The Importance of Feed and Feed Mill Biosecurity
饲料及饲料厂生物安全的重要性

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Addressing Feed Safety
如何解决饲料安全问题

1. Is it likely to get infected?
饲料有可能被污染吗？

2. Can it survive?
微生物能存活下来吗？

3. Is it infectious?
它是否可以感染动物？

4. How can it be prevented?
如何预防？

5. How can it be mitigated?
如何减轻危害？

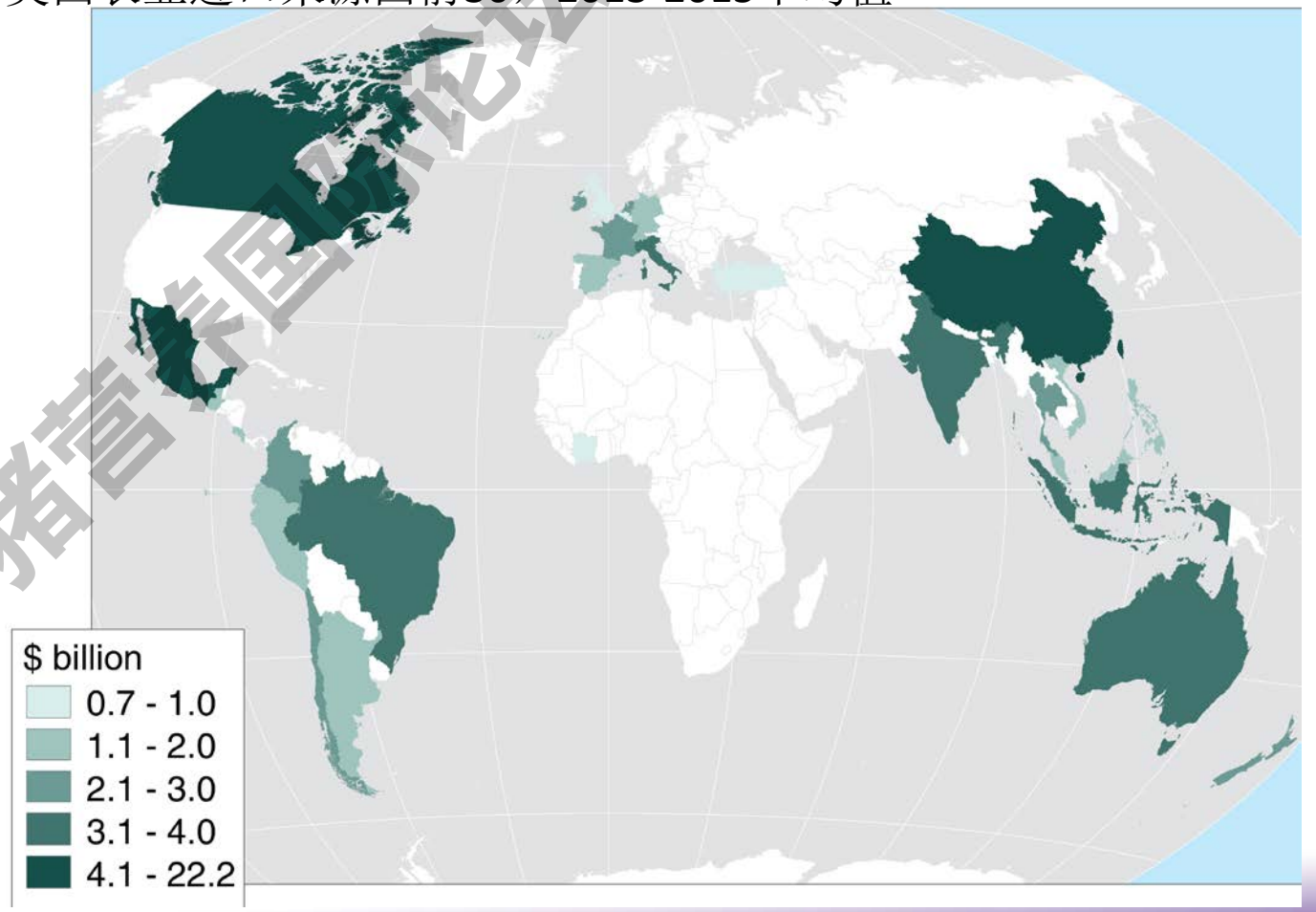
1. Is it likely to get infected?
饲料有可能被污染吗？

- What ingredients do you utilize that are at risk for getting infected with the pathogen of concern?你使用的哪些原料有被重要病原菌污染的风险？
  - Geographical considerations地域因素
    - Countries/regions with active disease outbreaks正在爆发疾病的国家和地区
    - Location of pigs with disease relative to location of ingredient production原料产地附近的猪病
  - Agricultural practices农业活动
  - Packaging 包装
    - Single use bags or totes vs. re-used totes or bulk trailers 一次性包装袋、吨袋 VS. 重复使用的吨袋或散装车

1. Is it likely to get infected?
饲料有可能被污染吗？

Ingredient 原料	Tons imported 进口量(t)
Soybeans 大豆	98,623
Lys HCl 赖氨酸	23,666
Soybean meal 豆粕	7,311
Tetracycline 四环素	1,556
DL-Met 蛋氨酸	372

Top 30 U.S. agricultural import sources, 2013-15 average
美国农业进口来源国前30，2013-2015平均值



USDA, 2017
US Harmonized Tariff Schedule/Dee et al., 2016

1. Is it likely to get infected?
饲料有可能被污染吗？

- What ingredients do you utilize that are at risk for getting infected with the pathogen of concern? 你使用的哪些原料有被重要病原菌污染的风险？

– Examples示例:

- **Higher Risk:** Rice hulls and corn cob carriers from China, Russia, Georgia, Estonia, Poland, Ukraine, Latvia, Lithuania, Romania

  高风险：来源于中国、俄罗斯、格鲁吉亚、爱沙尼亚、波兰、乌克兰、拉脱维亚、立陶宛、罗马尼亚的米糠和玉米芯载体

  Porcine-based 猪源性原料

- **Lower Risk:** Synthetic amino acids from same countries packaged in individual, single-use bags

  低风险：这些国家使用一次性包装袋的晶体氨基酸

2. Can it survive?
病原微生物能存活吗？

= Infectious virus
= No Infectious virus
= No data

Ingredient	流行性腹泻病毒 PEDV	塞贝卡病毒A Senecavirus A (FMDV surrogate)	非洲猪瘟病毒 African Swine Fever Virus	猪水泡病毒 Porcine Sapelovirus (Swine Vesicular Disease Virus surrogate)	猪圆环病毒 PCV2	伪狂犬病毒 Pseudorabies Virus (via surrogate)	猪繁殖与呼吸综合征病毒 PRRSV 174
普通豆粕 Soybean meal-Conventional							
有机豆粕 Soybean meal-Organic							
压榨豆饼 Soy oil cake							
DDGS DDGS							
赖氨酸 Lysine							
胆碱 Choline							
维D Vitamin D							
湿猫粮 Moist cat food							
湿狗粮 Moist dog food							
干狗粮 Dry dog food							
猪香肠肠衣 Pork sausage casings							
全价料(正对照) Complete feed (+ control)							
全价料(负对照) Complete feed (- control)							

Dee et al., 2018

2. Can it survive?
病原微生物能存活吗？

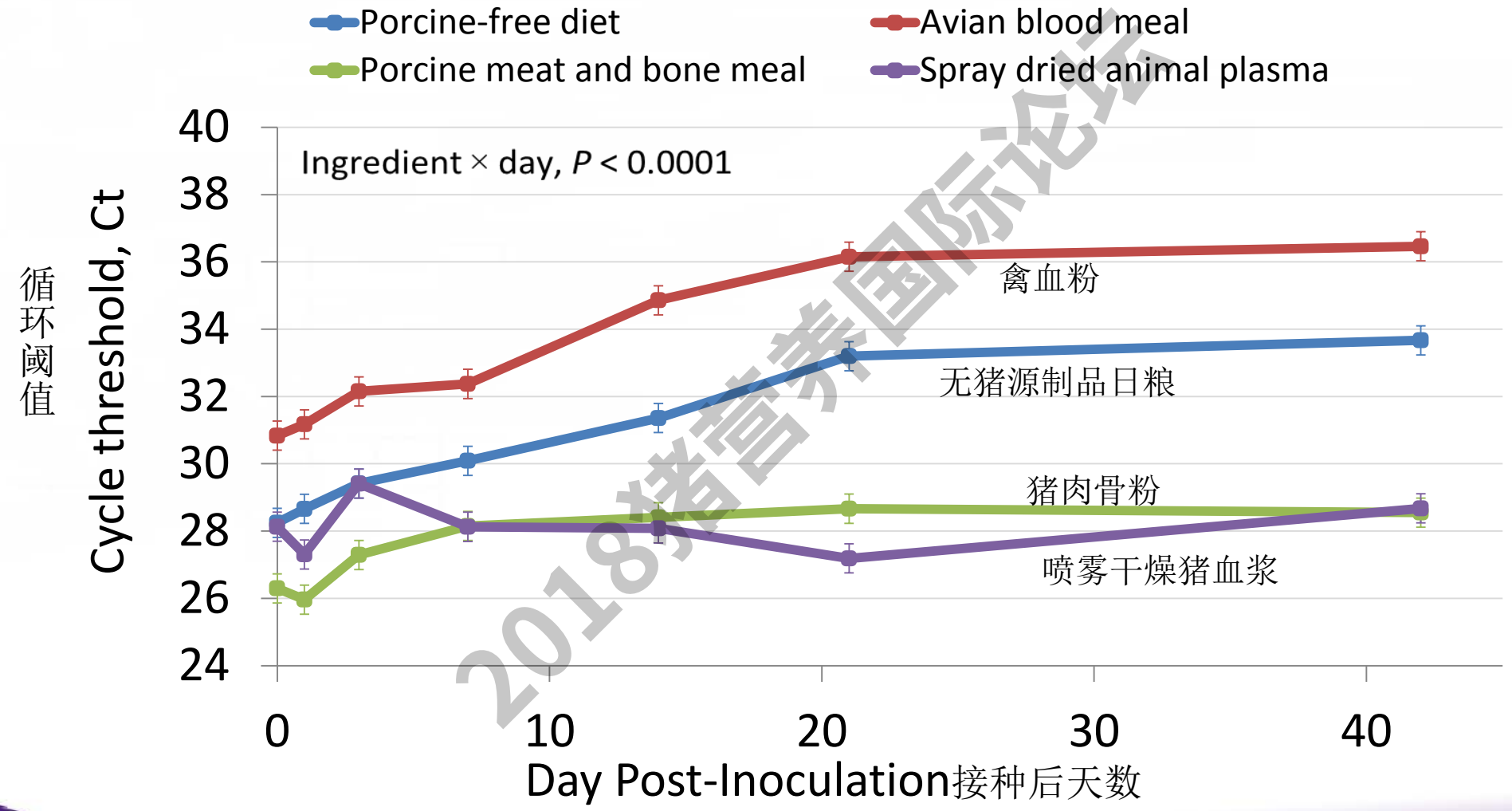
- Insufficient data on pathogen × ingredient × environment

病原菌、原料、环境之间的互作研究不够充分

= Infectious virus
= No Infectious virus
= No data

Ingredient	FMD 口蹄疫	CSF 猪瘟	ASF 非洲猪瘟	PRV 伪狂犬	PEDV 流行性腹泻
Corn 玉米					
Soybean meal 豆粕					
DDGS 玉米酒糟粕					
Wheat midds 次粉					
Fish meal 鱼粉					
Porcine plasma 血浆					
Whey 乳清					
Choice white grease 精炼白脂					
Monocal P 磷酸一钙					
Limestone石粉					
Salt 盐					
Vitamin premix 维生素预混料					
TM premix 矿物元素预混料					
Choline Cl 氯化胆碱					
L-Lys 赖氨酸					
DL-Met 蛋氨酸					
L-Thr 苏氨酸					
CTC 金霉素					

2. Can it survive?
病原微生物能存活吗？



Cochrane et al., 2016

2. Can it survive?
病原微生物能存活吗？

- Observations about ingredients that tend to harbor virus能庇护病毒原料的观察结果:
  - High protein (esp. natural protein)高蛋白(尤其是真蛋白)
  - Porcine-based 猪源性原料
  - Relatively large surface area:mass (soybean meal > soybeans) 比表面积较大(豆粕＞大豆）
    - Exposure to protein?与蛋白接触？
  - Microingredients with carriers 加载体的微量原料

3. Is it infectious?
是否具有感染性？

- Establish infectivity (VI or bioassay) 确定传染性（VI或生物实验）
- Identify infectious dose 确定感染剂量

Pathogen 病原微生物	Feed MID 饲料最小感染剂量	Source 文献
Indiana PEDV 印第安纳流行性腹泻病毒	$10^{1.0}$ $TCID_{50}$	Schumacher et al., 2016
East African ASFV 东非非洲猪瘟病毒	$10^{2.9}$ HAD_{50}	Parker et al., 1969
Malawi ASFV 马拉维非洲猪瘟病毒	$10^{2.0}$ to $10^{5.0}$ HAD_{50} based on method	Howey et al, 2013
Tanzania ASFV 坦桑尼亚非洲猪瘟病毒	$10^{5.4}$ HAD_{50}	Greig, 1972

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是否具有感染性？

- Establish infectivity (VI or bioassay) 确定传染性（VI或生物实验）
- Identify infectious dose 确定感染剂量

- 注意Considerations
  - Current diagnostic capabilities to assess infectivity are limited
    现有的评估感染性的检测能力是有限的
  - Example: PEDV 示例：流行性腹泻病毒
    - PCR is relatively low cost and available; positive ≠ infectious and negative ≠ not present
      PCR是相对低成本和可用的方法；阳性≠感染性，阴性≠不存在
    - VI is not widely available or proven; VI negative ≠ non-infectious
      VI并没有被广泛使用，也没有被证实；VI阴性≠无感染性
    - Bioassay is expensive and not widely available; bioassay negative ≠ non-infectious
      生物实验成本高，没有被广泛使用；生物实验阴性≠无感染性
    - Diagnostic tests have not been developed or validated for most pathogens in feed or ingredients 饲料和饲料原料中大部分病原微生物的检测方法还没有被开发和证实

4. How can it be prevented?
如何预防？

Feed mill biosecurity plans: A systematic approach to prevent biological pathogens in swine feed

Roger A. Cochrane, MS; Steve S. Dritz, DVM, PhD; Jason C. Woodworth, MS, PhD; Charles R. Stark, MS, PhD; Anne R. Huss, MS, PhD; Jean Paul Cano, DVM, PhD; Robert W. Thompson, DVM, MS; Adam C. Fahrenholz, MS, PhD; Cassandra K. Jones, MS, PhD

饲料厂生物安全规划：阻止猪饲料中病原微生物的系统性方案

May/June 2016
Journal of Swine Health and Production
www.ksuswine.org

4. How can it be prevented? 如何预防？

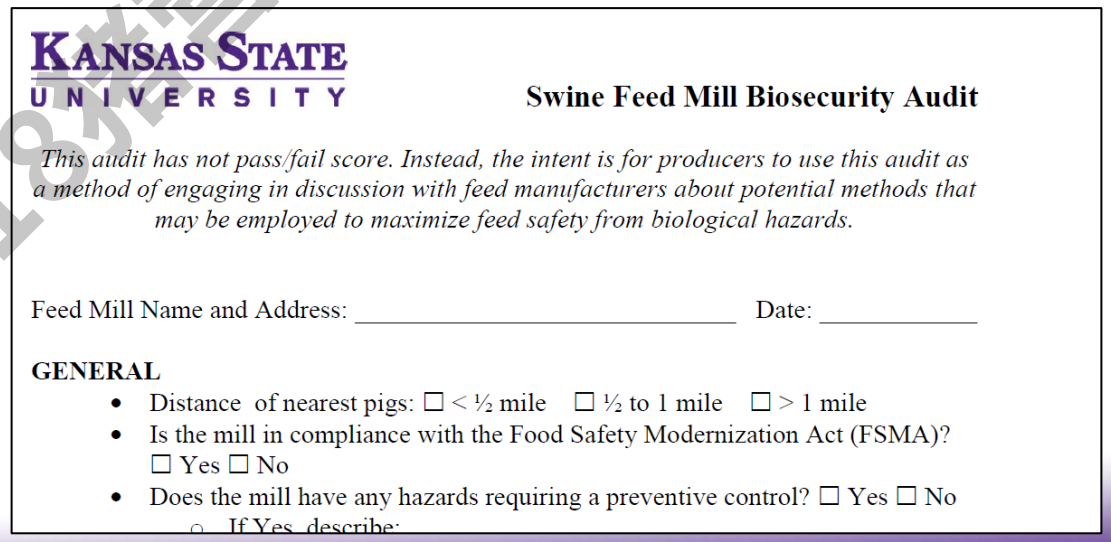
- Establish receiving procedures 建立接收程序

- Eliminate high-risk ingredients from the mill 考虑停止使用高风险原料
  - Communicate with procurement 与采购沟通
  - Confirm other ingredients are not potentially contaminated by shared lines or transport 确认其它原料不会在共用线路和运输中被污染
  - Look for non-obvious sources 寻找其它低风险原料

4. How can it be prevented?
如何预防？

- Establish receiving procedures 建立接收程序

- Use only approved vendors and haulers
  供应商和搬运工需经过批准
  - Establish through contracts, confirm via audits 签订合同，并检查确认
  - New biosecurity audit is posted at www.ksuswine.org
    生物安全新检查表已经上传至 www.ksuswine.org



KANSAS STATE UNIVERSITY

Swine Feed Mill Biosecurity Audit

This audit has not pass/fail score. Instead, the intent is for producers to use this audit as a method of engaging in discussion with feed manufacturers about potential methods that may be employed to maximize feed safety from biological hazards.

Feed Mill Name and Address: _____ Date: _____

GENERAL

- Distance of nearest pigs: ☐ < ½ mile ☐ ½ to 1 mile ☐ > 1 mile
- Is the mill in compliance with the Food Safety Modernization Act (FSMA)? ☐ Yes ☐ No
- Does the mill have any hazards requiring a preventive control? ☐ Yes ☐ No
  - If Yes, describe:

4. How can it be prevented?
如何预防？

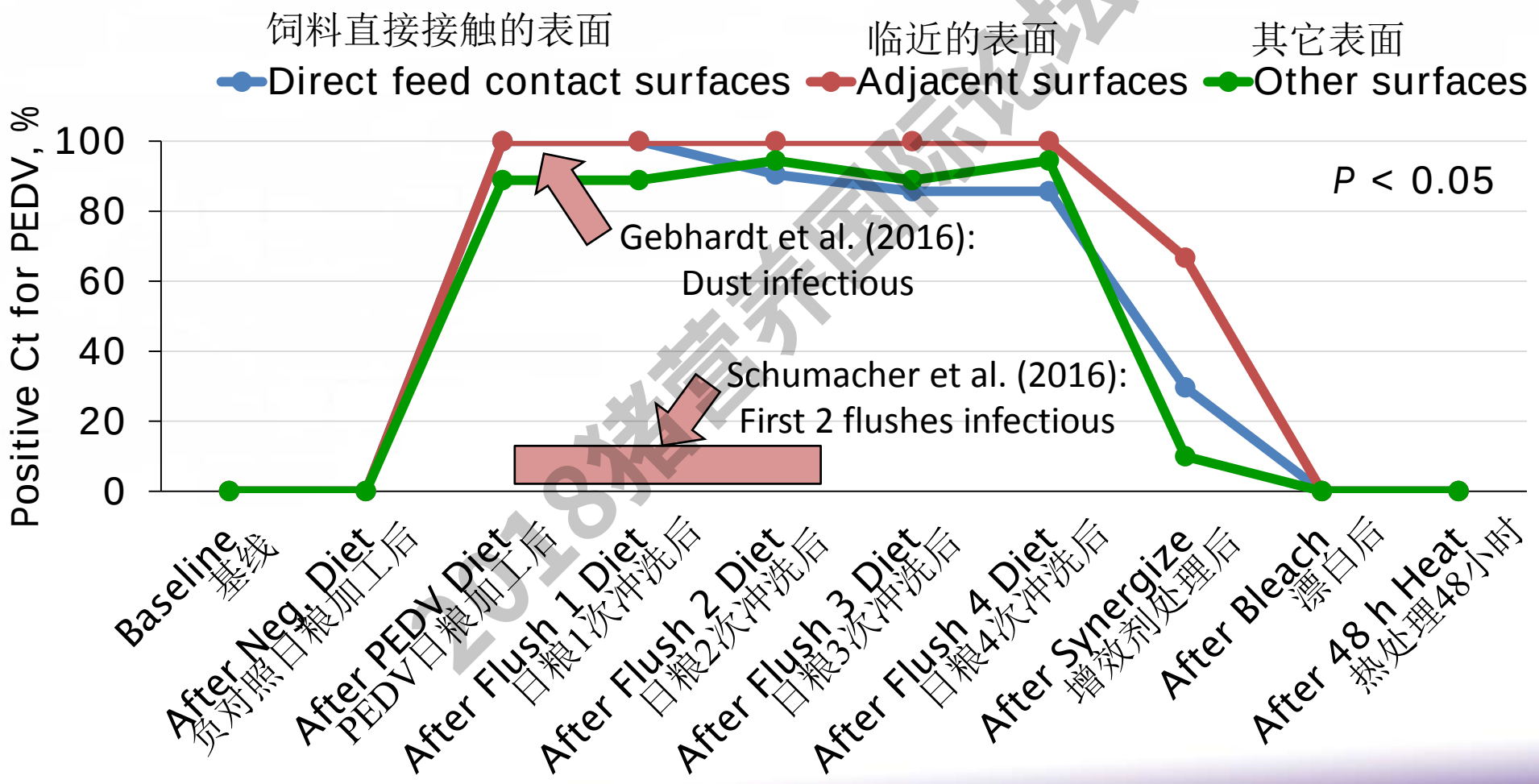
- Establish receiving procedures 建立接收程序

- Limit contamination from trucks and people
  限制卡车和人员造成的污染
  - Use receiving mats/funnels 接收原料口使用垫子/漏斗
  - When possible, don't let drivers out of trucks
    如果没有必要，不要让司机下车
    - Use your own employees to unload 卸货时使用自己的员工
    - Start treating your mill like your farm – physical barriers, foot baths, zoning 像管理养殖场一样管理饲料厂 – 物理隔离、靴子消毒池、分区管理
- In high stress times, sanitize trucks
  在高风险时期，将卡车消毒

Pictures by Scott Dee and Jason Woodworth

4. How can it be prevented?
如何预防？

- 建立接收程序Establish receiving procedures
- 减少粉尘 Minimize dust



Schumacher et al., 2017

4. How can it be prevented?
如何预防？

- 建立接收程序Establish receiving procedures
- 减少粉尘 Minimize dust
- 监控环境 Monitor the situation

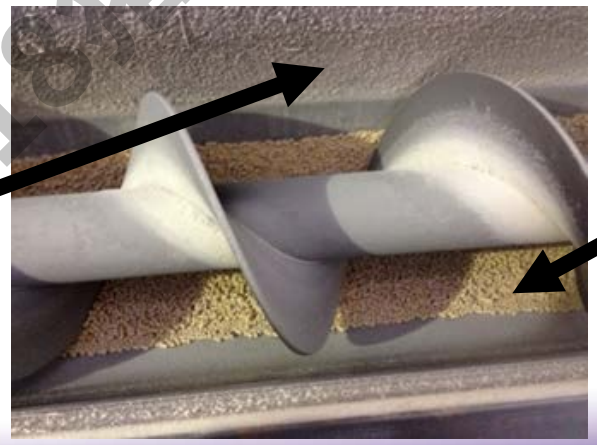
- Consider environmental monitoring 考虑监控环境
  - Take feed and ingredient samples - www.ksuswine.org
    饲料及原料取样
  - Swab environment as indicator of pathogen presence
    环境取样作为病原菌存在的一个指标
    - Working Hypothesis: Sampling dust (vs. feed or ingredients) provides a greater representation of the population of viruses/bacteria
      推测：与饲料和饲料原料相比，灰尘取样对病毒/细菌流行度的指示性更好

4. How can it be prevented? 如何预防？

- 建立接收程序Establish receiving procedures
- 减少粉尘 Minimize dust
- 监控环境 Monitor the situation

- Why environmental monitoring? 为什么要监控环境？
  - Based on knowledge from human, pet food safety 基于食品和宠物食品安全的认识：
    - Environmental monitoring gives you a more consistent and accurate picture of contamination of equipment, ingredients, and finished product.
      环境监控可以对设备、原料、成品的污染有更稳定和准确的认识

Dust that contacts multiple subsequent batches
灰尘会接触后续好几批饲料



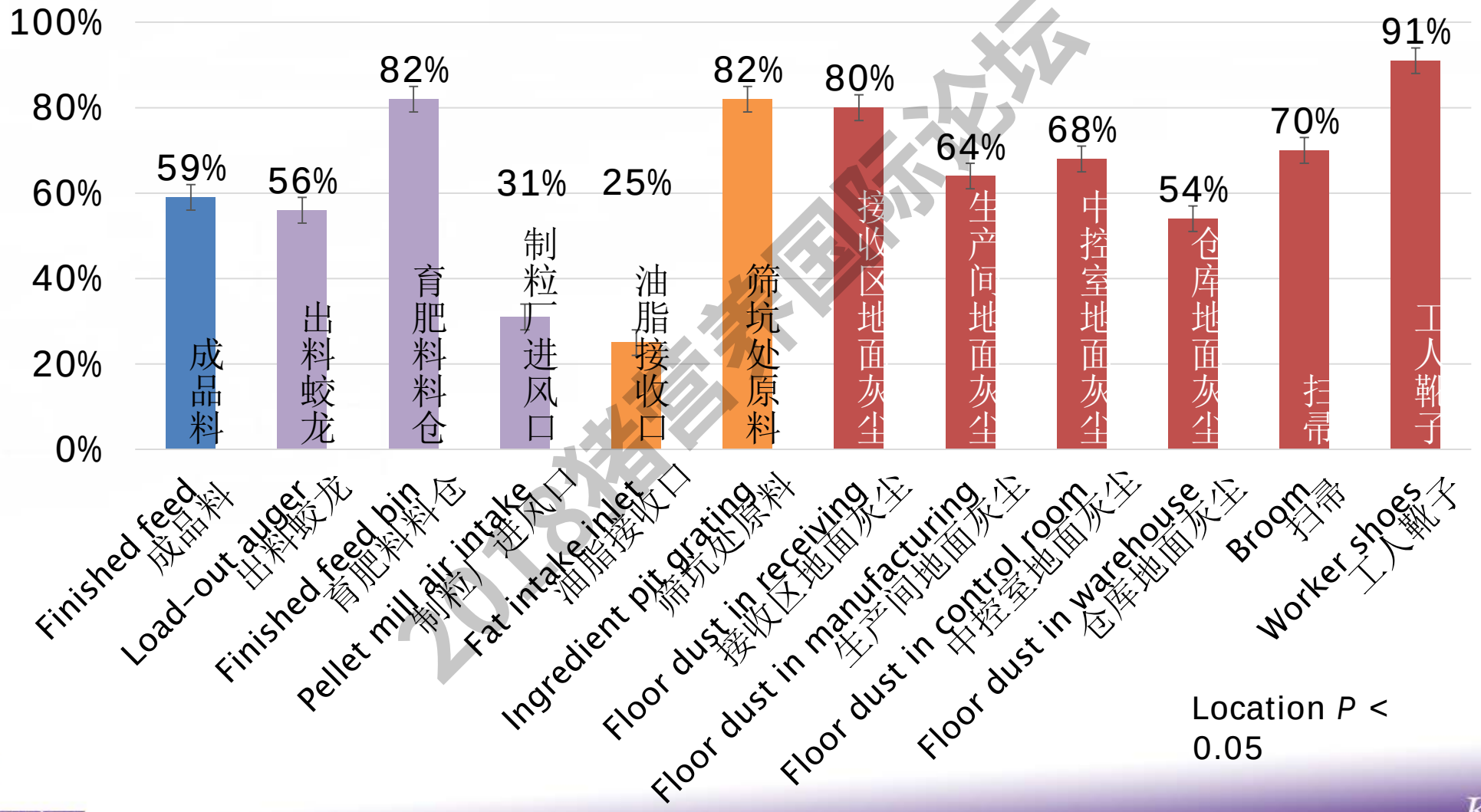
'Empty' feed conveyor with feed that contacts the next subsequent feed batch
“空”蛟龙中的饲料会与下一批饲料接触

4. How can it be prevented?
如何预防？

- 建立接收程序Establish receiving procedures
- 减少粉尘 Minimize dust
- 监控环境 Monitor the situation

- Why environmental monitoring?
  为什么要监控环境？

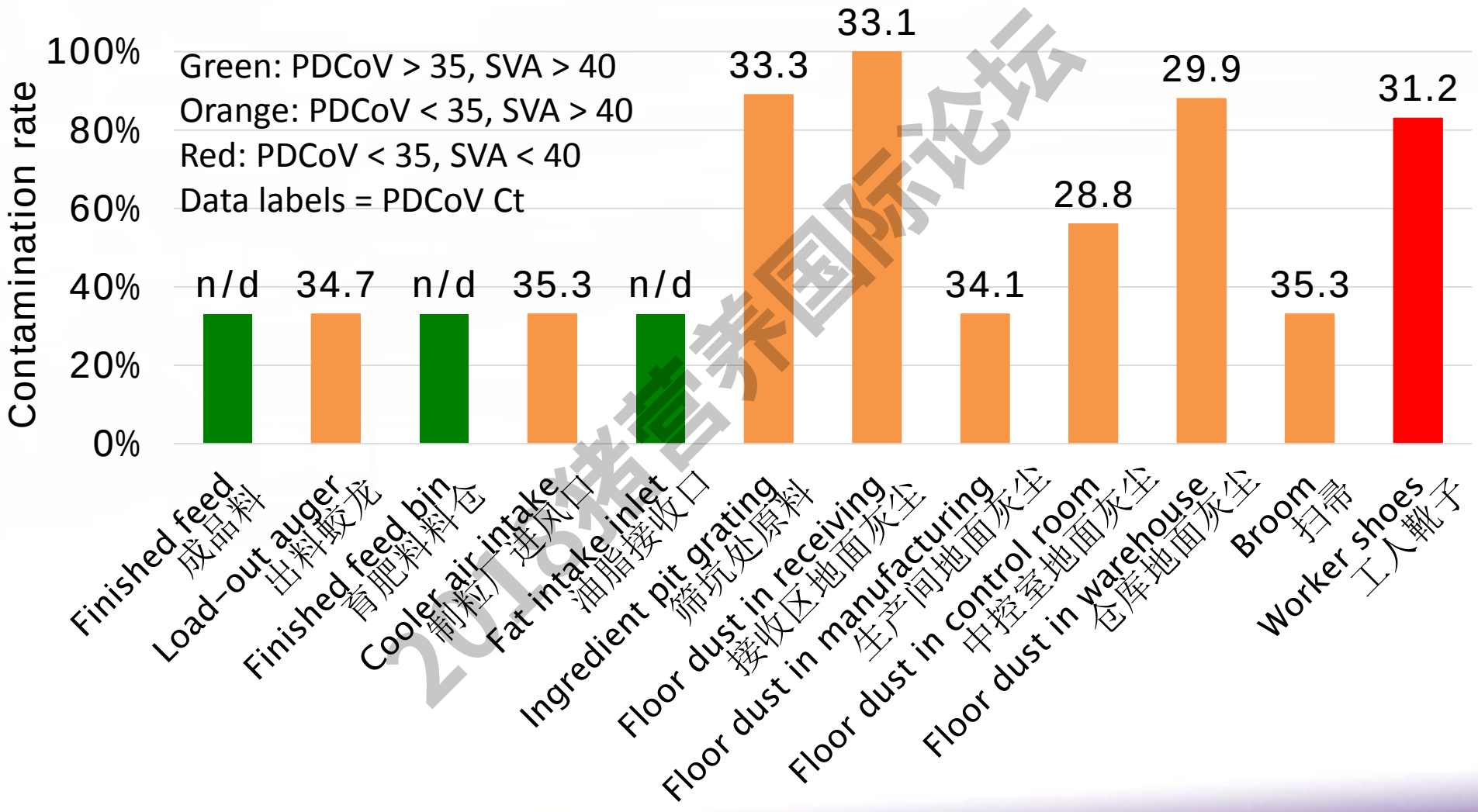
Enterobacteriaceae in 12 U.S. swine feed mills
美国12个猪饲料厂的肠道菌



Boccatto et al., 2017

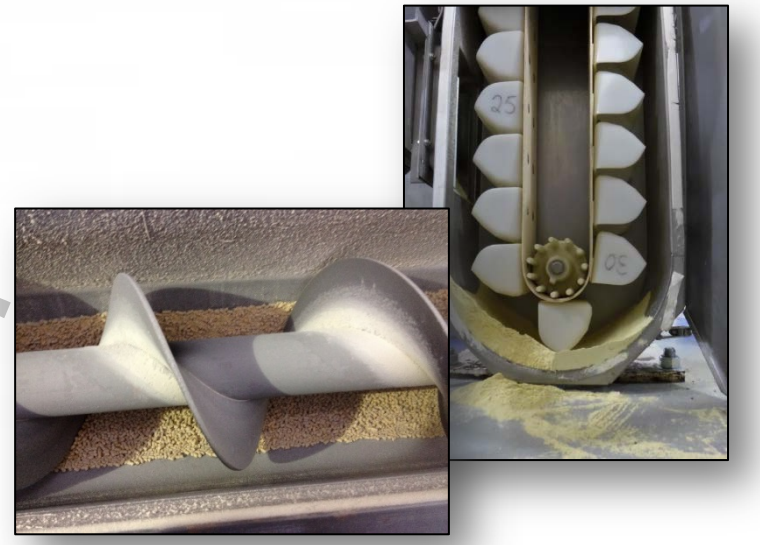
PDCoV in a single swine feed mill

一个猪饲料厂中的德尔塔冠状病毒

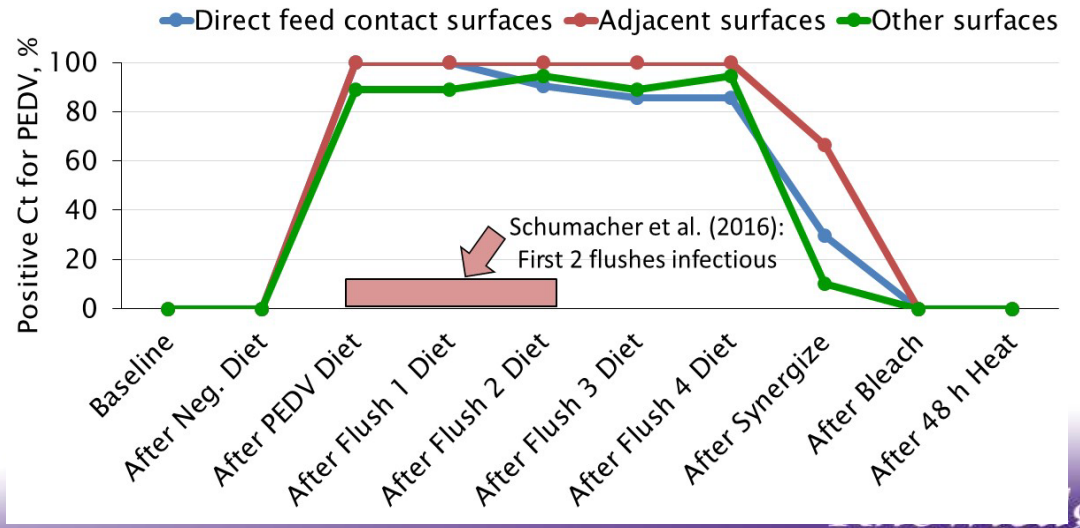


5. How can it be mitigated?
如何减轻危害？

- Point-in-Time 即时控制



- Types 分类
  - Point-in-Time 即时控制
    - Dilution to below minimum infectious dose 稀释至低于最小感染剂量
    - Irradiation 辐照
    - Thermal processing 热加工
  - Residual 持续控制

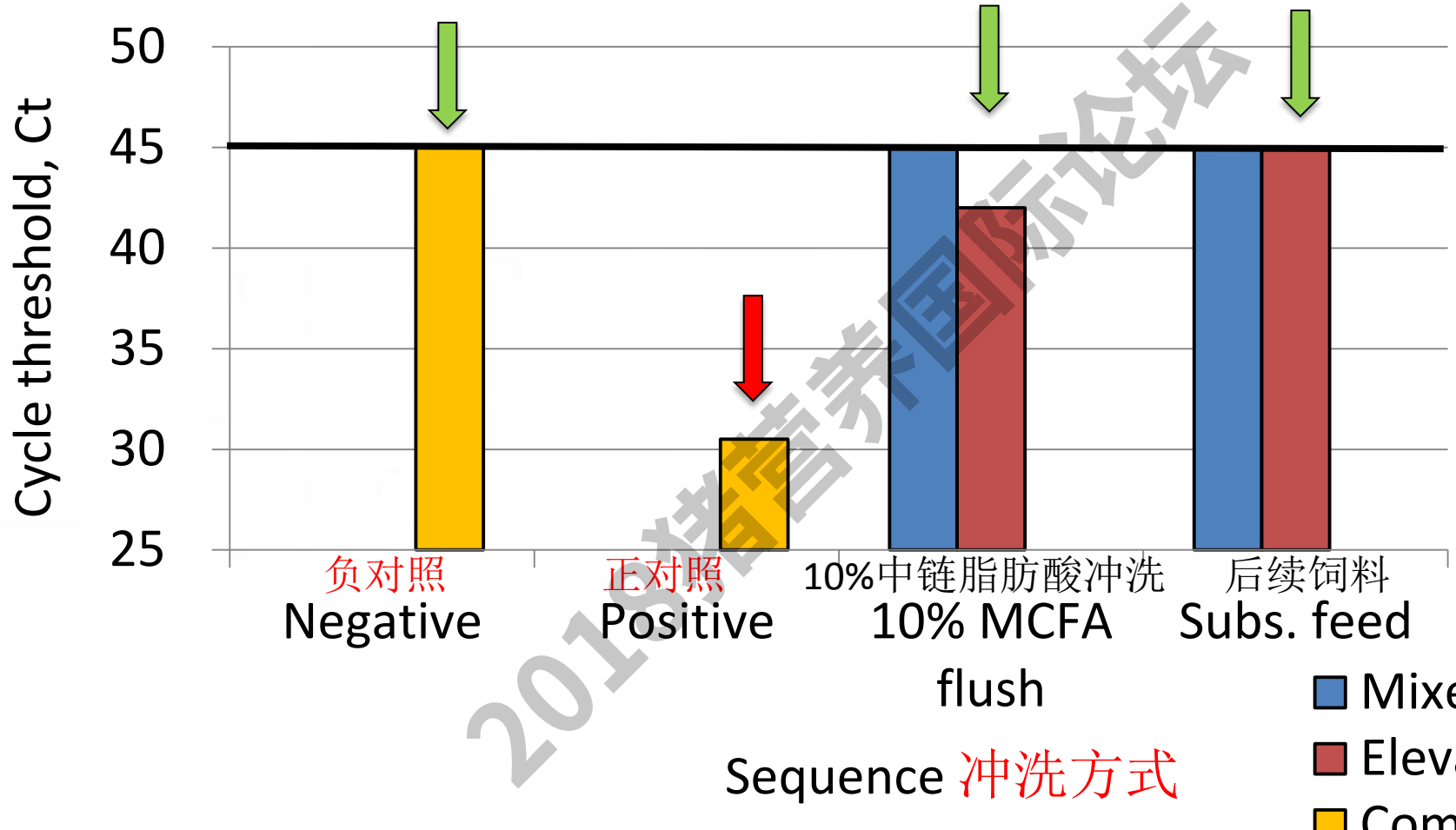


Schumacher et al., 2017

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time
- 10%中链脂肪酸稻壳冲洗
  10% MCFA rice hull flush

Cutoff = 45 cycles
SEM = 0.85



= Positive bioassay
生物实验阳性

= Negative bioassay
生物实验阴性

Gebhardt et al., 2018

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time

- Thermal Processing 热加工

Number of Pigs Infected with PEDV by Bioassay 被PEDV感染的猪只数量

	Feed	0 dpi	2 dpi	4 dpi	6 dpi	7 dpi	7 dpi Cecum
No PEDV	0	0	0	0	0	0	0
38°C	9/9	0	1/9	3/9	3/9	3/9	3/9
46°C	9/9	0	3/9	3/9	3/9	3/9	3/9
54°C	9/9	0	0	0	0	0	0
63°C	8/9	0	0	0	0	0	0
71°C	8/9	0	0	0	0	0	0

No infectivity in diets pelleted > 54°C

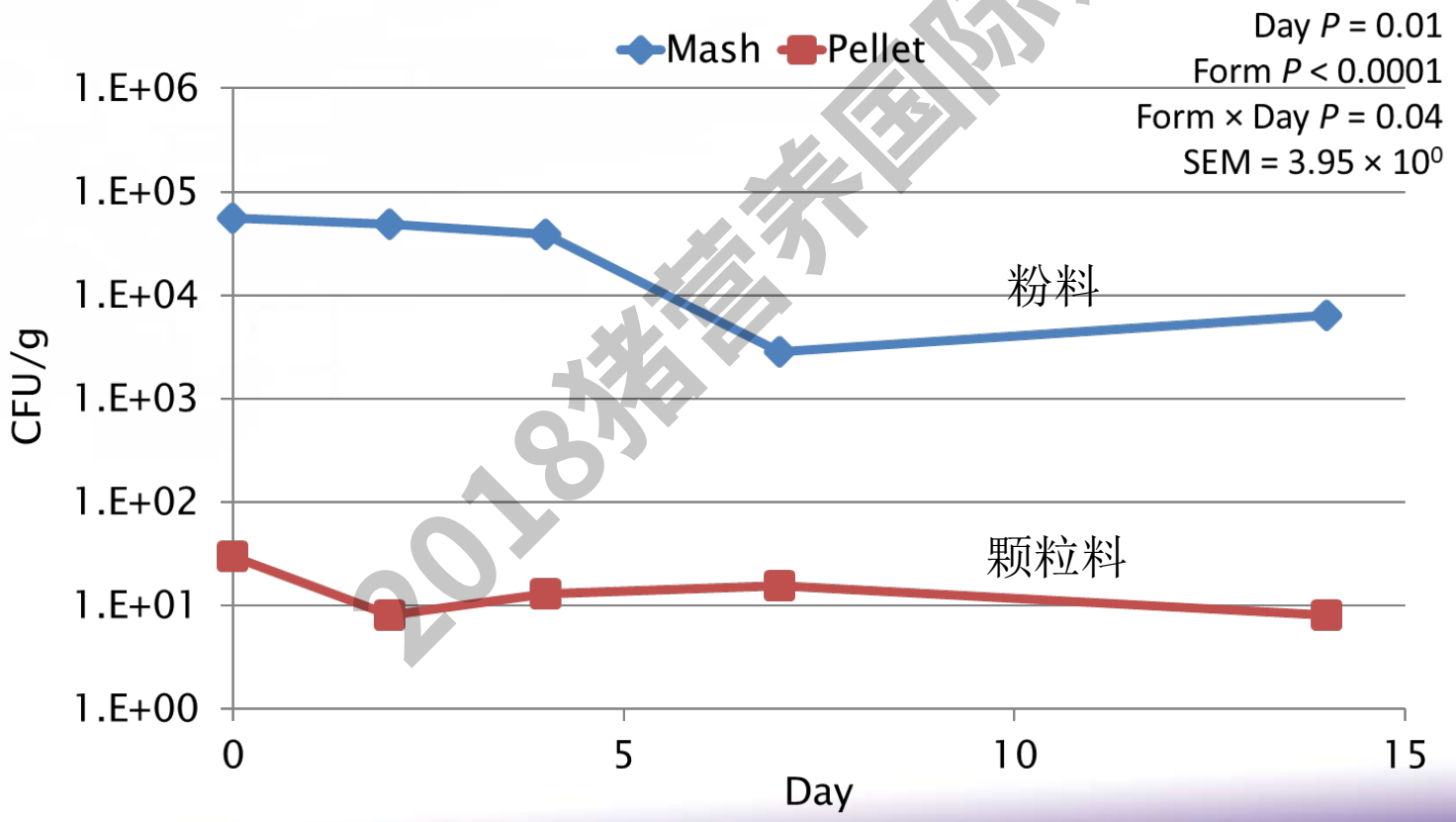
日粮制粒温度超过54.5℃后无感染性

Cochrane et al., 2018

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time

- Thermal Processing – Be aware of recontamination
  热加工-当心再次被污染

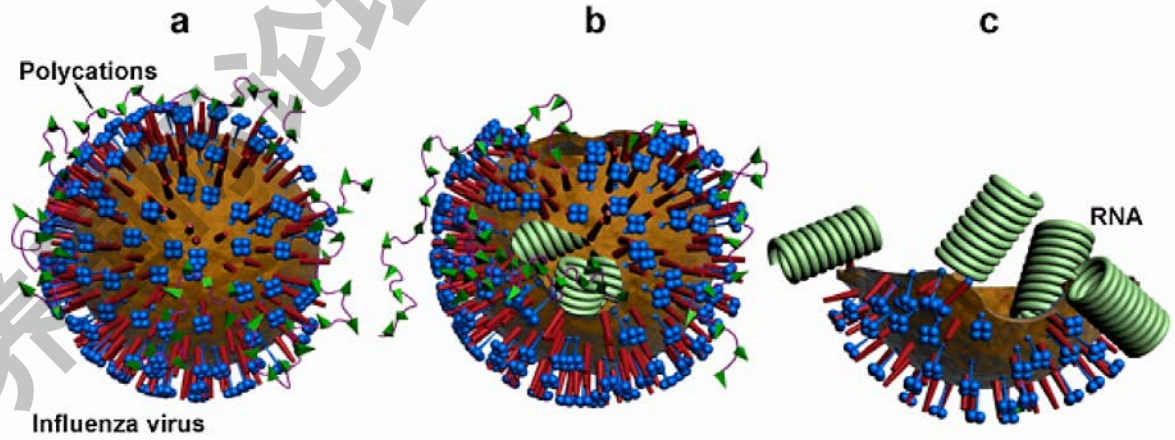


Cochrane et al., 2018

5. How can it be mitigated?
如何减轻危害？

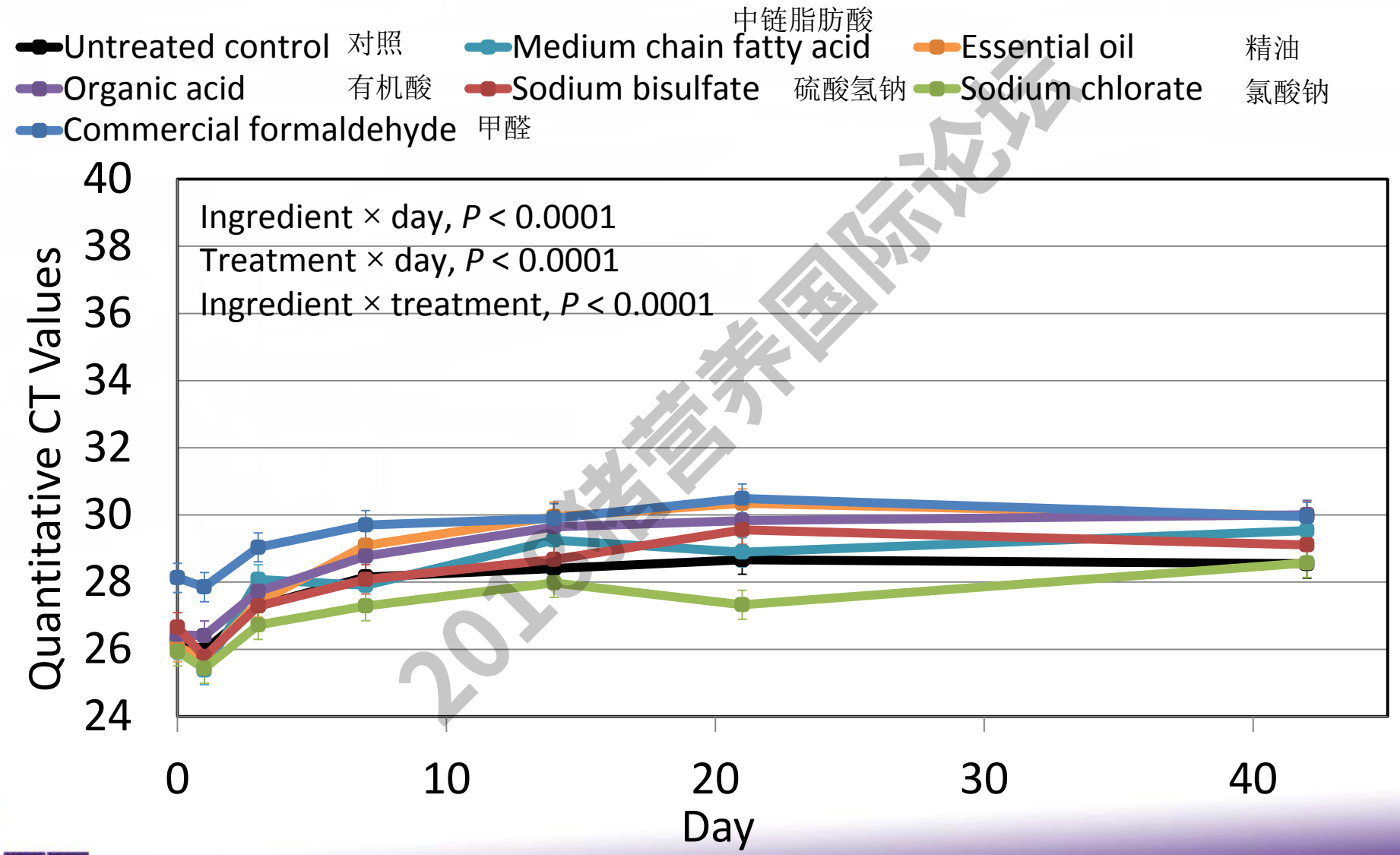
- 即时控制 Point-in-Time
- 持续控制 Residual

- Types 类型
  - Point-in-Time 即时控制
  - Residual 持续控制
    - Acids and alkalis 酸、碱
    - Essential oils 精油
    - Formaldehyde-based products 甲醛基产品
    - Medium chain fatty acids 中链脂肪酸

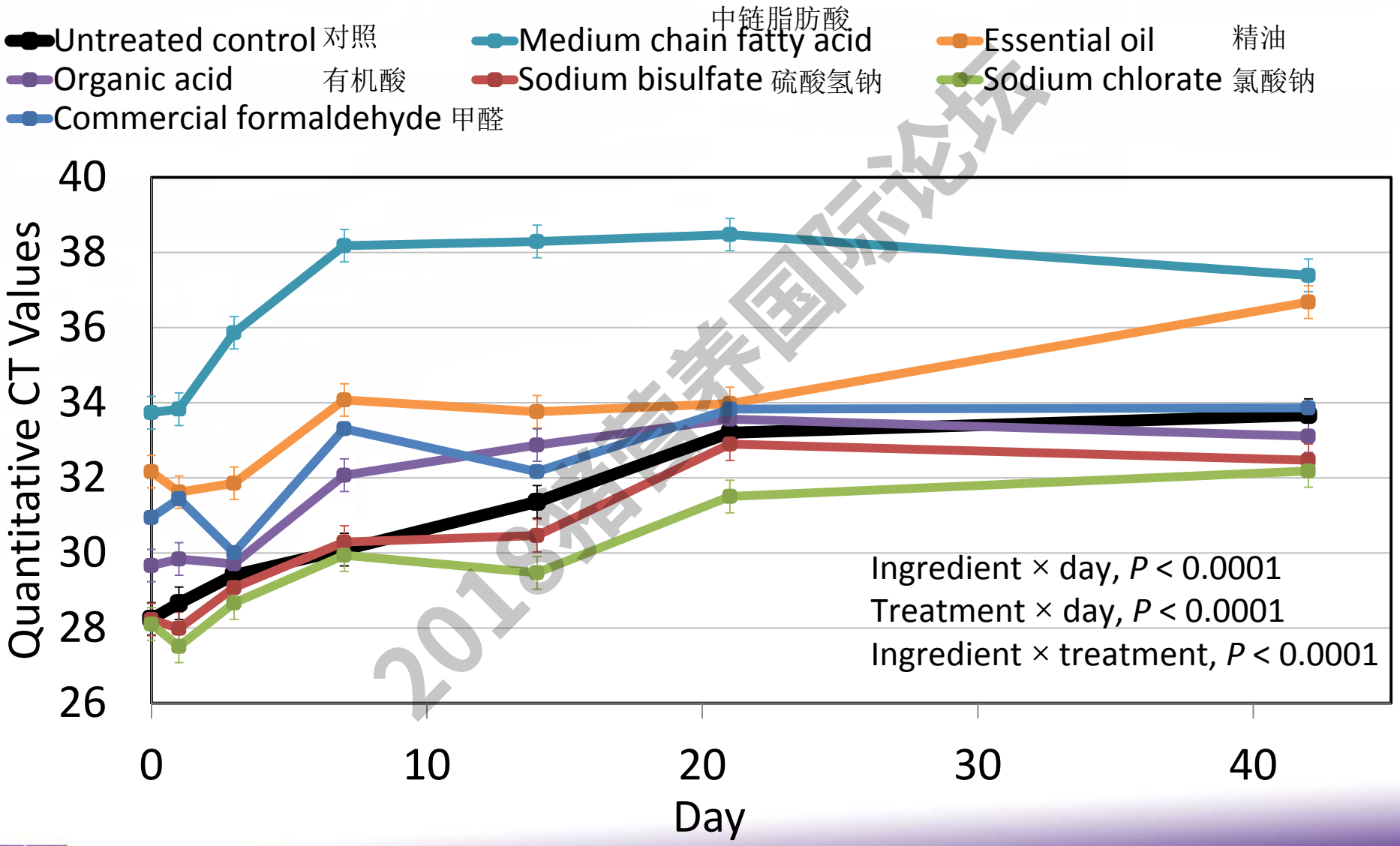


PEDv contamination post-treatment in **porcine meat and bone meal** stored at room temperature

猪肉骨粉在室温储存后PEDV的污染



PEDv contamination post-treatment in **swine diets** stored at room temperature
猪料在室温储存后PEDV的污染

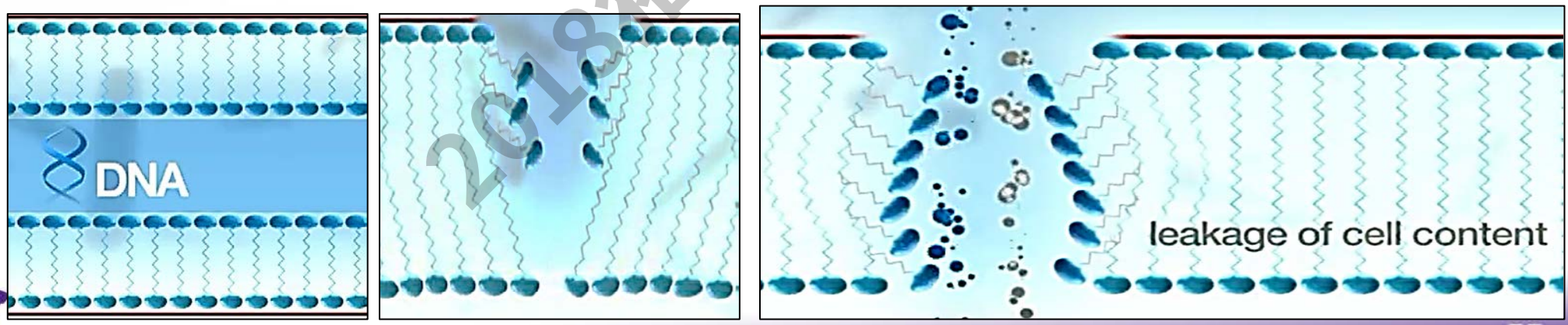


Cochrane et al., 2015

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time
- 持续控制 Residual

- Modes of actions differ across mitigant type 不同措施的作用机理不同
  - Double phospholipid bilayer 磷脂双层膜
  - Bind with cell membrane proteins 结合细胞膜蛋白
  - Incorporation into the cell membrane 融入细胞膜中
  - Causes destabilization of the cell membrane bi-layer and ‘pore’ for H^+ ions leak and cell to acidify 导致细胞膜稳定性降低，H+进入，降低细胞pH



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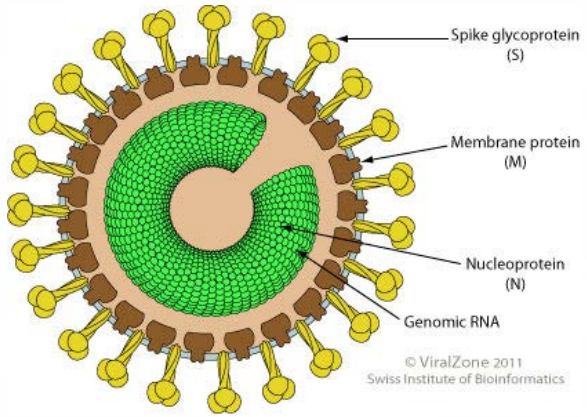
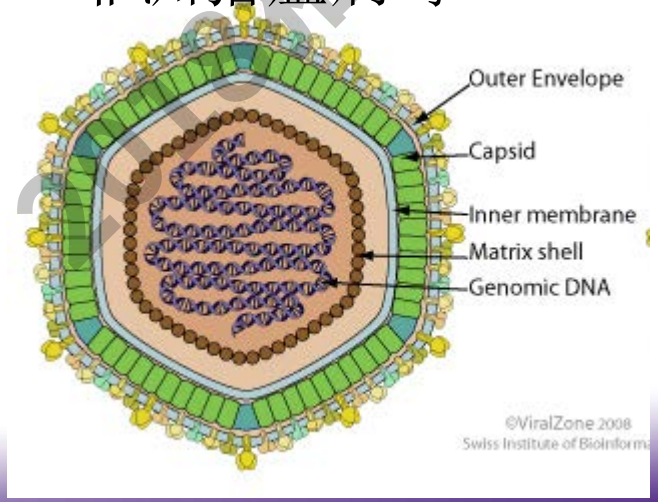
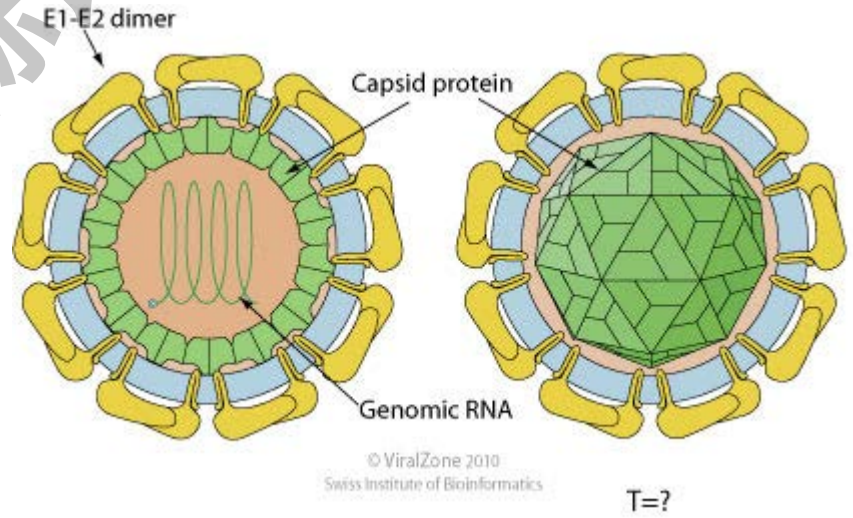


PEDV
流行性腹泻病毒

ASFV
非洲猪瘟病毒





CSFV
猪瘟病毒

5. How can it be mitigated?
如何减轻危害？

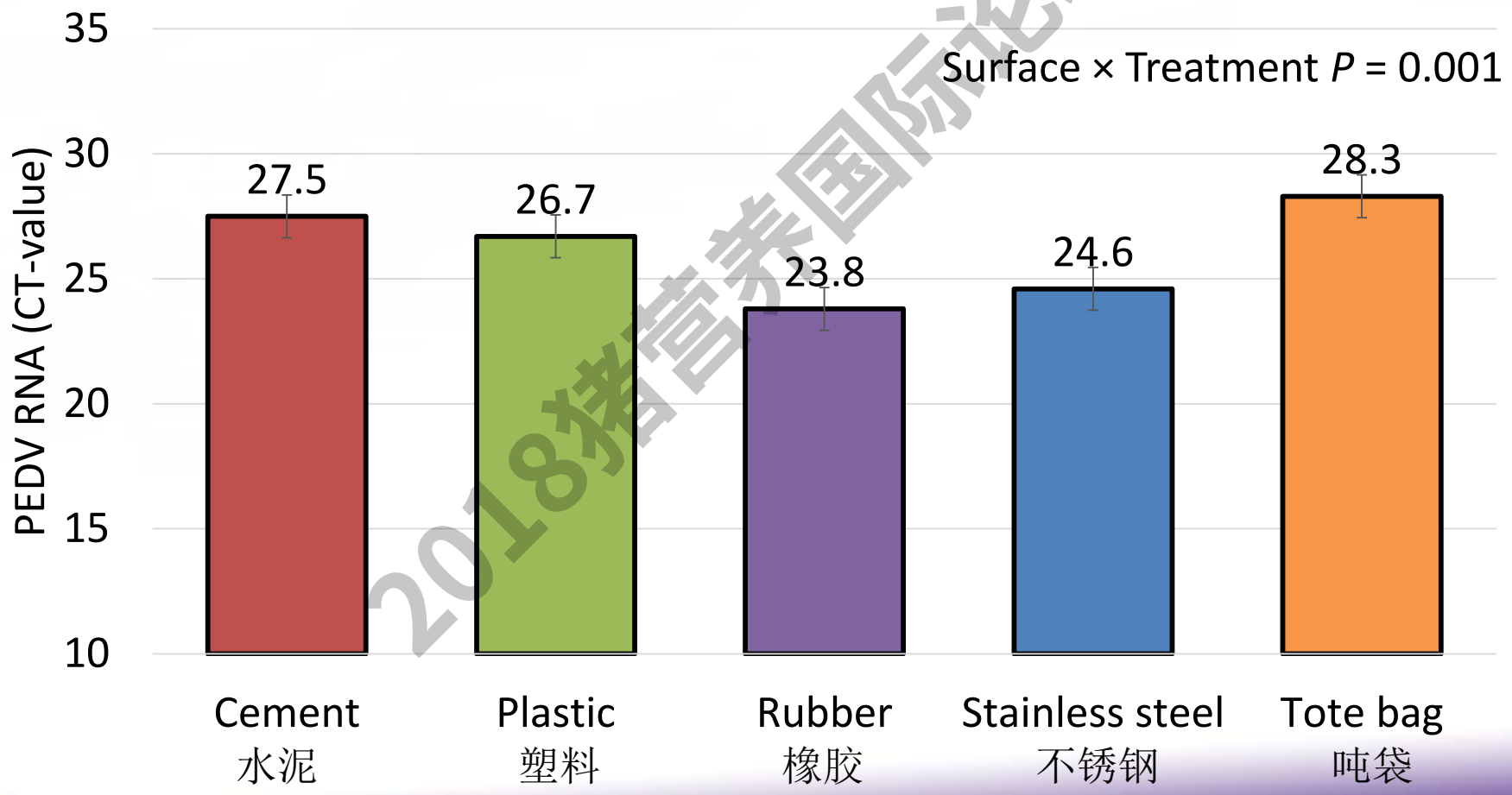
- 即时控制 Point-in-Time
- 持续控制 Residual

- Make sure you have at least 2 sequences of feed between ‘high risk’ ingredients and ‘high risk’ diets 保证在制做高风险原料和日粮之后至少有两批冲洗饲料
  - Consider using a chemical flush with a rice hull carrier 可以使用含化学试剂的稻壳载体进行冲洗
- Efficacy of chemical additives depends on 化学添加剂的效果取决于:
  - Type of virus and bacteria 病毒或细菌的类型
  - Ingredient or feed 原料或饲料
  - Time 时间
- Most impact CT value, but may leave genetically detectable material that is non-infectious. Efficacy in FAD unknown. 循环阈值的影响最大，但是即使是不具感染性的原料也可能检测到基因片段。FAD的效率未知。

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time
- 持续控制 Residual
- 消毒 Decontamination

- Effect of surface type on PEDV 不同类型表面对PEDV的影响

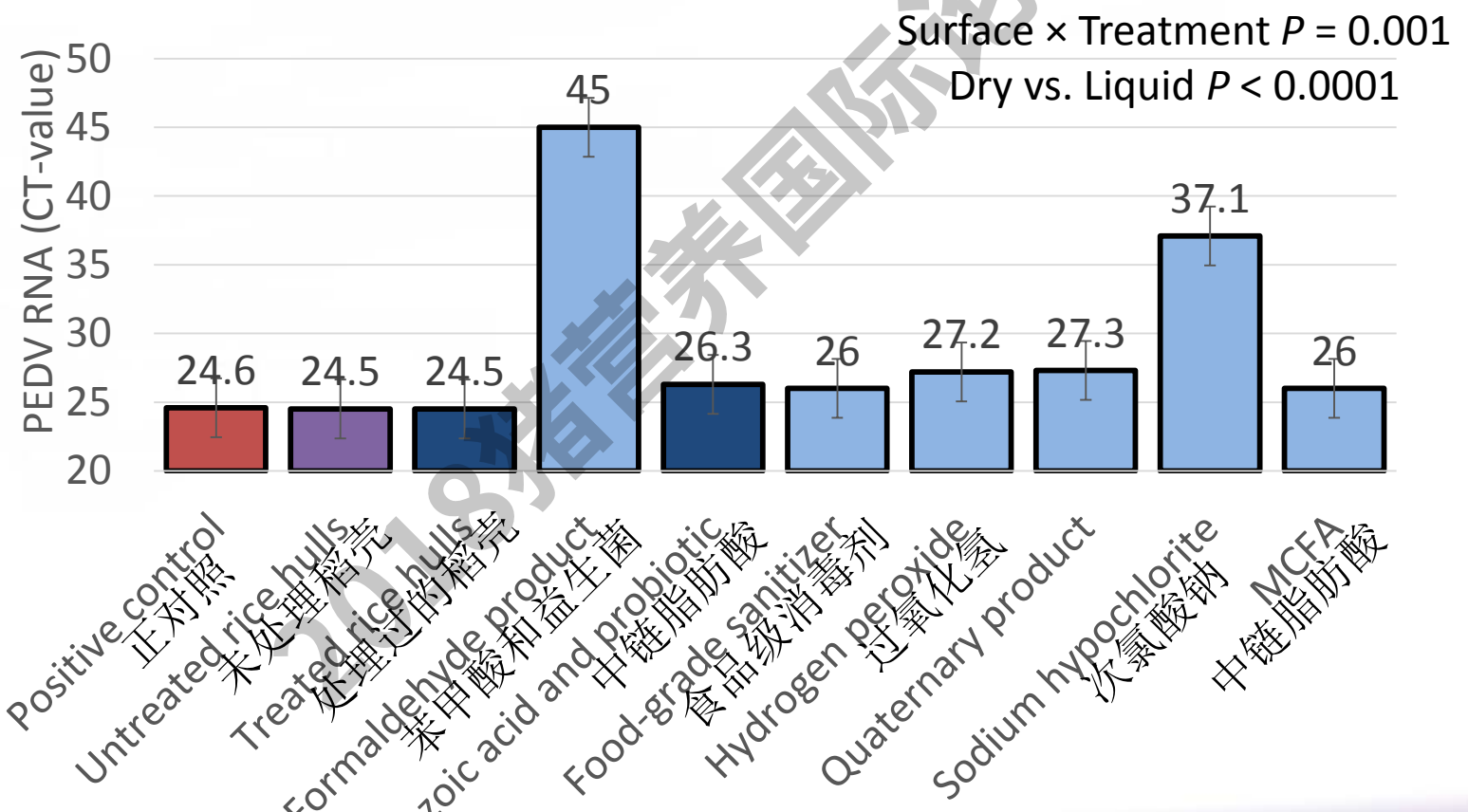


Muckey et al., 2016

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time
- 持续控制 Residual
- 消毒 Decontamination

- Effect of sanitizers on steel with PEDV 消毒剂对不锈钢上PEDV的影响



Muckey et al., 2016

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time
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- 消毒 Decontamination

- Appropriate disinfectants for ASFV 非洲猪瘟病毒合适的消毒剂
  - Ether 醚
  - Chloroform 氯仿
  - Sodium hypochlorite (2.3% chlorine for 30 minutes)
    次氯酸钠（2.3％氯，30分钟）
  - Sodium hydroxide (8/100 for 30 minutes) 氢氧化钠（8/100，持续30分钟）
  - Formalin (3/1000 for 30 minutes) 福尔马林（3/1000 30分钟）
  - Ortho-phenylphenol (3% for 30 minutes) 邻苯基苯酚（3％，30分钟）
  - Iodine compounds 碘化物

5. How can it be mitigated?
如何减轻危害？

- 即时控制 Point-in-Time
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- To further mitigate risk or actively combat a pathogen:
  进一步降低风险或主动消灭病原微生物
  - Point-in-time mitigants help reduce the risk, but cross- or recontamination must be prevented 即时控制措施有助于降低风险，但要防止交叉污染和再次污染
  - Consider chemical additives 考虑使用化学添加剂
  - Have a plan in place for mill decontamination 建立厂区消毒计划
    - Physically clean all surfaces, including equipment internal components
      物理清扫所有表面，包括设备内部
    - Power wash everything with 10% bleach 用10%漂白剂加压冲洗所有地方
    - Rinse and air dry, while preventing recontamination 冲洗并风干，同时防止再污染

Addressing Feed Safety
如何解决饲料安全问题

1. Is it likely to get infected?
饲料有可能被污染吗？

2. Can it survive?
微生物能存活下来吗？

3. Is it infectious?
它是否可以感染动物？

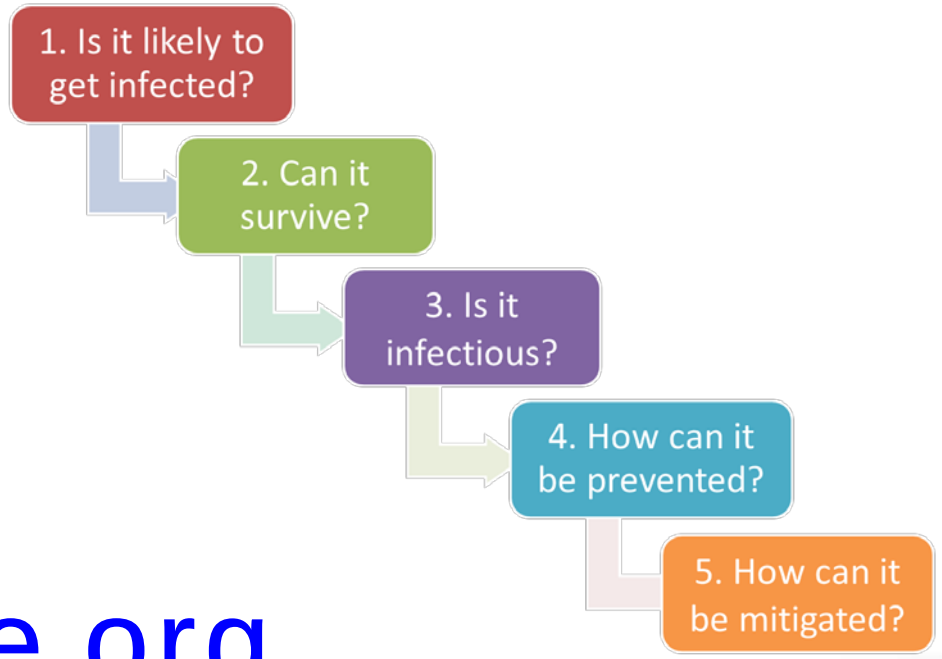
4. How can it be prevented?
如何预防？

5. How can it be mitigated?
如何减轻危害？

Conclusions

- Feed is one of *many* potential vectors of pathogens
  饲料是病原微生物潜在传播途径之一
- Limited information about all 5 steps 所有5个步骤的信息都很少

- ✓ Exclusion of high risk ingredients from high risk countries is currently best strategy
  将高风险地区的高风险原料剔除是现阶段最好的策略
- ✓ Improve supplier communications 加强与供应商沟通
- ✓ Ramp up biosecurity 持续提高生物安全性
- ✓ Consider feed/environment testing 考虑检测饲料/环境
- ✓ Consider proactive mitigants 考虑主动缓解措施
- ✓ Stay tuned as more research is reported
  随时关注进一步研究



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