Impact of technological treatment of feed ingredients on feed efficiency in farm animals

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Summary

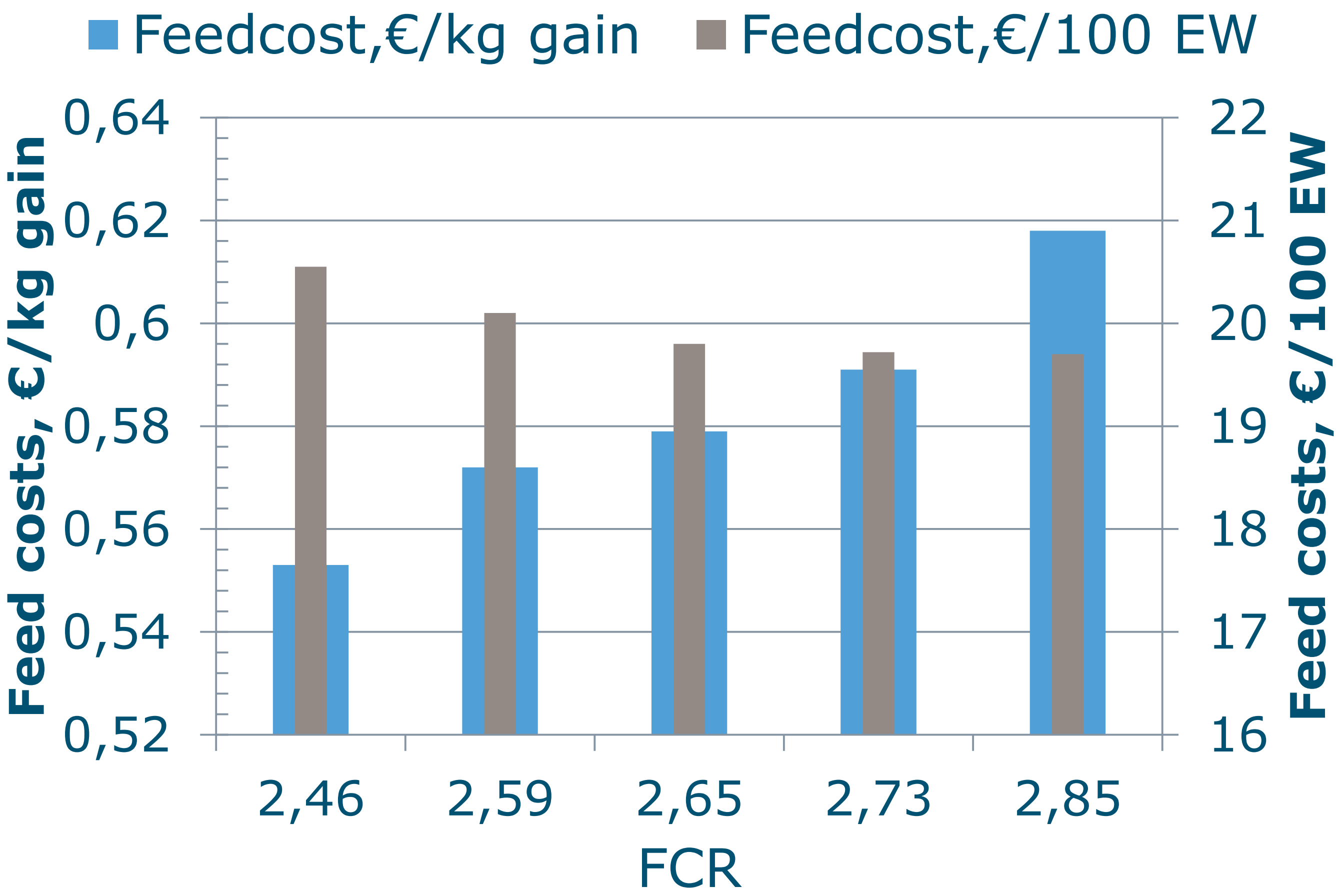
- Competition for ingredients → increase in use of by-products, of which quality is affected by processing → more attention for nutritional value required and rewarded in feed efficiency
- Present feed evaluation systems do not adequately include effects of processing and need to be improved at this point (e.g. for LYS)
- Research and implementation of feed processing in the compound feed industry should focus more on underlying mechanisms and consequences for optimal nutrient utilisation

Reasons to focus on feed efficiency

- Optimal use of limited resources to meat the demands of the increasing world population
- Competition between feed, food and fuel/green chemicals
  - Use of byproducts in animal feed
  - Changes in nutrient content of byproducts
  - Large influence of production/biorefinery processes
- Environmental consequences
- Cost efficiency of animal production at farm level

Variation in feed costs of GF pigs (118 kg)

(Agrovision 2010)



Bars represent 20% of pig farms

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Effect of processing on SBM and RSM diets

(Hulshof et al., 2013)

SBM and pSBM

RSM and pRSM

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Effect of processing on gain:feed ratio

- Processing affected feed utilisation

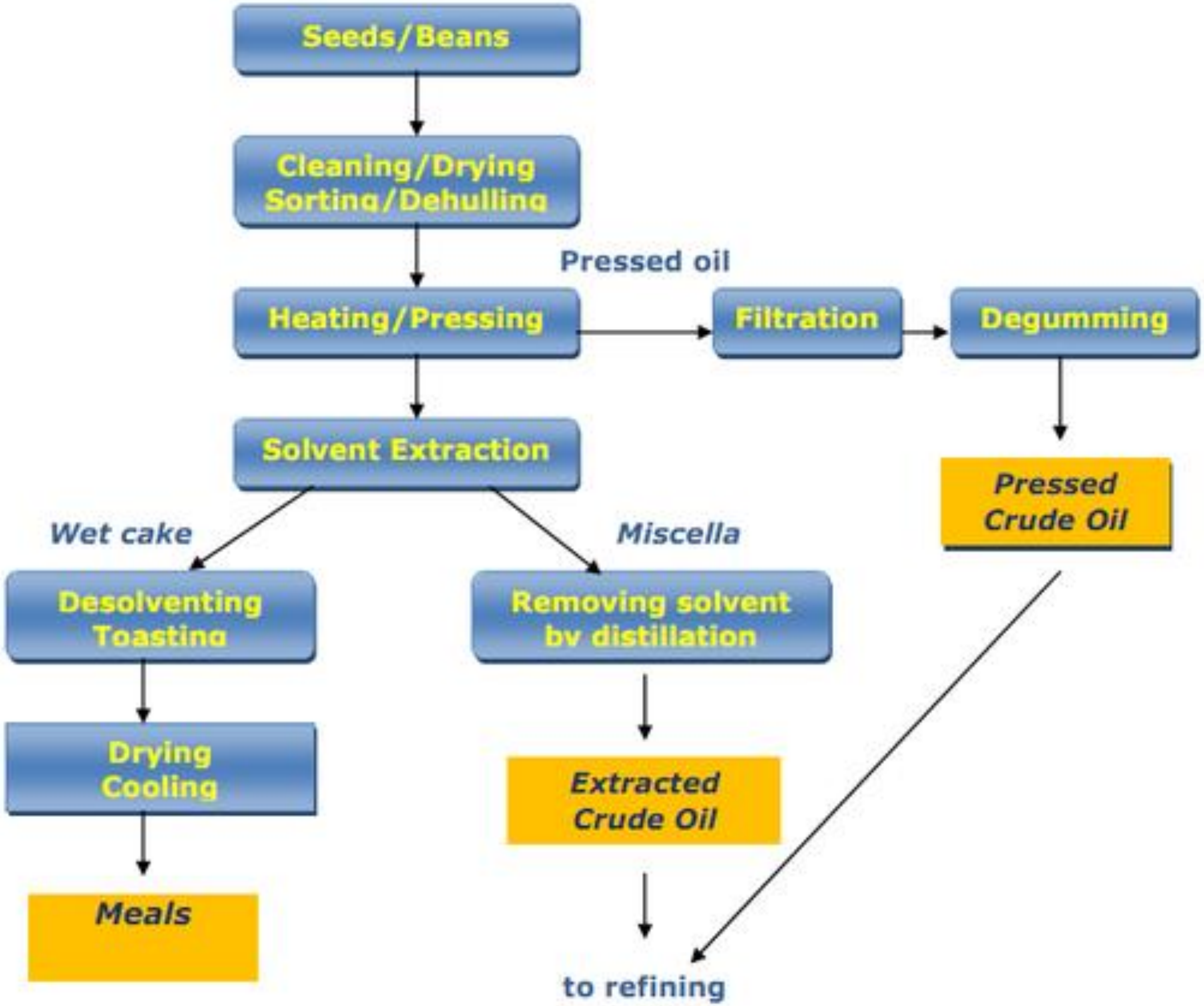
	SBM diet	pSBM diet	RSM diet	pRSM diet	SEM	P-value processing
Gain:feed	0.52	0.42	0.46	0.39	0.030	0.006

Related to decreased content and digestibility of amino acids

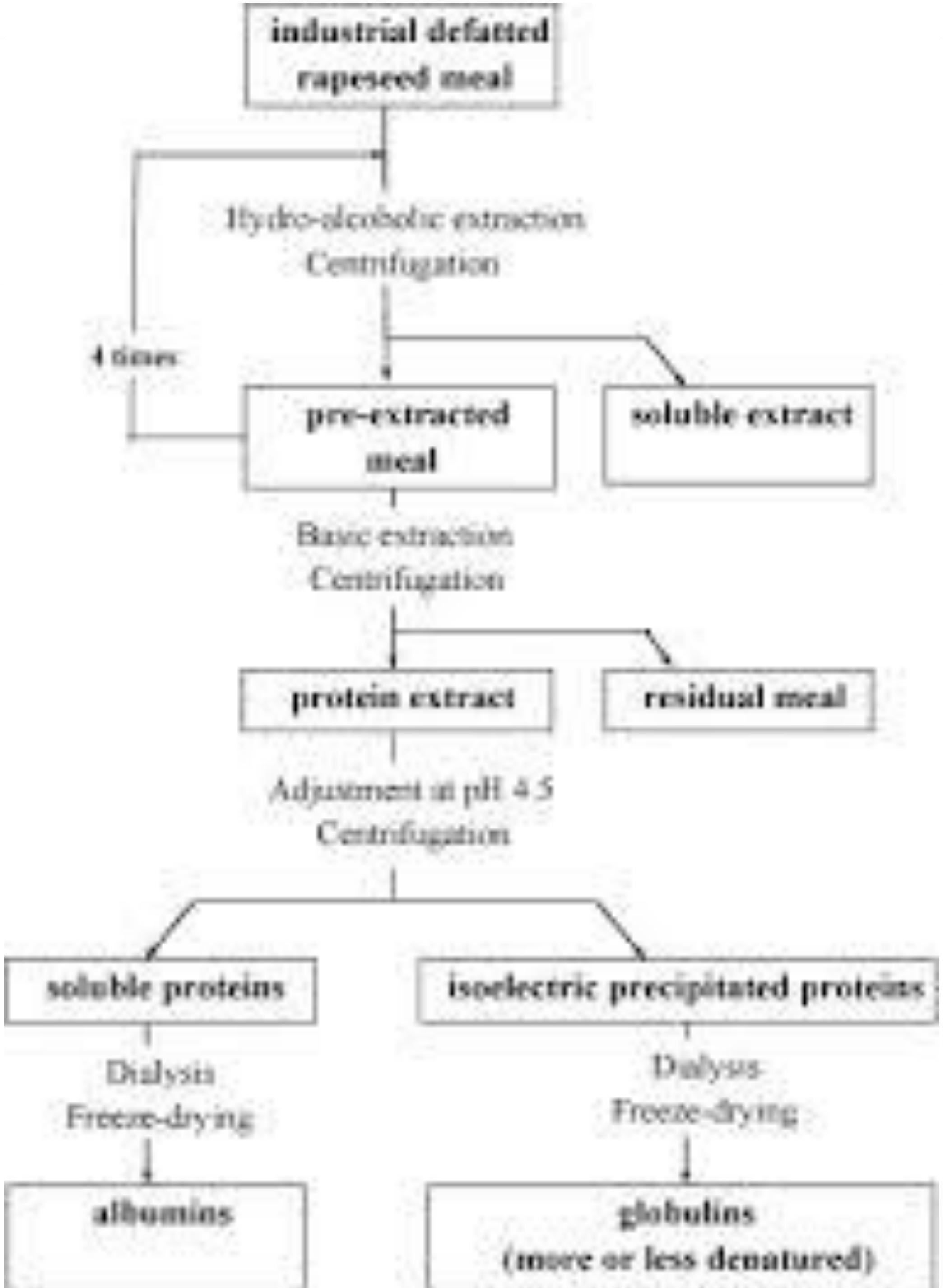
Processing of feed ingredients (1)

- To obtain primary products for human consumption, feed ingredient as residue
  - Oil seed meal: SBM, RSM, SSM
  - Cereal by-products: bran, middlings, gluten meal (D)DGS
- Number of processes involved, in general optimised for primary product
- Additionally: decrease of anti-nutritional factors, e.g. TIA, glucosinolates, etc.

Oilseeds crushing



Rapeseed biorefinery



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Processing of rapeseed (Li et al., 2002)

	Prepressed RS Meal	High T pressed RS cake	Low T pressed RS cake
Cfat	32	62	100
CP	389	409	361
Lys	23.8	17.9	21.0
Ileal digestibility			
CP	55.1	54.0	65.4
Lys	62.4	40.6	69.7

Extraction at 115/65°C, pressing at 130°C or 80°C, respectively

- Overall relatively low ileal digestibility
- Differences due to processing and variety

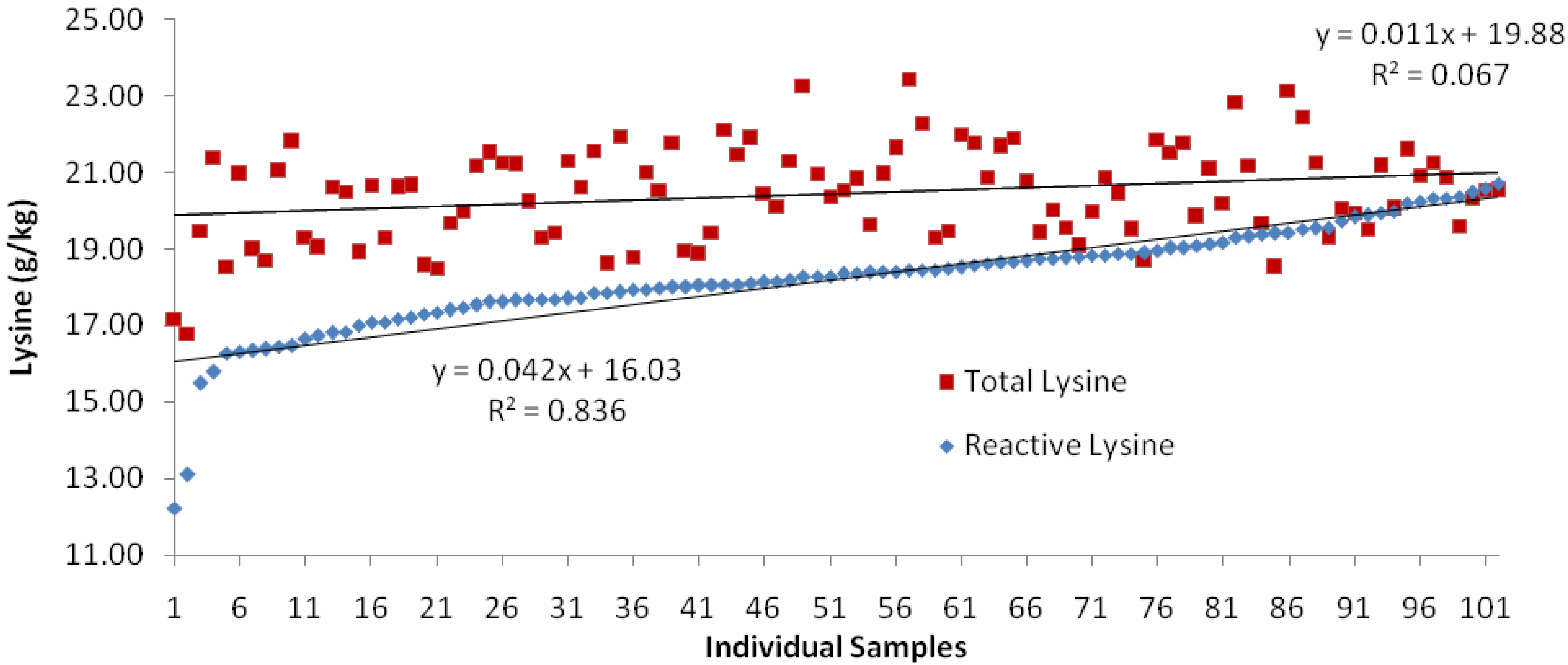
Nutrients in rape seed products, g/kg DM

(Kracht et al., 2002)

	RS	RSM	RSM dehulled	RScake	RScake dehulled
Cfat	495	21	21	120	128
CP	190	396	424	321	363
CF	65	117	72	102	61
Lys	10.5	19.0	22.0	18.6	20.3
Digestibility					
OM piglets		68	78	59	74
OM GF-pigs		69	79	74	84
AID CP		75	78	68	74
AID Lys		81.0	83.9	75.4	85.8

- Effects of dehulling: in cake > meal, in piglet > GF pig

Reactive and total LYS in individual canola samples (Spragg and Mailer, 2008)



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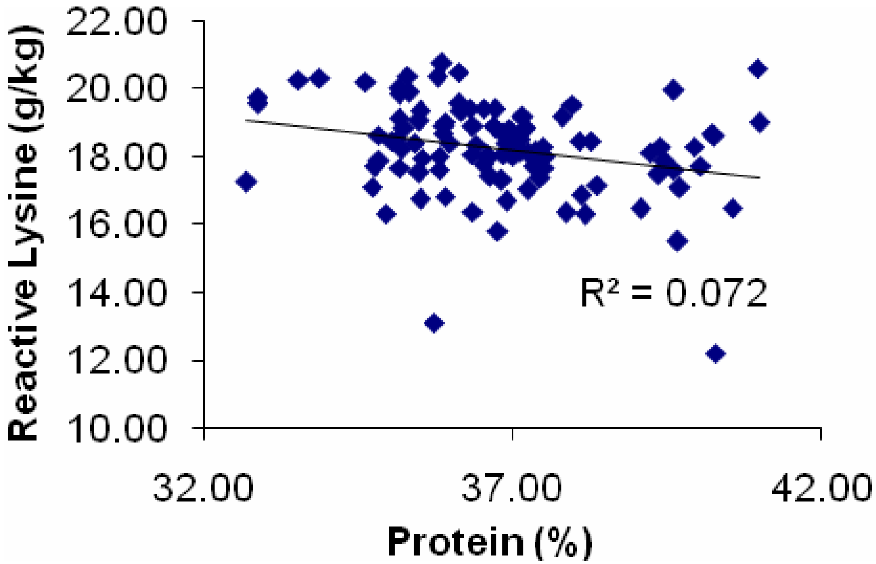
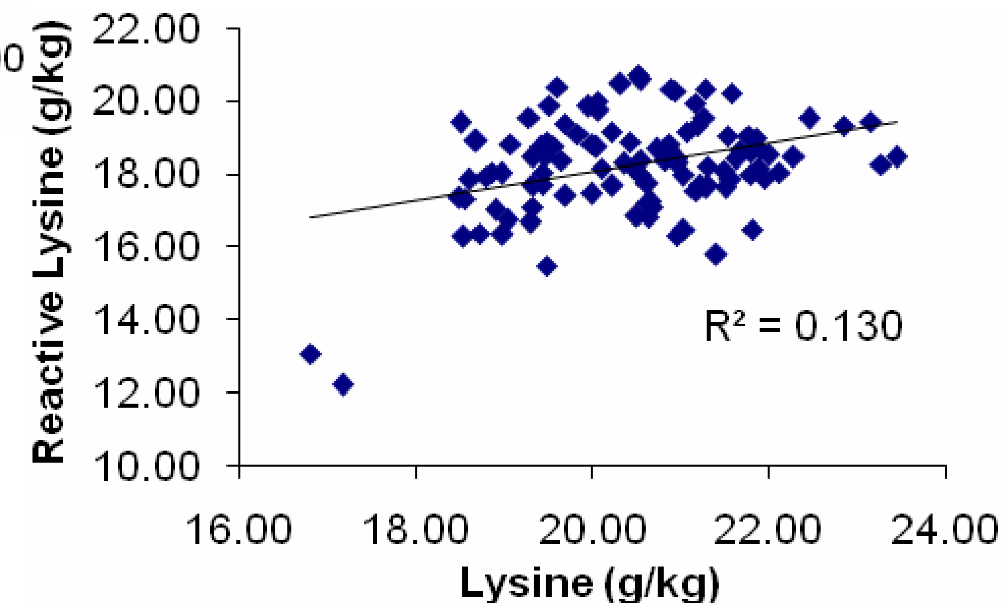
Reactive vs CP or total LYS in canola meal

(Spragg and Mailer, 1988)



Reactive (intact lysine) is not predicted by CP or LYS



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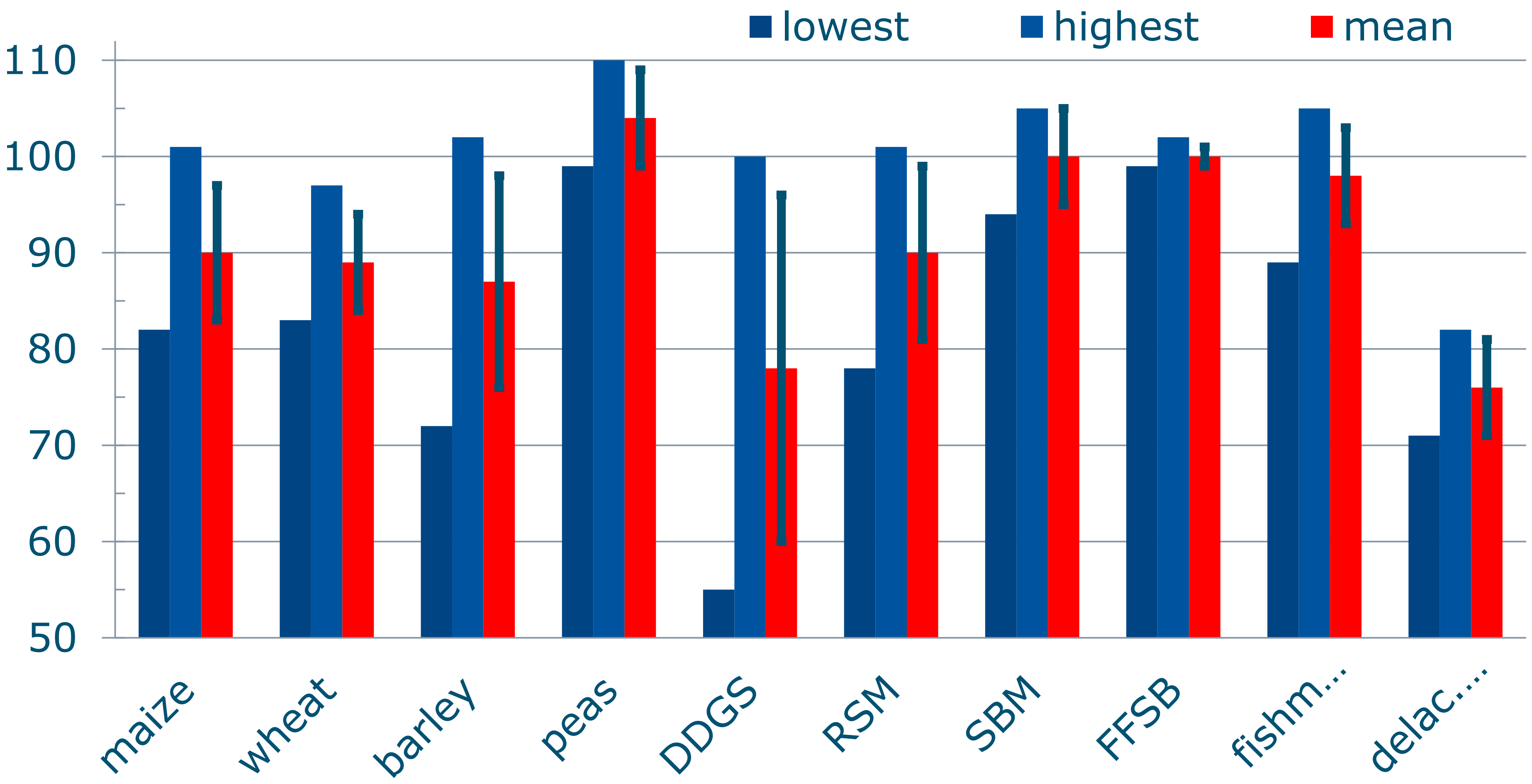
Dutch feed ingredients: reactive/total lysine



Van der Poel and Bikker, 2012, unpublished.

Literature data on reactive LYS in feedstuffs

	n	total, g/kg	reactive, g/kg	RL/TL, %	ref
Maize DDGS	16	3.1-8.8	2.4-6.8	55-86	1,2
Wheat DDGS	10	2.7-11.7	1.6-10.0	60-86	3
Soy bean meal	3	32-36	24-32	90-100	2,4
Fishmeal	5	42-58	26-39	74-89	2
Wheat	1	3.5	3.1	91	4
Maize, dried	1	3.2	2.3	70	4
Lucerne mix	1	19.4	12.5	64	4
MBM	1	89.2	88	94	4
SMP	1	28.7	17.7	62	4

1 Pahm et al. (2008), 2 Boucher et al. (2009), 3 Cozannet et al. (2010), 4 Rutherfurd et al. (1997)

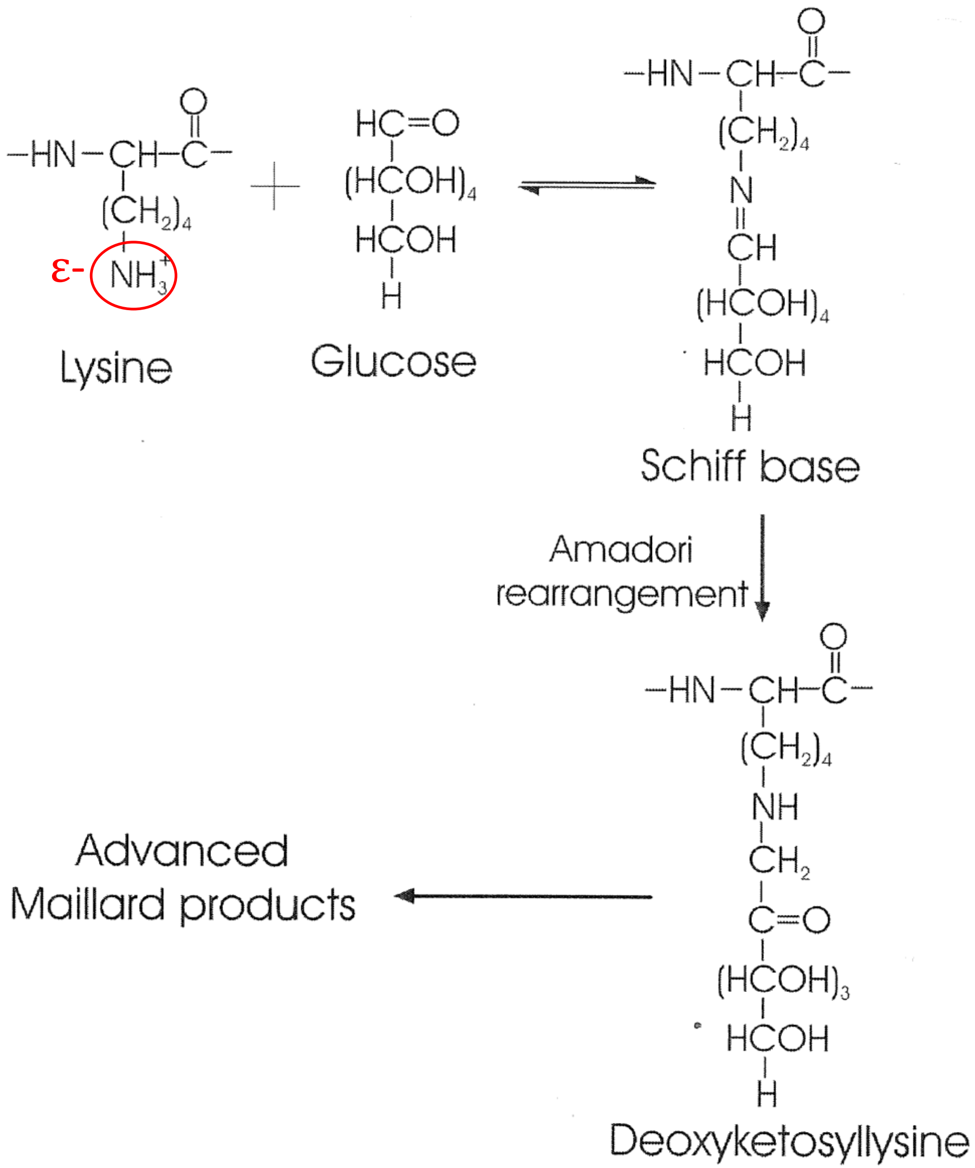
Ileal digestibility of total LYS 9-82%

Intermediate summary

- The major byproducts used in animal feed have undergone intensive feed processing
- Processes are optimised for production of the primary product, e.g. oil, starch, ethanol
- Large variation in nutritional quality of the byproducts for animal feed affects feed efficiency
- Challenge:
  - Producers: nutritional value
  - feed industry: variation (→ criteria?)

Bioavailability of amino acids: lysine

- Maillard reaction (e.g. Rutherfurd, 2010)



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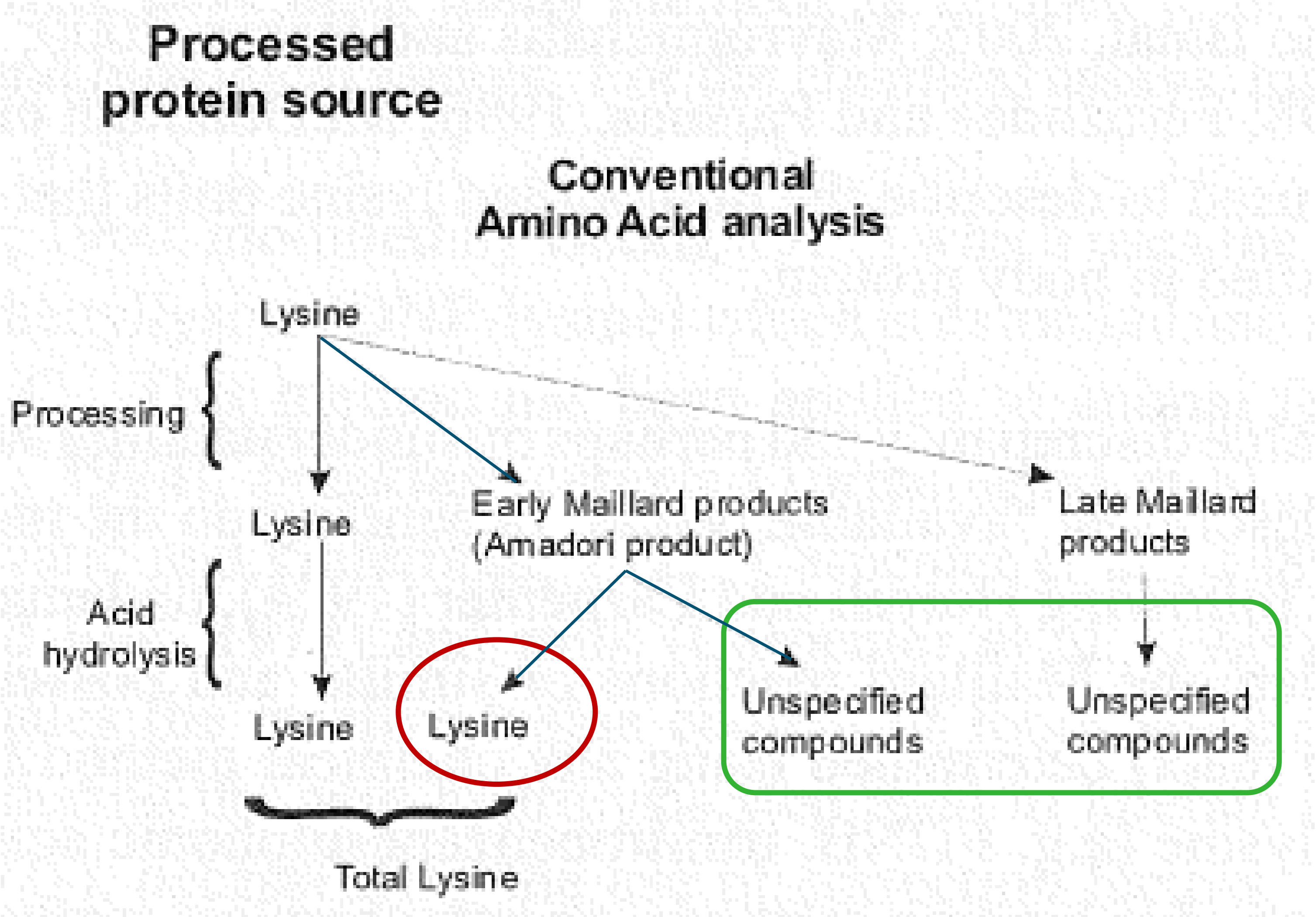
Fate of lysine during processing and analysis



Methods to determine undamaged lysine (chemically reactive lysine)

- Based on reaction products, e.g.
  - in milk: fructosyllysine → furosine / lysine / pyridosine
- Based on unreacted ε-amino group, e.g.
  - FDNB (also α-amino group)
  - homoarginine method

Bioavailable lysine in heated peas

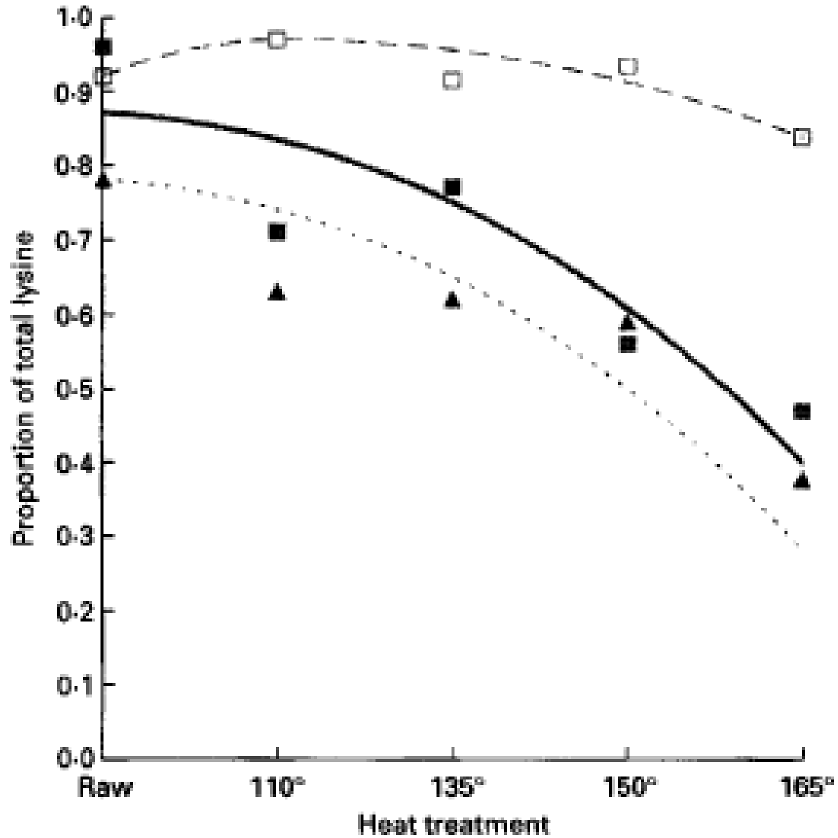


Fig. 7. Relationship between lysine digestibility (□---□), availability (■——■) and utilization (▲····▲) in raw field peas (*Pisum sativum* cultivar Dundale) and field peas heated for 15 min at 110°, 135°, 150° or 165° using a forced-air dehydrator.

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Lysine digestibility in (heated) casein

	Heated SMP	EHC (1)	EHC (2)
Uncorrected lysine dep., g/d	10.7	5.4	9.1
Corrected lysine dep., g/d	9.1	5.4	9.1
Corrected PD, g/d	133	87	115
Corrected BWG, g/d	660	569	677
(1)Based on digestibility total lysine (2)Based on digestibility reactive lysine			

Digestibility of reactive lysine → better prediction of PD

(Rutherfurd et al.. 1997)

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Diet optimisation

RL barley 72%, wheat 83%, maize 82%, RSM 78%

Ingredients	basis	reactive	
barley	30.0	20.0	max / min
maize	20.0	20.0	max
wheat	16.8	31.9	
SBM	15.0	15.0	max
RSM	8.0	3.3	max
molasses	4.0	4.0	max
fat / oil	2.8	2.0	
L-Lysine-HCl	0.32	0.45	!!
RE	172.8	165.5	
dv lys/EW	8.3	8.7	
dv RL/EW	7.8	8.3	
costs, €	26.29	26.72	

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Effects on other amino acids

- Van Barneveld et al. (1994)
  - Limited decrease in AA at T > 150°C compared to LYS
- Rutherfurd and Moughan (1997)
  - Milk: lower AA dig. ≥ 10 min 121°C (mild)
  - Peas: lower AA dig. ≥ 150C° (drastic)
- Pahm et al. (2008), drying of DDG+CDS
  - Increased variation in other AA content
- Boucher et al. (2009) 150°C, 90 min
  - 0-10% loss of total AA, more for ARG, TRP

Effect of ingredient processing on protein quality

- Heat treatment may reduce total and reactive lysine content and their ileal digestibility
- ID reactive lysine rather than ID total lysine is a better indicator of bioavailable lysine
- Variation in RL may contribute to variation in animal performance and feed utilisation
- Effects on other AA is lees but not negligible
- **Processing affects protein nutritional value, but effects are not adequately reflected in present feed evaluation → additional characteristics need to be included**

Processing in the compound feed industry

- Grinding, mixing, conditioning, pelleting
- Aggregation of feed mash in larger units (i.e. pellets)
  - Reduce segregation
  - Sanitation, hygiene
  - Weight/volume (bulk density)
  - Nutritional value

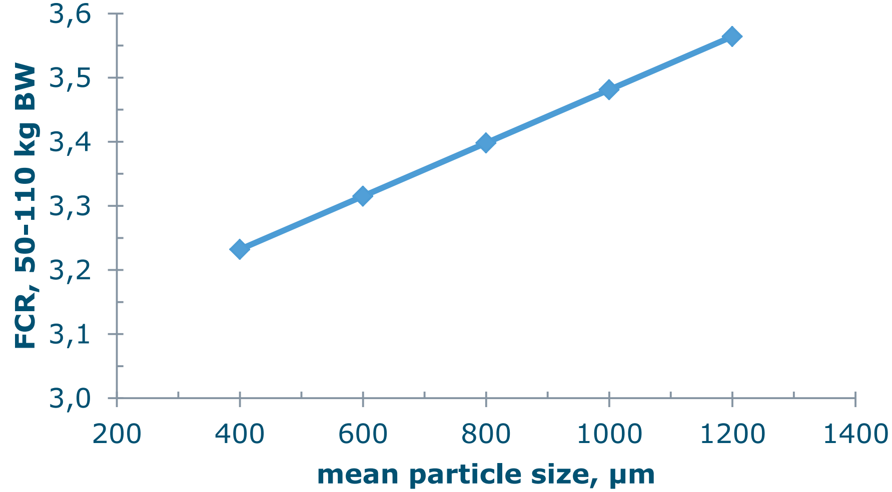
Focus: handling properties and cost of production

Nutritional benefits?

Further opportunities: ingredient and/or feed processing for nutrient utilisation?

Benefits of processing

- Grinding, smaller particle size → higher feed efficiency
  - Results KSU in meal
  - GF pigs and sows
  - Farms: 75%>800 µm



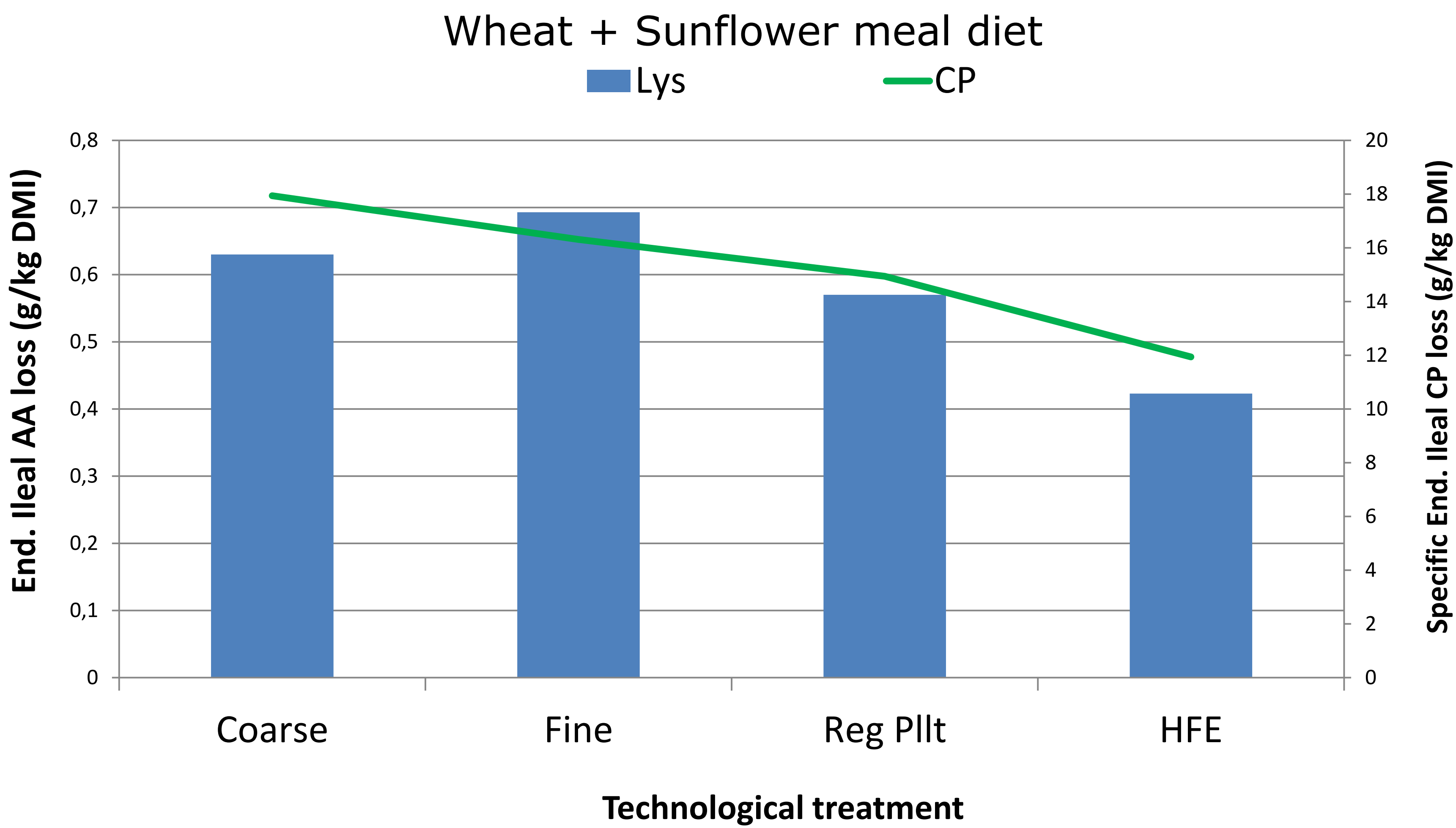
- Pelleting: upto 8% improved feed efficiency (Stark, 2012)
  - Particle size reduction
  - Feed spillage
  - Gelatinisation of starch, denaturation of CP

Effect of intensive feed technology

(Bruininx, pers. comm. 2013)

processing	Pellet	HTST Extrusion	SEM	p-value
Number of pens	28	28	-	-
Body weight at start (kg)	25.7	26.1	-	-
Body weight at end (kg)	115.7	115.5	0.84	Ns
ADG (g/day)	862	873	14.0	Ns
ADFI (kg/day)	2.12[a]	2.05[b]	0.049	*
FCR (kg/kg)	2.46[a]	2.35[b]	0.029	**

Technological processing may reduce specific endogenous losses



(Lahaye et al. 2004)

Effect of extrusion of pig diets on ileal and faecal nutrient digestibility

(Raedts and Van der Poel, 2008, unpublished)

+4.4% ileal CP dig. (34 of 42 exps.)

+3.6% fecal cfat dig. (9 of 11 exps.)

+4.0% ileal starch dig. (13 of 17 exps.)

+1.6% fecal starch dig. (5 of 7 exps.)

- Extrusion improves mean nutrient digestibility
- But effects vary and depend on processing conditions and diet composition

Processing individual ingredients

- Particle size reduction of cereals and legume seeds improves digestibility, but optimum depends on type of cereal / legume (and age of pig)
- Pelleting and expanding may improve digestibility, effect depends on ingredient, process conditions (and studies!)

Required

- Scope for improvement by treatment of individual ingredients compared to complete diets?
- Better understanding of processing: heat, shear and moisture and interaction with ingredient characteristics

Summary

- Competition for ingredients → increase in use of by-products, of which quality is affected by processing → more attention for nutritional value required and rewarded in feed efficiency
- Present feed evaluation systems do not adequately include effects of processing and need to be improved at this point (e.g. for LYS)
- Research and implementation of feed processing in the compound feed industry should focus more on underlying mechanisms and consequences for optimal nutrient utilisation

Thank you for your kind attention

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