Recent Developments in Net Energy Research for Pigs

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Introduction (1)

- Cost of feed > 50-60% of cost of pig meat production
- Energy is the main feed cost
- More and more ingredients are available + competition between animal species, with biofuels, with humans, etc.
- Feed composition has an obvious impact on animals performance and economical results
- Pigs (genetics, sex, BW, health, …), environmental conditions (T, …) and production objectives are variable
- New challenges and constraints (↘ pollution, …)

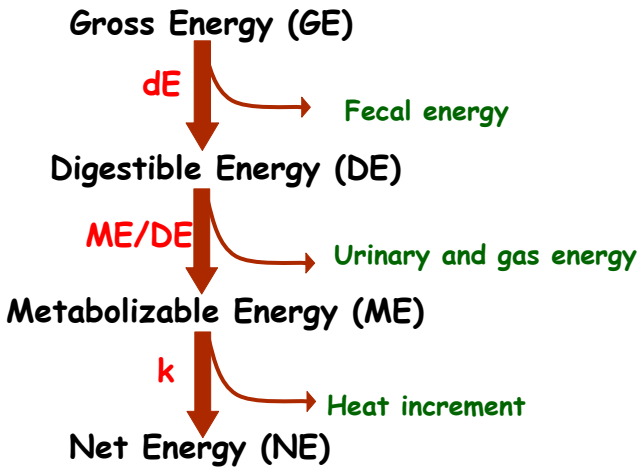
Introduction (2)

- Nutritional values: precise hierarchy ⇨ New concepts?
- Recommendations : variable ⇨ Factorial approach + modeling
- Coherence of nutritional values and nutrient requirements
- Precise animal requirements and feed nutritional values are necessary

What new on (net) energy for swine?

Methods for evaluating energy in pig feeds

Energy utilization



Effect of BW on dE (1) (4 diets)

BW, kg	DM intake, g/d	Energy digestibility, %
38	1250	82.6
49	1680	83.0
61	1940	83.6
72	2015	84.2
80	2060	84.8
90	2120	85.3
35-95	1845	83.6

Fecal digestibility measurements should be carried out in 60-70 kg BW pigs (/20-100kg)

Effect of BW on dE (2)

BW, kg	45	100	150
Mean (7 diets)	83.2	85.5	86.3
Starch rich diet	90.6	91.6	92.0
Fiber rich diet	71.6	75.6	78.0

Effect of BW is dependent on feed characteristics

Effect of physiological stage on dE (n=77)

Stage	Growing	Adult
BW, kg	61	234
DM intake, g/d	1854	2104
dE, %	82.1	85.2

The difference between young and adult pigs should be considered in energy evaluation systems

Effect of physiological stage on dE

Trial (n diets)	1 (14)		2 (77)	
Stage	Growing	Adult	Growing	Adult
BW, kg	43	208	61	234
DM intake, g/d	1373	1485	1854	2104
dE, %	75.8	84.7	82.1	85.2

The difference between young and adult pigs should be considered in energy evaluation systems

 Noblet and Shi, 1993; Le Goff and Noblet, 2001

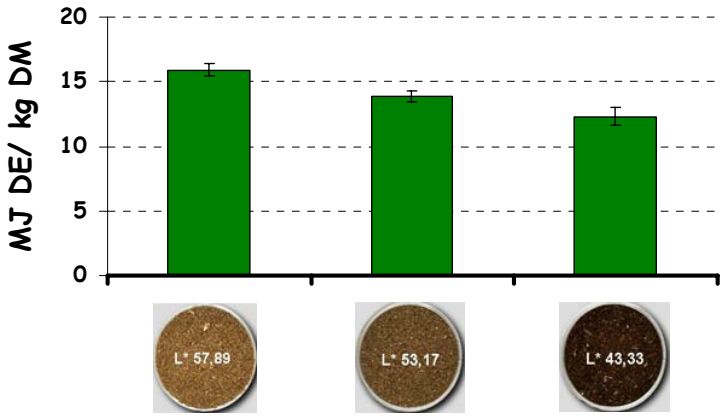
Effect of technology on dE

Technology	Mash		Pellet
Wheat-SBM diets (n=2)	88.6	*	89.2
Corn-SBM diets (n=3)	88.4	**	90.3
Corn (n=5)	87	**	90
Full-fat rapeseed	35	**	83
Linseed (extrusion)	51	**	84

Technology affects dE; it has to be considered in energy evaluation of feeds for swine

 INRA data

Effect of technology on DE value of wheat DDGS



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Effect of ash content on dE

Minerals, %*	1.0	4.0	7.0
Ash, % DM	4.6	7.2	9.8
dN, %	85.4	82.4	81.7
dE, %	85.5	83.2	82.4

* *Calcium carbonate + dicalcium phosphate*

Minerals level should be kept constant in diets for measuring digestibility (difference method)

ASAS 2008 | Energy systems | J Noblet, unpublished

Urinary and gas energy

- In the growing pig:
  - E urines, MJ/kg DM=0.19+0.031xN urines (g/kg DM)
    (N urines = 50% digestible N)
  - E methane # 0.4% of DE (related to fermented energy)
- In the adult pig:
  - E methane # 2-3 times higher than in growing pigs

Urinary energy should be calculated; methane energy is estimated (or neglected in young pigs)

 Le Goff and Noblet, 2001; Noblet et al., 2004

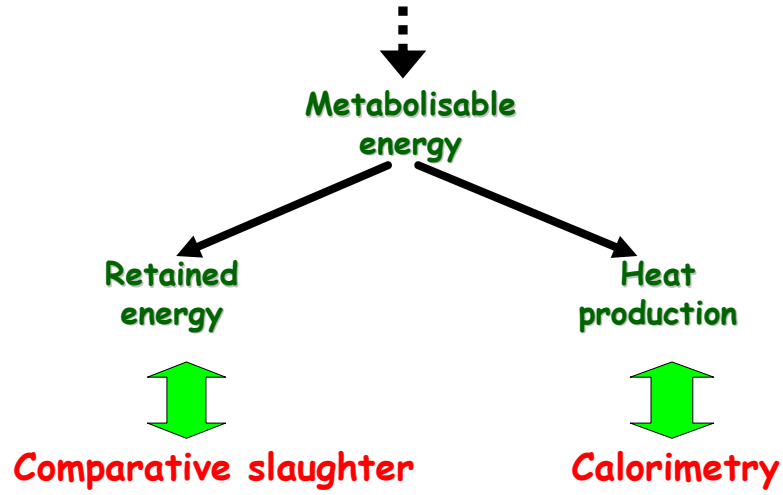
Methodological aspects of DE and ME measurements

- dE is affected by
  - BW
  - Technology
  - Ash
  - Gut health
  - Etc.

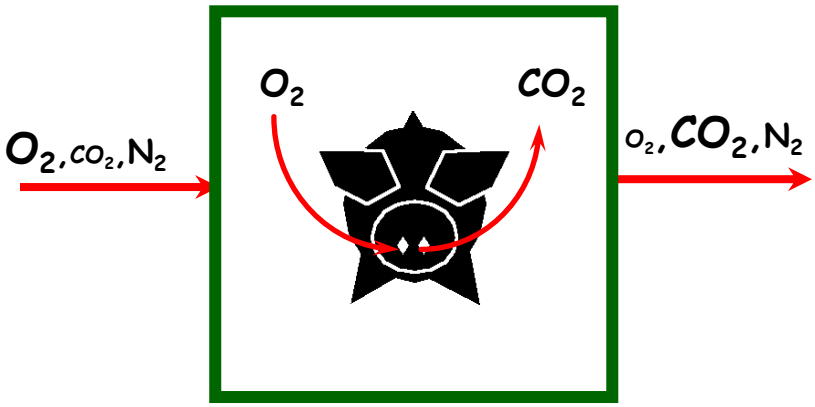
→ Conditions should be standardized

- Methods: total collection, markers, in vitro, NIR, prediction equations, etc.
- ME can be estimated from DE values

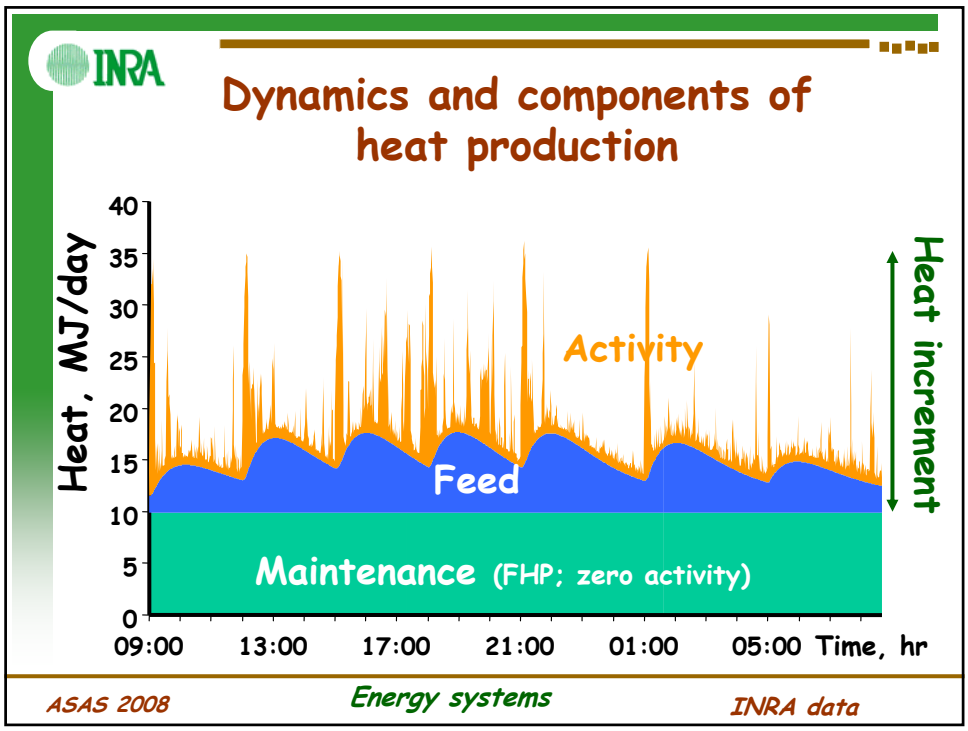
Utilisation of energy



Indirect calorimetry



Heat production = f(O2, CO2, ….)


INRA
Dynamics and components of heat production
Heat, MJ/day
40
35
30
25
20
15
10
5
0
Activity
Feed
Maintenance (FHP; zero activity)
Heat increment
09:00
13:00
17:00
21:00
01:00
05:00
Time, hr
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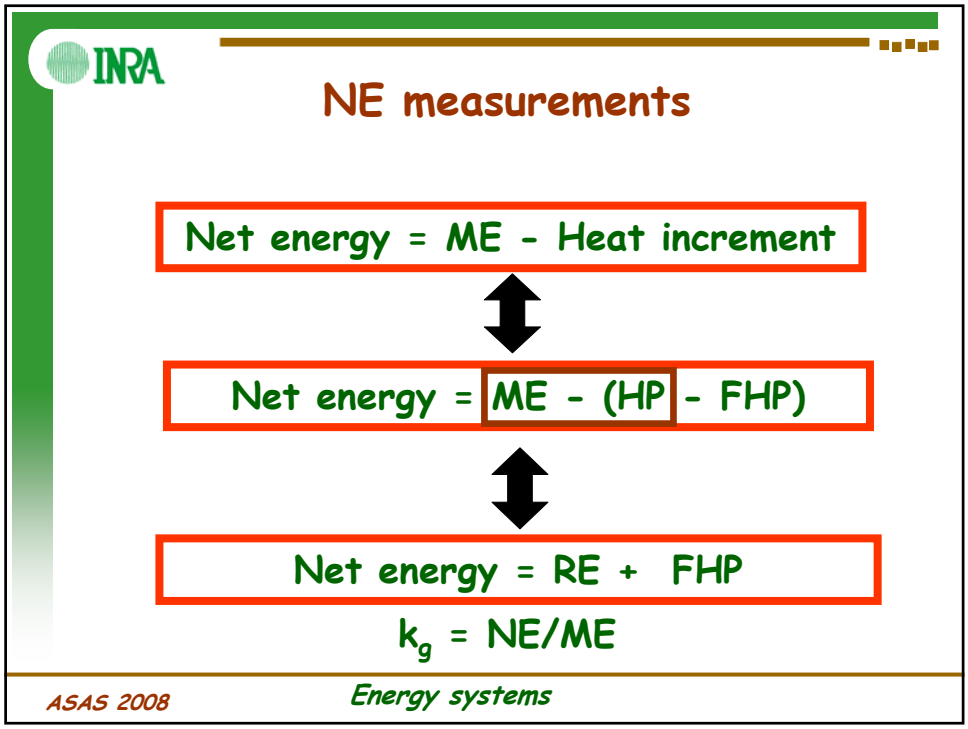
INRA data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NE measurements
Net energy = ME - Heat increment
Net energy = ME - (HP - FHP)
Net energy = RE + FHP
k_g = NE/ME
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Methodological aspects of NE measurements

- NE is related to FHP values and amount and composition of energy gain ➔ genotype, BW, sex, feeding level, diet balance (AAs), environment conditions, behavior, etc. have to be standardized for measuring NE values
- NE values measured or calculated under different conditions are not comparable
- Validation of a NE system is necessary
- INRA system: 45 kg boars; indirect calorimetry; FHP = 750 kJ/kg $BW^{0.60}$; n=61 diets; evaluated in heavier pigs and adult sows

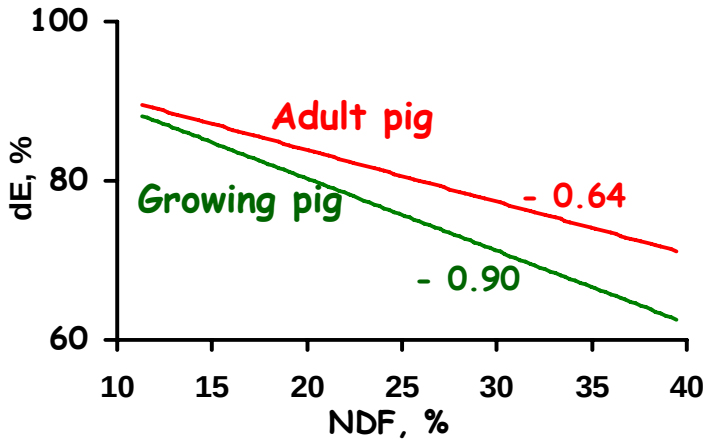
Energy evaluation of pig feeds

Contribution of nutrients to energy supply in growing pigs (kJ/g) (77 diets)

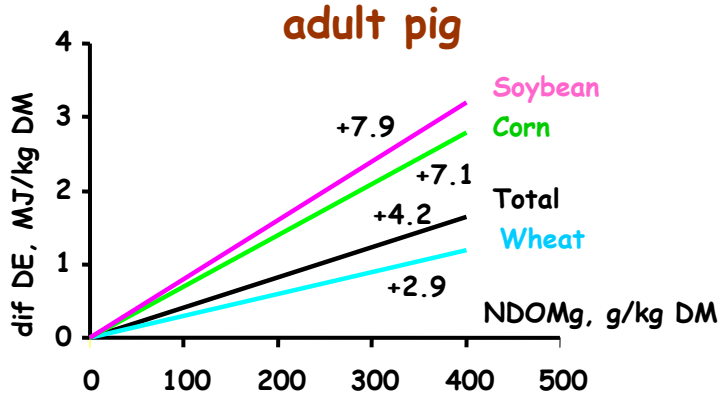
	CP	EE	ST	NDF
Gross energy	22.7	38.8	17.4	19.0
DE growing pig	22.5	31.7	17.2	3.2
DE adult pig	22.5	31.7	17.2	6.4

Fat affects energy concentration
Dietary fiber is a major factor of variation of DE
Two energy values for adult and growing pigs

Digestibility of energy in growing and adult pigs (n=77)



Digestibility of energy in the adult pig



NDOMg: Undigestible organic matter in the growing pig
dif DE = DE adult pig – DE growing pig (MJ/kg DM)

Digestibility of energy in growing and adult pigs

	Growing	Adult	Δ, %dEg
Wheat	87.6	89.2	+1.8
Corn	87.9	91.4	+4.0
Soybean meal	85.2	90.4	+6.2
Wheat bran	56.7	62.7	+10.4
Corn gluten feed	65.6	76.4	+16.5
Soybean hulls	51.4	70.3	+36.8

Metabolic utilization of energy

- k_g , % = 74.7 + 0.009 x Starch + 0.036 x EE - 0.023 x CP - 0.026 x ADF
  - *In "40 kg" growing boars, 130 g daily protein gain, 2.2 x MEm, 22°C, 61 diets*
  - *Chemical composition: g/kg DM*
- The coefficients of the equation are not affected by pig BW (Protein:Fat) and physiological stage (maintenance vs growth)

The same NE system/equation can be used at all stages of pig production

Efficiencies of utilization of ME of nutrients (k_g, %)

Crude protein	58
Crude fat	90
Starch	82
Dietary fiber	58

- Comparable (relatively) in the growing pig and in the adult sow (at maintenance)
- No effect of BW/composition of BW gain on efficiencies
- Values confirmed in recent trials and with different methodologies

Estimation of NE content (MJ/kg DM)

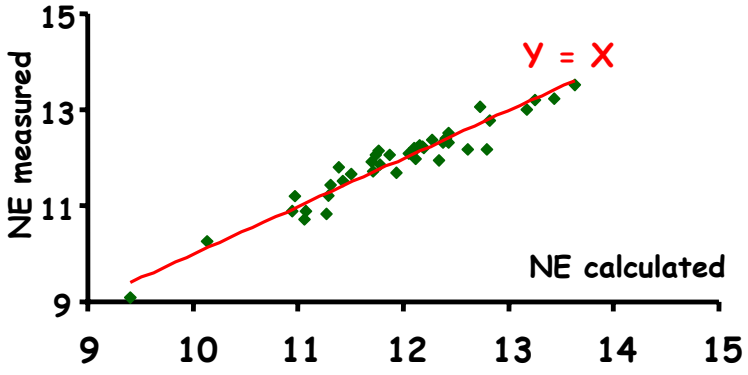
NE2 = 0.0121 DCP + 0.0350 DEE + 0.0143 Starch
+ 0.0119 Sugars + 0.0086 DRes (RSD = 0.25)

NE4 = 0.703 DE + 0.0066 EE + 0.0020 Starch
- 0.0041 CP - 0.0041 CF (RSD = 0.18)

NE7 = 0.730 ME + 0.0055 EE + 0.0015 Starch
- 0.0026 CP - 0.0041 CF (RSD = 0.17)

Equations
- can be used at all stages of pig production
- applicable to compound feeds and ingredients
- have been validated

Validation of NE equations (n = 41)



Dietary crude protein and energy utilization in growing pigs

	Diet 1	Diet 2	Diet 3
CP, %	11.7	22.6	23.1
Lysine, g/d	10.2	11.0	27.3
N gain, g/d	19.8	19.6	30.0
Heat production*	1.33[a]	1.42[b]	1.42[b]
Retained Energy*	1.23[a]	1.13[b]	1.13[b]

*$MJ/kg^{0.60}$; adjusted for the same ME intake

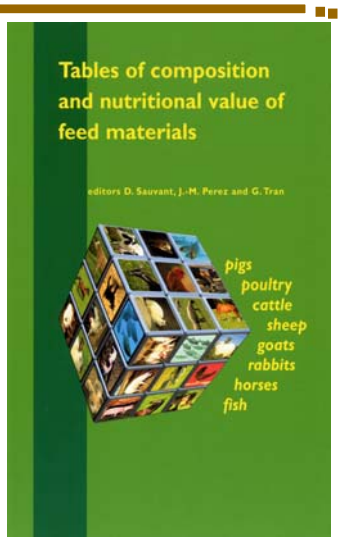
No effect of final use of CP on efficiency

Contribution of nutrients to energy supply (in growing pigs; % of starch)

	Starch	Fat	Crude protein	Dietary fiber
Gross energy	100	221	129	106
DE	100	174	123	3
ME	100	177	109	3
NE	100	195	80	-6

INRA & AFZ feeding tables

Languages: French, English, Spanish, Chinese



More info at:
http://www.zootechnie.fr/tables/index.htm

Six energy values per ingredient

- DE, ME and NE for growing pigs (+ piglets)
- DE, ME and NE for adult pigs (pregnant and lactating sows)

A software will be proposed soon

Comparison of energy systems

Comparison of energy systems*

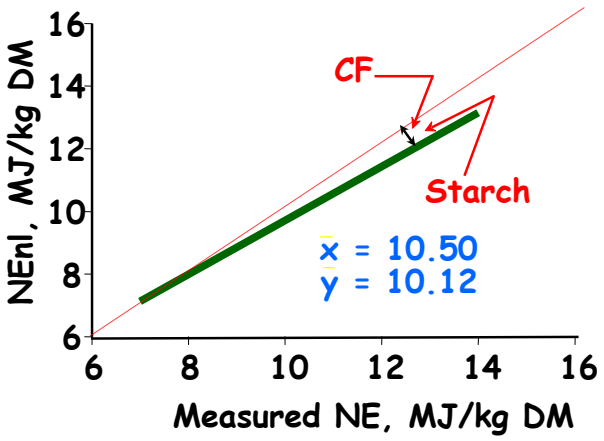
	DE		ME		NE	NE/ME
Ingredients						
Fat	243	+	252	++	300	90
Corn	103	=	105	+	112	80
Wheat	101	=	102	+	106	78
Pea	101	=	100	-	98	73
Wheat bran	68	=	67	-	63	71
Soybean meal	107	-	102	- -	82	60

** As % of the energy value of a compound feed (wheat: 67%, soybean meal: 16%, fat: 2.5%, wheat bran: 5%, peas: 5%, …)*

Hierarchy between feeds is dependent on energy system

Comparison of NE systems

(n = 61 diets; MJ/kg DM)



Performance of growing pigs according to energy evaluation system (1)

CP, %	19.0		14.6
Amino acids	+		+++
Energy intakes, MJ/d*			
DE	38.9[a]	>>	37.3[b]
ME	37.1[a]	>	36.1[b]
NE	27.6	=	27.5

Energy intakes 30-100 kg and adjusted for the same BW gain (1080 g/day) and the same body composition at slaughter

Performance of growing pigs according to energy evaluation system (2)

Fat addition, %	0	2	4	6
Feed : gain*				
MJ ME/kg	100	100	99	98
MJ NE/kg	100	100	100	100

**Adjusted for the same feeding level*

NE requirements

- Most energy requirements have been established on DE or ME bases with cereals based diets (k_g # 75%)
- No interaction between stage of growth or feeding level and diet composition on k_g ➔ The same equations can be used at all stages
- NE requirements can be expressed as NE for growth at all stages

➔NE = 0.75 x ME or 0.72 x DE

Conclusions (1)

- Energy value (Ed mainly) is dependent on methods/conditions used for its determination
- At least two energy values should be used for pig feeds: piglet + growing + finishing *vs* adult pig
- Hierarchy between feeds and least cost formulation results depend on energy system
- The importance of a "reliable" energy system is emphasized when more non conventional ingredients (co-products, etc.) are available

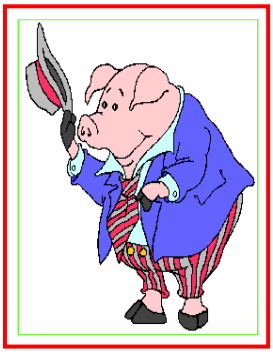
Conclusions (2)

- NE system is better for a satisfactory estimate of "true" energy value of feeds and pigs performance
- Energy value of feeds for pigs is highly dependent on digestibility ➔ Improvement of knowledge
- Effects of technology, enzymes, ….?
- An accurate protein evaluation system is also necessary: "standardized" ileal digestible amino acids

Future?

- To implement available knowledge!
- To be careful in using (digestibility) methods!
- To improve knowledge and technologies on utilization of dietary fiber
- Multi-formulation: feeds vs all animal species
- Resources are limited/demand: To improve the output(meat):input (feed, energy, C, etc.) ratio in connection with social demand
- ???????

Thanks:



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