母猪PSY 30+：被忽略的营养素，纤维的重要角色

Achieving PSY 30+: the overlooked role of dietary fibre in unlocking sow reproductive potential

汇报人：姚任杰 青年研究员
Presenter：Renjie Yao, Young Researcher

合作导师：车炼强 教授
Collaborating supervisor: Prof. Liangqiang Che

四川农业大学动物营养研究所
Animal Nutrition Institute, Sichuan Agricultural University

Science-driven solutions®

姚任杰 Renjie Yao

目前职位：四川农业大学动物营养研究所，青年研究员
Current position: Animal Nutrition Institute, Young Researcher

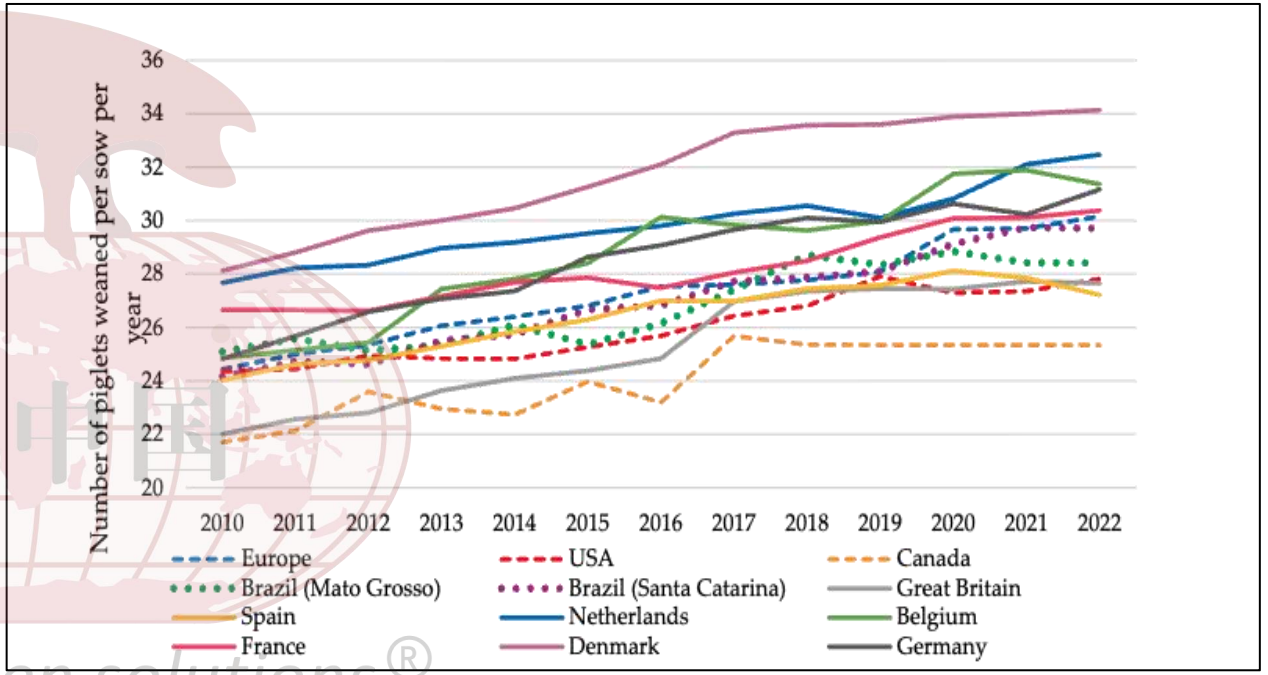
学习经历 Curriculum Vitae:

- 2020-2025 Ghent University, Belgium 比利时根特大学兽医学院　PhD
- 2017-2020 Sichuan Agricultural University 四川农业大学动物医学院 MSc
- 2013-2017 Sichuan Agricultural University 四川农业大学动物医学院 BSc

Science-driven solutions®

➢ 我国近几年母猪PSY与部分欧美国家的比较

The comparison of sow PSY in recent years between China and Europe-America countries



李曼中国
Science-driven solutions®

2024年，我国4070万母猪存量且每年有7.05亿出栏，那么实际上，我国的MSY约等于17.3?

Given 40 million of sows with 700 million marketed pigs, the marketed pigs per sow per year is **17.3?**

有差距，但也有更多的发展空间

Gap indicates greater potentials

➢ 我们应该做什么?

What should we do?

- **一胎多产≈易受外界因素影响 （高产基因来源于驯化前的外界危机）**

-Prolificacy indicates fragility to external factors

-Gene from a bet-hedging strategy?

疾病防控

营养抗病

Disease-resistant nutrition

营养调控与管理

激发潜力

Unlock the potential

基因育种

Disease control and prevention

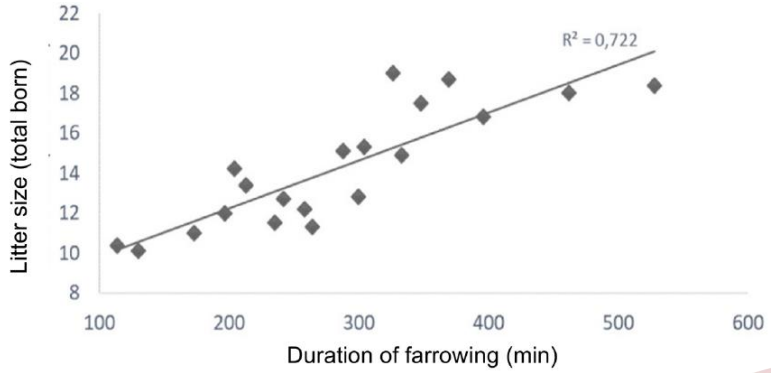
Nutrition and management

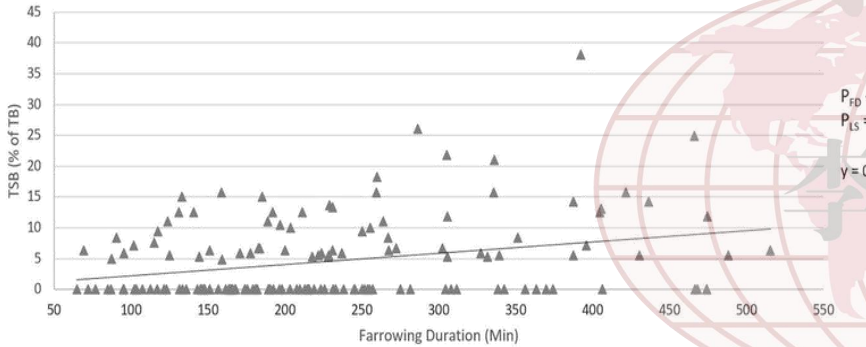
Genetic selection

Science-driven solutions ®

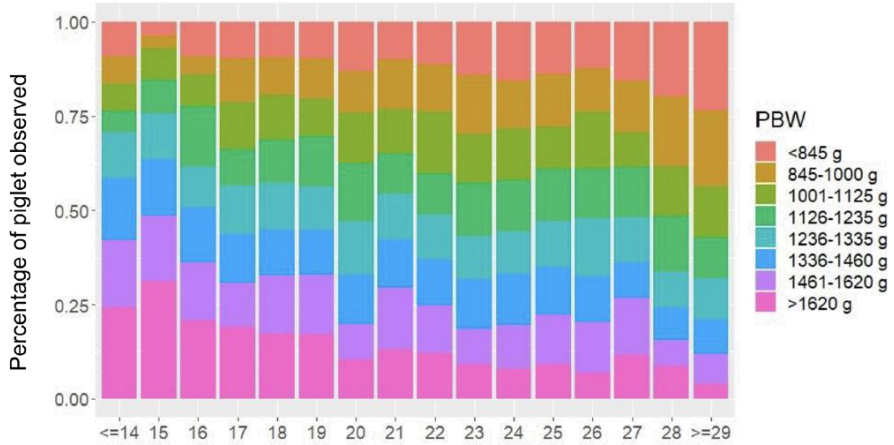
(Cardillo et al, 2008;Gibson et al. 2015; Ferreira et al., 2020)

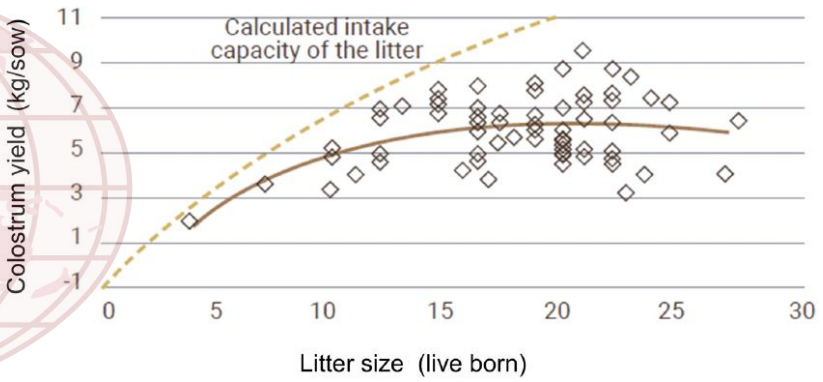
➢ 我们应该做什么?
What should we do?





- **产仔数、产程和死胎数的关系**
  The associations among litter size, farrowing duration and the number of stillbornpiglets



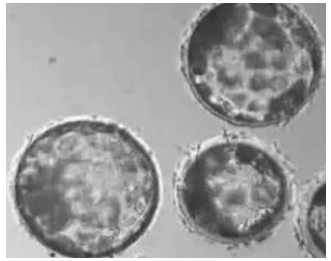


- **产仔数、窝内仔猪体重分布和初乳摄入量的关系**
  The associations among litter size, body weight distribution and colostrum intake

李昊中国
Science-driven solutions®

母猪及其后代需要什么?
What are requirements of sows and their offspring?

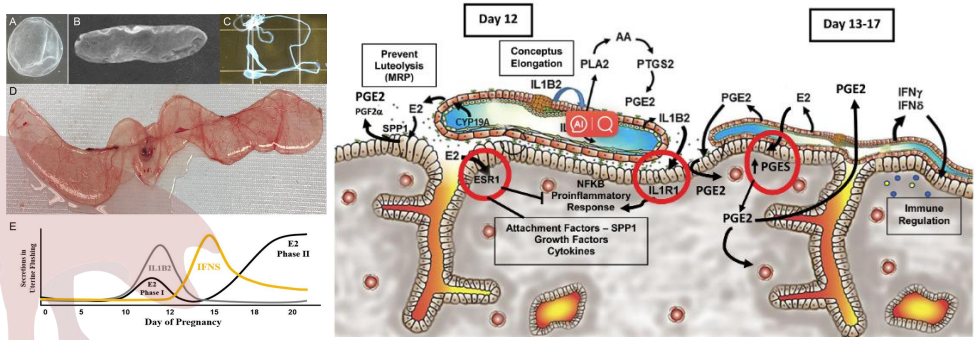
➢ 母猪需要什么?
What does sow require?



母猪每周期排卵20–25个
Sow ovulate 20 and 25 per cycle

● 早期胚胎定植
The embryo implantation of sow during the early gestation

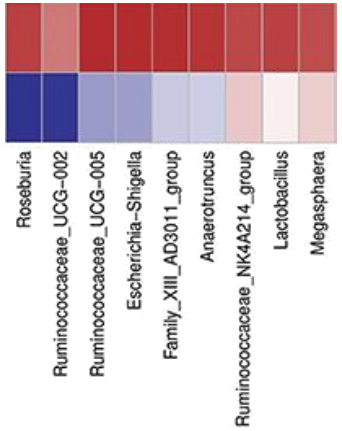
95%的受精率
95% fertilization rate



雌激素（E2）、孕激素（PROG）和细胞因子 （IL-6, IL-11）等协同作用于早期胚胎定植
Synergistic roles of hormone and cytokines in early embryo implantation

相互作用
Mutually influential relationship

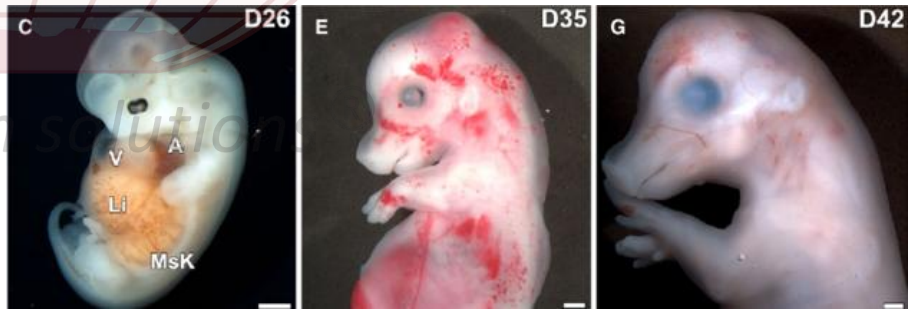
着床期有30%的胚胎丢失
30% conceptus loss during peri-attachment



产仔数>15母猪妊娠D30

产仔数<15母猪妊娠D30

早期妊娠肠道菌群在高、低产仔数母猪中差异显著
Sow with different litter sizes harbor distinct gut microbiota



部分胎儿因生长过快，10-15%的胎儿生长停滞
Fetal growth results in some conceptus attachment sites (CASs) exceeding their uterine space

(Yang et al., 2022; Rami et al., 2015; Groothuis et al., 2007; Liu et al., 2023)

Science-driven solutions

➢ 母猪需要什么?
What does sow require?

- **产前筑巢行为**

The nesting-building behavior during the late-gestation

-采食量降低 low feed intake

-衔草 grass-gathering

-咀嚼 chewing

-咬栏、拱地等行为 biting, rooting repetitively

李曼中国
Science-driven soluti

发掘母猪的天性喜好、缓解母猪产前紧张行为、同时避免产前低采食量导致能量不足

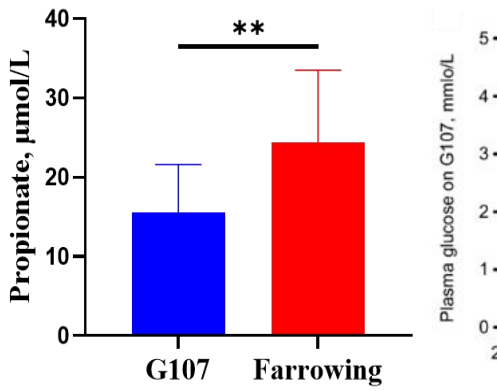
Exploring sows' natural behavioral needs, alleviating prepartum stress, and mitigating energy deficits during parturition caused by low feed intake.

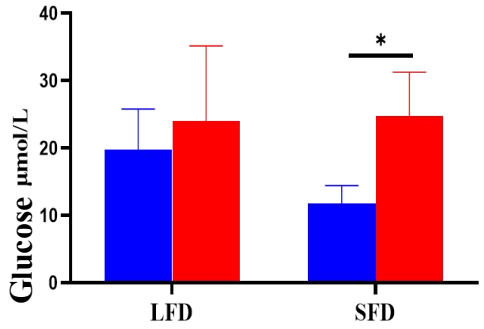
(Diane et al., 2009; Nystén et al., 2023; Jinhyeon et al., 2015)

➢ 母猪需要什么?

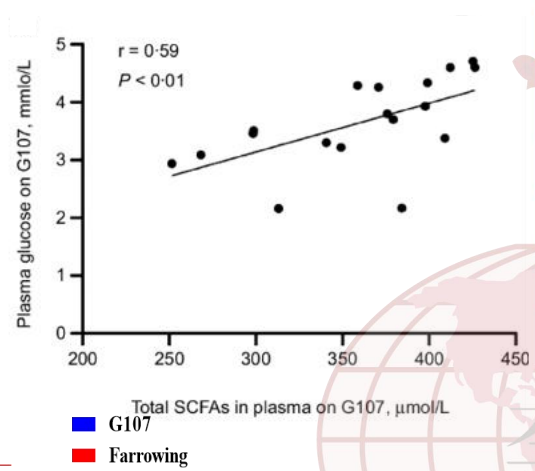
What does sow require?

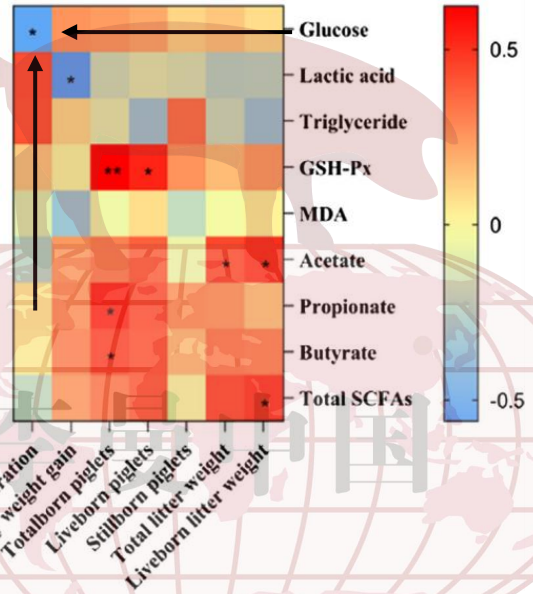
- **本团队发现产程与产前血糖、血液中丙酸含量密切相关 The correlation between propionic acid and farrowing duration**



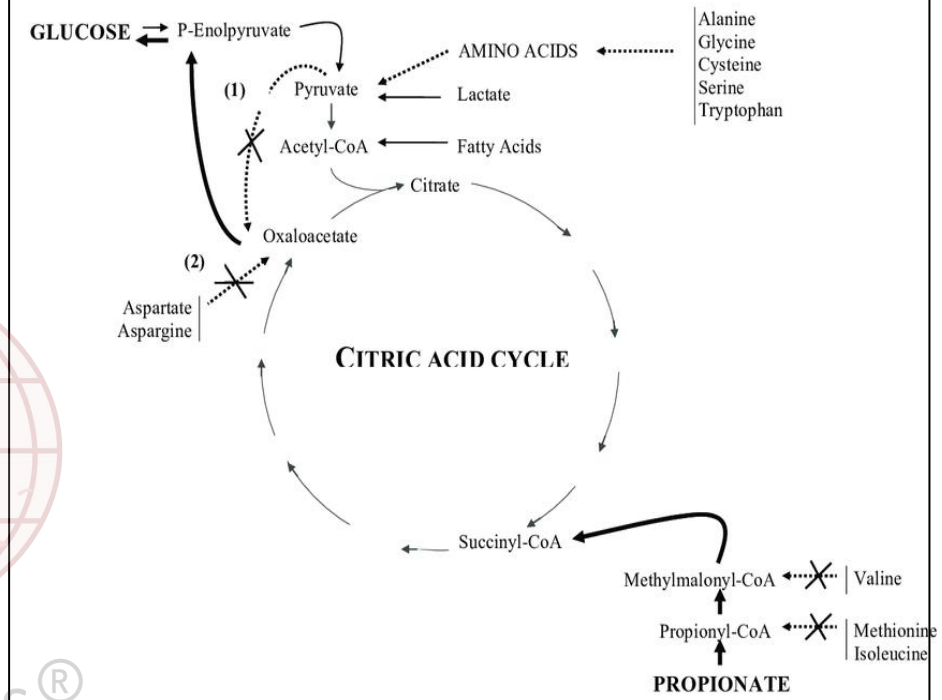


LFD: Long farrowing duration
SFD: Short farrowing duration





短产程与血糖浓度密切相关，且血糖浓度与血液内短链脂肪酸浓度密切相关；
A short farrowing duration is associated with blood glucose, which in turn is related to plasma SCFAs levels; (Liu et al., 2021)

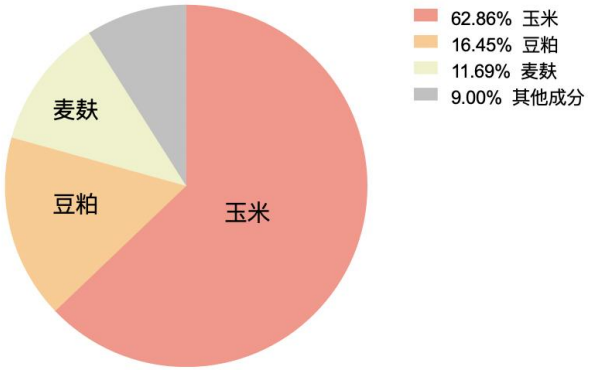


丙酸是作为糖异生过程中的低物和信号分子；
Propionic acid acts both as the substrate and signaling molecule during the gluconeogenesis

寻求围产期能为母猪持续提供短链脂肪酸并维持母猪血糖，为妊娠阶段提供充足能量的饲喂方式

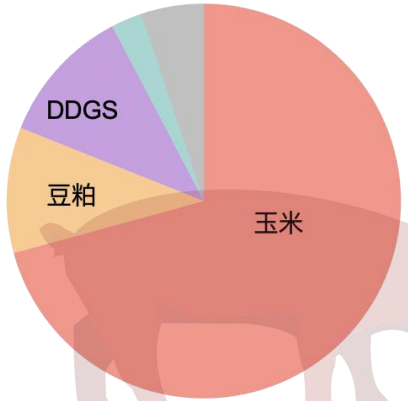
Explore feeding strategies that continuously supply sufficient SCFAs and maintain glycemia levels in sows during the peripartum period, thereby ensuring adequate energy.

世界各地区母猪妊娠晚期典型饲粮中主要成分占比 Typical proportions of major feed ingredients in late-gestation sow diets across different regions



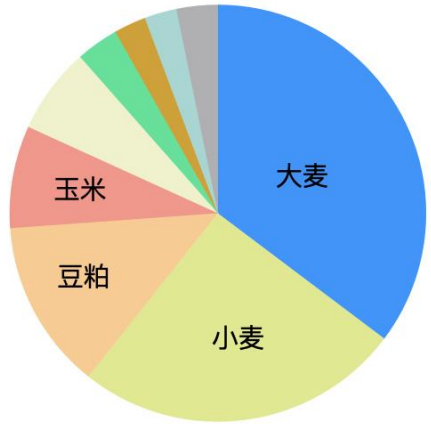
62.86% 玉米
16.45% 豆粕
11.69% 麦麸
9.00% 其他成分

中国China



70.75% 玉米
10.30% 豆粕
11.25% DDGS
2.57% 大豆皮
5.13% 其他成分

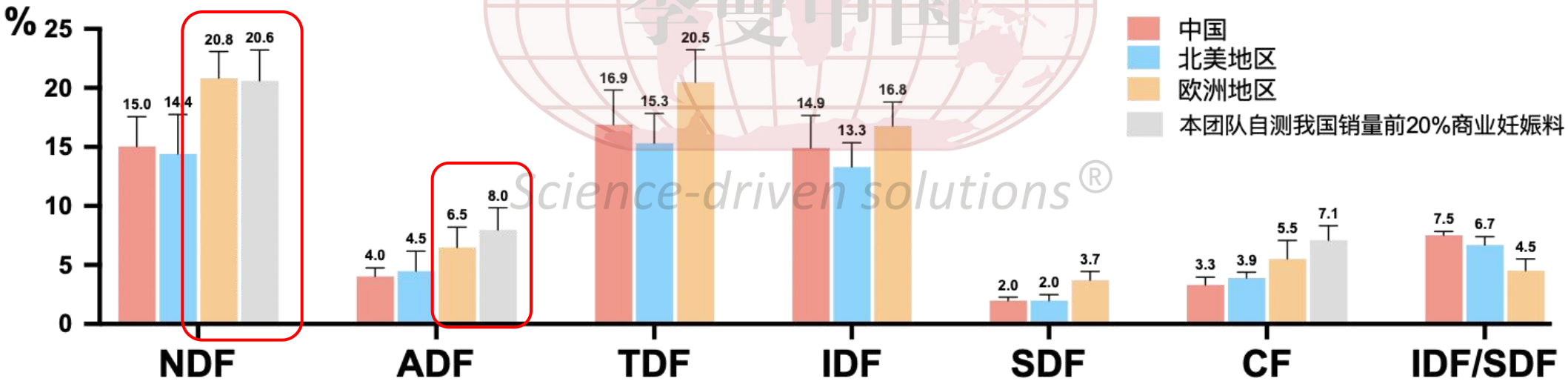
北美地区North America



35.27% 大麦
25.41% 小麦
13.17% 豆粕
7.95% 玉米
6.70% 麦麸
3.30% 甜菜渣
2.50% 葵花粕
2.50% 大豆皮
3.20% 其他成分

欧洲地区Europe

Science-driven solutions®



各纤维成分在典型饲粮中的计算值与本团队实际测量值
The calculated fibre content by our groups

➢ 纤维为什么被忽略?

Why is fibre often ignored?

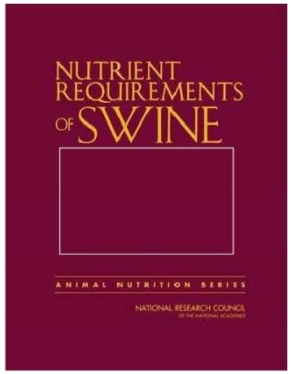
- **能量低，传统营养成分含量低**

Treated as a non-nutrient with low net energy

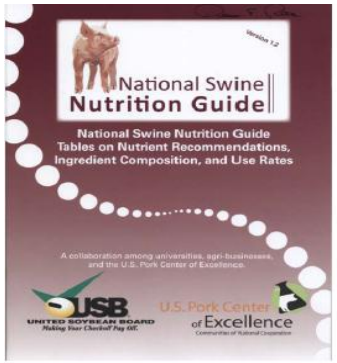
- **标准在哪里?**

Where is the feeding standard?

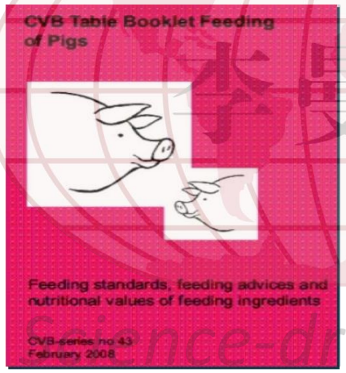
NRC（2012）



NSNG（2011）



荷兰CVB（2008）



Science-driven solutions

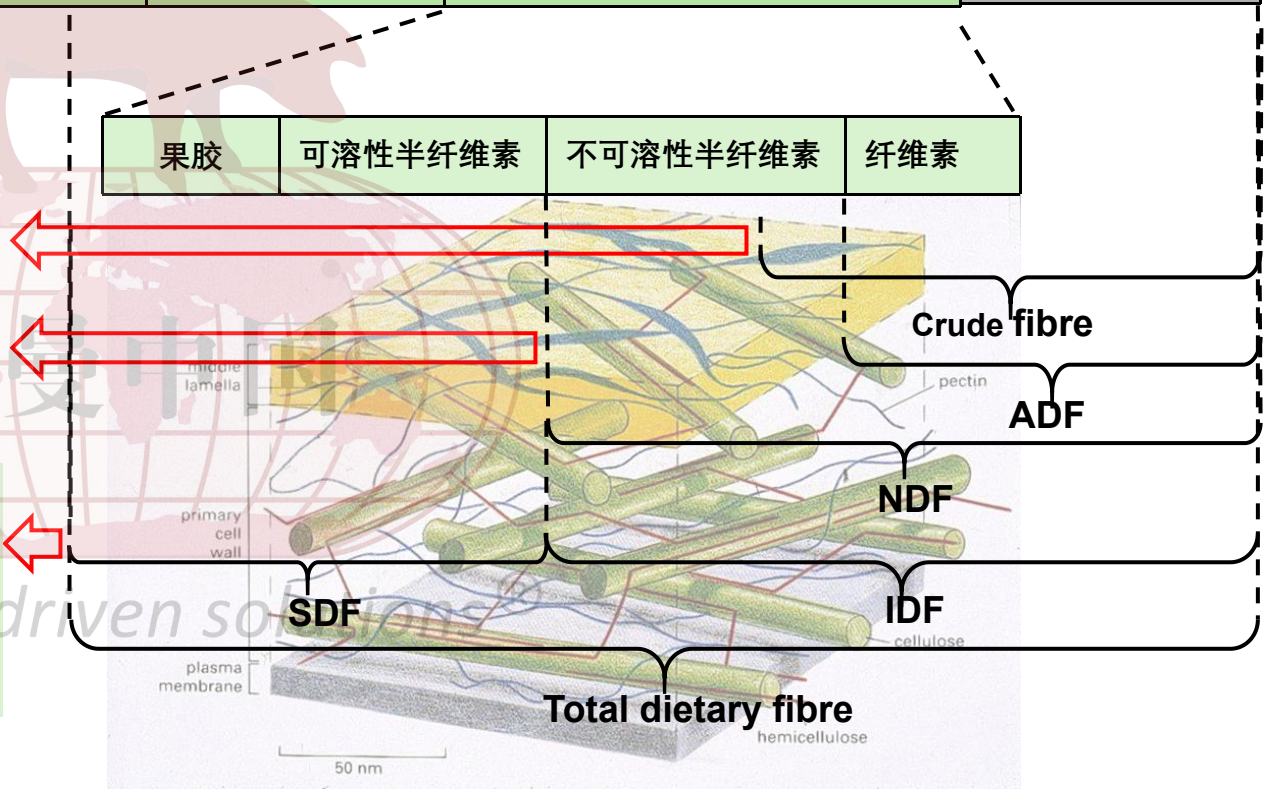
➢ 膳食纤维的分类及检测方法的演变 What is fibre and how to define it?

碳水化合物						
可消化碳水化合物			不可消化碳水化合物			木质素
单糖	双糖	多糖	低聚糖	抗性淀粉	非淀粉多糖	

粗略分析纤维成分(AOAC,978.10)，**数据积累多**，欧盟法规必要信息。但**严重低估发酵性更强的纤维**，营养学意义落后；

(Goering & Van Soest, 1970)，部分反映**可消化性、化学特性**，但仍**不能全面评估膳食纤维成分**；

(AOAC, 985.29), 将纤维以**水溶性**为理念分类，相对更真实反应**发酵性和生理功能**，但**操作繁琐，成本昂贵，家畜营养上不常用**；



High — Fermentability — Low

➢ 膳食纤维是如何发挥作用的呢? How does fibre work?

物理特性 Physical property

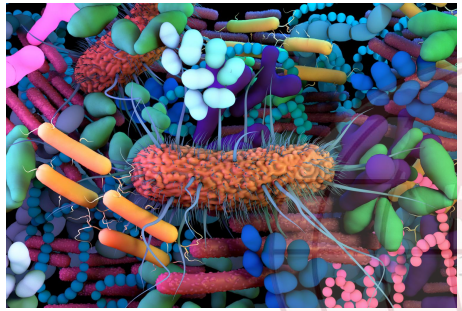
粘性 Viscosity	以可溶性纤维为主	● 增加饱腹感、降低食糜流动速率， ● 改善血糖上升速率；
吸水性 Water-holding capacity	可溶和不可溶（如木质素）分别通过溶解性与多孔性	● 降低消化物硬度 ● 因粘性不同，改善便秘效果不同；
膨胀性 Swelling capacify	以不可溶性纤维为主	增大消化物容积，拉伸肠道平滑肌，促进其蠕动能力；
韧性 Hardness	以不可溶性纤维为主	增加动物咀嚼，释放生产焦虑、压力，减少刻板行为 (咬尾、拱栏等)。

(Kyriazakis and Emmans, 1995; Montagne et al., 2003; Deepak and Sheweta, 2013; Jaworski, 2016; Aryee et al., 2018; *Do S* et al., 2023).

➢ 膳食纤维是如何发挥作用的呢?
How does fibre work?

化学特性
Chemical property

肠道微生物发酵
Microbial fermentation



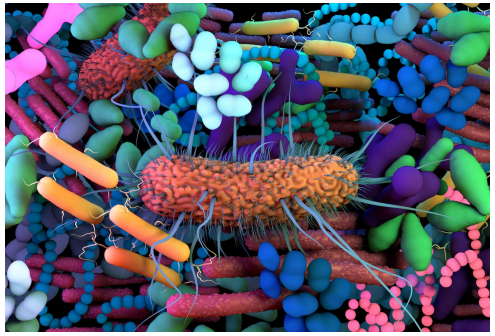
肠道内微生物可分泌纤维降解酶

气体:
-二氧化碳
-氢气
-……

短链脂肪酸:
-乙酸≈60%
-丙酸≈25%
-丁酸≈15%
-……

其他有机酸:
-乳酸
-支链脂肪酸
-……

反作用于菌群,调节、驯化微生态结构



- 为肠道发育能源;
- 提高其他养分降解水平;
- 机体免疫功能;
- 繁殖性能
- 提高肉质、调节血压、呼吸道疾病免疫能力等
- etc……

Science-driven solutions®

(Simpson & Campbell, 2015; Williams et al., 2017 Le Blanc et al., 2017; Mayor, 2019; Saliu et al., 2022; Zeng et al., 2022).

➢ 膳食纤维是生产母猪中的应用效果 The effect of fibre on sows reproductivity

试验对象	试验体量	处理方式	试验结果	文献来源
妊娠母猪	L×Y母猪（317头）	NDF+5%, +10%	日粮15.8%NDF可改善母猪产仔数。	林燕，2011（四川农业大学）
妊娠母猪	L×Y母猪（60头）	SF+2.05%	高SF降低产程的同时仔猪出生均匀度。	周盼，2018（四川农业大学）
妊娠母猪	大约克母猪（60头）	SF+10%, ISF+10.11%	高ISF降低母猪产程的趋势。	刘阳，2019（四川农业大学）
妊娠母猪	丹系L×Y母猪（190头）	DF(17.4%; 17.7%; 18.1%; 18.4%; 18.8%)	日粮18.8%DF显著提高母猪活产仔猪，活产仔数与DF水平成正线性关系。	冯波，2019（四川农业大学）
妊娠母猪	L×Y母猪（45头）	CON(DF：11.37%) SBP(DF：21.60%) WB(DF：21.81%)	饲喂SBP、WB显著提高母猪在妊娠和泌乳期的粪便SCFAs浓度。	Shang et al., 2021 (JASB)
妊娠母猪	L×Y母猪（48头）	CON(NDF：16.01%) 苜蓿粉(NDF：20.12%) 甜菜浆(NDF：20.13%) 大豆皮(NDF：20.11%)	苜蓿粉组提高母猪粪便中的SCFAs含量。	Liu et al., 2021 (Host-Microbial)
妊娠母猪	L×Y母猪（46头）	CON(DF：12.08%) HF(DF：34.38%)	日粮34.38%DF可改善母猪产仔出生体重和分娩持续时间。	Li et al., 2023 (JASB)
妊娠母猪	PIC母猪（150头）	CON 10%燕麦或小麦秸秆	日粮添加燕麦秸秆后提高了母猪泌乳期采食量与仔猪断奶重。	Agyekum et al., 2019 (Anim)
妊娠母猪	PIC母猪（420头）	CF+3%	高CF可改善母猪总产仔数。	Valadares et al., 2021 (JAS)
妊娠母猪	L×Y母猪（29头）	CON(DF: 13.3%) 大豆皮(DF: 23.4%)	大豆皮组提高初乳免疫球蛋白浓度，降低仔猪断奶死亡率。	Loisel et al., 2013 (JAS)
妊娠母猪	L×Y母猪（245头）	CON(NDF: 10%) 30%黑麦(NDF: 20%)	母猪日粮中添加30%黑麦可降低新生仔猪死亡率。	Mazroua et al., 2025 (CJAS)
围产母猪	L×Y母猪（644头）	DF+ 300g/kg	高膳食纤维能够降低死胎率及仔猪总死亡率。	Feyera et al., 2017 (JAS)
围产母猪	BHZP母猪 （80头）	组合纤维源(CF+150g/kg)	日粮添加膳食纤维改善母猪微生物群落。	Schwennen et al., 2016 (Anims)
妊娠母猪	L×Y母猪（48头）	甜菜浆(TDF：471g/t) 大豆壳(TDF：507g/t) 棕榈仁(TDF：651g/t) 混合纤维(TDF：437g/t)	高纤维日粮能量利用效率更高，但降低母猪氮的利用效率。	Wisbech et al., 2023(JAS)
妊娠母猪	L×Y母猪（2173头）	SF:+15kg/t	高SF可提高新生仔猪存活率。	Wilcock et al., 2023 (JAS)

……

Science-driven solutions

文献结果汇总 A brief conclusion of literatures

DF增量%	NDF增量%	IDF/SDF比值变化	产程降低%	活仔数提高%
4.8	2.9	+0.54		9
4.8	2.9	+0.54	15	
13.99	10.01	+1.07	24	
6.3	5.3			10
14.46		+20.76		5.56
0		+0.4		2.44
10.1	10.2	+1.3		8.5
13.99	10.01	-2.48	7	
22.3	13.17	-1.29	27	
22.93	17.28			2.2
1.3		-1.2		1.4
8.53		-5.2		5
2.52	3.23	-1.5		20.90
8.8	6.93	-6.62		8.47
0.88	0.48	-1.2		12.79
1.33	-0.02	-2.77		1.82

影响纤维功能水平是因为可溶和不可溶比例的变化，还是总膳食纤维含量的增加？
Is the functional effect of DF mainly determined by the IDF/SDF ratio or by the overall increase of DF?

(Huaqi Song)

Science-driven solutions®

- **IDF/SDF相同时，总膳食纤维占比升高，能显著降低产程、提高活仔数;**
  Under a constant ratio of IDF to IDF, an increase in TDF significantly shortens farrowing duration and increases the number of live-born piglets;
- **TDF相同时，IDF占比升高，降低产程的效果更显著。**
  When the TDF remains constant, elevating IDF proportion exerts a stronger effect in reducing farrowing duration.

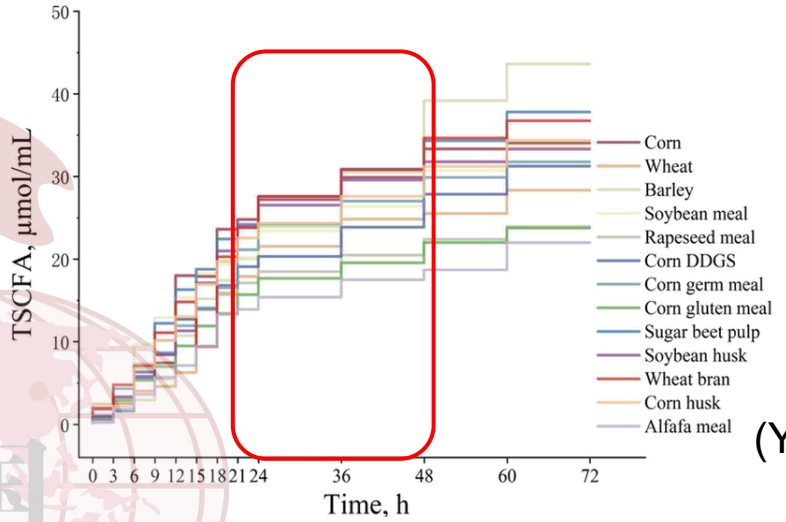
(Liu et al., 2019; Yang.,2019)

➢ 传统检测方式还适合纤维吗？Could traditional methods assess fermentation of fibre?

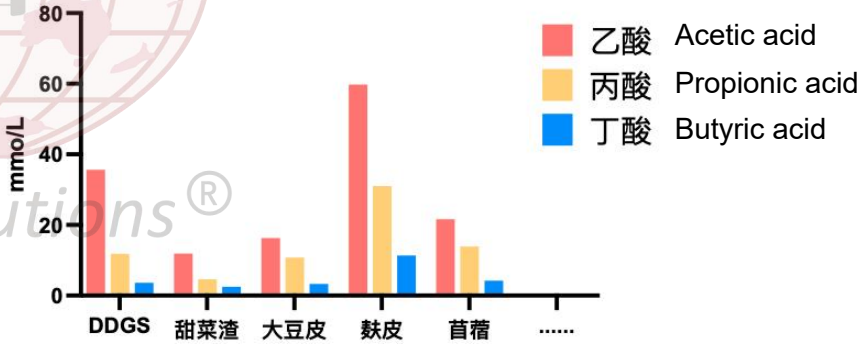
● 不同纤维源的纤维成分对比
The component of often-used fibre source

Item	Corn	Wheat	Barley	Corn husk	Wheat bran	Soybean husk	Soybean meal	Rapeseed meal	Sugar beet pulp	Corn germ meal	Corn gluten meal	Corn DDGS	Alfalfa meal
CF, %	2.41	2.65	5.45	21.60	11.11	40.25	6.14	10.77	28.93	14.56	3.07	11.65	27.10
NFE, %	72.19	70.66	67.62	55.47	54.88	37.78	30.34	40.03	47.29	56.91	26.11	47.11	35.02
TDF, %	12.09	11.91	20.45	57.83	39.98	54.39	18.59	32.23	69.51	47.61	8.23	32.66	45.66
SDF, %	1.39	1.66	5.57	6.17	4.74	9.61	2.44	7.83	29.30	5.81	1.60	3.76	8.44
IDF, %	10.24	9.73	14.66	51.66	35.86	44.78	16.15	24.4	40.21	41.43	6.63	29.90	37.22
SDF/IDF	0.14	0.17	0.38	0.12	0.13	0.21	0.15	0.32	0.73	0.14	0.24	0.13	0.23
ADF, %	2.62	2.25	5.66	14.14	10.98	45.95	5.37	22.15	22.33	13.94	1.35	10.25	31.51
NDF, %	11.33	16.27	23.72	49.47	37.05	64.00	12.09	32.61	37.53	48.79	4.54	30.07	43.29
Cellulose, %	1.88	0.86	4.36	7.45	8.17	40.36	4.52	14.14	20.25	9.31	0.74	5.21	26.10
Lignin, %	0.74	1.39	1.30	6.69	2.81	5.59	0.85	7.75	2.08	4.63	0.61	5.04	5.41
NSP, %	11.35	10.52	19.15	51.14	37.17	48.80	17.74	24.48	67.43	42.98	7.62	27.62	40.25
β-Glucan, %	0.11	0.81	6.66	2.32	0.17	0.42	0.61	0.83	0.97	5.86	0.33	6.26	0.26
Arabinose, %	2.27	0.94	2.32	0.61	10.00	3.21	0.31	0.29	18.11	8.61	0.58	4.99	0.29

● 体外发酵不同纤维源后产生短链脂肪酸的动态变化
Dynamic changes in SCFAs production during *in vitro* fermentation of different fibre source



(Yong et al., 2025)



高不可溶纤维并不代表发酵速度慢!
Higher Insoluble fibre content does not indicate slower fermentation

Science-driven solutions®

总膳食纤维、酸性洗涤纤维与体内外检测快、慢速发酵纤维的方法，对纤维营养、功能评判存在差异
Methods for determining total dietary fiber, acid detergent fiber, and fast/slow fermentable fibers (in vivo and in vitro) differ in their implications for nutritional and functional assessment.

纤维干预母猪途径
Fibre interventions on sows

妊娠前期胚胎定植
Embryo implantation in early-gestation

纤维通过菌群发酵介导，宿主直接感受的通路
Direct-sensing pathway/microbial mediation

妊娠中期胎儿快速发育
Rapid fetal development in mid-gestation

避免过度肥胖与胰岛素抵抗、维持消化道环境
Prevent excessive fat accumulation and insulin resistance

围产期的行为、能量需求
Specific behavior in late-gestation

筑巢行为、血糖维持
Satisfy the nest behavior and maintain blood glucose

哺乳期的高营养需求
High nutrition demand during the lactation

加速胃排空、增加胰岛素敏感、减少翻窝等
Accelerate gastric emptying, enhance insulin sensitivity, avoid crushing

产仔数
Litter size ↑

胎儿均匀度
Feral uniformity ↑

产程
Farrowing duration ↓

采食量
Feed intake ↑

Science-driven solutions®

➢ 那母猪的后代呢？What about their offsprings?

Feral piglets

哺乳期 suckling duration

8-16 weeks (gradual transition)

在野外的仔猪在第一周龄即有拱地、咀嚼的行为，且胃内容物中发现大量的非乳源固体成分
Feral piglets start rooting and chewing during the first week of age

(Petersen, 1994; Schouten, 1985; van Hees *et al*., 2023)

Food availability in the wild

Farmed piglets

哺乳期 suckling duration

21-35 days

Science-driven solutions®

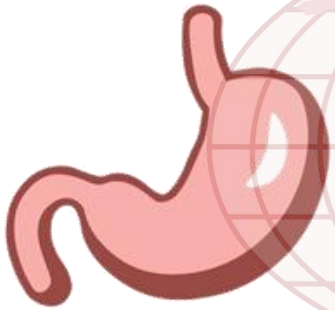
教槽料creep feed

- **-低采食量 Often-disappointing intake**
- **-效果不显著 Limited function**
- **-高成本 High cost of feed**
- **-对后续生长表现效果不显著 No clear long-term effect**

- **本团队试验开展— Experiment 1**

野生哺乳仔猪组
Feral piglet group

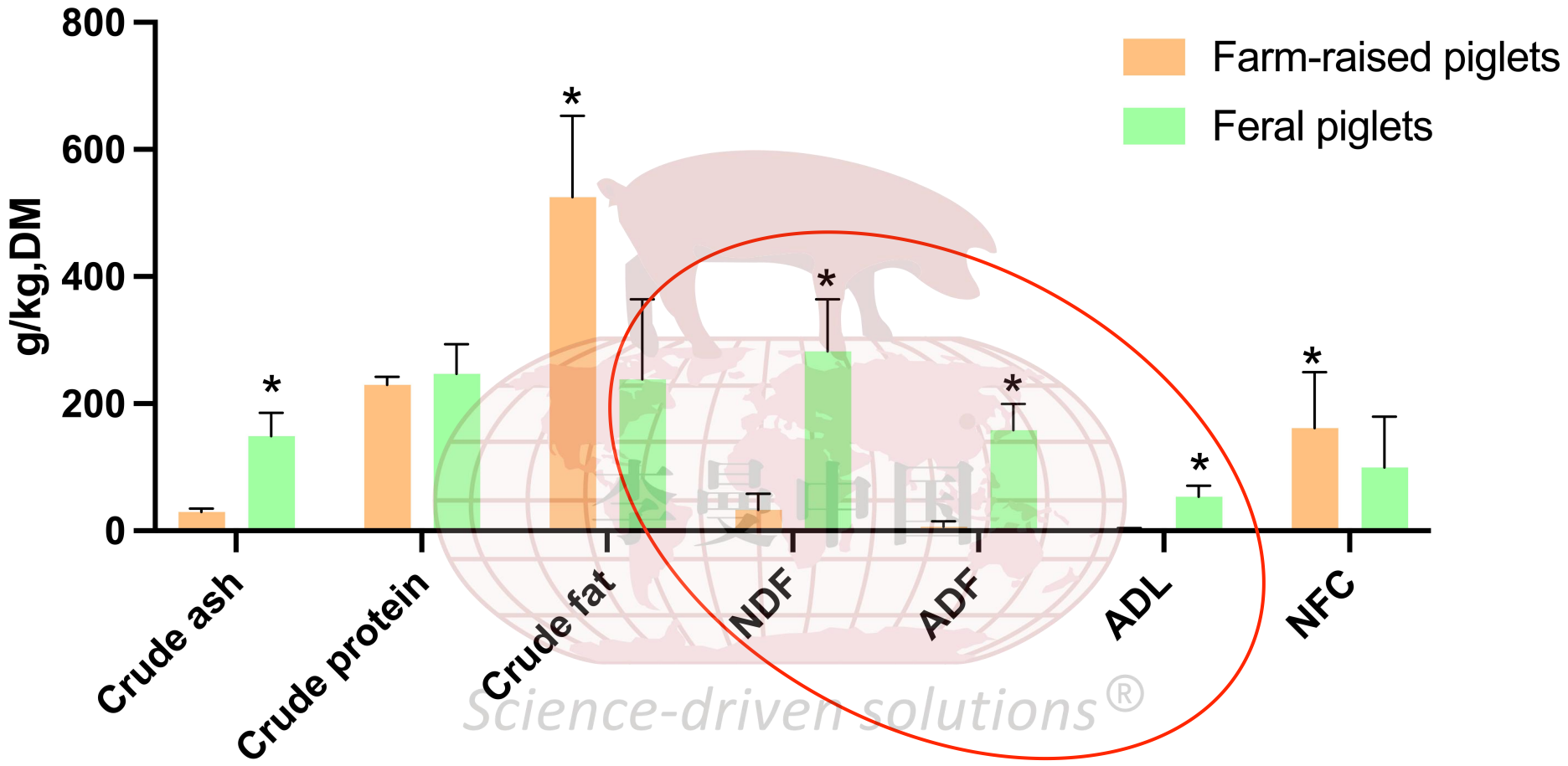
家养哺乳仔猪组
Farmed piglet group



比较两组胃内容物营养成分
The concentrations of macronutrients in the stomach content analysed and compared.

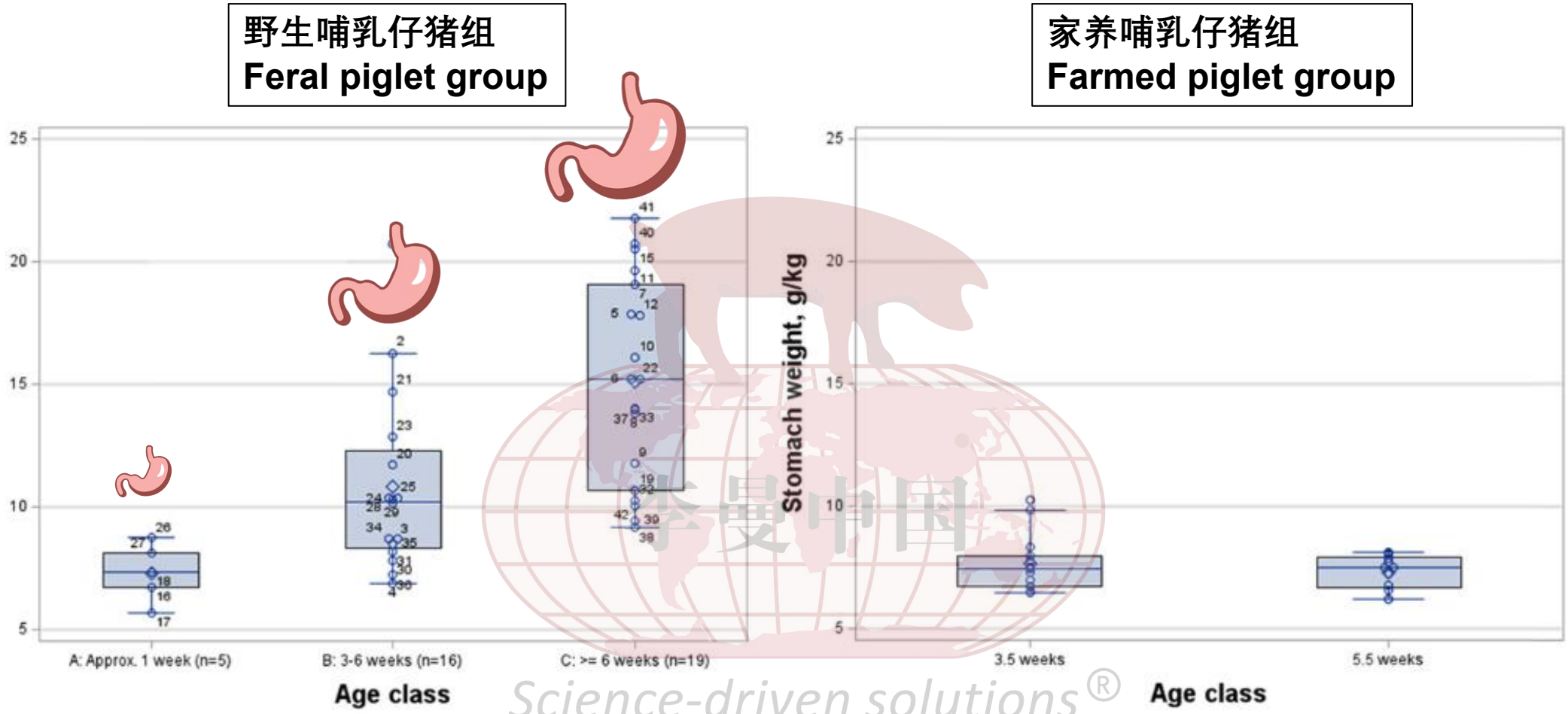
Science-driven solutions®

trouw nutrition
a Nutreco company



野生仔猪和家养仔猪的胃内容物营养成分比较

The macronutrient profile of gastric content in farm-raised piglets and feral piglets. Neutral detergent fibre (NDF), acid detergent fibre (ADF) , acid detergent lignin (ADL), and non-fibre carbohydrates (NFC)



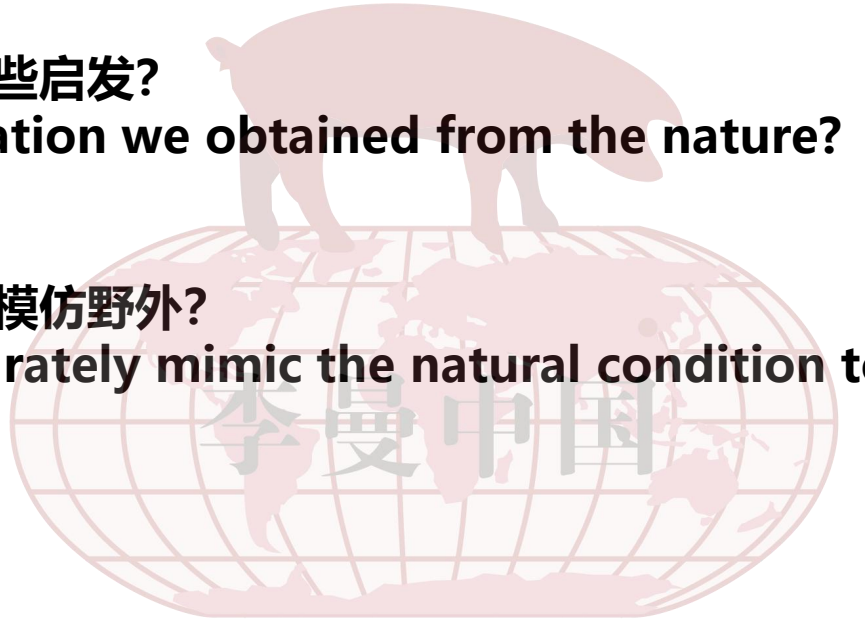
华曼中国
Science-driven solutions®

野生仔猪和家养仔猪的胃部生长比较

The comparison of relative weight of stomach between feral piglets farmed piglets

我们获得了哪些启发?
What inspiration we obtained from the nature?

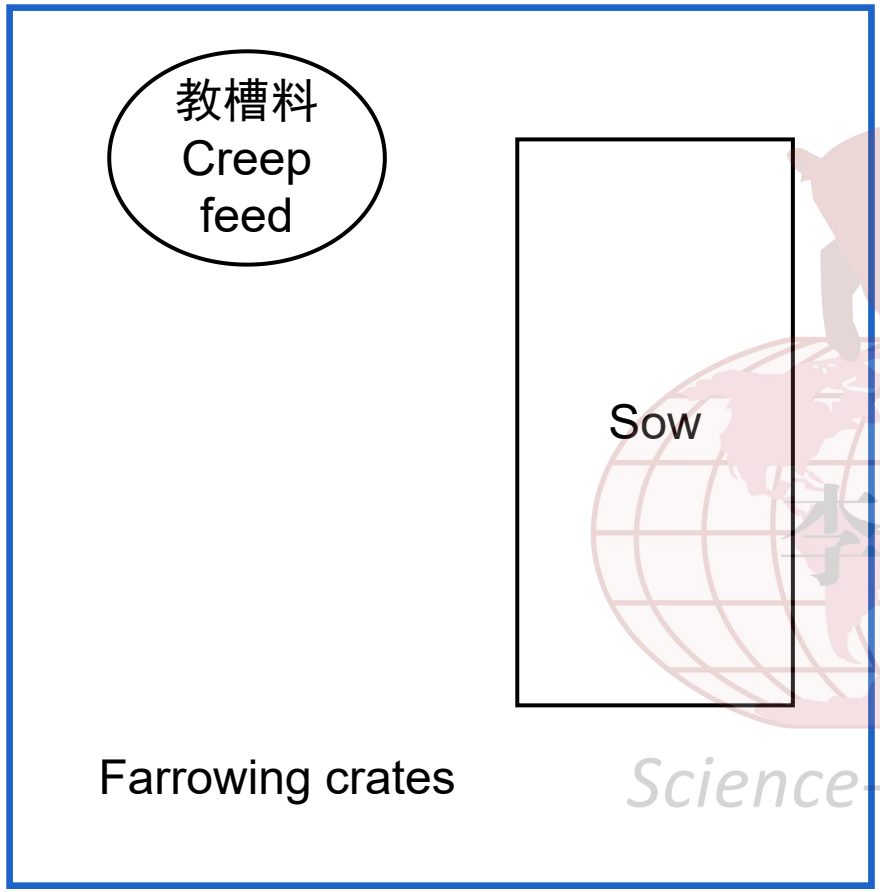
如何去真实的模仿野外?
How to accurately mimic the natural condition to which feral piglets are exposed?



Science-driven solutions®

- **本团队试验开展二 Experiment 2**

哺乳期处理 Suckling treatments



对照组

Control group (CON)

粗切割干草组

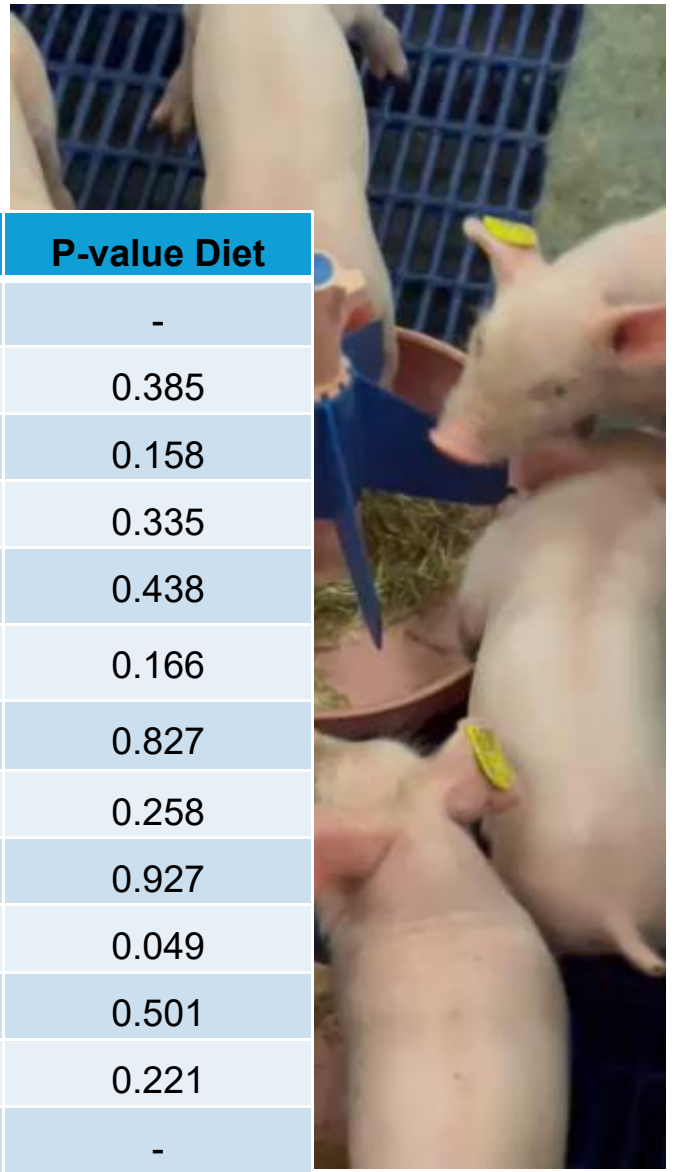
Grass hay group (GH)

李曼中国
Science-driven solutions®

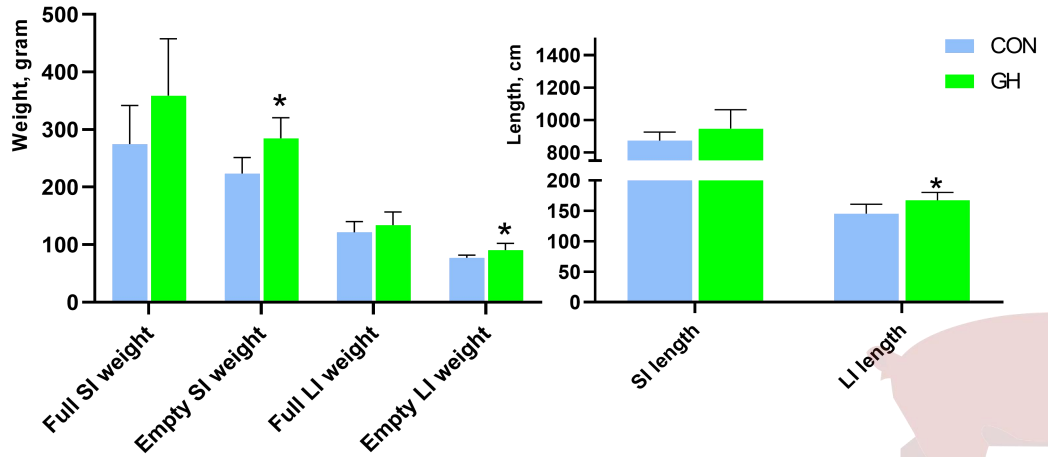
断奶时（28日龄）生长性能比较

Zootechnical performance in the suckling period (d 28)

Item	Con	GH	P-value Diet
Litters	7	8	-
Birth weight	1.49	1.58	0.385
Body weight d 14, kg	4.09	4.34	0.158
Body weight at weaning, kg	7.91	8.38	0.335
Average daily gain during weaning, g/d [1]	245	249	0.438
Weight gain with low Birth weight piglets in total, kg	5.73	6.38	0.166
Weight gain with median Birth weight, kg	6.53	6.62	0.827
Weight gain with high Birth weight, kg	6.82	7.28	0.258
Creep feed intake in Week 1, g/piglet	1.95	1.88	0.927
Creep feed intake in Week 2	14.39	21.90*	0.049
Creep feed intake in Week 3	53.11	56.92	0.501
Creep feed intake in Week 4	116.32	133.21	0.221
哺乳期间干草采食量, g/piglet Grass hay feed intake	-	57.05	-



泰曼中国
Science-driven solutions®



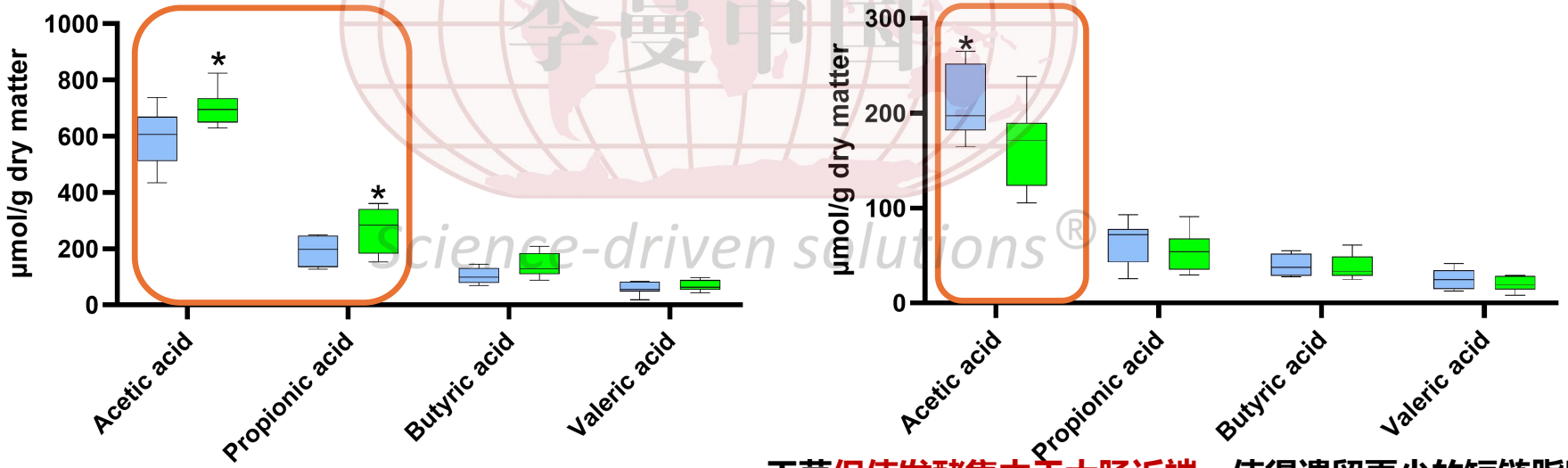
消化道形态发育比较

Gastrointestinal tract **morphometrics** at weaning

SI: small intestine;
LI: large intestine

盲肠 **Caecum**

结肠 **Colon**



盲肠和结肠中锻炼脂肪酸浓度比较

SCFAs in cecum and colon

干草促使发酵集中于大肠近端，使得遗留更少的短链脂肪酸到远端肠段

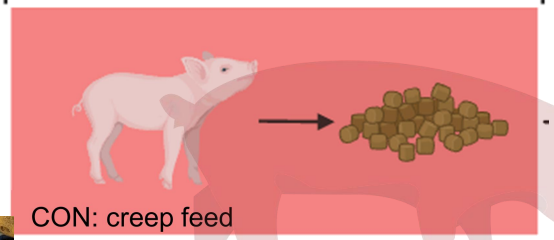
Higher concentrations of SCFAs were exhibited through fermentation in caecum of GH, but fewer yielded in colon than CON.

李曼中国 Science-driven solutions®

- **本团队试验开展三 Experiment 3**

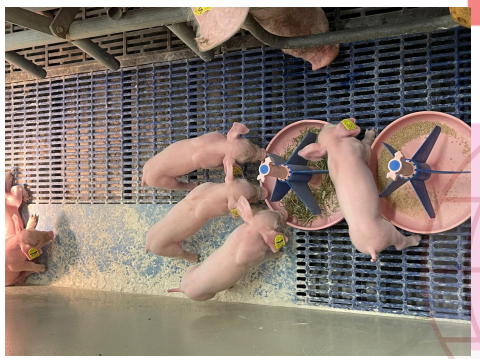
哺乳期处理 suckling treatments

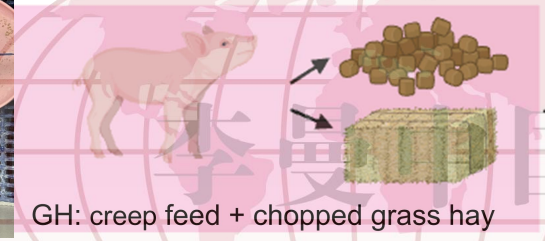
D 2 to weaning (d 23)



CON: creep feed

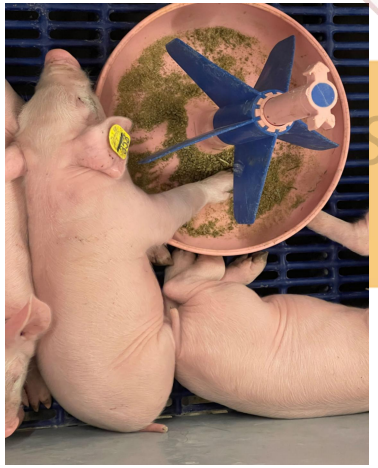
对照组 Control group (CON)

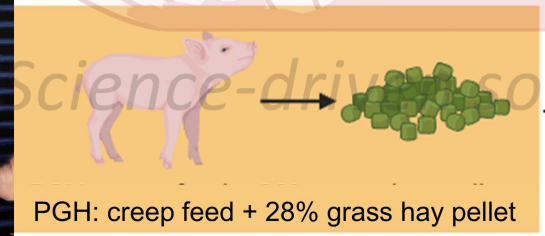




GH: creep feed + chopped grass hay

粗切割干草组 Chopped grass hay group (GH)





PGH: creep feed + 28% grass hay pellet

干草制粒组 Pellet grass hay group (PGH)

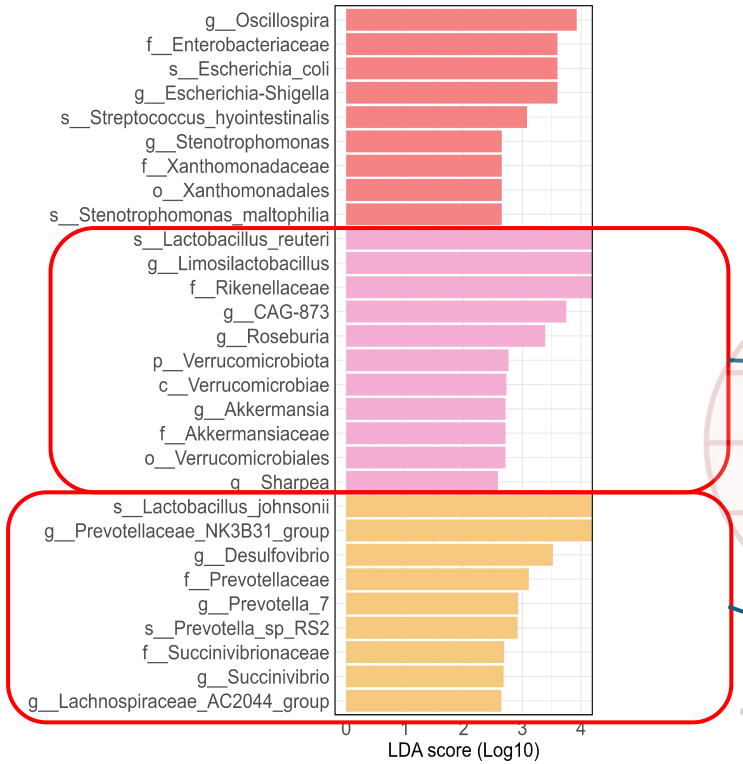
Science-driven solutions®

在断奶时（d 23）消化道形态发育情况
Gastrointestinal tract morphometrics of piglets euthanised on the day prior to weaning

Items	CON	GH	PGH	*P*-diet
空胃重量, g	40	39	40	0.840
含内容物小肠重量, g	227[b]	240[a]	220[b]	0.033
空小肠重量, g	214[b]	222[a]	202[b]	0.044
小肠长度, cm	792[b]	851[a]	758[b]	0.012
含内容物结肠重量, g	73	72	69	0.739
空结肠重量, g	46	50	44	0.065
结肠长度, cm	117	128	125	0.074

Science-driven solutions®

盲肠微生物菌群LEfSe分析结果
The LEfSe result of cecal microbiome

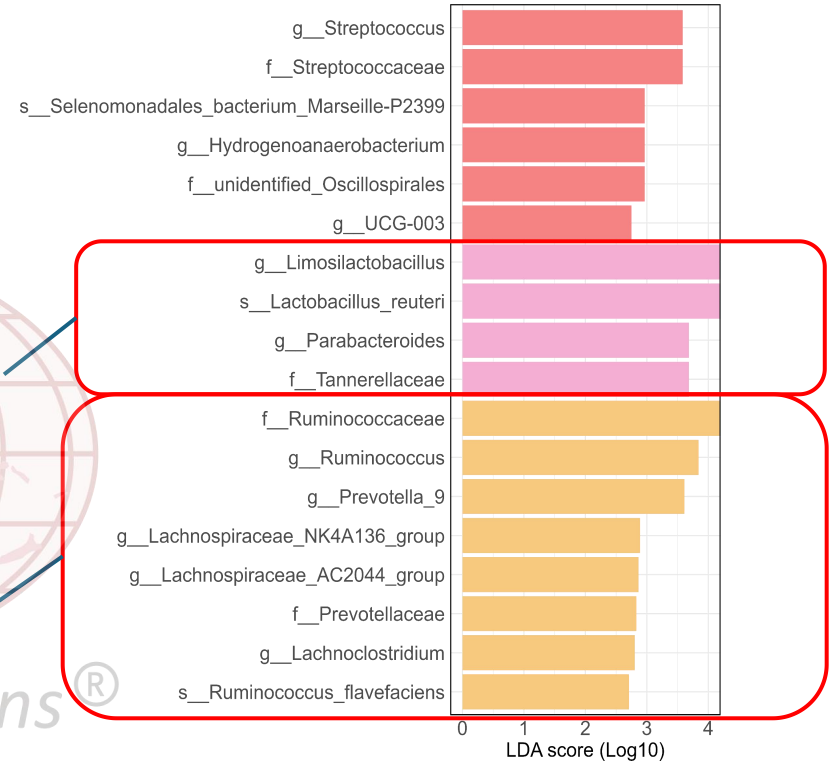


Group
CON
GH
PGH

乳酸杆菌及其他营养代谢菌
Enriched in *Lactobacilli* and other nutrient-metabolizing mircrobes

纤维降解菌
Enriched in fibre-degrading microbes

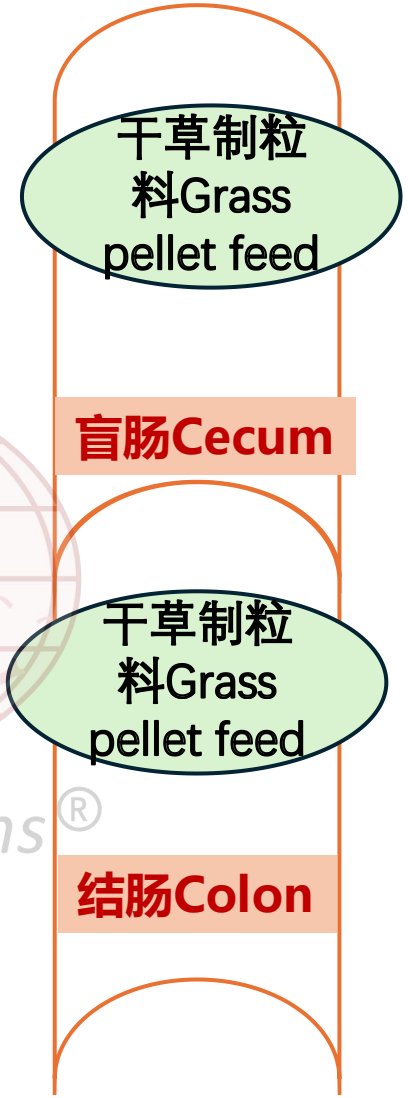
结肠微生物LEfSe分析结果
The LEfSe result of colonic microbiome



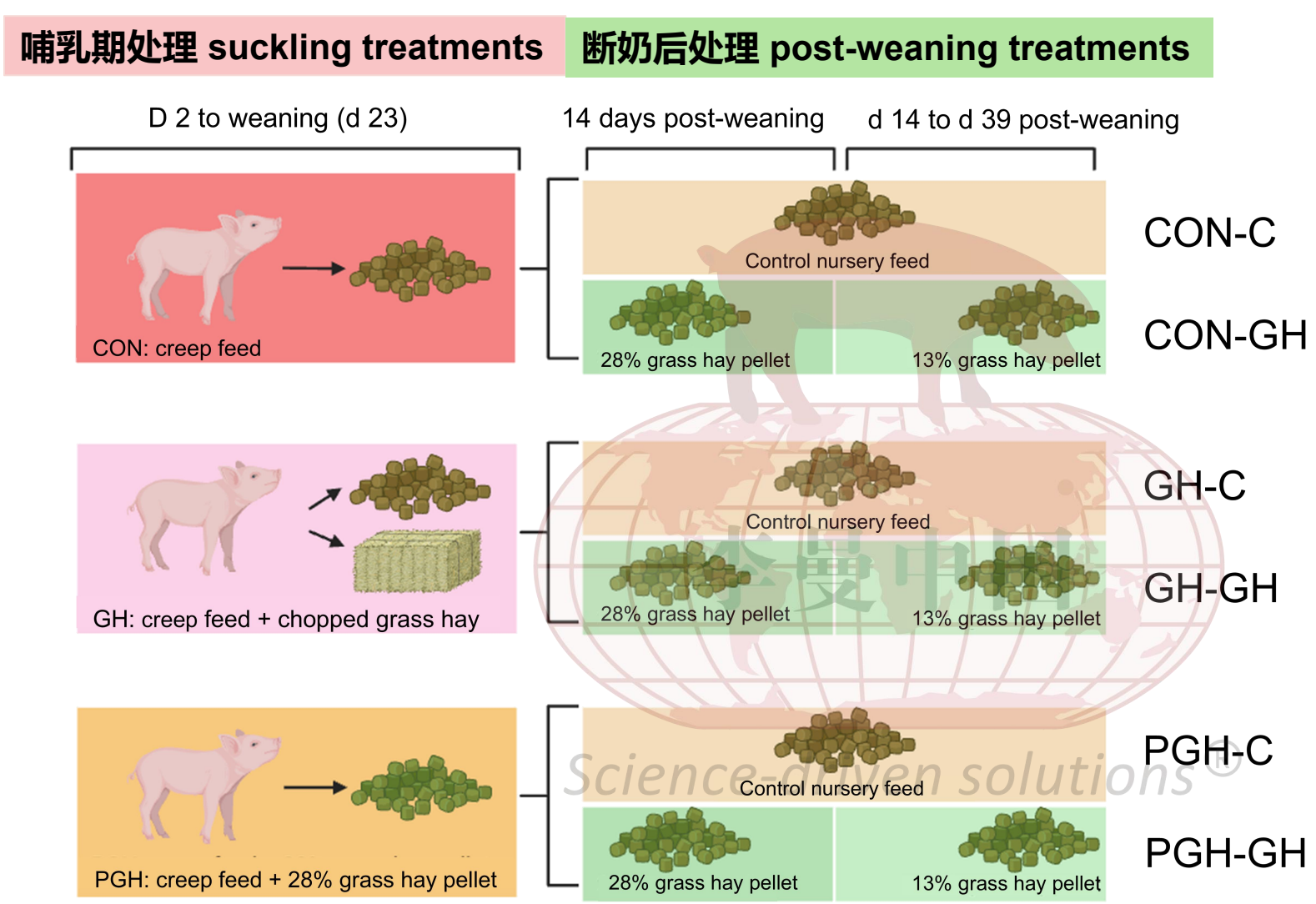
Science-driven solutions®

粗切割干草组
Chopped grass hay group (GH)

干草制粒组
Grass pellet group (PGH)



李曼中国
Science-driven solutions®

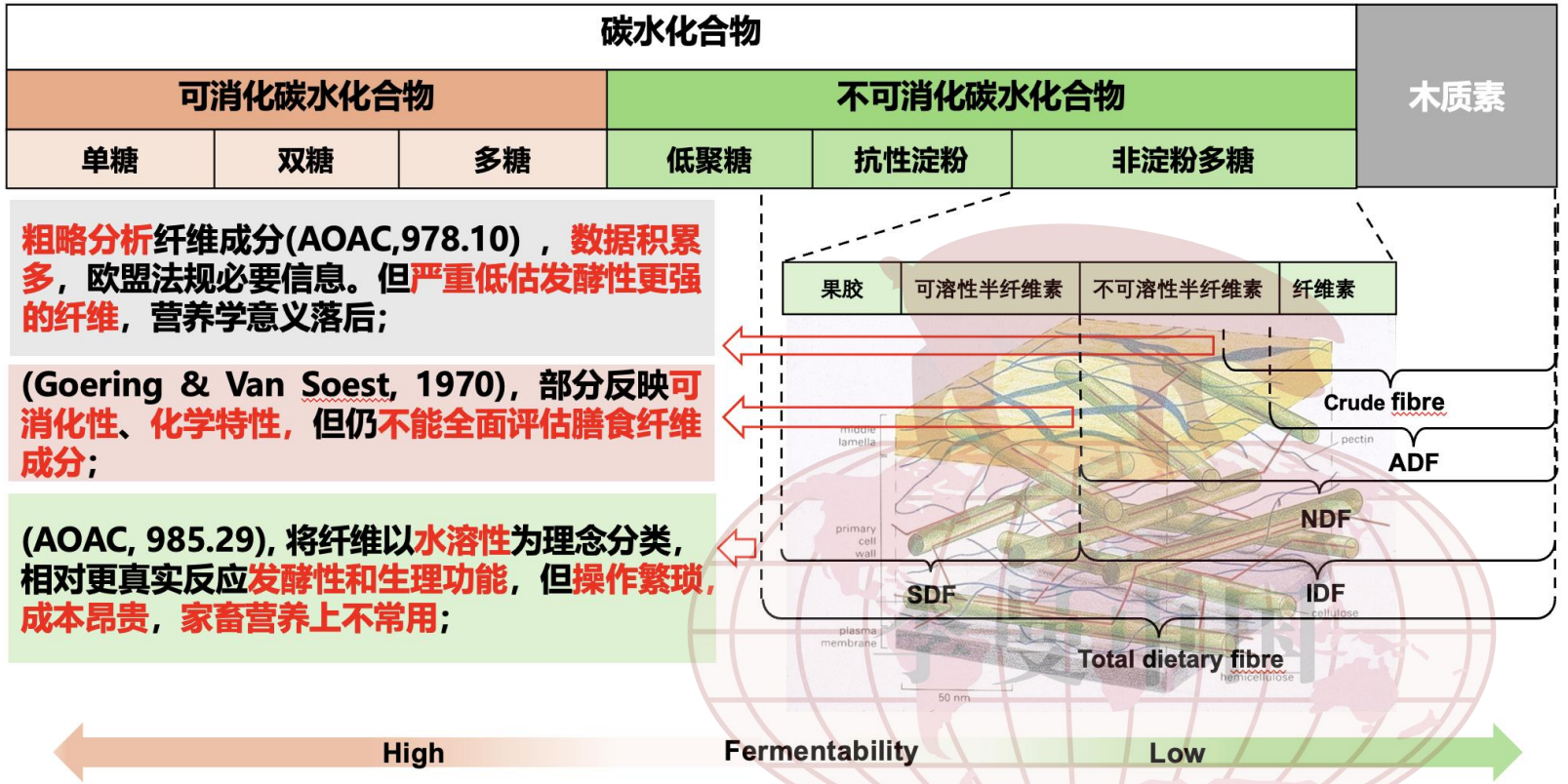

哺乳期处理 suckling treatments
断奶后处理 post-weaning treatments
D 2 to weaning (d 23)
14 days post-weaning
d 14 to d 39 post-weaning
CON: creep feed
Control nursery feed
28% grass hay pellet
13% grass hay pellet
CON-C
CON-GH
GH: creep feed + chopped grass hay
Control nursery feed
28% grass hay pellet
13% grass hay pellet
GH-C
GH-GH
PGH: creep feed + 28% grass hay pellet
Control nursery feed
28% grass hay pellet
13% grass hay pellet
PGH-C
PGH-GH
Science-driven solutions

断奶后仔猪生长性能
Zootechnical performance post-weaning

断奶后处理	CON			GH			SEM[5]	P -suckling	P - nursery	P -suckling × nursery
哺乳期处理	CON	GH	PGH	CON	GH	PGH				
Number of pens	12	12	12	12	12	12	-	-	-	-
断奶时体重, kg	6.72	6.63	6.69	6.72	6.55	6.80	0.17	0.607	0.956	0.875
Phase 1 (d0-14)（28%干草制粒料）										
断奶后d14体重, kg	10.1*	10.0*	10.1*	9.43	9.04	9.74	0.25	0.483	**0.001**	0.084
ADFI[1], g/day/piglet[6]	261*	261*	263*	221	216	234	13	0.912	**0.001**	0.773
ADG[2], g/day/piglet[6]	225*	226*	228*	182	168	194	11	0.553	**<0.001**	0.240
FCR[3], g/kg	1.16	1.16	1.16	1.22*	1.22*	1.20*	0.022	0.897	**0.001**	0.954
饲料净能转化效率[4], kcal/kg	2.76*	2.75*	2.73*	2.66	2.65	2.60	0.02	0.902	**0.001**	0.967
Phase 2 (d14-39)（14%干草制粒料）										
断奶后 d 39体重, kg	23.0	22.5	23.0	22.4	21.2	23.3	0.6	0.223	0.424	0.635
ADFI, g/day/piglet[6]	705	688	709	763*	764*	814*	17	0.099	**0.002**	0.188
ADG, g/day/piglet[6]	514	490	507	519*	504*	547*	13	0.149	0.056	0.501
FCR, g/g	1.39	1.41	1.41	1.45*	1.45*	1.48*	0.02	0.451	**0.001**	0.453
饲料净能转化效率, kcal/g	3.29*	3.35*	3.35*	3.20	3.21	3.26	0.06	0.425	0.006	0.827

李曼中国 Science-driven solutions®

➢ 如何重新定义纤维How to redefine it?



粗略分析纤维成分(AOAC,978.10)，数据积累多，欧盟法规必要信息。但严重低估发酵性更强的纤维，营养学意义落后；

(Goering & Van Soest, 1970)，部分反映可消化性、化学特性，但仍不能全面评估膳食纤维成分；

(AOAC, 985.29)，将纤维以水溶性为理念分类，相对更真实反应发酵性和生理功能，但操作繁琐，成本昂贵，家畜营养上不常用；

Science-driven solutions®

基于什么特性?
What characteristics should be considered?

- **发酵特性：肠道发酵后的产酸特性;**
  Fermentation property?
- **物理特性：吸水、膨胀、韧性、多孔性等?**
  Physical property?

快速发酵 和 慢速发酵纤维?
Fast-fermenting and slow fermenting fibre?

➢ 未来展望Future perspectives

- 对不同养殖阶段纤维（特性）的选择
Stage-specific selection of dietary fibre (characteristics)

- 如何明确组合纤维源互补不同理化特性，从而优化纤维源干预方式
Strategically combine fibre sources to complement their physicochemical properties and optimize fibre intervention

- 更深层挖掘纤维作用机制（主动信号分子？多维数据组合？）
In-depth explore fibre mechanistic roles (e.g signaling molecules, multi-dimensional data integration, etc...)

science driven solutions ®

➢ Take-home messages

- 母猪应同时从行为、生理的角度去优化饲喂方案；
  Feeding strategies for sows should be optimized from both behavioral and physiological perspectives;

- 膳食纤维营养在母猪整个繁殖周期都占据重要角色；
  Dietary fibre plays an important role throughout the entire reproductive cycle of sows;

- 更高水平的不可溶纤维是可以被哺乳仔猪接受的，且能有效促进仔猪肠道成熟、提高饲料净能利用率；不同物理形态对仔猪的影响方式不同；
  A higher insoluble fibre inclusion in suckling piglets is acceptable, potentially beneficial, and worth considering as a replacement for the original nutrient-dense creep feeds;

- 纤维的物理和化学特性都应被纳入营养功能评价范畴，但评价标准仍有待进一步探究；
  Both the physical and chemical properties of fiber should be considered in the evaluation of its nutritional functions, yet the approaches for assessing fiber function warrants further investigation;

Science-driven solutions®

- 膳食纤维并非万能，但在母猪和仔猪饲喂中纤维营养被忽略了！
  Dietary fiber is not a panacea, yet its insufficiency in the diets of sows and piglets is evident.

➢ Acknowledgement

感谢您宝贵的时间，欢迎您指正！
Thanks for your time and warmly welcome any comments!

Our team, headed by Prof. Che

Science-driven solutions
WSE 2025
四川农业大学 ANI 动物营养研究所
FACULTY OF VETERINARY MEDICINE
accredited by EAEVE