Componenti della razione e salute del tratto gastrointestinale: Recenti progressi in tema di alimentazione e nutrizione del suino

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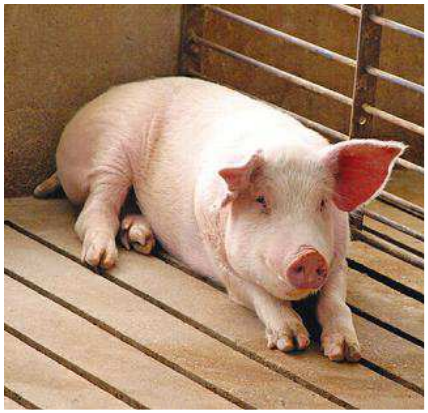
SIPAS, Lazise, October 2013



Pig production

Objectives

- ✓ Reduce cost of production
  - ✗ Piglets/sow per year > 27
  - ✗ ADG (20 to 108 Kg) > 800 g; IC < 2.45
- ✓ Improve carcass and meat quality traits
- ✓ "Social requirements"
  - ✗ Food safety
  - ✗ Sustainability and environment
  - ✗ Animal welfare

Pig production, Spain
Conventional white pigs

- ✓ Fresh products (butcher)
- ✗ Slaughtered at 105-108 kg BW
- ✗ Mostly entire males
- ✗ Pietrain and meat type sires
- ✓ Dry cured industry
- ✗ Slaughtered at 115-125 kg BW
- ✗ Castrated males (females?)
- ✗ Increased use of Duroc sires

Pig production, Spain
Iberian pigs

- ✓ Close to 300,000 sows
- ✗ 650,000 in 2007
- ✓ Extensive production (25 or 90 kg BW to slaughter)
- ✗ Slaughtered at 150-165 kg BW
- ✗ Males and females castrated
- ✗ IB or Duroc sires
- ✓ Intensive production
- ✗ Slaughtered at 140-148 kg BW
- ✗ Duroc sires
- ✓ Good segmentation of the market


¡GRACIAS!
20,95
9,10
17,75
8,05
10,70
13,05
11,65
6,30
21,00
59,95
18,95
47,95
10,65
12,10
9,60
7,80
10,50
6,95
12,00


JAMON IBÉRICO BELLOTA
AL CORTE 5 J
SANCHEZ ROMERO
149,00 €

Swine industry, EU-27
Relative production, 2011

	BW kg	FCR (g/g)	Mortality (%)	Weaned (sow/year)
Spain	**108**	**100[1]**	**100[2]**	**100[3]**
Italy	**165**	**125**	**41**	**95**
Denmark	**107**	**99**	**97**	**117**
France	**116**	**100**	**84**	**108**
Netherlands	**116**	**93**	**66**	**115**
Germany	**121**	**101**	**82**	**104**
Iowa	**123**	**104**	**93**	**99**

[1] 2.90; [2] 6.8% from weaning; [3] 24.6 piglets

Interpig, 2013

Reducing feeding cost

Strategies

- ✓ Design feeding programs to meet the physiological needs of the pigs
- ✓ Re-check on limits imposed in the diet to:
- ✗ Fats, small grains, and fibrous ingredients
- ✓ Improve quality control of raw materials
- ✗ Soybean, fats, DDGS, food by-products
- ✓ Reduce safety margins in feed formulation
- ✗ NE *vs.* ME systems; SID vs. total AA
- ✗ Dig. P vs. available P
- ✓ Judicious use of additives

SBM, 47% CP
Energy content, pigs

Institut.	Year	CP (%)	AMEn (kcal/kg)	NE (kcal/kg)
INRA	2002	47.2	3,290	2,000
Japan[1]	2009	47.1	3,190	1,995
Fedna	2010	47.0	3,200	2,000
NSWG	2010	47.5	3,380	1,995
CVB	2011	47.5	-	1,980
Brazil[1]	2011	47.1	3,220	2,035
NRC	2012	47.7	3,294	2,087

[1] Avge of 2 types. Calculated NE from DE. SID ≈ 90%

SBM, 47% CP
Lys content, pigs%

Instit.	Year	CP (%)	SID Lys (%)
INRA	2002	47.2	2.66-92
Japan[1]	2009	47.1	2.75-xx
Fedna	2010	47.0	2.59-90
NSWG	2010	47.5	2.72-90
CVB	2011	47.5	2.63-89
Brazil[1]	2011	47.1	2.63-91
NRC	2012	47.7	2.63-89

[1] Avge of 2 types
2 Calculated NE from DE. SID ≈ 90%

SBM, 47% CP
Proximal analyses, %

	INRA (2002)	Japan (2009)	Fedna (2010)	Brazil (2011)	CVB (2011)	NRC (2012)
Moist.	12.4	10.1	12.0	10.8	12.0	10.0
CP	47.2	49.1	47.0	48.1	47.0	47.7
EE	1.5	1.3	1.9	1.5	1.7	1.5
Ash	6.3	6.4	6.2	5.7	6.1	6.3
NDF	8.9	8.6	9.1	14.9	9.2	8.2
Σ	76.3	75.5	76.2	81.0	76.6	73.7

What is missing?

SBM survey (2007-2013)
Laboratory analyses, 88% DM

	n	CP	CF	NDF	EE
ARG	156	45.5^{c}	4.7^{b}	9.2^{b}	1.7^{ab}
BRA	144	46.7^{b}	5.5^{a}	10.5^{a}	1.8^{a}
USA	179	47.3^{a}	3.7^{c}	7.8^{c}	1.6^{b}
SEM		0.12	0.08	0.13	0.04
P		***	***	***	*

SBM survey
Mineral and sugar content, %

	Ash	P	Fe[1]	Sucrose	Oligo.[2]
ARG	6.6[a]	0.66[b]	110[b]	6.7[b]	6.1[b]
BRA	6.3[b]	0.61[c]	167[a]	5.7[c]	6.0[b]
USA	6.6[a]	0.69[a]	112[b]	7.3[a]	6.7[a]
SEM	0.04	0.004	3.8	0.08	0.03
P	***	***	***	***	***

[1] mg/kg
[2] Stachyose + raffinose

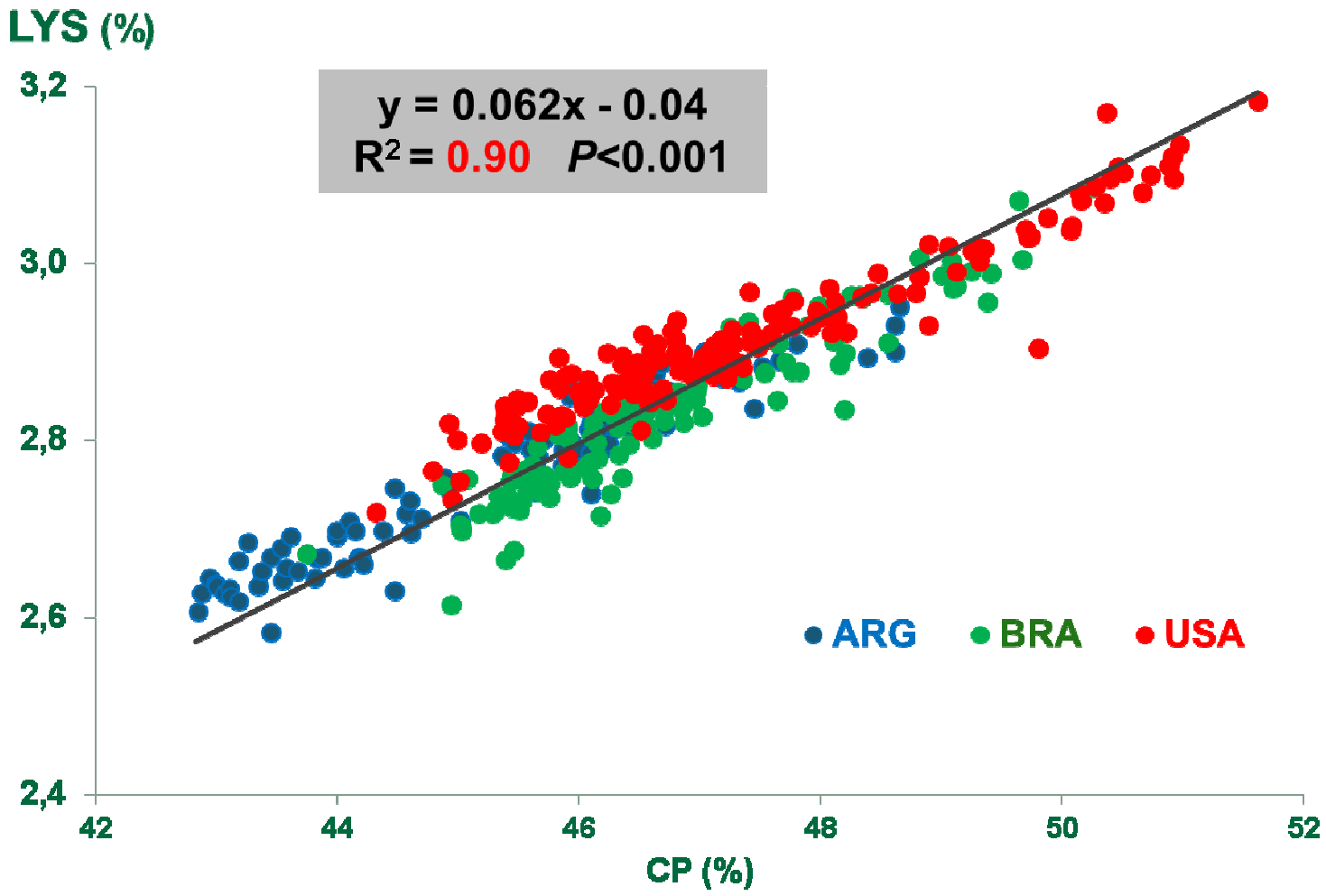
SBM survey

Amino acid profile SBM (% CP)

	ARG	BRA	USA	SEM	*P*
n	151	138	175		
Lys	6.09^{b}	6.05^{c}	6.16^{a}	0.005	***
Met	1.37^{a}	1.33^{b}	1.36^{a}	0.002	***
Cys	1.51^{a}	1.48^{b}	1.50^{a}	0.004	***
Thr	3.93^{a}	3.88^{b}	3.91^{a}	0.003	***
Trp	1.37^{a}	1.34^{c}	1.36^{b}	0.001	***

SBM, all origins (n=403)

LYS:CP ratio



SBM survey
Protein quality[1]

	n	TIA[2] (mg/g)	PDI (%)	KOH (%)	HDI (AmiRed)
ARG	132	2.5[b]	16.4[b]	81.6[c]	12.5[b]
BRA	135	2.6[b]	15.3[c]	82.6[b]	15.6[a]
USA	172	3.1[a]	19.7[a]	86.6[a]	8.8[c]
SEM		0.05	0.35	0.33	0.42
P		***	***	***	***

[1] Urease < 0.03 g N/g for all origins ($P < 0.01$)
[2] Kakade method (88% DM basis)

SBM in broilers[1]
SID of CP *vs.* protein quality

Variable	*r*	*P*
Crude protein	+ 0.51	0.05
TI activity	+ 0.54	0.01
Reactive Lys	+ 0.56	0.01
KOH solubility	+ 0.70	0.001

[1] n = 22 (Arg, Bra, USA)

Frikha *et al.*, 2012

Piglet feeding

- ✓ **Weaning effects**
  - × **↓ Feed intake**
  - × **↓ Endogenous enzyme production**
  - × **Atroply of the villous of the mucose**
- ✓ **Feeding programs, objectives,**
  - × **Quick access to feed and water**
  - × **Insure high feed intake**
    - • **↑ Management and feeding practices**
  - × **Keep cost under control**
- ✓ **Practical application**
  - × **Complex diets for the first days after weaning**
  - × **Corn-SBM diets in 12 kg BW pigs**

Weanling pigs
Villus development[1]

Author	Energy intake	Weaning age, d	Villus height, %
Pluske *et al.*, 1996 a	High	28	- 30
Pluske *et al.*, 1996 b	Medium	29	- 18
Kelly *et al.*, 1991	Low	14	- 55
Van Beers, 1998	Medium	28	- 40
Mateos *et al.*, 2002	High	24	- 31

[1] Relative reduction 4 to 6 d post-weaning

Main cereal of the diet

- ✓ Nutritionists from different countries show:
- ✗ Preferences for a specific cereal in the diet
- ✗ Limit the use of "unfamiliar" cereals
- ✓ All cereals (corn, wheat, barley, and sorghum) produce similar performance, even at high levels of inclusion, if well evaluated
- ✗ No limits for cereals in diets for swine
- ✗ Rice might be a prefered choice in piglets
- ✓ Heat processing improves nutrient digestibility and might improve FCR and BWG at weaning

Starch for piglets

Digestibility of starch is high but not complete

- **Higher for cereals than for legumes**
  - **Starch structure**
- **Better for rice than for corn**
  - **Granule size and structure**
- **Best if processed**
  - **Gelatinization**
  - **Release of starch granules from matrix**

Rice feeding and growth, g/d
Piglets, 21 to 31 d

Cereal[2]	Oat hulls[1] (%)			Avge
	0	2	4	
Rice	307	328	324	320[a]
Corn	306	273	276	285[b]
Avge	307	301	300	

[1] Interaction cereal x OH ($P < 0.05$)
[2] Cooked

Mateos *et al.*, 2006

Cereals processing
Piglets, 31 to 41 d

	Oat hulls	ADG[1] (g)	ADG (g)	FCR (g/g)
Cooked corn	-	409	702	1.71
	+	441	702	1.59
Cooked rice	-	450	747	1.65
	+	482	729	1.51
Deh. cooked oats	-	391	669	1.71
	+	455	759	1.66

[1] Fiber effect: P<0.01

Mateos et al., 2006

Cereal processing[1]

Piglets, 22 to 32 d

	BWG (g)	FCR
Cereal		
Barley	112[a]	1,85[a]
Maize	137[b]	1,51[b]
H at proc.		
Raw	114[a]	1,77
Cooked	135[b]	1,59
Feed form		
Mash	119	1,87[a]
Pellets	129	1,49[b]

[1] No growth promoters

Medel et al., 2004

Pig growth, 22-32 d
Main effects[1]

	22-32 d		32-42 d	
	ADG (g)	FCR (g/g)	ADG (g)	FCR (g/g)
Feed form				
Mash	119	1.87[a]	365	1.40[a]
Pellets	129	1.49[b]	386	1.13[b]
Cereal processing				
Raw	114[a]	1.77	378	1.27
Cooked	135[b]	1.59	373	1.27
Main cereal				
Barley	112[b]	1.85[a]	371	1.31
Corn	137[a]	1.51[b]	380	1.23

[1] No growth promoters

Medel et al., 2004

Heat processing Recommendations

- ✓ Only justified in piglets
  - ✗ < 35 - 40 d de edad
- ✓ Improve digestibility
  - ✗ > 70% experiments
- ✓ Not always improves feed efficiency
  - ✗ < 60% experiments
- ✓ Seldam. benefits in growth
  - ✗ < 20% experiments
- ✓ HP of corn vs. HP of rice

Starch gelatinization
Piglets, 25 to 35 d

Cereal	Gelat. (%)	BWG (g/d)	FI (g)	FCR (g/g)
Corn	83.7	618^{b}	407^{b}	1.51
Rice	11.1	681^{a}	459^{a}	1.49
Rice	51.5	680^{a}	482^{a}	1.41
Rice	76.2	672^{a}	456^{a}	1.47
SEM (n=8)		16.3	9.4	0.03

Vicente et al., 2009

Lactose in feed[1,2]
Weanling pigs, 27-39 d

	Lactose (7%)	Lactose (10%)	P
BWG, g/d	276	314	**
ADFI, g	410	429	NS
FCR, g/g	1.49	1.37	+
PWD, %	15.1	10.9	*

[1] No medication or additives in feed
[2] 48 reps (6 piglets each)

Saldaña et al., 2013

Fat digestibility

Piglets

	Relative value, %
Coco oil	98-100
Sunflower/soy oil	95-100
Lard	86-80
Palm oil	83-87
Tallow	78-84
Unsaturated soapstacks	80-85
Saturated soapstacks	60-80

Mateos, 2012

Complex diets[1,2]
Weanling pigs, 21-28 d

	Complex[3]	Standard
BWG, g/d	152	138
ADFI, g	182	172
FCR	1.20	1.25
PWD, %	2.6[b]	4.6[a]

[1] No medication (mortality = 0%)
[2] 6 reps/treatment
[3] 40 vs. 0% heated corn; 14 vs. 7% lactose; 10 vs. 4% fish meal, 72%

Berrocoso *et al.,* 2012

Feed quality (cost)
Pigs, 42-50 d[1]

	Complex[3]	Standard
ADG, g	507	492
ADFI, g	726	693
FCR	1.43	1.49
PWD, %	4.3	4.9

[1] No medication (mortality = 0%) Berrocoso *et al.,* 2012
[2] 6 reps/treatment
[3] 21-42 d of age: 40 vs. 0% heated corn; 14 vs. 7% lactose; 10 vs. 4% fish meal

Nutrient requirements, %
Weanling pigs

	NRC		Fedna	
	(1998)	(2012)	(2006)	(2013)
BW, kg	5-10	7-11	7-12	7-12
NE, kcal/kg	2.450	2.450	2.470	2.460
CP	23.7	20.5[1]	19.0	19.0
Lys	1.35	1.53	1.40	1.43
SID Lys	1.19	1.35	1.25	1.29
Thr	0.86	0.95	0.91	0.91
Ca	0.80	0.80	0.70	0.70
Na	0.20	0.50	0.20	0.22

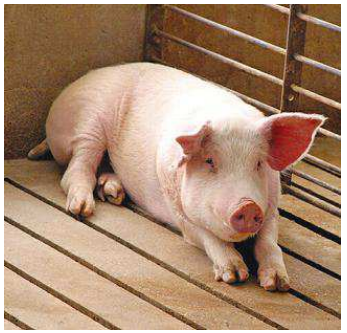
[1]Estimated (N x 6.25)

Ideal protein, % SID Lys

Piglets[1]

	NRC		Fedna	
	(1998)	(2012)	(2006)	(2013)
BW, kg	5-10	7-11	7-12	7-12
SID Lys, %	1.19	1.35	1.25	1.28
	% Lys			
Met + cys	57	55	59	59
Thr	62	58	64	64
Trp	18	16	20	20
Val	68	64	71↓	68
Ile	55	51	58↓	55

Weanling pigs
CP level (< 18.0%)



- ✓ Certain AA (Val, Ile) may be limiting
  - × ↓ Growth and FI
- ✓ Check nutrition standards (SID)
  - × Formulate with at least 6 indispensable AA
  - × ↑ CP, ↑ SBM o ↓ lys
- ✓ Many commercial feeds are not correct
  - × Frequently found: CP < 18.0% but Lys > 1.60%

Iberian pigs, 28-49 d
Diet composition, %

	High	Low
Heated cereals	30	15
Fullfat soya	8	4
Soybean meal	5	16
Fish meal	8	4
Dried whey	12	6
NE, Mcal/kg	2.45	2.45
CP	20.5	18.5
Lys	1.51	1.21

Feed form
Iberian pigs, 28-49 d

	Pellet	Mash	SE (n=18)	P
ADG, g	351	348	10	NS
ADFI, g	496	536	14	*
FCR	1,408	1,538	0.01	***
PWD, %	14.6	11.2		***

Berrocoso et al., 2013

Feed quality
Iberian pig growth, 28-49 d

	High qual.	Low qual.	SE (n=18)	P
ADG, g	340	359	10	NS
ADFI, g	495	537	14	+
FCR, g/g	1,449	1,492	0.015	NS
PWD, %	13.8	12.0		+

[1]Postweaning diarrhea

Berrocoso et al., 2013

Prestarter feed supply
Iberian pig growth, 28-63 d

	Prestarter feeding			SEM	
	7 d	14 d	21 d	(n=12)	P
ADG, g	453^{a}	453^{a}	414^{b}	10	**
ADFI, g	774^{a}	777^{a}	676^{b}	15	***
FCR	1,695^{b}	1,724^{b}	1,639^{a}	0.02	**
PWD, %	6.8^{b}	9.1^{a}	9.0^{a}	-	**

Berrocoso et al., 2013

Diet and microbial growth
Feeding practices

- ✓ Crude protein content of the feed
- ✗ Avoid excess of CP in large intestine
- ✓ Dietary fiber
- ✗ Effects on GIT function and motility
- ✓ Heat processing
- ✗ ↑ Digestibility but also soluble fiber viscosity
- ✓ Antinutritional factores
- ✗ Trypsin inhibitors, glucosinolates, tanins
- ✗ Oligosaccharides?
- ✓ Additives
- ✗ Enzymes, organic acids, pro and prebiotics

Dietary fiber and GIT Piglets

- ✓ **Traditionally, fiber has been considered as a diluent and an antinutritional factor**
  - ✗ **↓FI, nutrient digestibility, and growth**
  - ✗ **↑Microbial growth**
  - ✓ **Recent research indicates that this might not be the case**
  - ✗ **Type, level, and particle size of the fiber source, as well as health status of the piglet, affect the response**

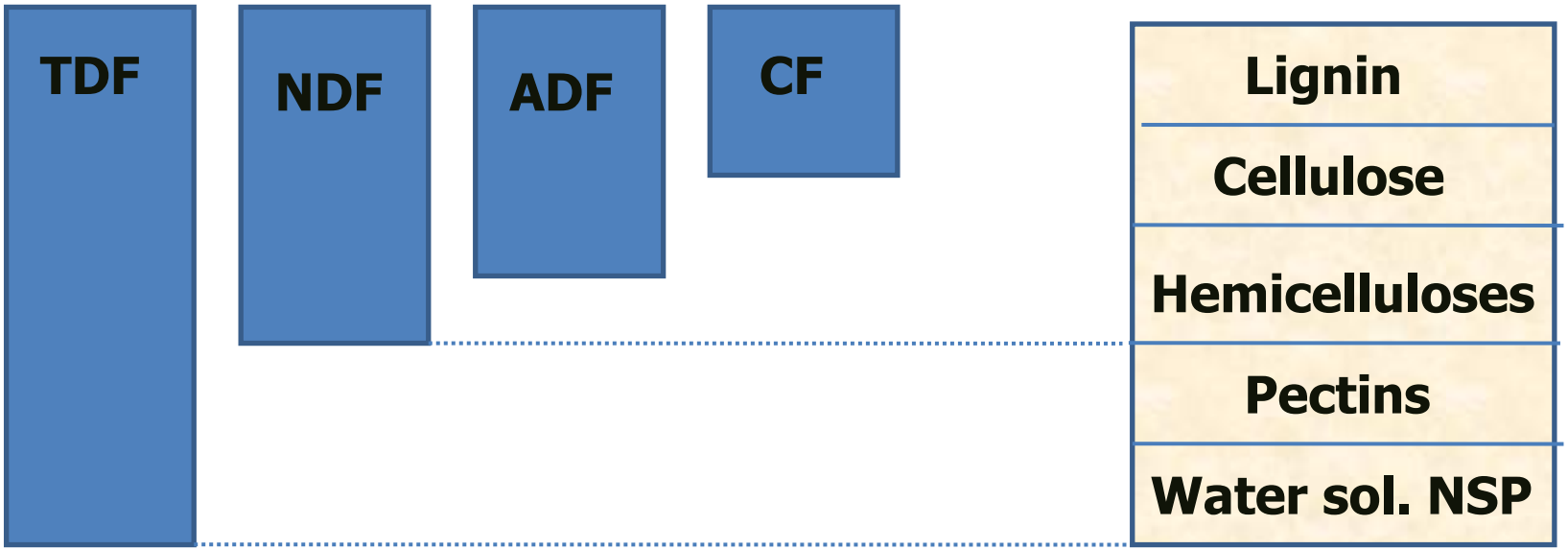
Dietary fiber and GIT

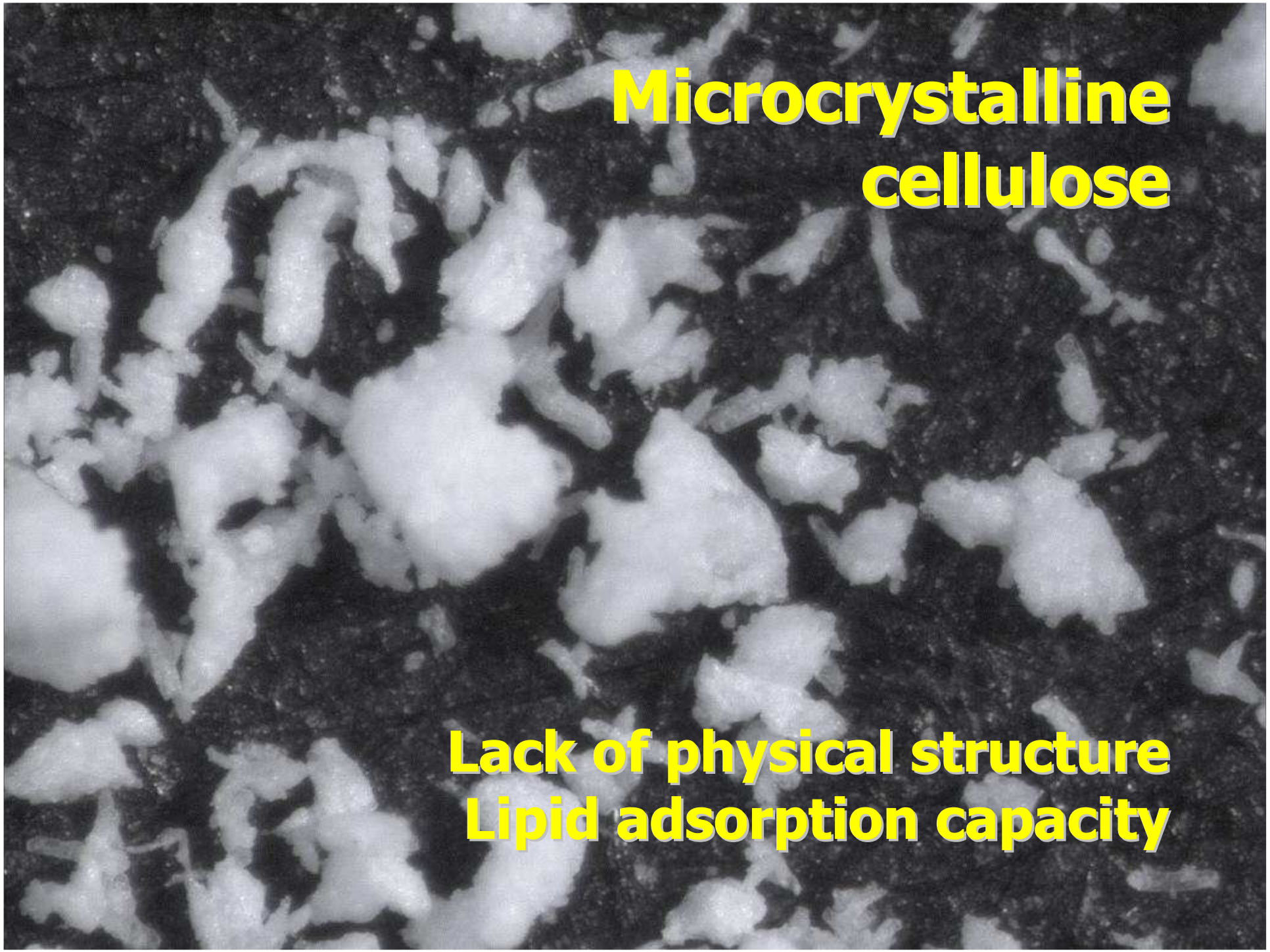
New concepts

- ✓ Dietary fiber might improve gut health and pig welfare
  - ✗ ↓ Consistency of the faeces
  - ✗ ↓ Canibalism and stereotipias
  - ✗ Feed intake regulation
- ✓ Soluble fiber sources can be fermented
  - ✗ ↓ Modifies microbial growth in the hindgut
- ✓ Insoluble fiber sources affect GIT function
  - ✗ Prevent adhesion of pathogens to the epitelial surface
  - ✗ Decrease pH in foregut

Fiber concept

- ✓ Crude fiber (CF)
- ✓ Neutral detergent fiber (NDF)
- ✓ Dietary fiber (TDF)

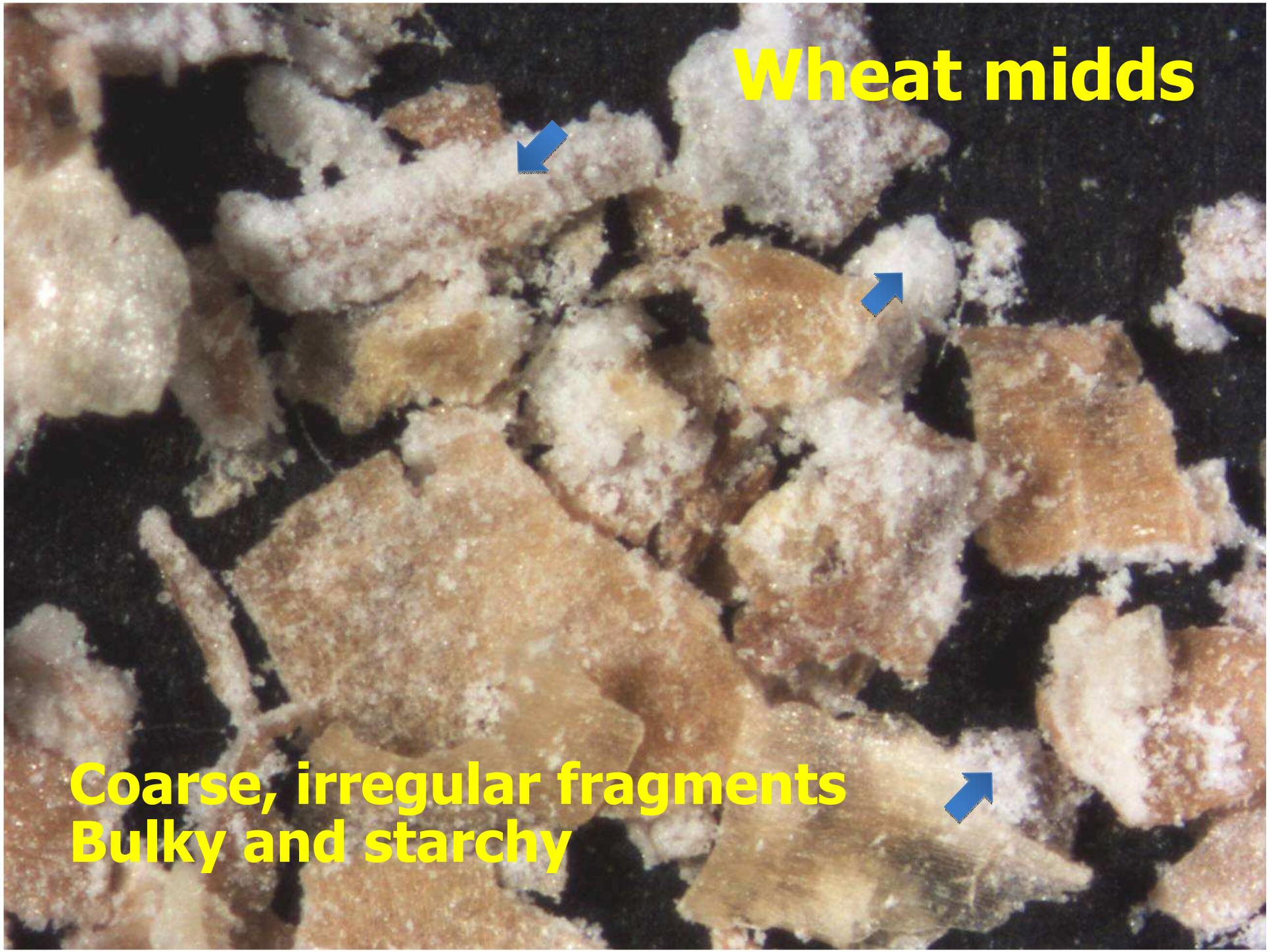



Microcrystalline cellulose
Lack of physical structure
Lipid adsorption capacity


Sugar beet pulp
Fragments are hard and amorphous
High WHC and SWC


Soy hulls
Irregular fragments
Bulky
Low lignin content


Pea hulls
Smooth, relatively curved hulls, and thin plates
Resistant to pressure breakage
High WHC, low SWC, starchy


Wheat midds
Coarse, irregular fragments
Bulky and starchy


Oat hulls
Thick, fusiform, flexible
Resistent to grinding


Sunflower hulls
Highly lignified, bulky
Easily deformed with force
Low resistance to pressure breakage with low moisture content


Cereal straw (NaOH)
Elongated and laminar structure
High rigidity to breakage, abrasive
Low WHC


Rice hulls
Thin, rectangular, smooth edges and sides
Abrasive (silica)

Sugar beet pulp
Piglets

	SBP	
	-	+
Farms, n =	7	7
Litters, n =	71	71
Piglets weaned, n =	678	650
Mortality, %[1]	4.3	4.3
PWD, %[2]	36	21

[1] 3 to 8 wk of age
[2] Litters affected

Goransson, 1995

Fiber inclusion and BWG, g/d
Pigs, 21 to 41 d

Cereal[2]	Oat hulls, %			Avge
	0	2	4	
Rice	307	328	324	320[a]
Corn	306	273	276	285[b]
Avge	307	301	300	

[1] Interaction cereal x OH inclusion ($P < 0.05$)
[2] Cooked

Mateos *et al.*, 2006

Fiber inclusion, clean barn
Pigs, 24-45 d

	BWG (g/d)	ADFI (g)	F:G (g/g)	PWD (%)
Control	560	691	1.234	1.2
Straw	503	636	1.265	1.7
OH	508	628	1.265	2.9
SBP	505	632	1.250	2.8
Wheat bran	535	662	1.234	2.1

[1] Avge of 2.5 and 5% fiber inclusion

Berrocoso et al., 2013

Fiber inclusion, dirty barn
Pigs, 24-45 d

	BWG (g/d)	ADFI (g)	F:G (g/g)	PWD (%)
Control	401	503	1.250	4.8
Straw	384	482	1.250	7.0
OH	409	515	1.265	7.7
SBP	407	514	1.265	5.8
Wheat bran	414	518	1.250	5.8

[1] Avge of 2.5 and 5% fiber inclusion

Berrocoso et al., 2013

Fiber inclusion
Pigs, 24-45 d

	Clean barn	Dirty barn
ADG, g		
Control	560[a]	400
+ fiber	511[a]	403
FCR, g/g		
Control	1.23	1.25
+ fiber	1.25	1.25
PWD, %		
Control	1.2[a]	4.8[a]
+ fiber	2.4[b]	6.6[b]

Berrocoso et al., 2013

Fiber inclusion
Pigs, 24-45 d

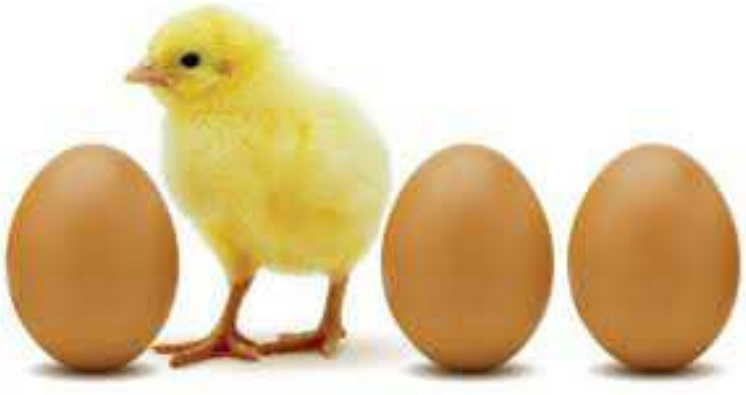
	Clean barn	Dirty barn	P[1]
ADG, g	517	403	***
ADFI, g	646	506	***
FCR, g/g	1.25	1.25	***
PWD, %	2.2	6.4	***

[1] Nine treatments and 4 reps (6 pigs)/ treatment

Berrocoso et al., 2013

Conclusions

- ✓ Management and health status are key factor in farm productivity
- ✓ Nutrition is important but can not “beat” genetics and management
- ✓ The importance of controlling the microbiota profile will increase in the future, especially in farms with a high level of production
- ✓ Avoid “excess of CP” and “defect of dietary fiber”



Thanks

Lysine requirements, %
NRC, 2012 vs. Fedna, 2013

BW[1] (kg)	NRC (1998)	NRC (2012)	Fedna (2006)	Fedna (2013)
5-7	1.50	1.70	1.48	1.53
7-11	1.35	1.53	1.40	1.45
11-25	1.15	1.40	1.31	1.35
25-50	0.95	1.12	1.07	1.10
50-75	0.75	0.97	0.95	0.97
75-100	0.63	0.84	0.90	0.90
> 100	0.58	0.71	0.74	0.74

Mineral requirements, %
Pigs, 10-20 kg

	Fedna (2006)	NSNG (2010)	NRC (1998)	NRC (2012)
BW, kg	12-22	11-20	10-20	11-25
Ca	0.70	0.75	0.70	0.70
Total P	0.62	0.65	0.60	0.60
Dig. P	0.40	0.33	0.32[1]	0.33
Na	0.20	0.18	0.15	0.28
Cl	0.17	0.18	0.15	0.32

[1] P disponible

Dietary fiber

New concepts

- ✓ Feed intake regulation
  - ✗ Improves FCR?
- ✓ GIT motility
  - ✗ ↑ Digesta mixing
  - ✗ ↑ Secretion of HCl and endogenoos enzymes
- ✓ Nutrient digestion
  - ✗ ↑ Mineral solubility
  - ✗ Pepsinogen activation
- ✓ Modification of microbial profile

Dietary fiber

- ✓ Chemical characteristics
- ✗ Soluble *vs*. insoluble fiber
  - Fermentation
  - Primarily in the large intestine
- ✗ Lignified *vs*. non-lignified fiber
  - GIT motility and organ size
  - Primarily in the proximal part
- ✓ Physical properties
- ✗ Particle size, surface area, and porosity
- ✗ Hydration and viscous characteristics