能量利用和能量体系
Energy utilization and energy systems

Jaap van Milgen

大纲 Outline

❖ 前言　　**Introduction**

❖ 总能、消化能和代谢能　**Gross energy (GE), digestible energy (DE), and metabolizable energy (ME)**

❖ 产热和净能组分　**Components of heat production and net energy (NE)**

❖ 能量转换的化学计量法　**Stoichiometry of energy transactions**

❖ 结论　**Conclusions**

大纲
Outline

前言 Introduction

❖ 能量不是一种营养素，但是一个物质的特性 **Energy is not a nutrient, but a property of objects**

❖ 能量不会丢失，且存在于不同的形式 **Energy cannot be lost and exists in different forms**

❖ 能量是日粮中最重要的组分 **Energy is the most expensive component of the diet**

❖ 能量主要与蛋白质和脂肪一样沉积在体内 **Energy is mainly retained in the body as protein and lipid**

❖ 能量如**ATP**是在许多代谢过程中所需要的 **Energy, as ATP, is required in numerous metabolic processes**

仅部分摄入能被沉积
Only part of the ingested energy is retained
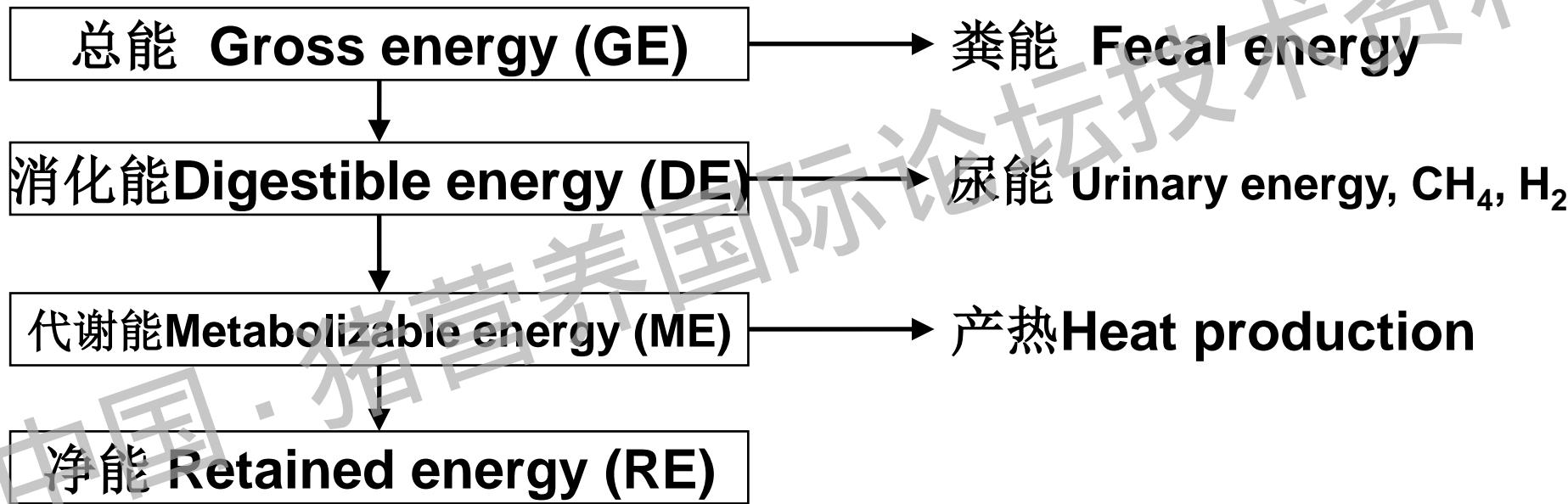
总能 Gross energy (GE)	→	粪能 Fecal energy

↓

消化能Digestible energy (DE)	→	尿能 Urinary energy, CH_4, H_2

↓

代谢能Metabolizable energy (ME)	→	产热Heat production

↓

净能 Retained energy (RE)

仅部分摄入能被沉积
Only part of the ingested energy is retained

粪 Feces

甲烷+尿
Methane + urine

产热
Heat production

沉积净能
Retained
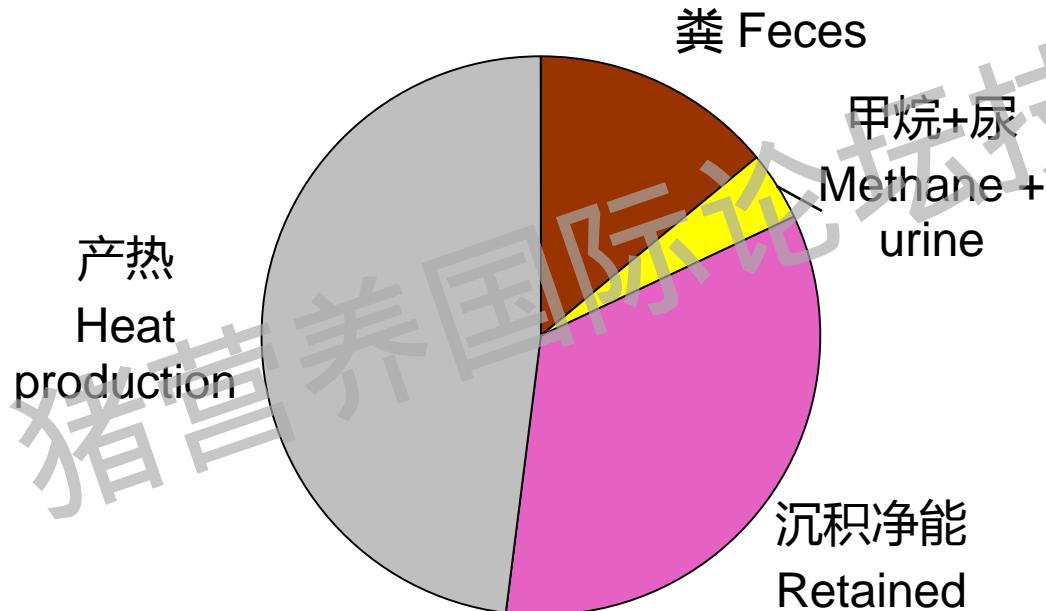
大纲 Outline

饲料原料的总能
GE values of feed ingredients

Energy utilization and energy systems
Jaap van Milgen
Chinese Swine Industry Symposium, October 30-31, 2014
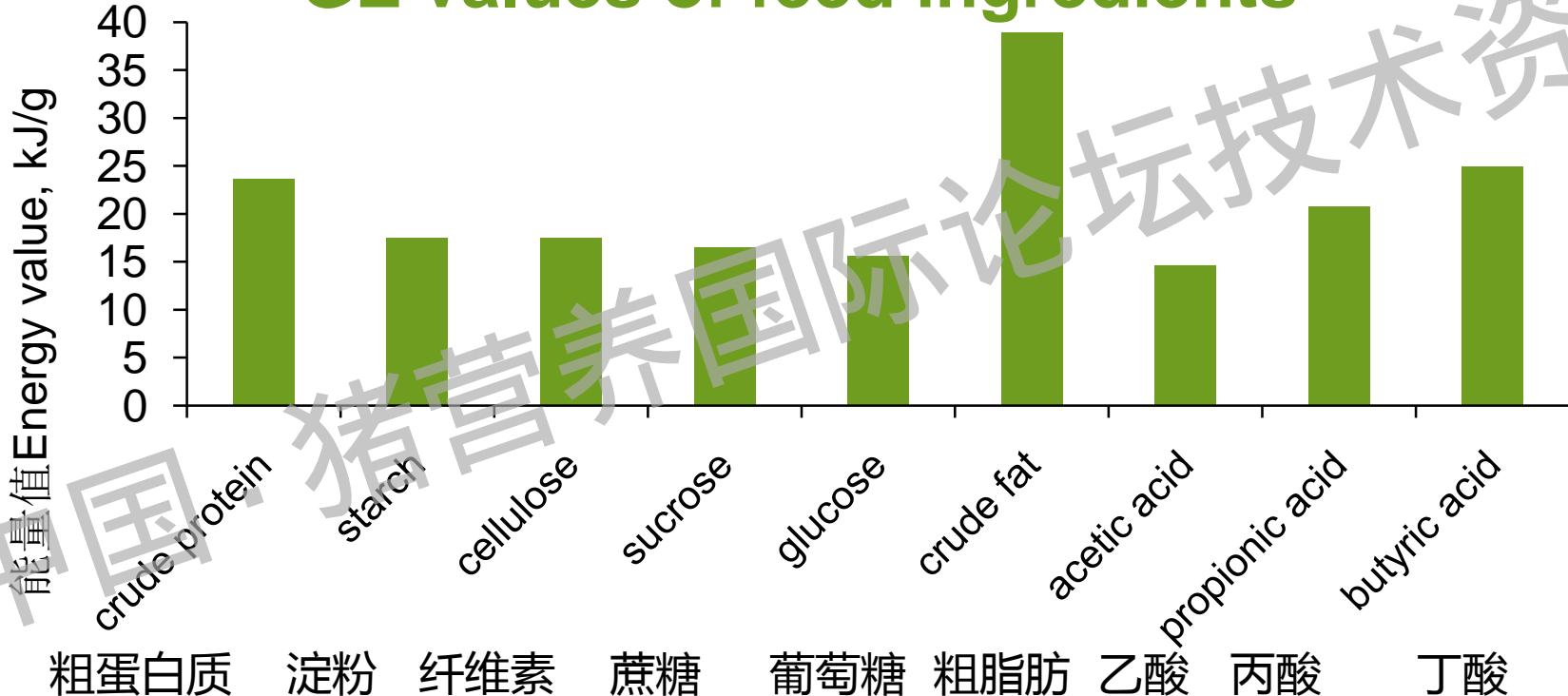
总能的估算
Estimation of GE values

总能=17.33+0.628蛋白质+2.34脂肪-1.84灰分

GE = 17.33 + 0.628 CP + 2.34 fat – 1.84 ash

(NRC, 1998)

总能=22.6粗蛋白质+38.8脂肪+17.5淀粉+16.7糖+18.6残留物

残留物=有机物质-(粗蛋白质+脂肪+淀粉+糖）

GE = 22.6 CP + 38.8 fat + 17.5 starch + 16.7 sugars + 18.6 residue

residue = OM – (CP + fat + starch + sugars)

(Noblet *et al.*, 1994. J. Anim. Sci. 72:344-354)

纤维对能量消化率的影响
Effect of fiber on energy digestibility

Y-axis: 能量消化率 Energy digestibility, %
X-axis: 中性洗涤纤维 NDF (%)

生长猪growing pigs: 0.90
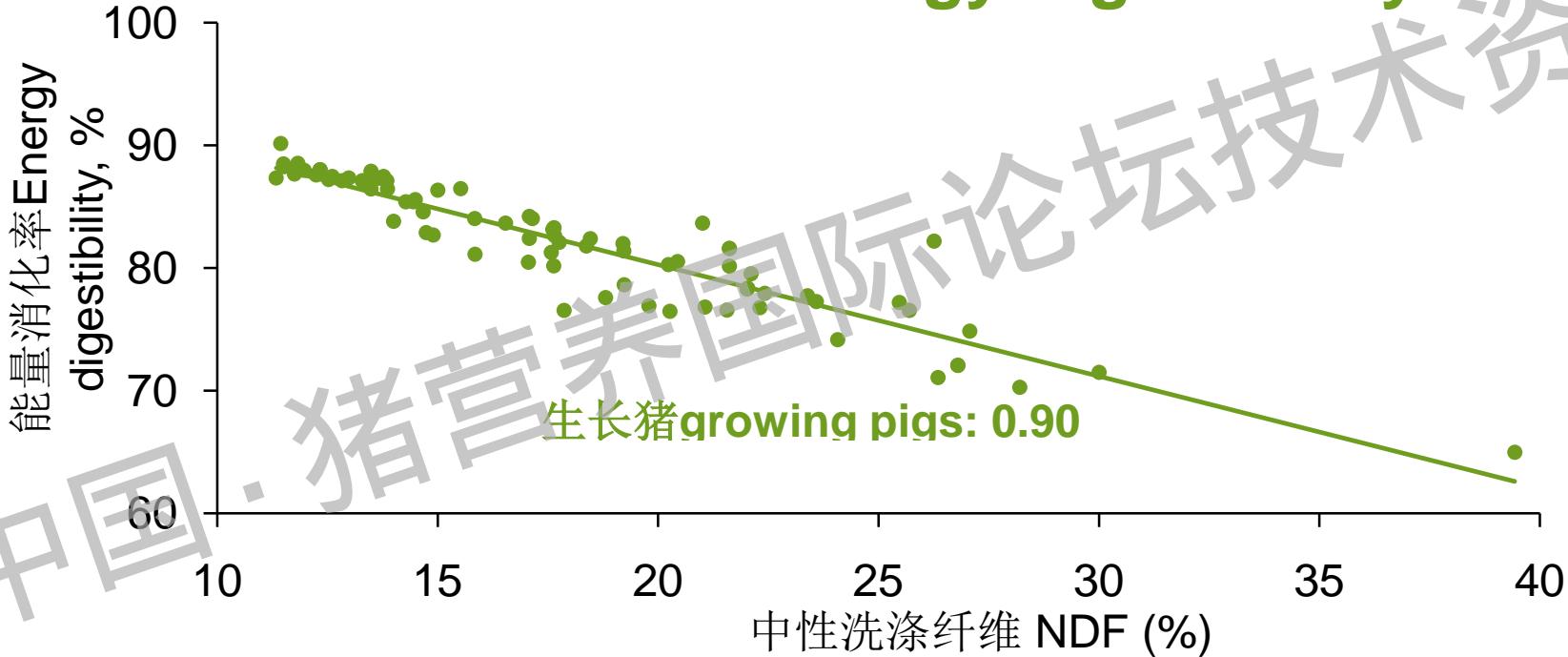
Le Goff and Noblet (2001) J. Anim. Sci. 79: 2418-2427

纤维对能量消化率的影响
Effect of fiber on energy digestibility
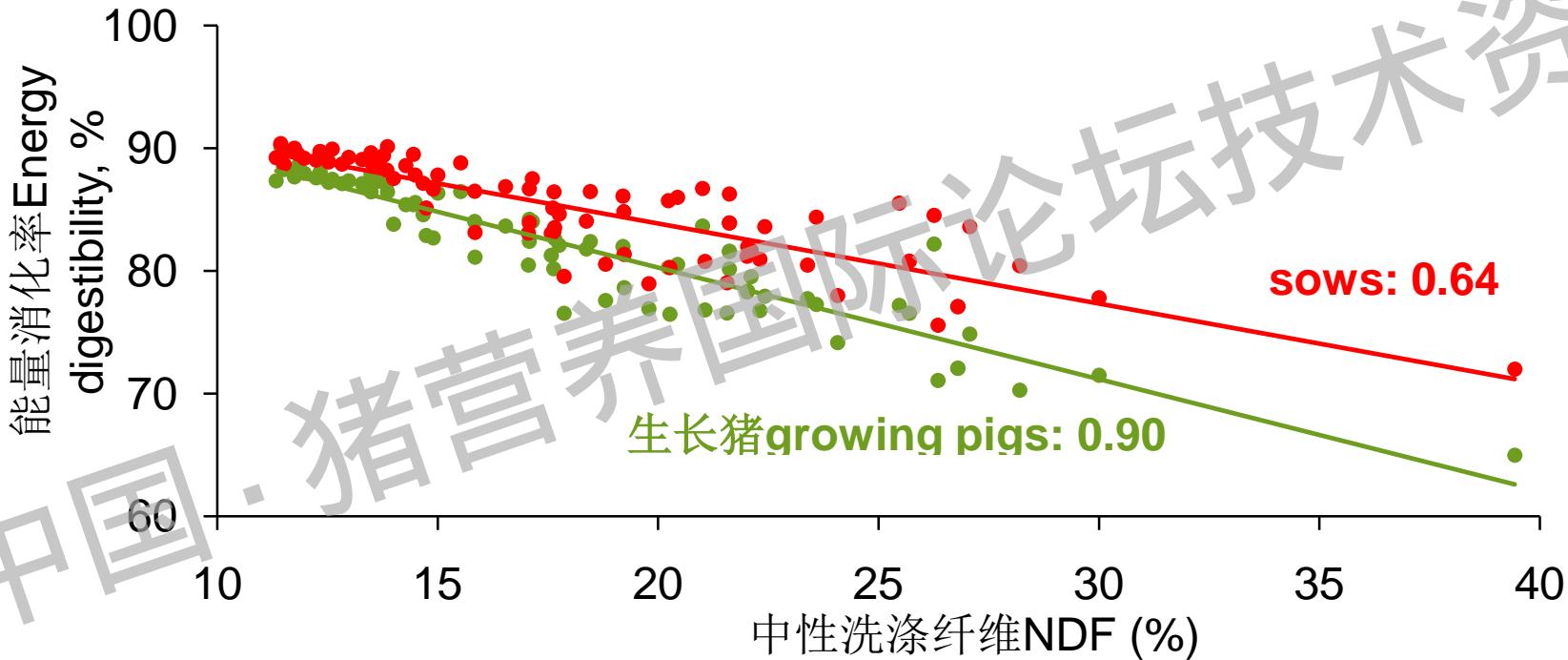
Le Goff and Noblet (2001) J. Anim. Sci. 79: 2418-2427

粪能损失
Fecal energy losses

饲料原料组成和营养价值表

❖ 能量消化率随着纤维含量增加而降低 **Energy digestibility decreases with fiber content**

❖ 母猪对纤维的消化能力高于生长猪**(**例：**2**个消化能值**)**
Sows digest fiber better than do growing pigs (i.e., 2 DE values)

Tables of composition and nutritional value of feed materials

editors D. Sauvant, J.-M. Perez and G. Tran

pigs
poultry
cattle
sheep
goats
rabbits
horses
fish
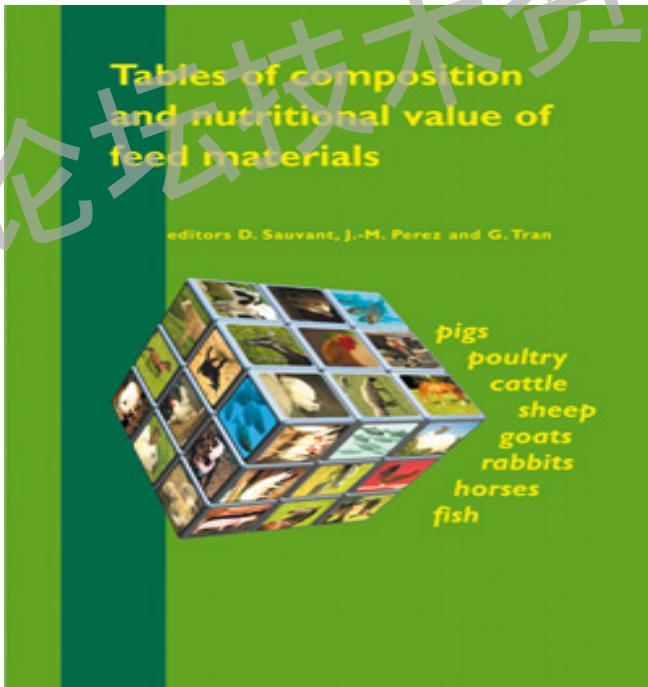
日粮蛋白质对能量利用率的影响
Effect of dietary protein on energy availability

代谢能/消化能 ME/DE, %

粗蛋白质，占干物质% Crude protein, % in DM
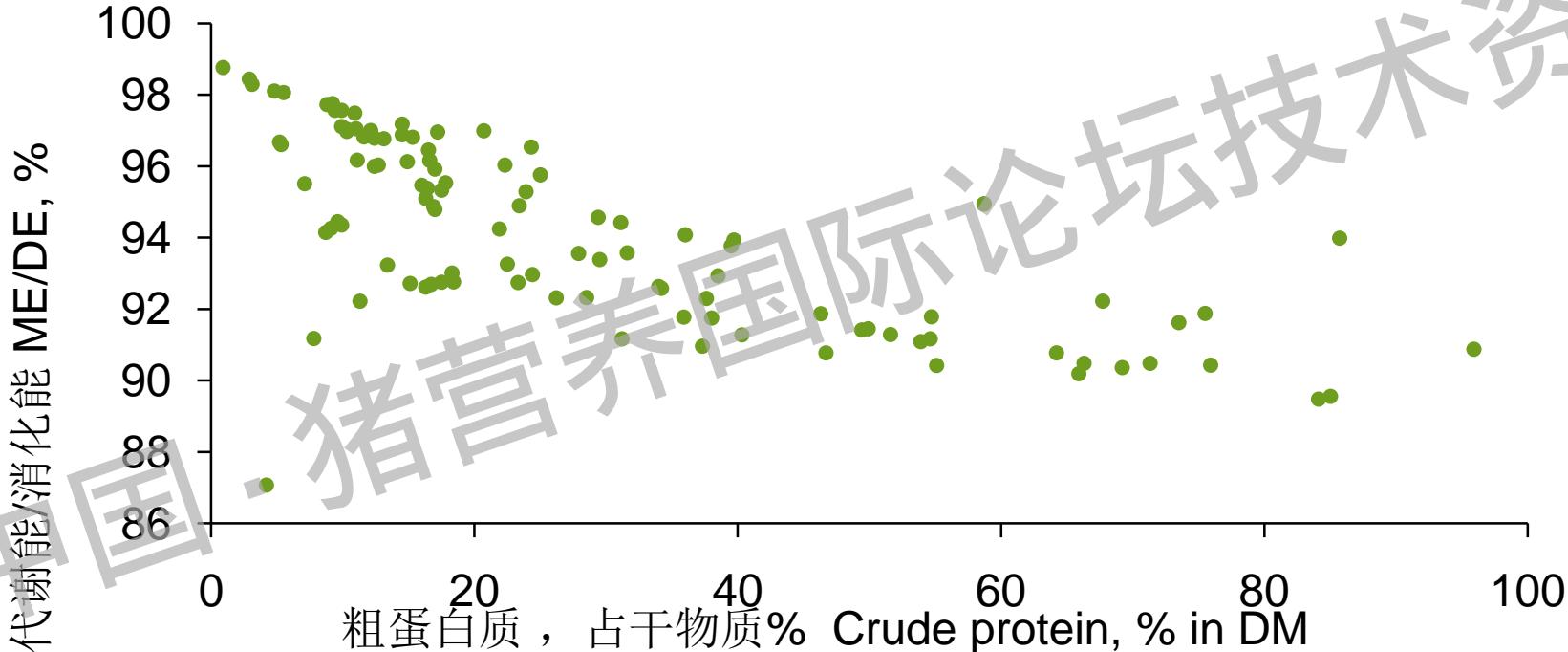
Sauvant *et al.* (2004) Tables of composition and nutritional value of feed materials

蛋白质的代谢能取决于它的利用率
The ME value of protein depends on its utilization

```
                    ┌─────────────────────┐
                    │     可消化蛋白        │
                    │ Digestible protein  │
                    └─────────────────────┘
                              │
                 ┌────────────┴─────────────┐
                 ▼                          ▼
    ┌─────────────────────┐    ┌─────────────────────┐
    │     过量蛋白质        │    │     沉积蛋白质        │
    │   Excess protein    │    │  Deposited protein  │
    └─────────────────────┘    └─────────────────────┘
              │
      ┌───────┴────────┐
      ▼                ▼
┌───────────┐   ┌──────────────────────┐
│ 尿素 urea  │   │  碳链carbon chain     │
└───────────┘   └──────────────────────┘
```
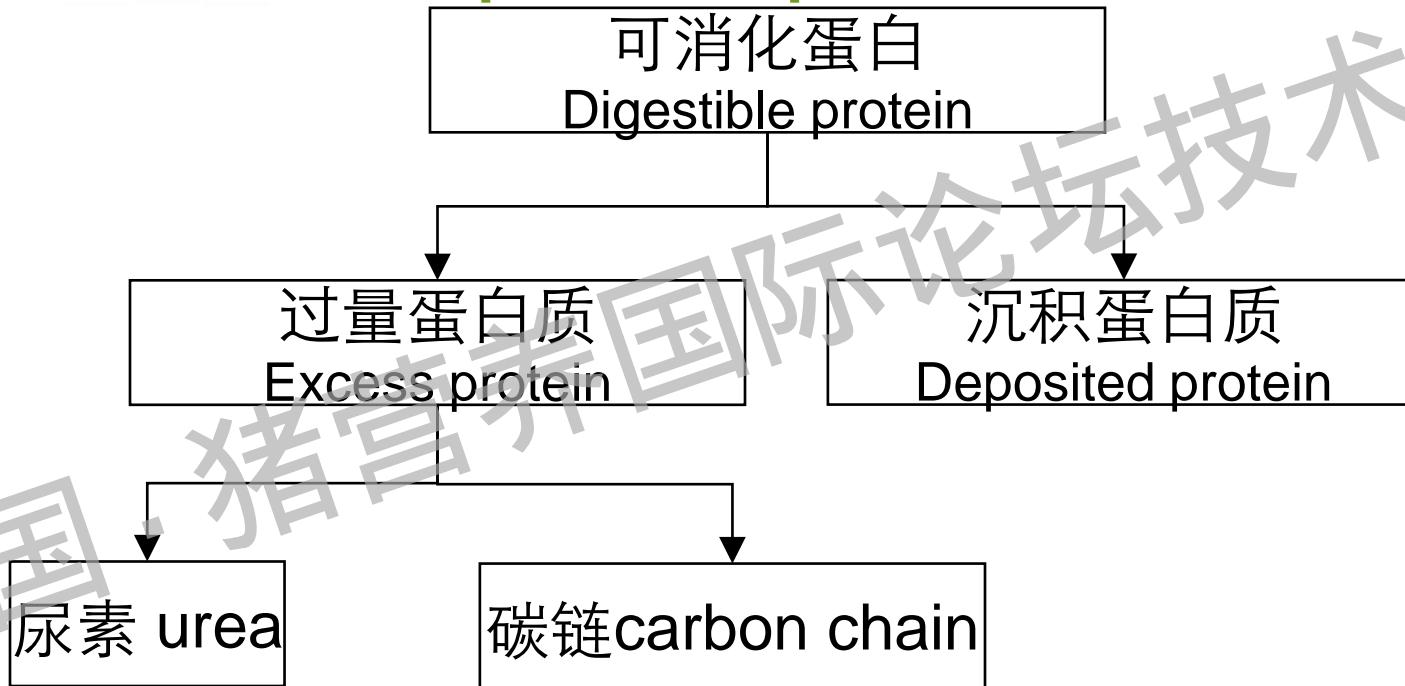
# 蛋白质的代谢能取决于它的利用率
The ME value of protein depends on its utilization
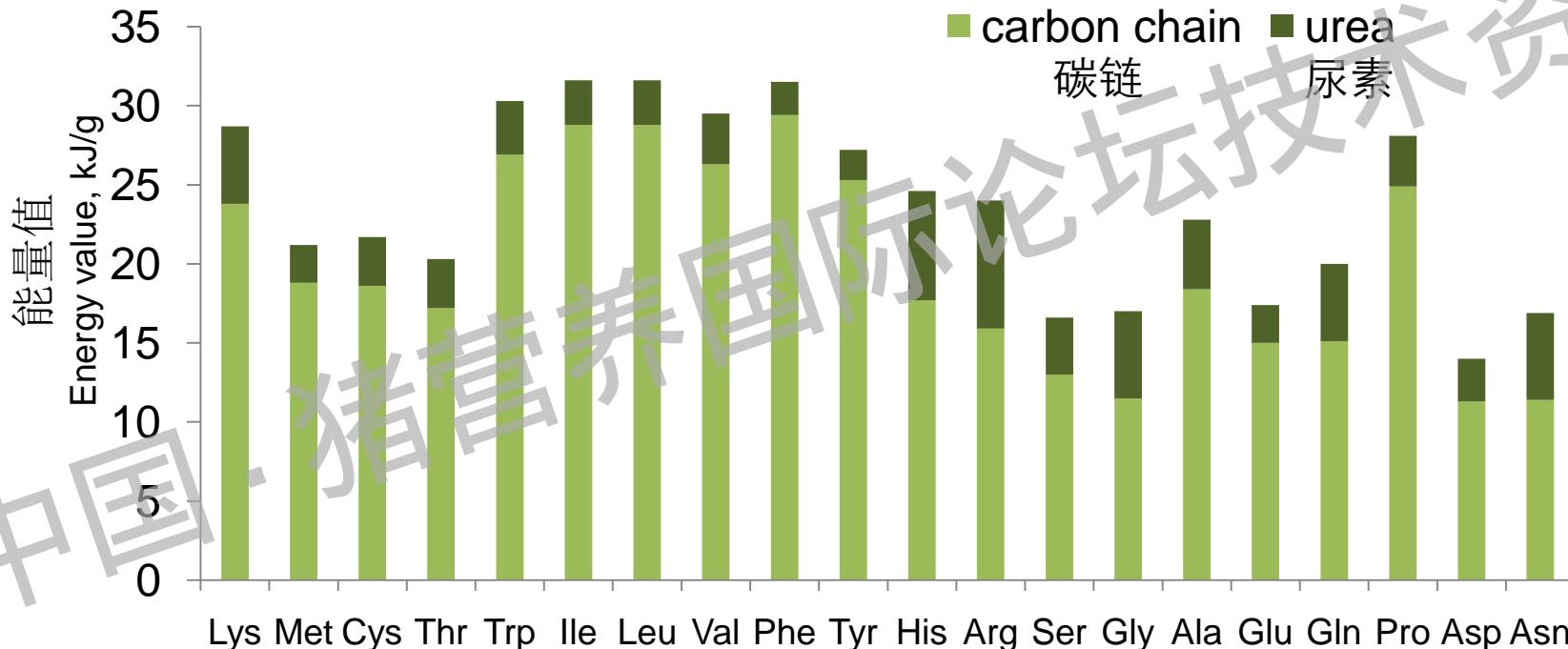
大纲 Outline

❖前言 　　　Introduction

❖总能、消化能和代谢能 　Gross energy (GE), digestible energy (DE), and metabolizable energy (ME)

❖产热和净能组分 　　Components of heat production and net energy (NE)

❖能量转换的化学计量法 　Stoichiometry of energy transactions

❖结论 　Conclusions

能量损失和能量体系
Energy losses and energy systems
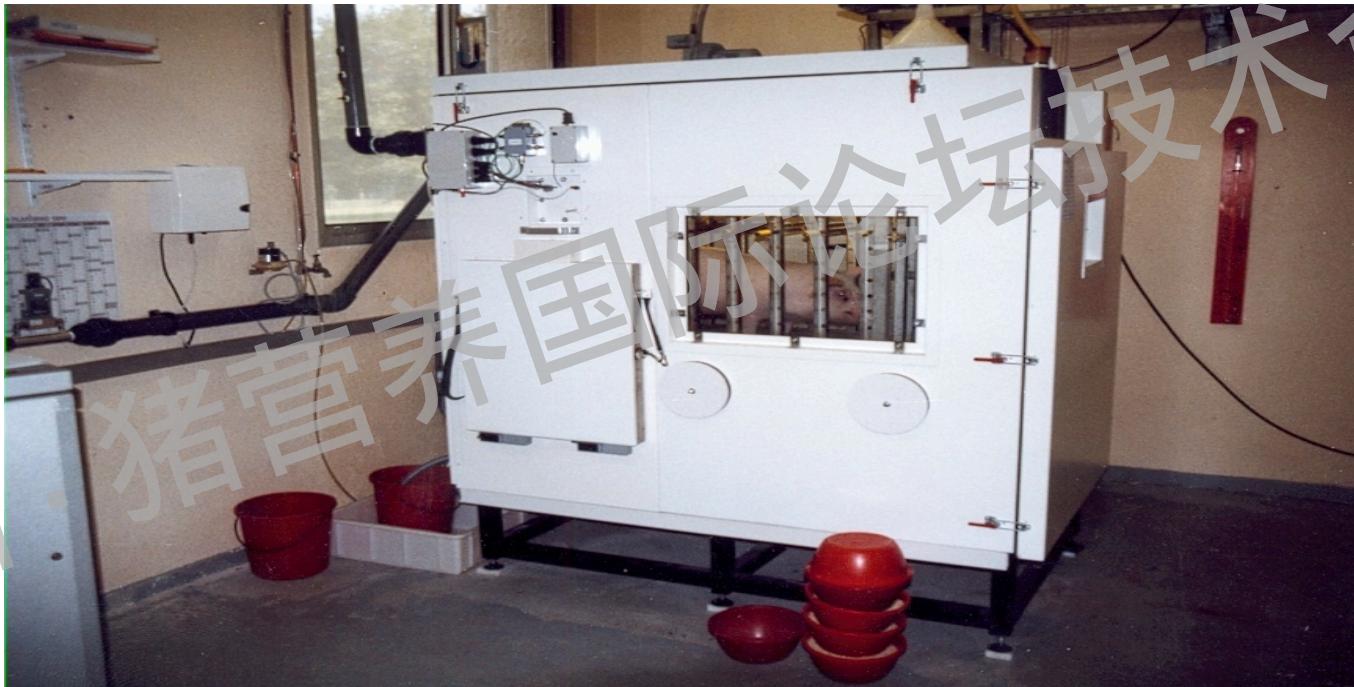
总能　**GE** → 粪能 Fecal energy

消化能　**DE** → 尿能，甲烷，氢气 Urinary energy, CH_4, H_2

代谢能　**ME** → 热增耗 Heat increment

· 净能　**NE** → 空腹产热 Fasting heat production

沉积净能　**RE**

间接测热(呼吸室)
Indirect calorimetry (respiration chamber)

间接测热(呼吸室)
Indirect calorimetry (respiration chamber)

温度调节
temperature regulation

照明
lighting

流量计 **flow meter**

O_2
CO_2
CH_4

红外线光束
infra-red beam

重量传感器
weight sensors

力传感器
force sensors

产热组分 Components of heat production

禁食　　　　热增耗(长期)　　　　　　　热增耗(短期)　　　　活动

■ Fasting　　■ Heat increment (long-term)　　■ Heat increment (short-term)　■ Activity
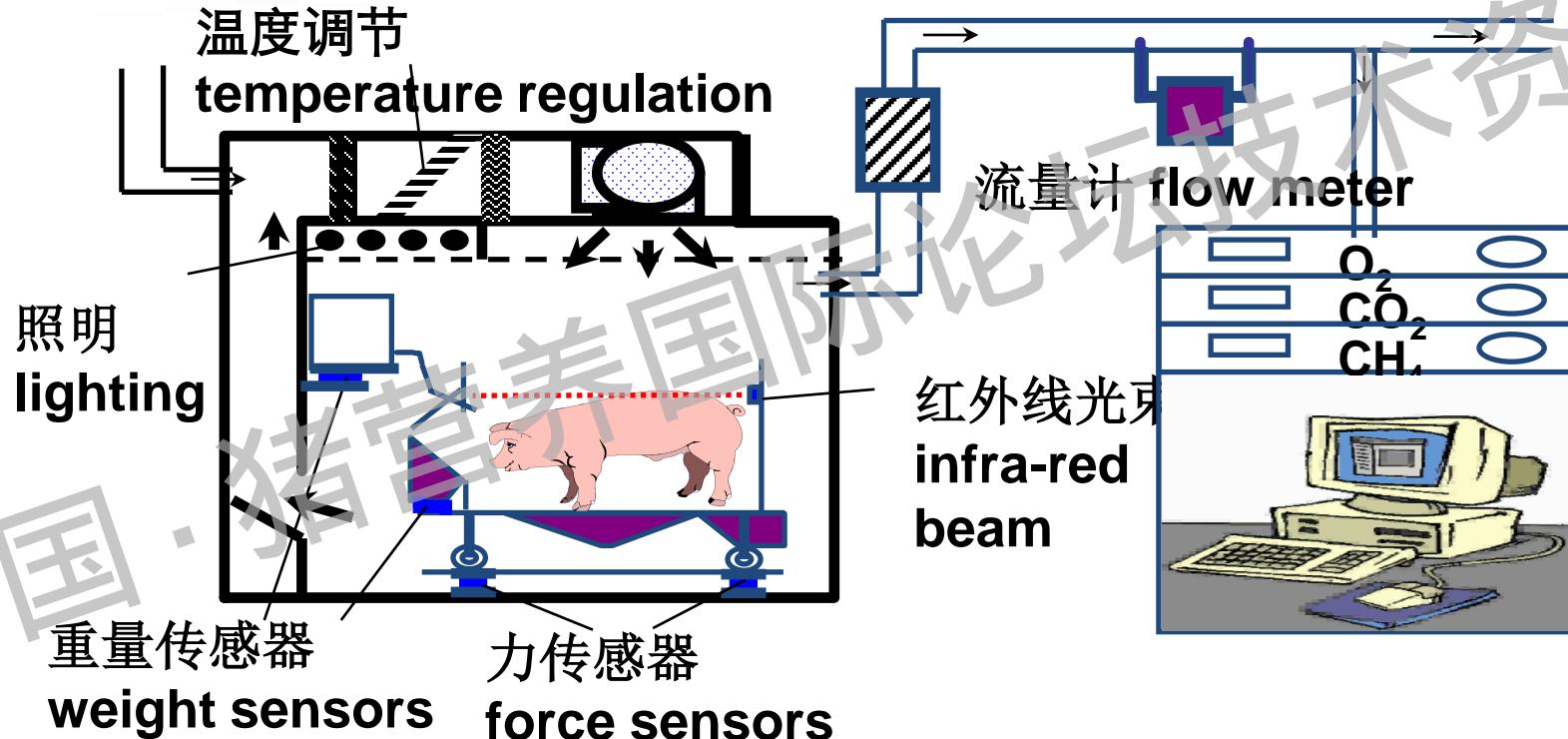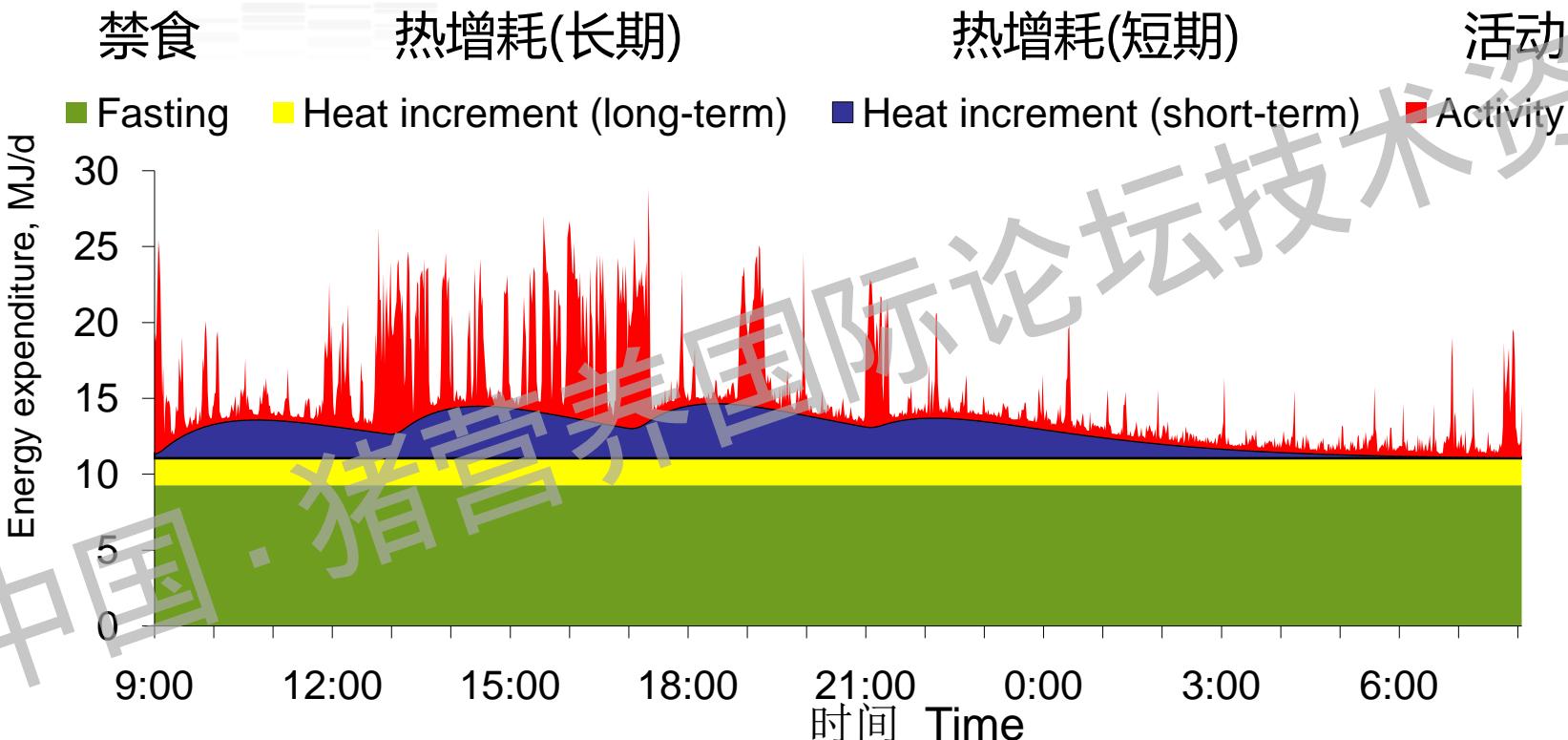
从可消化养分评估能量值
Estimating energy values from digestible nutrients

	消化能DE (kJ/g)	代谢能ME (kJ/g)	净能NE (kJ/g)	ME:DE (%)	NE:ME (%)
蛋白质Protein	23.3	20.4	12.1	88	59
油脂Lipid	38.7	39.3	35.0	101	89
淀粉Starch	17.5	17.5	14.3	100	82
糖Sugars	16.8	16.5	11.9	98	73
纤维Fiber	16.7	15.5	8.6	93	56

Noblet *et al.* (1994) J. Anim. Sci. 72:344-354

饲料原料的优先顺序取决于所用的能量体系
The ranking of feed ingredients depends on the system of expression

	总能GE	消化能DE	代谢能ME	净能NE
玉米Corn (kJ/g)	100 (18.7)	100 (16.4)	100 (16.0)	100 (12.8)
小麦Wheat	97	97	97	94
高粱Sorghum	101	100	100	99
豆粕Soybean meal	105	102	95	72
麦麸Wheat bran	101	65	63	56
豆油 Soy oil	210	203	207	232

Sauvant *et al.* (2004) Tables of composition and nutritional value of feed materials

INRA
SCIENCE & IMPACT

AGRO CAMPUS OUEST

大纲 Outline

能量转换的化学计量
Stoichiometry of energy transactions

氨基酸
Amino acids

油脂
Lipids

碳水化合物
Carbohydrates

代谢中间产物
Intermediary metabolism

氨基酸
Amino acids

油脂
Lipids

三磷酸腺苷
ATP
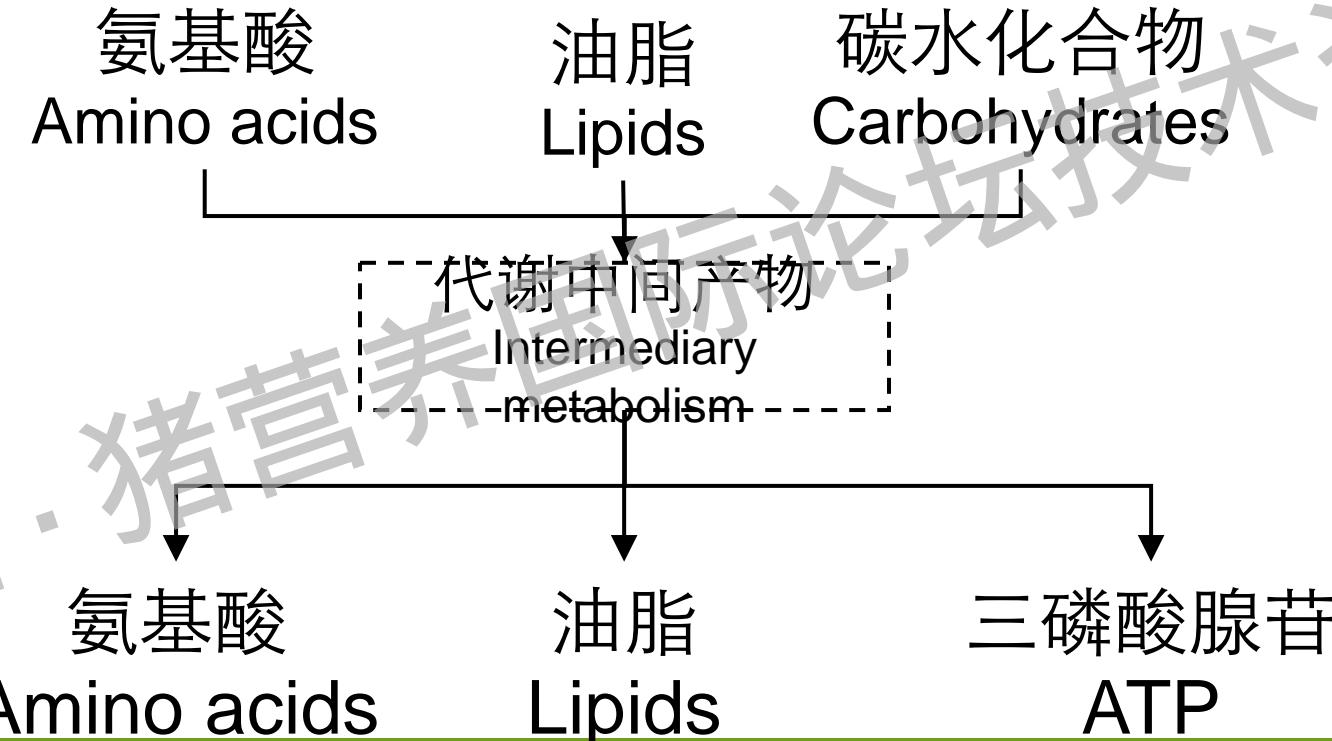
合成ATP的理论效率
Theoretical efficiency of ATP synthesis
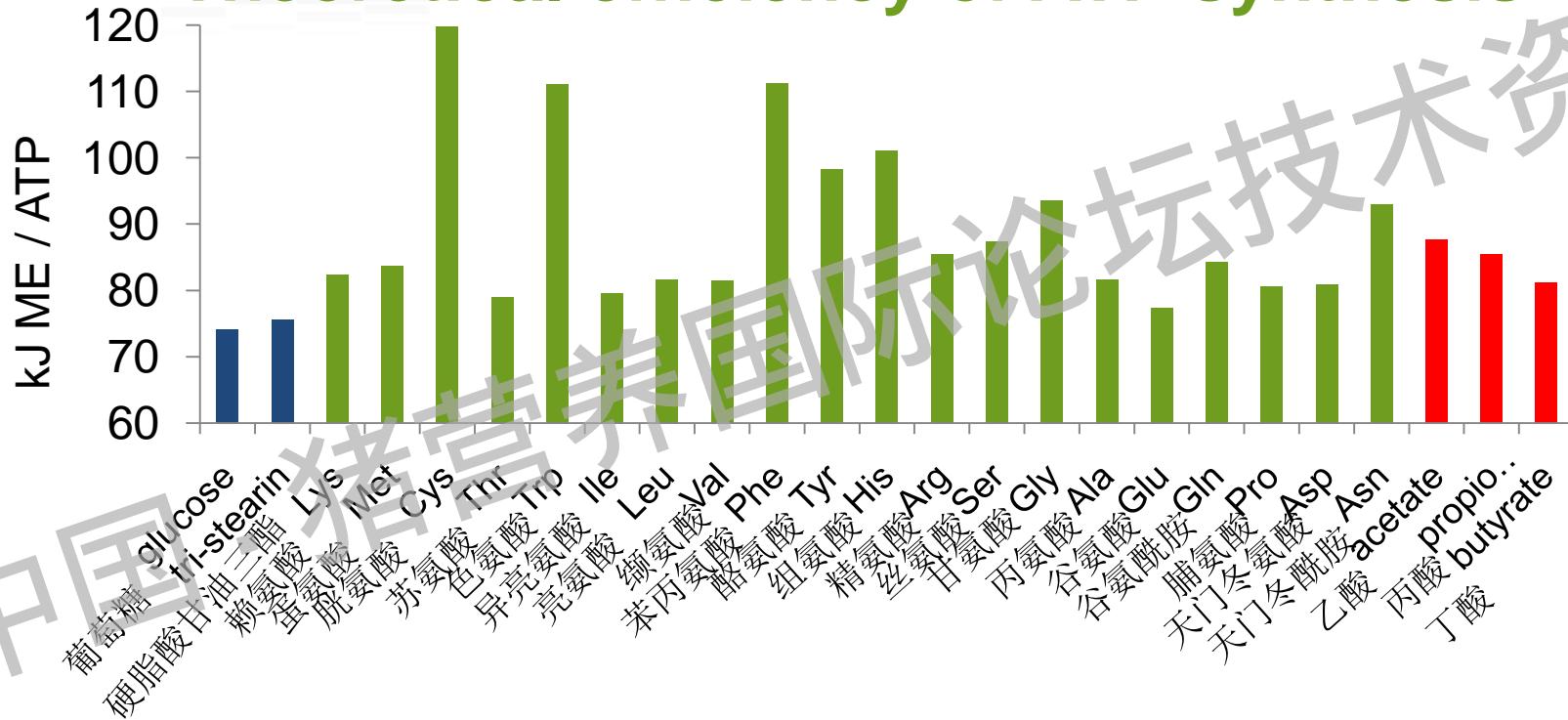
van Milgen (2002) J. Nutr. 132:3195-320

营养转换效率
Efficiency of nutrient transformations

	理论值Theoretical	实测值 Experimental
淀粉-油脂 Starch → Lipid	0.84	0.84
油脂-油脂 Lipid → Lipid	0.97	0.88
蛋白质-油脂 Protein → Lipid	0.67*	0.52
蛋白质-蛋白质 Protein → Protein	0.87*	0.60

*不含蛋白质周转 no protein turnover

van Milgen (2002) J. Nutr. 132:3195-320

Energy utilization and energy systems
Jaap van Milgen
Chinese Swine Industry Symposium, October 30-31, 2014

结论 Conclusions

❖ **母猪对能量的消化率大于生长猪** **Energy digestibility is greater in sows than in growing pigs**

❖ **效率是代谢能体系中能量需求的一部分，也是净能体系中能量值的一部分** **Efficiency is part of the energy <u>requirement</u> in an ME system and part of the energy <u>value</u> in an NE system**

❖ **饲料原料的优先顺序取决于所用的能量体系**The relative ranking of feed ingredients depends on the system of expression

❖ **有相当一部分的热增耗和能量效率可以用生物化学来解释**

A considerable part of the heat increment and energy efficiency can be explained by biochemistry

Freely available from
www.evapig.com