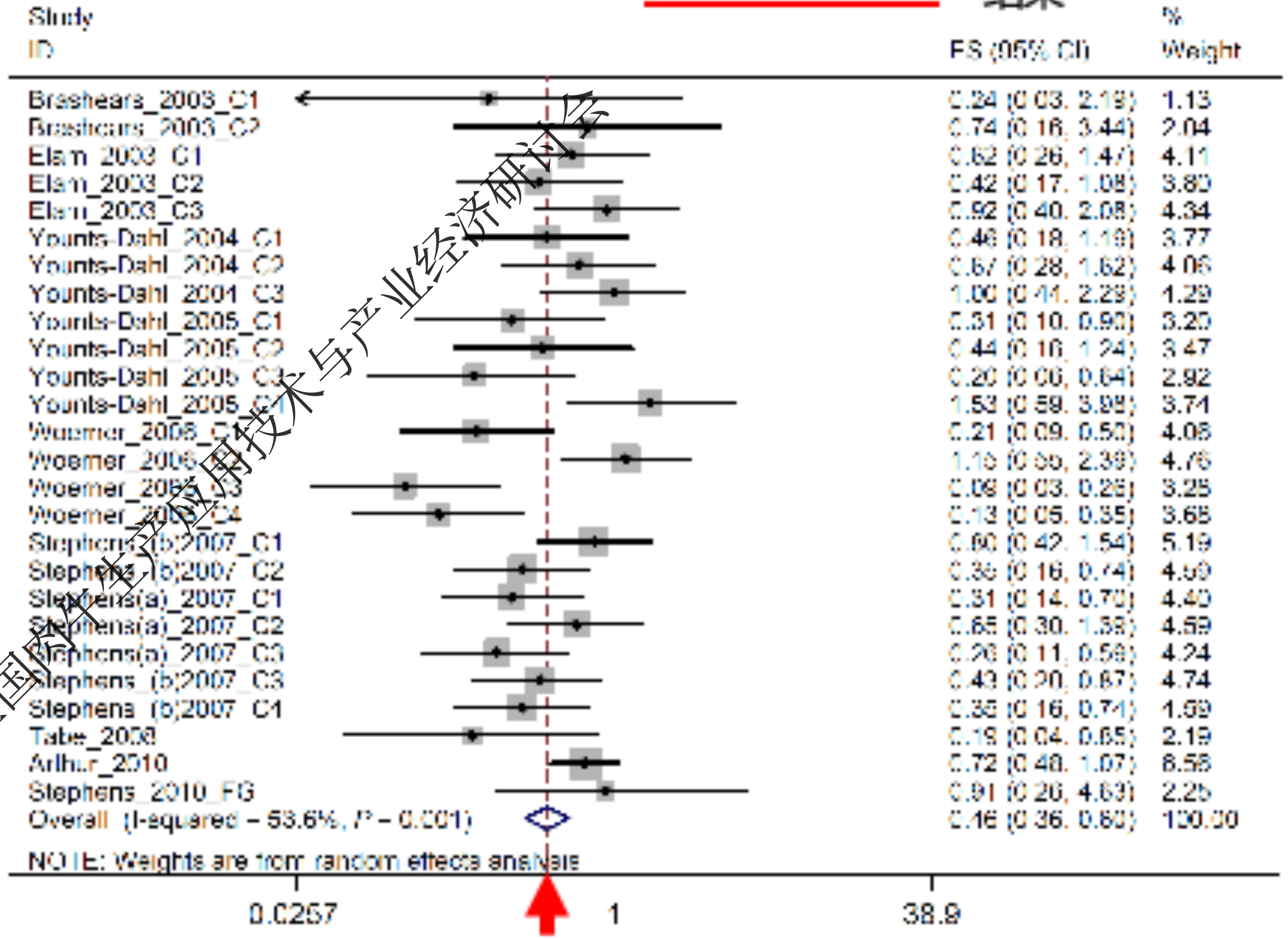
直接饲用微生物影响大肠杆菌排出

Wisener et al., Zoonoses Public Health 62: 75-89

DFM - *E. coli* O157 - beef cattle

Outcome as measured at the end of the trial

试验结束测定的结果



Random effects forest plot

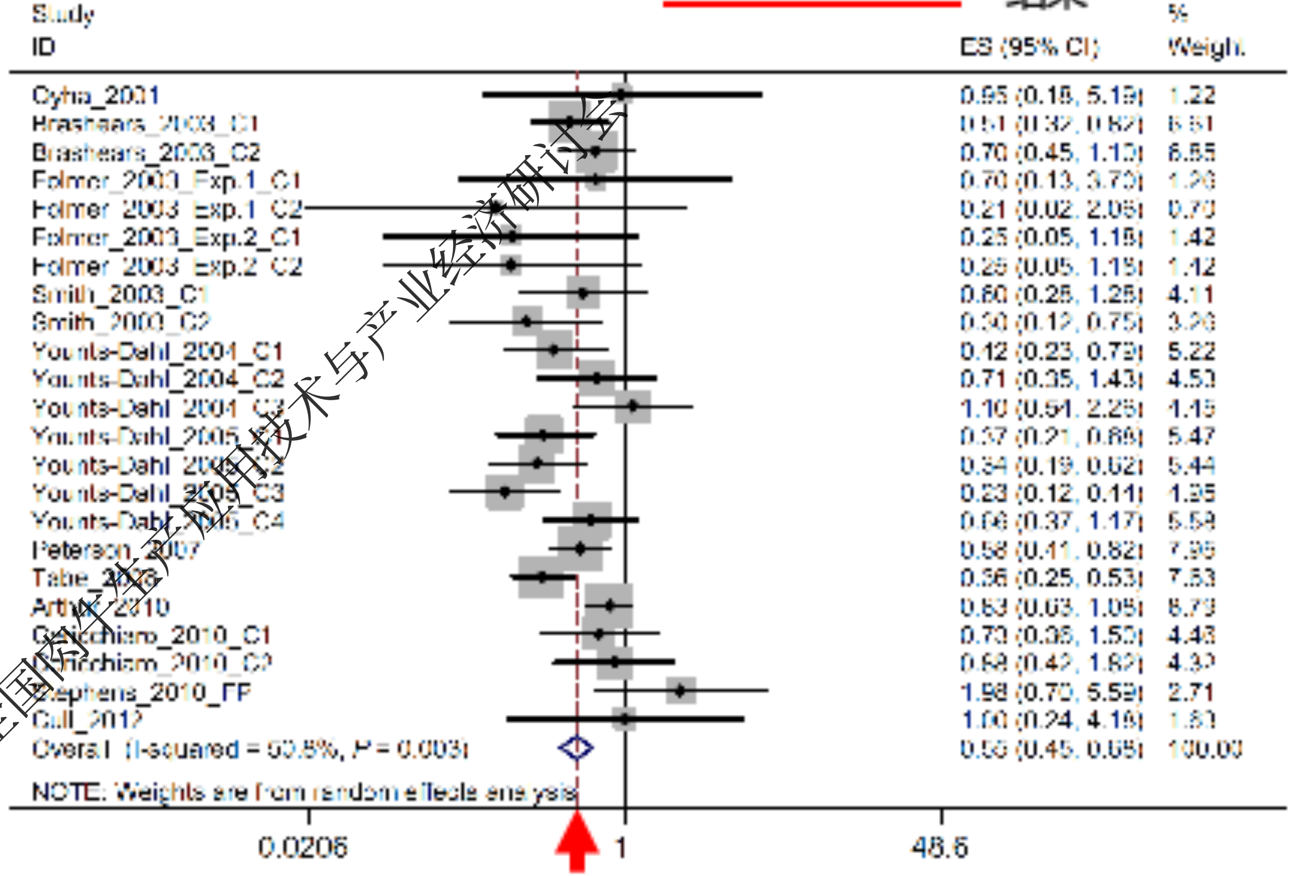
Wisener et al., Zoonoses Public Health 62: 75-89

THE OHIO STATE UNIVERSITY COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

DFMs affect *E. coli* O157 shedding from beef steers.

直接饲用微生物影响大肠杆菌排出

Wisener et al., Zoonoses Public Health 62: 75-89

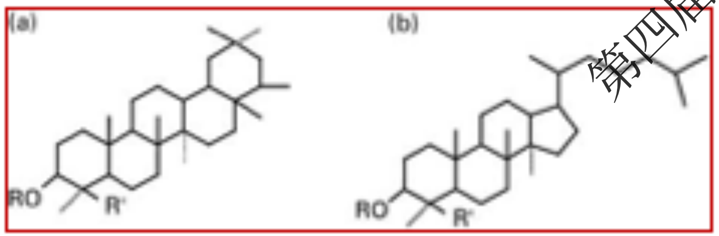


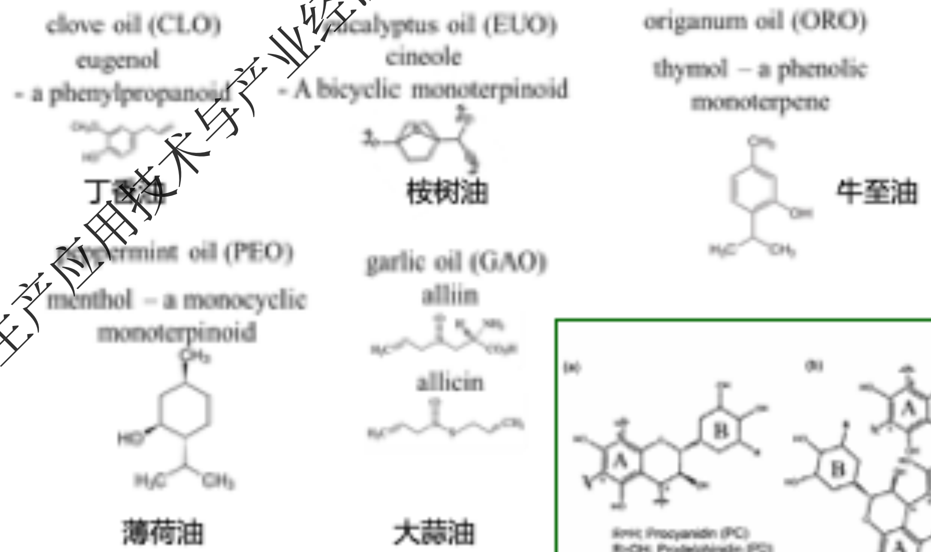
试验结束测定的结果

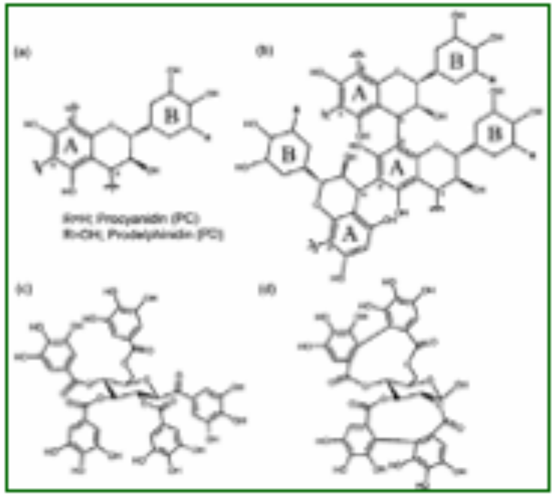
✓ Mechanisms not well understood.

Bioactive phytochemicals
具有生物活性的植物化学物质

- Natural products of plants 植物的天然产物
- GRAS status, no need or easier to obtain government approval 无需或更容易获得政府审批
- Acceptable to consumers 消费者易于接受
- Essential oils 精油
- Saponins (a, b) 皂苷
- Tannins 单宁
-







皂苷或含皂苷植物对体内原虫数量和瘤胃发酵的影响

Table 1. Effects of saponins or saponin-containing plants on protozoal numbers and rumen fermentation *in vivo* and performance of an

Saponin type*	Animal	Dosage (g/kg DM)†	Feed (F:C)	Effect‡ Prot	NH_3	TVFA	A:P	Dig	MPS	Met	FI	ADG	MY
Biophytum petersianum	Goats	13 mg/kg BW	70:30	↓	↓	↓	↓	=	=	×	×	×	×
B. petersianum	Goats	26 mg/kg BW	70:30	↓	↓	=	↓	↓	↑	×	×	×	×
B. petersianum	Goats	19·5 mg/kg BW	70:30	↓	↓	↓	↓	=	↑	×	×	×	×
Enterolobium cyclocarpum	Sheep	25, 75 g/d	88:12	↓	×	×	×	×	[illegible]	×	↑	↑‖	×
E. cylocarpum	Sheep	100 g/d	100:0	↑	↓	×	×	=§	×	×	↑	↑‖	×
E. cylocarpum	Sheep	300 g/d	100:0	↓	↓	×	×	↓§	×	×	=	↑‖	×
E. cylocarpum	Sheep	200 g/d	60:40	↓	=	=	=	[illegible]	×	×	×	×	×
Lucerne (27·8 %)	Sheep	10	100:0	↓	×	=	=	[illegible]	×	=	=	×	×
Lucerne (27·8 %)	Sheep	20 to 40	100:0	↓	×	=	[illegible]	[illegible]	×	=	=	×	×
Lucerne saponins	Sheep	20	60:40	↓	↓	=	[illegible]	=	×	=	=	×	×
Lucerne saponins	Sheep	40	60:40	↓	↓	↓	[illegible]	=	×	↓	=	×	×
Lucerne saponins	Sheep	20	40:60	↓	=	↓	[illegible]	↑	×	=	=	×	×
Lucerne saponins	Sheep	40	40:60	↓	↓	↓	↑	↑	×	=	=	×	×
QS extract (10 %)	Heifers	8	91:9	=	=	[illegible]	↑	=	=	×	=	×	×
QS extract (5·7–8·1 %)	Sheep	13·5	60:40	=	↓	[illegible]	=	↑	=	=	=	×	×
QS plant (3 %)	Dairy cows	10	51:49	=	=	[illegible]	=	=	×	=	↑	=	=
Sapindus saponaria fruit	Sheep	8 g/kg $BW^{0·75}$	100:0	↑	[illegible]	=	↓	↓	↑	×	↑	×	×
S. saponaria fruit (12 %)	Sheep	5 g/kg $BW^{0·75}$	67:33	↓	[illegible]	↑	↓	↓	×	↓	=	↑	×
S. saponaria pericarp	Sheep	25 g/d	72:28	↓	[illegible]	×	=	×	×	×	=	×	×
S. saponaria pericarp	Sheep	50 g/d	72:28	↓	↓	×	↓	×	×	×	=	×	×
Sarsaponins	Dairy cows	0·077	40:60	[illegible]	=	=	=	=	×	×	=	=	=
Sarsaponins	Dairy cows	0·2, 0·41, 0·62	36:64	[illegible]	↓	=	=	×	×	×	=	=	=
Sarsaponins	Calves	0·02	54:46	[illegible]	×	×	×	×	×	×	=	↑¶	×
Sarsaponins	Sheep	0·002, 0·03	50:50	=	↓	=	=	=	×	=	=	×	×
Sarsaponins	Dairy cows	0·044	67:33	×	×	×	×	=	×	×	=	×	=
YS	Steers	0·43	92:8	×	×	=	×	×	↑	=	=	↑	×
YS (4·4 %)	Wether	0·24	85:15	×	↓	=	↓	×	↑	×	=	×	×
YS extract	Dairy cows	0·38	60:40	×	=	×	×	×	×	×	=	×	=
YS extract	Dairy cows	0·38	51:49	×	=	×	×	×	×	×	=	×	=
YS extract	Dairy cows	1·46	6[illegible]	×	×	×	×	=	×	×	=	×	=
YS extract	Dairy cows	3·1	[illegible]	×	×	×	×	=	×	×	↓	×	=
YS extract	Steers	1·25	[illegible]	↓	×	↓	=	=	×	×	=	×	=
YS extract	Steers	2·56	[illegible]3:37	↓	×	↓	=	=	×	×	=	×	=
YS extract	Sheep	0·13	75:25	×	↓	↑	↓	=	×	↓	=	×	×
YS extract	Sheep	0·12	70:30	×	↓	=	=	=	=	↓	=	×	×
YS extract	Dairy cows	0·07	48:52	×	×	×	×	=	=	×	↓	×	×
YS extract	Dairy cows	0·06	48:52; urea added	×	×	×	×	=	=	×	↑	×	×
YS extract	Dairy cows	0·03 to [illegible]	38:62	×	=	=	=	×	×	×	=	×	×
YS extract	Steers	0·07[illegible]	92:8	×	=	=	=	×	×	×	=	×	×
YS extract	Steers	0·075	96:4	×	=	=	=	×	×	×	=	×	×
YS extract	Steers	0·075	45:55	×	=	=	=	×	×	×	=	=	×
YS extract	Steers	0·075	48:52	×	=	=	=	×	×	×	=	=	×
YS extract (10 %)	Dairy cows	2·8	40:60	=	=	=	=	=	×	×	=	×	=
YS extract (9·6–11·7 %)	Sheep	13·8	60:40	=	↓	↓	=	=	=	=	=	×	×
YS plant (4·4 %)	Heifers	1·96	61:39	↓	=	=	↓	=	=	×	=	×	×
YS plant (4·4 %)	Heifers	5·83	61:39	↓	↓	=	↓	=	=	×	=	×	×
YS plant (6 %)	Dairy cows	10	51:49	=	↓	=	=	=	×	=	↑	=	=

Patra and Saxena, 2009, Nutr Res Rev 22(2): 204

Ionophores – alternatives 离子载体-替代物

Feeding the combination of essential oils and exogenous α-amylase increases performance and carcass production of finishing beef cattle[1]

Murillo A. P. Meschiatti,[†] Vinícius N. Gouvêa,[‡] Lucas A. Pellarin,[†] Camila D. A. Batalha,[†] Marcos V. Biehl,[†] Tiago S. Acedo,[‡] João R. R. Dórea,[‡] Luis F. M. Tamassia,[‡] Fredric N. Owens,[||] and Flavio A. P. Santos[†,1]

混合饲喂精油和外源α-淀粉酶提高育肥牛生产性能和胴体产量

J Anim Sci 2019, 97: 456-71

- EO blend ↑ DMI (over monensin), but similar feed efficiency
  精油混合物提高日增重（优于莫能菌素），但饲料效率相似
- EO blend ↑ total tract digestibility of CP
  精油混合物提高全消化道粗蛋白消化率
- EO blend and α-amylase ↑ DMI (by 810 g/d), ADG (by 190 g/d), final BW (by 18 kg), HCW (by 12 kg)
  精油混合物和α-淀粉酶提高了干物质采食量，平均日增重，末重，热胴体重

✓ EO blend = thymol, eugenol, limonene, and vanillin
✓ 精油混合物=百里酚，丁子香酚，柠檬烯和香草醛

Diarrhea in calves 犊牛腹泻

- Diarrhea is a leading cause of sickness and death of beef and dairy calves in their first month of life. **腹泻是肉牛和奶牛犊牛在出生后第一个月生病和死亡的主要原因**
- 75% of early calf mortality in dairy herds is caused by acute diarrhea in the pre-weaning period (Svensson et al., 2006).
  奶牛群早期犊牛死亡的75%是由断奶前急性腹泻引起的（Svensson等，2006）
- The economic losses: from mortality, morbidity; treatment costs, time to care (chronic ill-thrift nature), reduced growth rate (Bazeley, 2003)
  经济损失：死亡率，发病率；治疗费用，治疗时间（慢性病-节约天性），生长速度降低（Bazeley，2003）
- Common pathogens: *Cryptosporidium*, rotavirus, coronavirus, *Salmonella*, EHEC, EPEC, STEC], F5 (K99) *E. coli*.
  常见病原体：隐孢子虫，轮状病毒，冠状病毒，沙门氏菌，大肠杆菌（EHEC，EPEC，STEC，F5（K99））

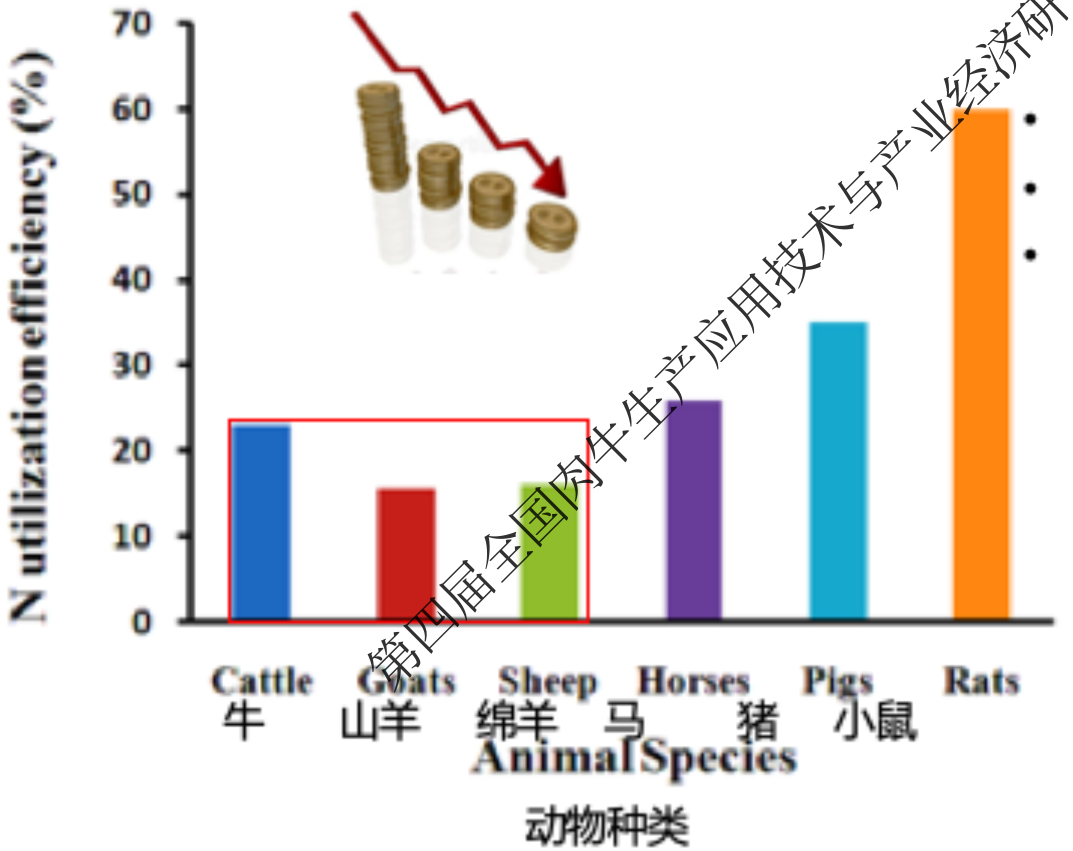
Repeated inoculation of calves with rumen fluid decreased diarrhea 犊牛重复接种瘤胃液降低腹泻

		Treatment		P-Value
		Ctrl (AD)对照	Inoculated (RD)接种	
总体腹泻发病率	Overall incidence of diarrhea	91	69	<0.01
腹泻频率	Diarrhea frequency	13.13	8.96	<0.01
断奶前腹泻发病率	Incidence of diarrhea before weaning	66	36	<0.01
断奶前腹泻频率	Diarrhea frequency before weaning	14.97	7.35	<0.01
断奶后腹泻发病率	Incidence of diarrhea after weaning	25	33	>0.05
断奶后腹泻频率	Diarrhea frequency after weaning	9.92	11.79	>0.05

Unpub. data

Targeted specific control of rumen microbes –protozoa 瘤胃微生物的特定靶向调控-原虫

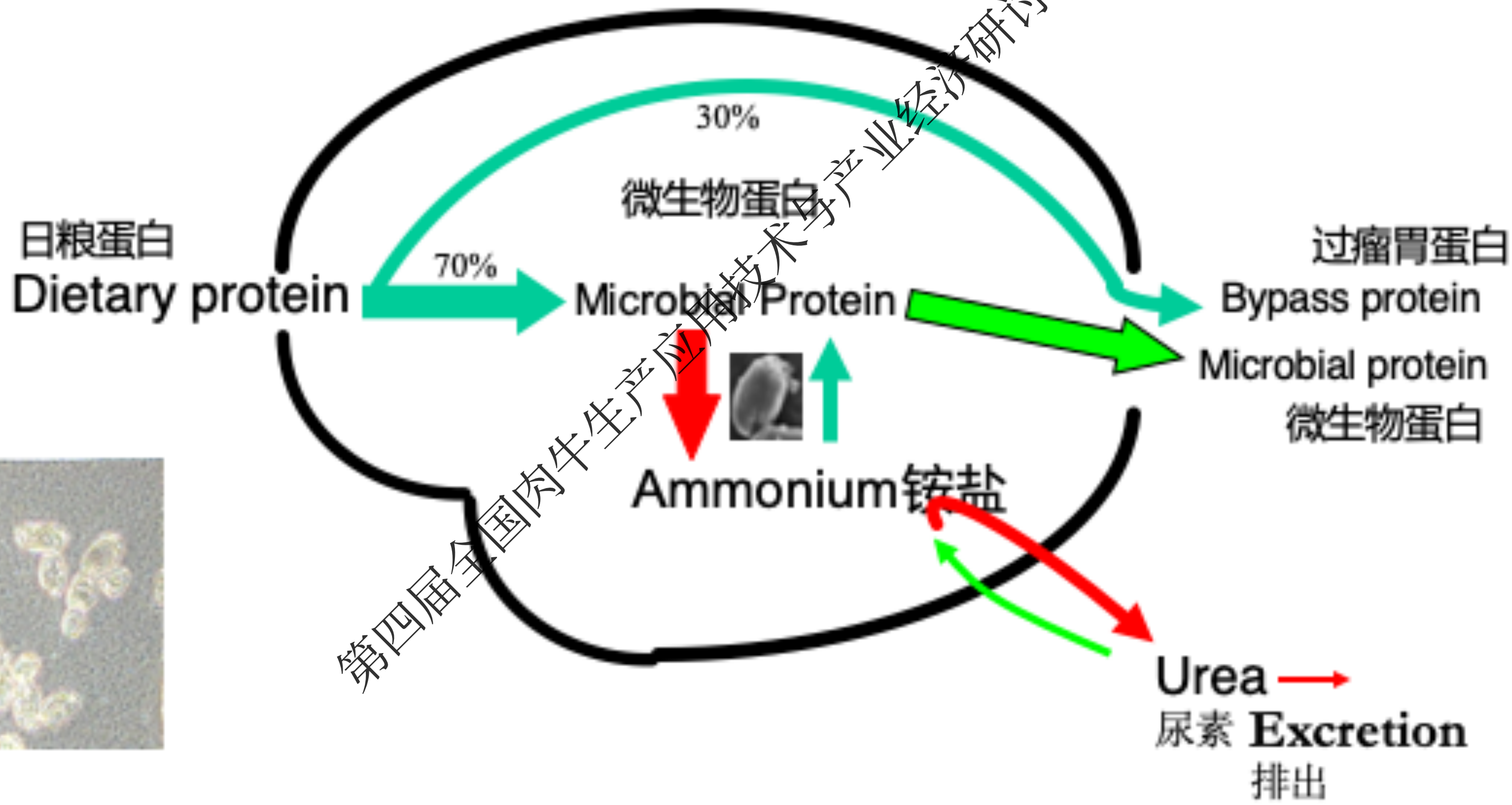
Low N utilization efficiency in cattle 牛氮利用率低

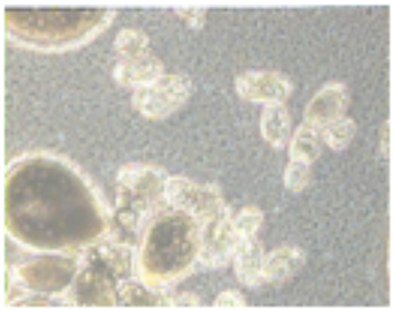


- ↑ production cost生产成本
- ↓ profitability margin盈利率
- ↑ environmental pollution环境污染

Kohn *et al.*, 2005

Intraruminal recycling of microbial proteins mediated by rumen protozoa 瘤胃原虫介导的微生物蛋白的瘤胃内循环

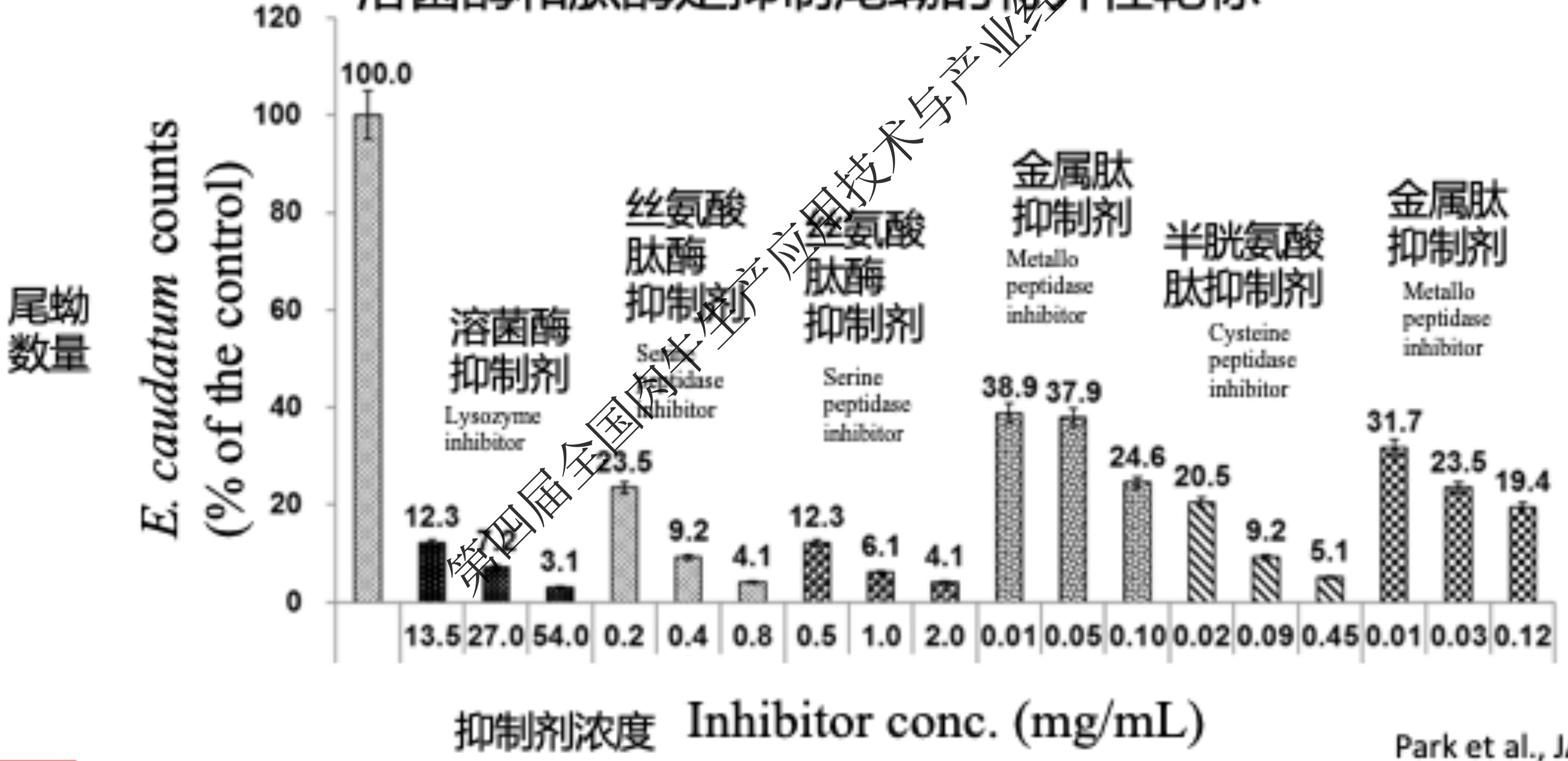




Inhibiting rumen protozoa by inhibiting their key enzymes
通过抑制瘤胃原生动物的关键酶来抑制瘤胃原虫

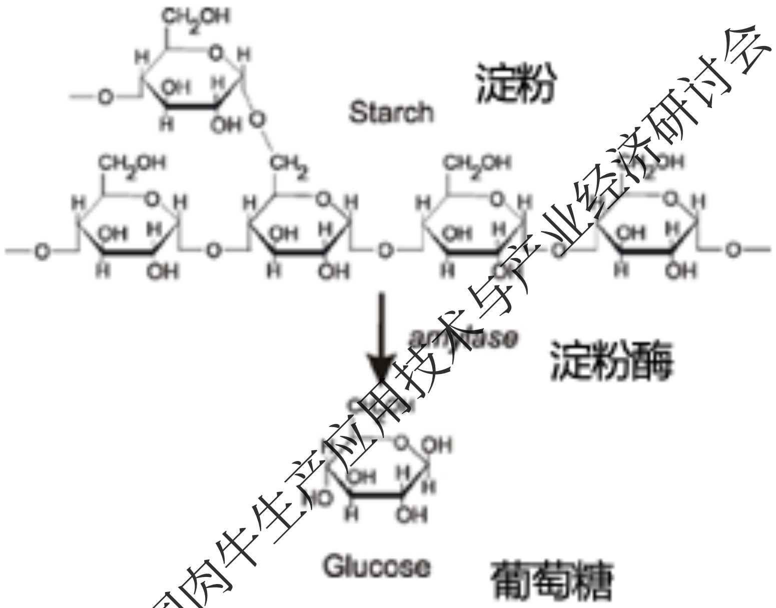
Lysozyme and peptidases are specific targets to inhibit *E. caudatum*

溶菌酶和肽酶是抑制尾蚴的特异性靶标

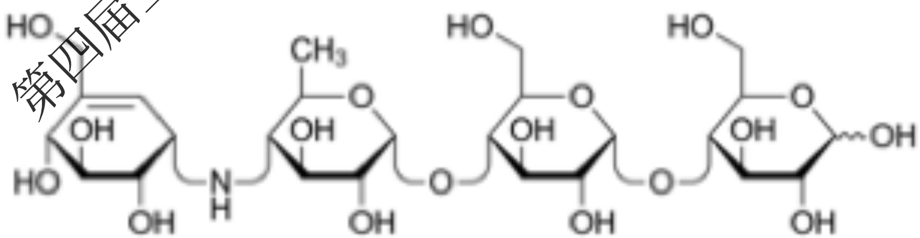


Park et al., JAM, 2019

Acarbose prevents rumen acidosis
阿卡波糖可预防瘤胃酸中毒



Analog of starch
淀粉类似物



饲喂阿卡波糖、莫能菌素和碳酸氢钠后，pH低于4.5的动物头数，pH降到4.5所需的时间，瘤胃液VFA含量以及总乳酸含量

Table 3. Number of animals with pH <4.5, median time to pH 4.5, and rumen fluid VFA and total lactate concentrations measured in the last sample taken in experiment 3 after challenge with a high carbohydrate load with no treatment (control), acarbose, monensin, or sodium bicarbonate

		Treatment group		
Item	对照 Control	阿卡波糖 1.07 mg of acarbose/kg of BW	莫能菌素 12 mg of monensin/kg of DMI	1% DMI sodium bicarbonate 碳酸氢钠
总头数 Total number of steers	7	8	7	7
Number with pH <4.5	7	[illegible]	7	7
Median time to pH <4.5, h[1]	18.3	36	16.3	26.1
总VFA Total VFA, mM	123.2	75.3	101.5	112.0
乙酸 Acetate, %	80.9	66.4	73.7	79.1
丙酸 Propionate, %	7.4	14.0	17.7	13.2
丁酸 Butyrate, %	10.9	15.7	7.5	13.0
总乳酸 Total lactate, mM	74.2	47.3	66.9	53.3

[1]If no acidosis was experienced, a time of 36 h was used.
如果没有出现酸中毒，则使用36h

McLaughlin et al, JAS 92:2758

- But very expensive, ~$30 per gram as human medicine
  但很贵，作为人类药品约30美元/g

Our wish list in beef production
肉牛生产中我们的想要做到

- ✓ ↑ feed conversion to beef meat
  饲料转化为牛肉的转化率提高
- ✓ ↓ diseases or disorder 疾病或不适降低
- ✓ ↓ environmental impact 环境影响降低
- ✓ ↑ Affordable high-quality beef 可接受的高品质牛肉
- ✓ ↑ Sustainability 可持续性

Thank you!