Evaluation and Use of Co-Products from the Biofuel Industry in Pigs

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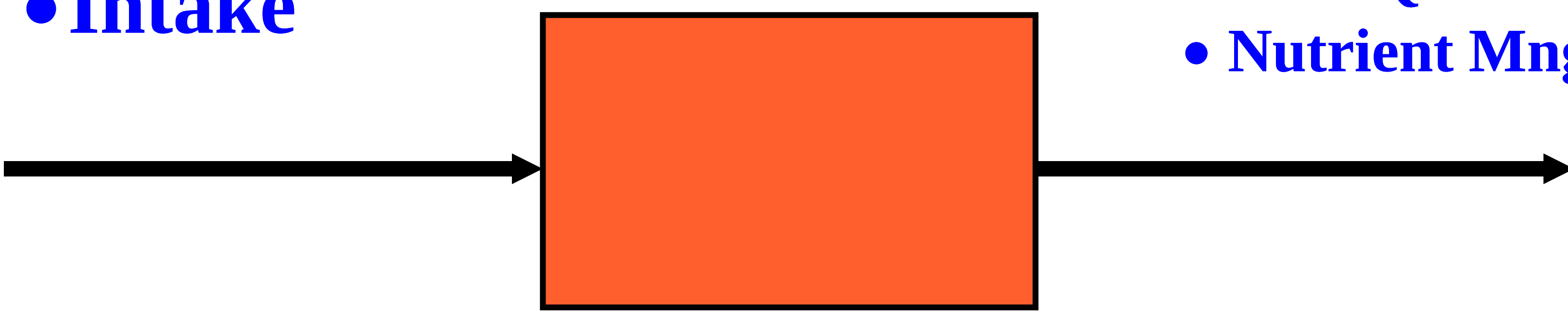
Importance of Feed Quality Evaluation

Input

- Feedstuffs
- Intake

Output

- Carcass Wt & Q
  - Pork Q
  - Nutrient Mngt



Pig

- Growth (predictable)
  - Animal Health
  - Welfare

The Big Problem: Feed Costs

Feedstuffs
THE WEEKLY NEWSPAPER FOR AGRIBUSINESS
July 26, 2004
Volume 76 • Number 30 • $4
www.Feedstuffs.com

SPECIAL REPORT

Ethanol, exports and livestock:

Will there be enough corn to supply future needs?

USDA projections for the year ahead indicate that the U.S. corn supply-demand balance is changing from one of chronic surplus production capacity to an extended period of tight supplies. If so, relatively high corn prices will be needed to allocate limited supplies among the growing alternative users. This article provides a more up-to-date look at trends in U.S. corn production and utilization during the next five years and implications for related industries.

By ROBERT N. WISNER and C. PHILLIP BAUMEL

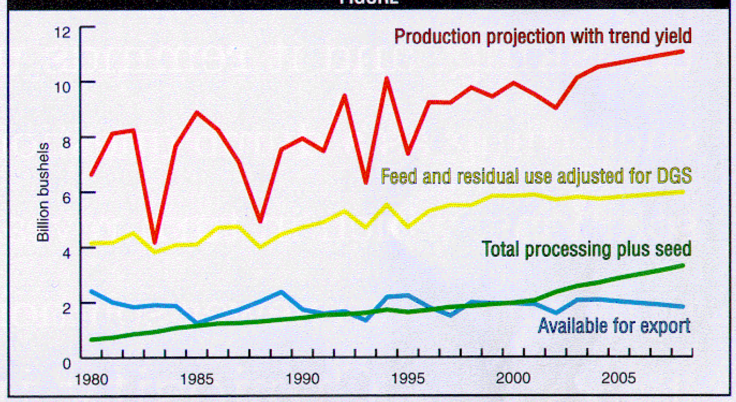
seven major world grain producing areas. Weather problems in 2003 cut foreign feed grain and wheat production 1.0 billion and 1.6 billion bushels, respectively, below normal production.

Emerging picture

American farmers harvested a record corn crop in 2003 that was insufficient to fill market requirements. The result was a sharp drawdown of U.S. and foreign feed grain carryover stocks. For the year ahead, official projections in June indicated U.S. farmers are likely to harvest another record corn crop that again will not be large enough to meet market requirements.

The 2004 crop projections reflect the earliest planting season ever recorded. With good weather this summer, the early plantings are expected to contribute to record yields. Based on a decline in total planted cropland acreage in the last several years, U.S. corn planted acreage shows signs of approaching an up-

FIGURE



1. U.S. corn production, domestic use, availability for exports, projections to 2008.

for corn and soybean meal, about 70% of corn's original weight is consumed in producing ethanol and is no longer available for feed or other uses.

If China shifts from its traditional position as the number-two or -three

the highest price for limited supplies;

(3) How corn production might be increased in the future, and

(4) Economic incentives for investment in non-corn feed stocks for ethanol production.

Vision: Co-products will become (more) important feed ingredients

Simple economics

Co-Products: Part of Solution

Feedstuffs in Swine Feed (2005)

Feedstuff	N. Am.	EU-25	NL
		(%)	
Cereals	65	48	19
Co-products ‘oil seed crushing’	15	25	32
Co-products ‘food industry’	5	14	32
Fats & oils	3	2	4
Miscellaneous	12	11	13

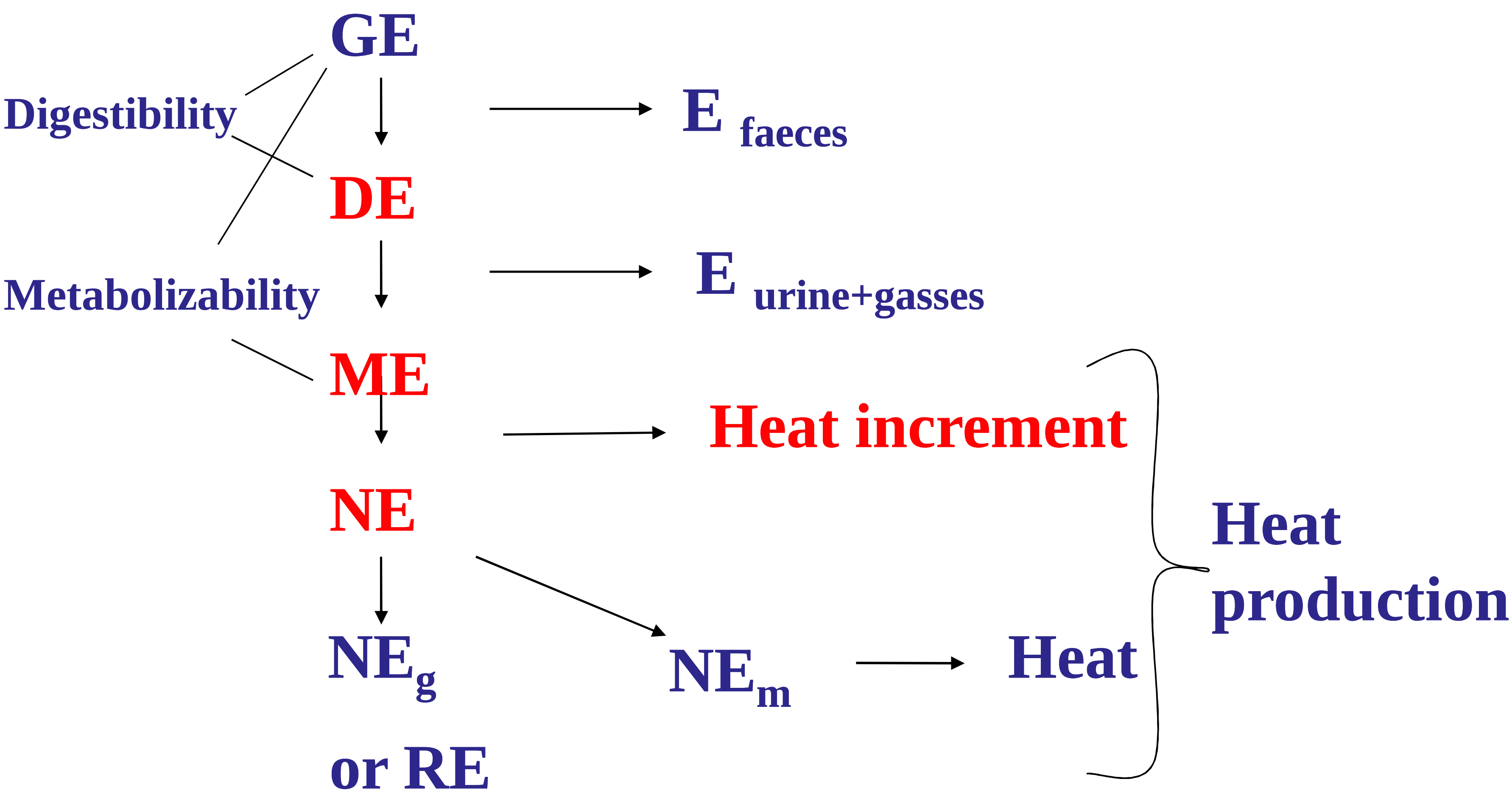
Diets with lower starch and higher fiber and protein content

- **How come the western European feed industry can manage?**

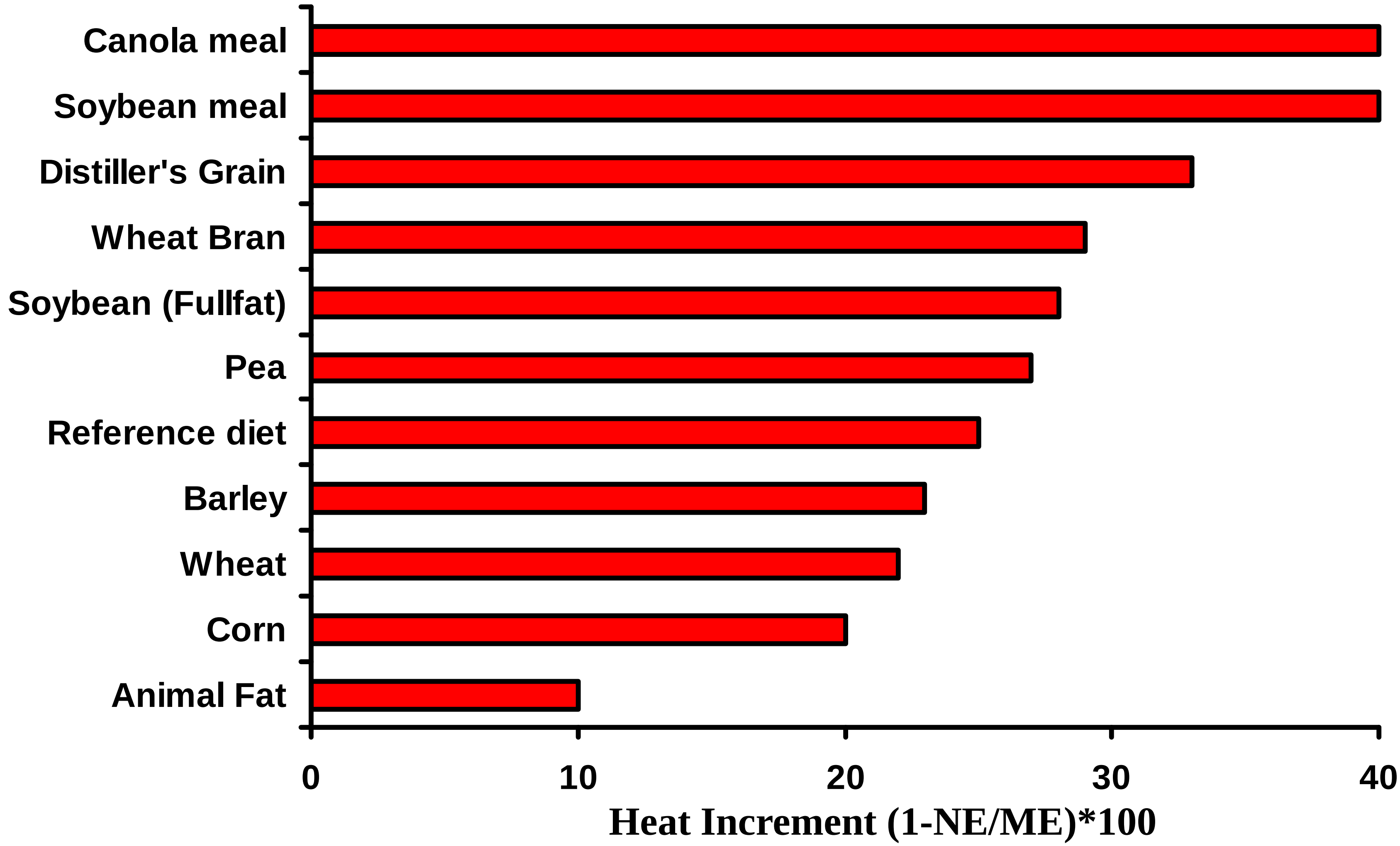
Co-products – Risk Management

- **Feedstuffs high in NSP and crude protein**
  - **Feed Quality Evaluation**
    - **Energy: NE versus DE/ME**

Digestible Nutrient Content



Ranges in Heat Increment



Important for placing value on feedstuffs

Energy Value of Nutrients

Nutrient	Starch	CP	EE	Fiber
Energy values, kJ/g				
DE	17.5 (100)	20.6 (118)	35.3 (202)	N/A
ME	17.5 (100)	18.0 (103)	35.3 (202)	N/A
NE	14.4 (100)	10.2 (71)	31.5 (219)	N/A
Heat production, kJ/g	3.1	7.8	3.8	N/A

(Noblet and Van Milgen, 2004)

Data on Energy Content

Relative DE, ME, and NE values

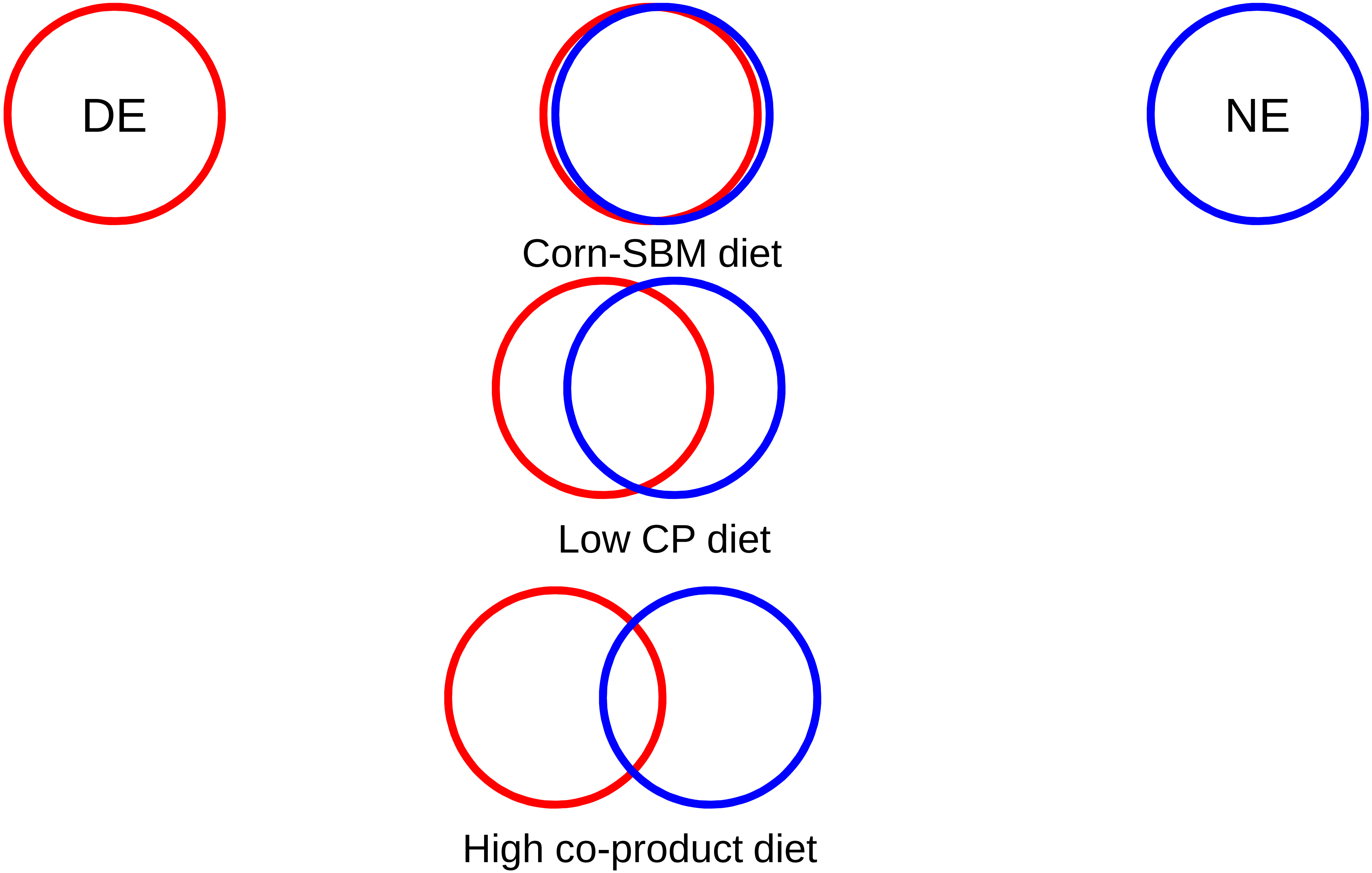
Feedstuff	DE	ME	NE	NE:ME
Animal fat	**243**	**252**	**300**	**90**
Corn	**103**	**105**	**112**	**80**
Wheat	**101**	**102**	**106**	**78**
Barley	**94**	**94**	**96**	**77**
Reference diet	***100***	***100***	***100***	***75***
Pea	**101**	**100**	**98**	**73**
Wheat bran	**68**	**67**	**63**	**71**
Distiller's Dried Grains	**82**	**80**	**71**	**67**
Soybean meal	**107**	**102**	**82**	**60**
Canola meal	**84**	**81**	**64**	**60**

Source: Adapted from Sauvant et al., 2004.

Our validation/growth trials: diets formulated with NE and SID AA

Benefits of NE

Risk Management



Co-products – Risk Management

- **Feedstuffs high in NSP and crude protein**
  - **Feed Quality Evaluation**
    - **Energy: NE versus DE/ME**
    - **Amino acid: AID, SID, TID; bioavailability**
    - **Mycotoxins, are concentrated in co-products**
    - **Minerals, can be concentrated or added in co-products**
    - **Description of other characteristics**
      - **Phytate, etc.**
  - **Variation in Feed Quality (within feedstuff)**
    - **Rapid feed quality evaluation**
  - **Feed Processing**
    - **Enzyme supplementation**
    - **Grinding, others, e.g., extrusion**

Biofuel Co-Products

- Ethanol production
  - Distiller's grain
  - Thin stillage
  - Combined: distiller's dried grain plus (thin) solubles (DDGS)
    - Corn, wheat, and other small grains used as feedstock
- Biodiesel production
  - Canola meal
  - Expeller-pressed canola meal
  - Canola press cake
  - Crude glycerol

Main Points for Today

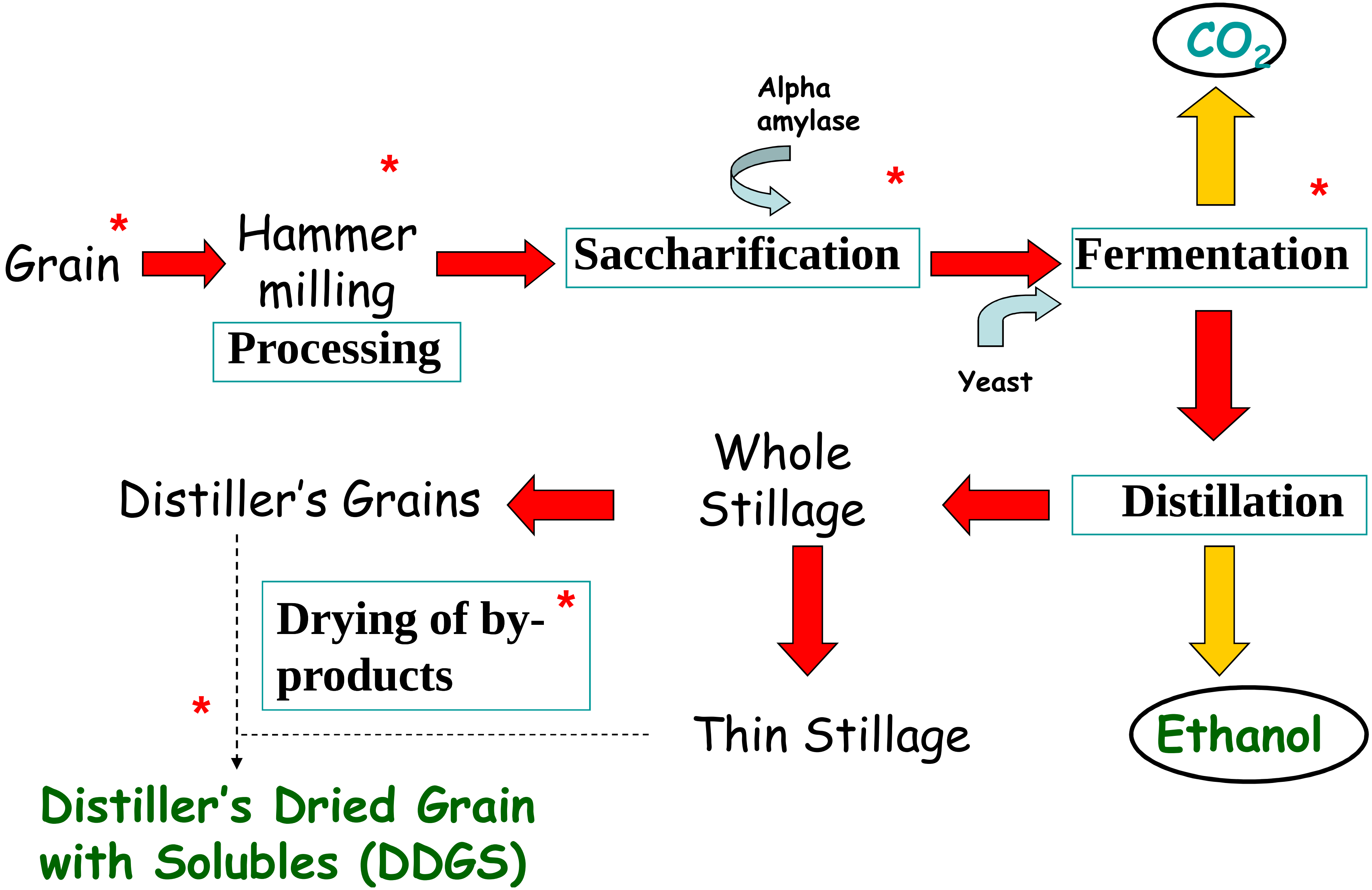
1. **Variability in Total Nutrient Content**
   – **Processing radically changes composition and adds variability**

2. **Variability in Nutrient Availability**
   – **Processing adds more variation that expected based on changes in nutrient composition**

3. **Mycotoxins and Residues**
   – **From original feedstock or processing**

4. **Impact on Carcass and Pork Quality**
   – **Further effects of fibre and fatty acids**

Ethanol Production



Characteristics of DDGS

Item, %DM	Wheat	DDGS Corn	DDGS Wheat+corn	DDGS Wheat [1]
Gross energy [2]	18.8	22.8	22.0	21.7
Crude protein	19.8	30.3	42.4	44.5
NPN	4.6	5.4	12.4	10.2
Crude fat	1.8	12.8	4.7	2.9
Crude fibre	2.4	7.0	7.8	7.6
ADF	2.7	14.6	19.5	21.1
NDF	9.4	31.2	30.6	30.3

[1] HRS origin; CPS DDGS, 37.3% CP DM

[2] MJ/kg DM

(Widyaratne and Zijlstra 2007)

Characteristics of DDGS

		DDGS		
Amino acid, %DM	Wheat	Corn	Wheat+corn	Wheat
Lysine	0.52	0.83	0.72	0.72
Threonine	0.54	1.09	1.22	1.28
Methionine	0.32	0.61	0.67	0.69
Tryptophan	0.23	0.23	0.37	0.44
Lys/CP	2.63	2.74	1.70	1.62

(Widyaratne and Zijlstra 2007)

Characteristics of DDGS

Item, %DM	Wheat	DDGS Corn	DDGS Wheat+corn	DDGS Wheat
Phosphorus	0.40	0.86	1.02	1.10
IP2	-	-	-	0.08
IP3	-	0.09	0.09	0.09
IP4	-	0.19	0.18	0.28
IP5	-	0.45	0.33	0.64
Phytate (IP6)	1.39	0.92	0.62	0.81

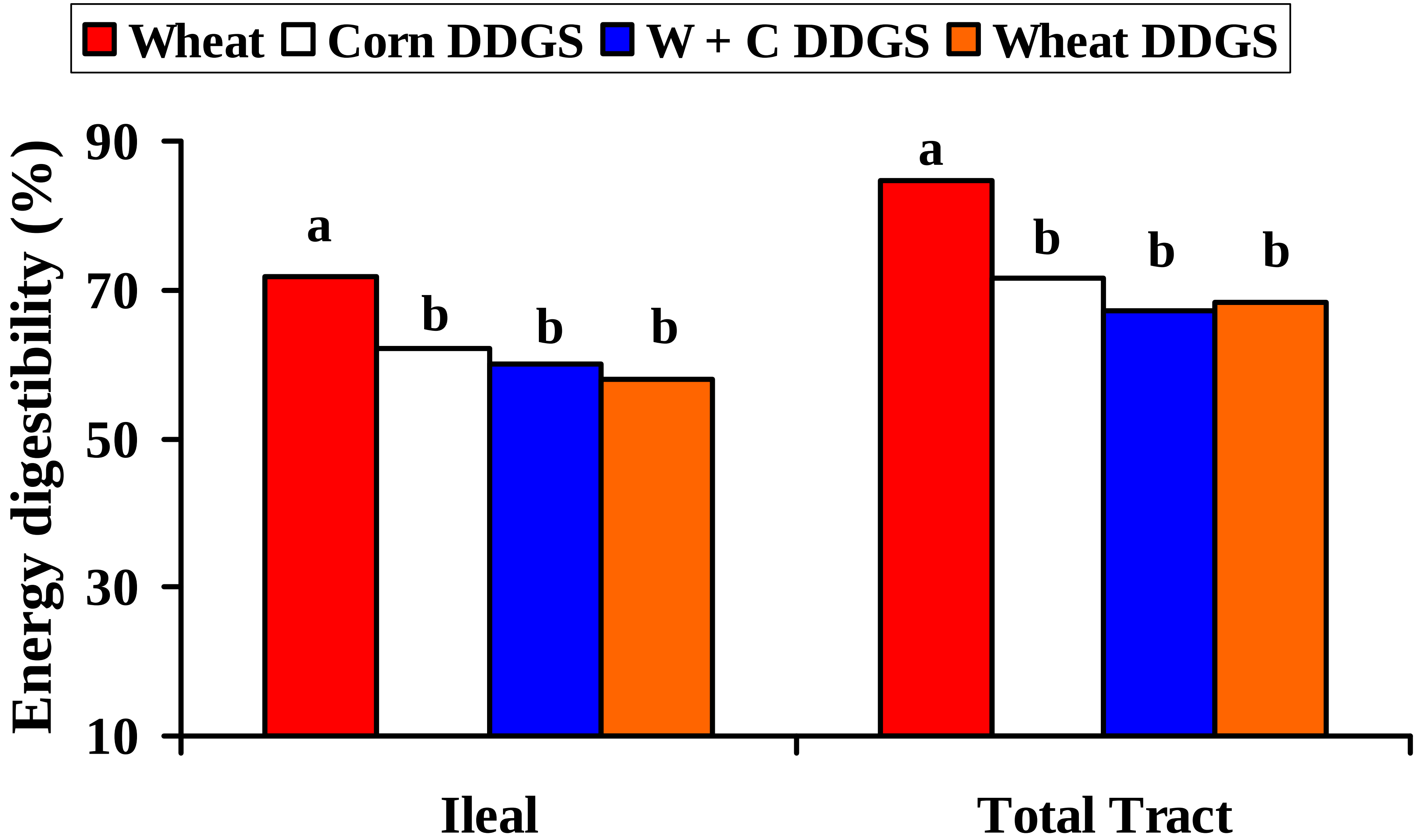
(Widyaratne and Zijlstra 2007)

Characteristics of DDGS

		DDGS		
Item, %DM	Wheat	Corn	Wheat+corn	Wheat
Total NSP	9.7	19.2	21.9	22.9
Soluble	2.2	1.4	5.4	7.8
Insoluble	7.5	17.8	16.6	15.1
Arabinose	2.3	4.3	4.7	4.9
Soluble	0.7	0.2	1.2	1.6
Insoluble	1.6	4.1	3.5	3.3
Xylose	3.4	6.2	8.1	8.1
Soluble	1.0	0.3	2.5	3.1
Insoluble	2.4	5.9	5.6	5.0

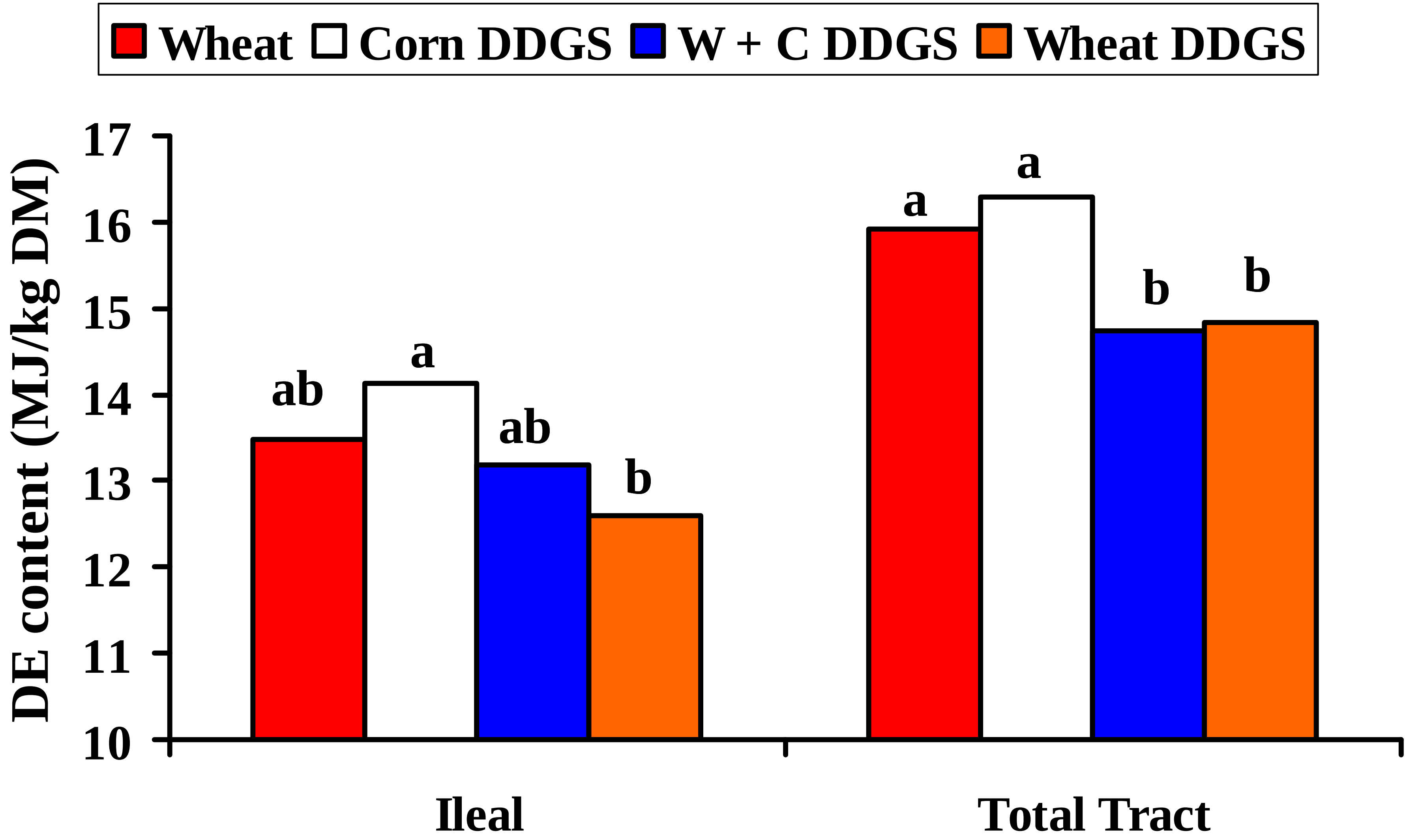
(Widyaratne and Zijlstra 2007)

Energy Digestibility



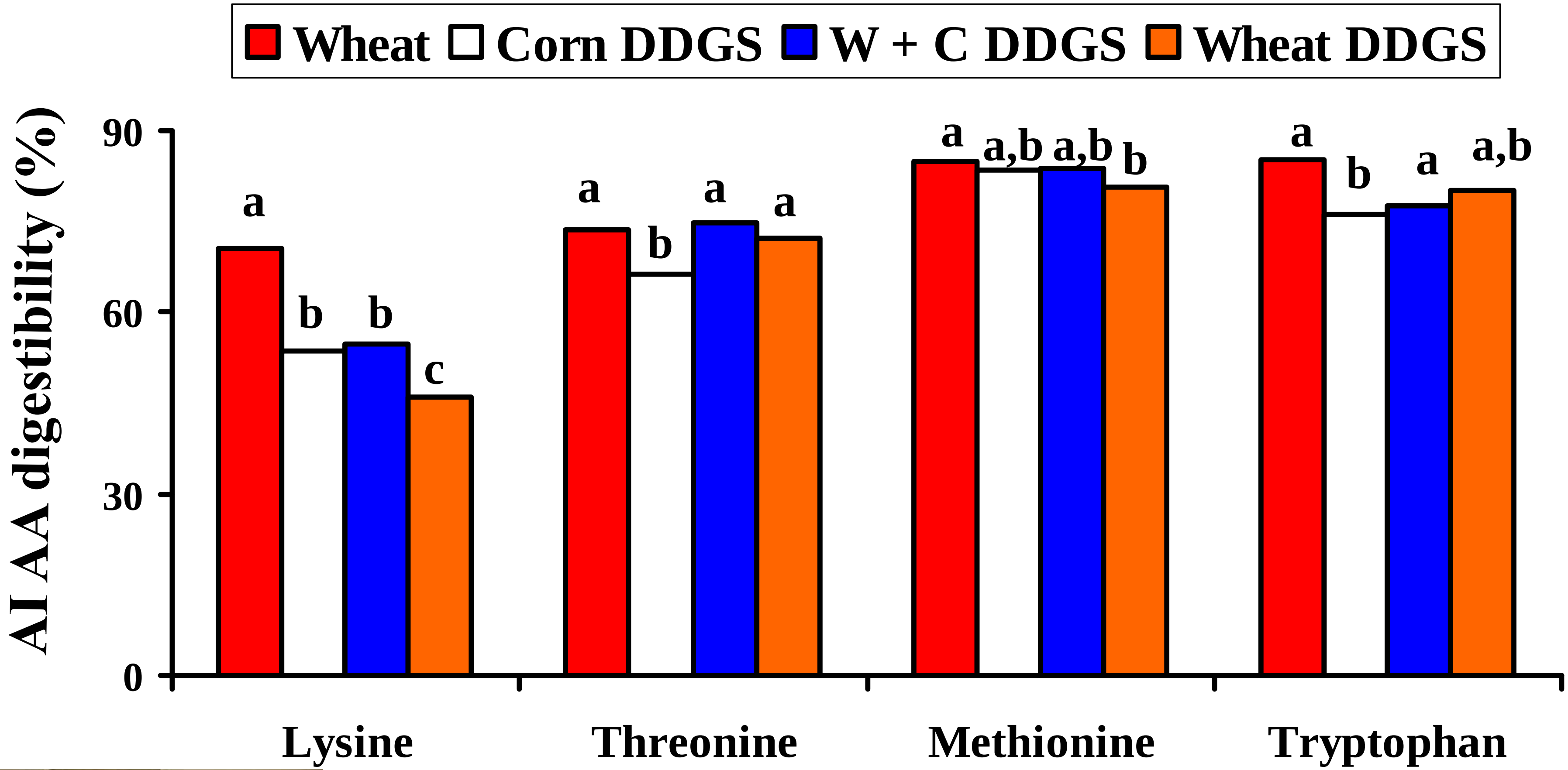
(Widyaratne and Zijlstra 2008E)

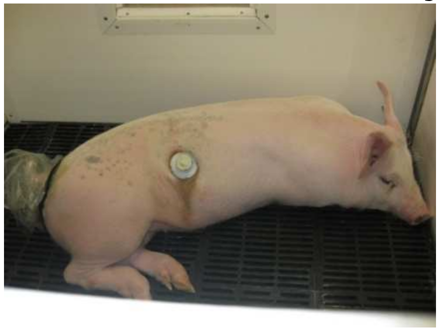
DE Content



(Widyaratne and Zijlstra 2008E)

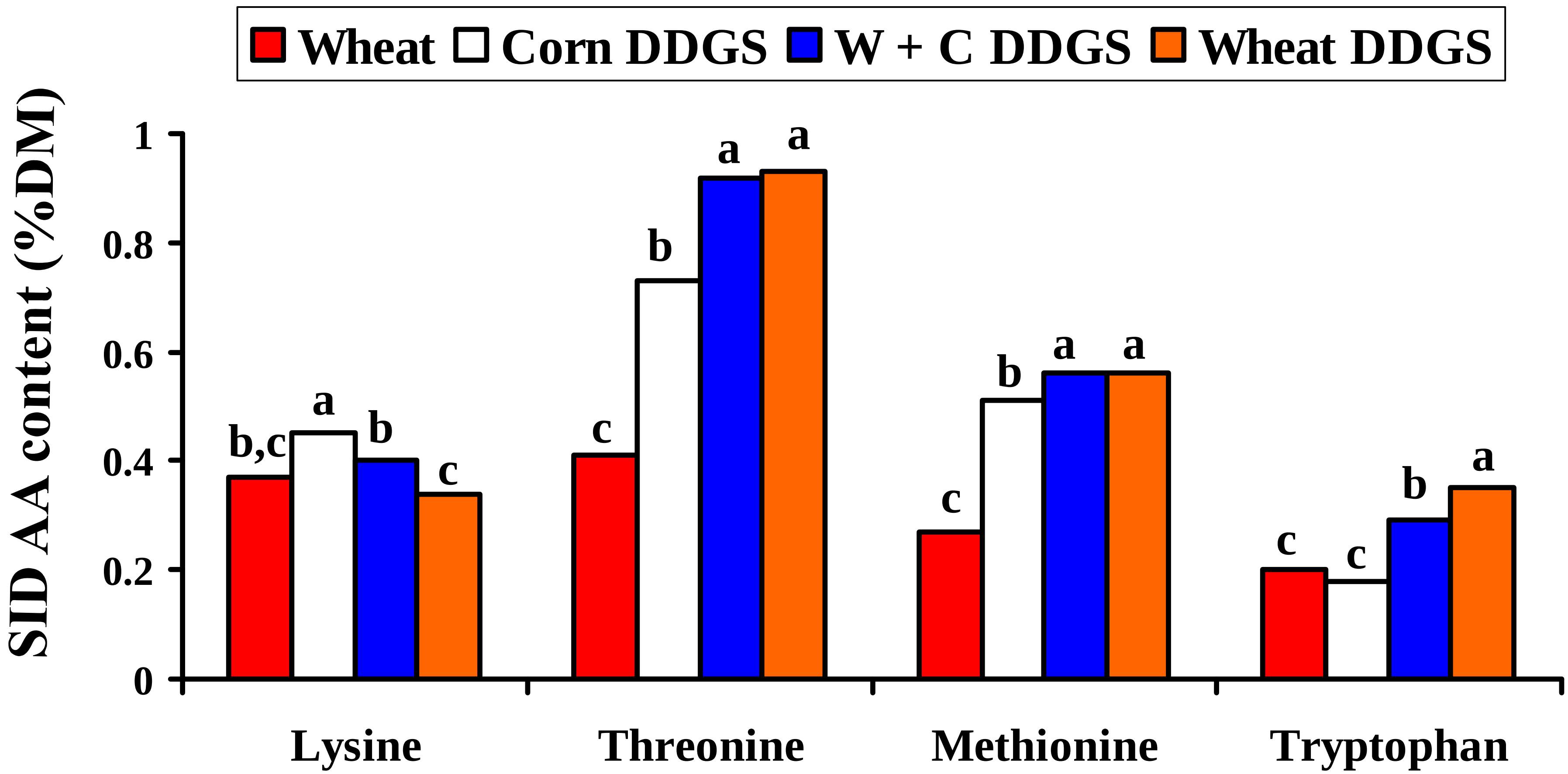
AID AA Digestibility





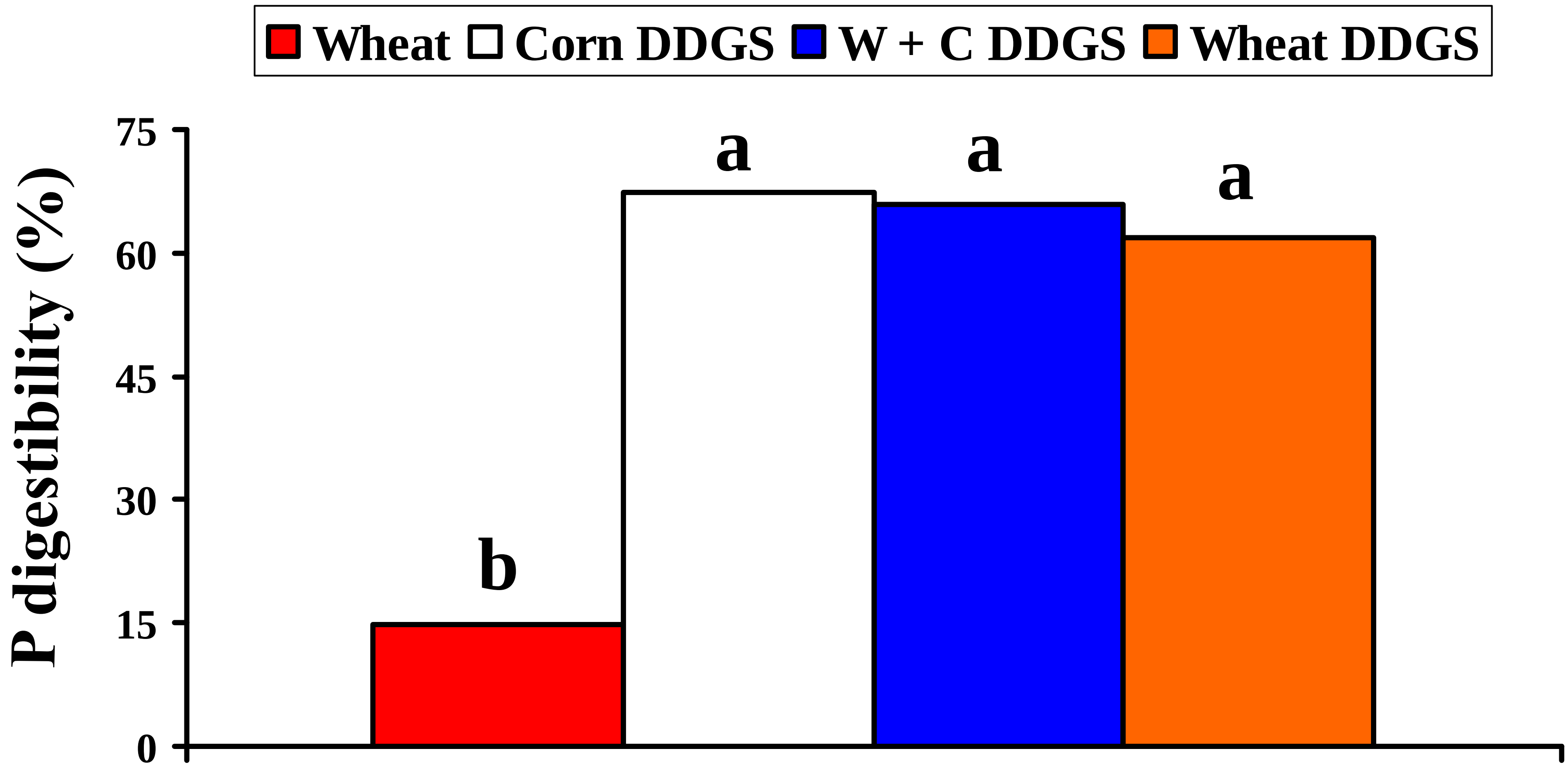
(Widyaratne and Zijlstra 2008E)

SID AA Content



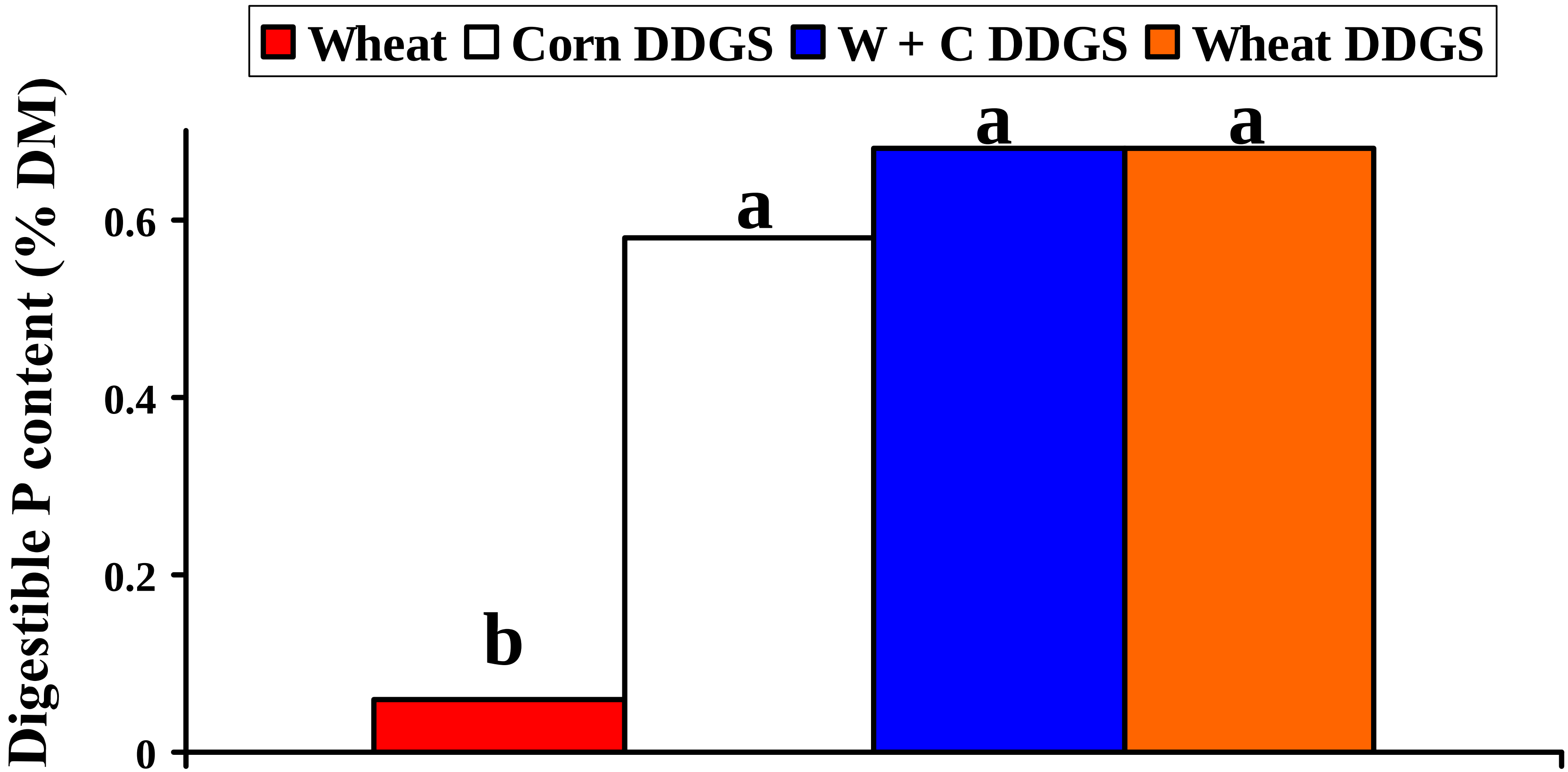
(Widyaratne and Zijlstra 2008E)

Apparent P Digestibility



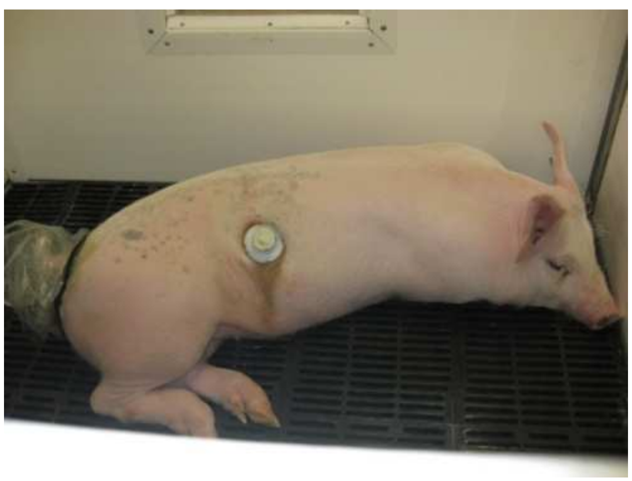
(Widyaratne and Zijlstra 2008E)

Digestible P Content



(Widyaratne and Zijlstra 2008E)

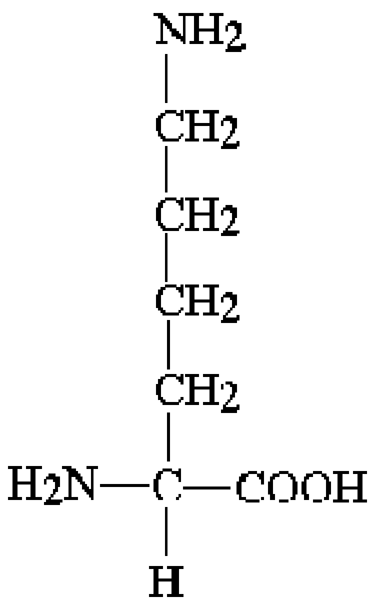

Sample #690
Wheat DDGS
L*-38.50 B*-25.26 A*10.




Sample #691
Wheat DDGS
L*-47.02 B*-26.52 A*-8.77

Variability in Wheat DDGS

	DDGS		
	Average	Lowest	Highest
ATTD, %	66.5	56.3	76.0
DE, MJ/kg	14.0	11.8	16.2
CP, %	36.1	32.6	38.9
Lys, % of CP	1.91	0.83	3.01
Avail Lys, % of CP	1.53	0.50	2.59
SID Lys, %	0.56	0.09	0.83
Starch, %	4.1	2.5	9.5
ADF, %	12.0	7.7	17.9



lysine

(Cozannet et al., 2010 ab)

Variability in Corn DDGS

	Corn	DDGS			
		Average	SD	Lowest	Highest
GE, MJ/kg	18.8	22.7	1.21	22.0	23.4
ATTD, %	90.4	76.8	2.7	73.9	82.8
DE, MJ/kg	17.1	17.3	0.88	16.5	19.2
EE, %	2.9	10.2	1.3	8.6	12.4
Starch, %	57.1	7.2	2.9	4.1	12.7
CP, %	7.2	28.3	1.9	25.9	32.4
ADF, %	2.3	10.2	1.2	8.6	12.0

(Pedersen et al. 2007)

Variability in Corn DDGS

	DDGS			
	Average	SD	Lowest	Highest
CP, %	27.5	1.8	24.1	30.9
Lys, %	0.78	0.09	0.54	0.99
Lys SID, %	62.3	7.61	43.9	77.9
Lys:CP, %	2.86		2.18	3.54

(Pedersen et al. 2007)

Lysine Q in Corn DDGS

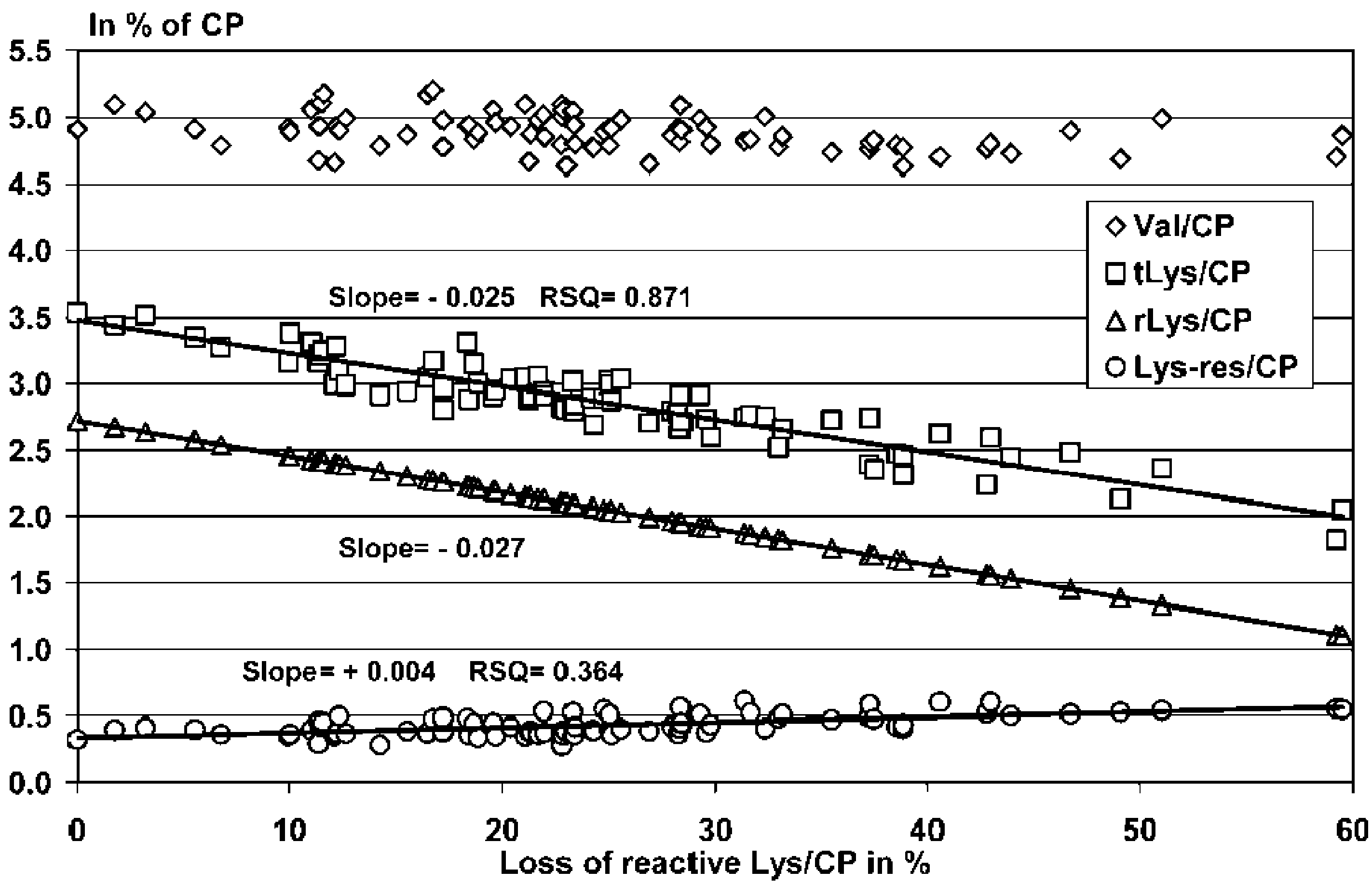


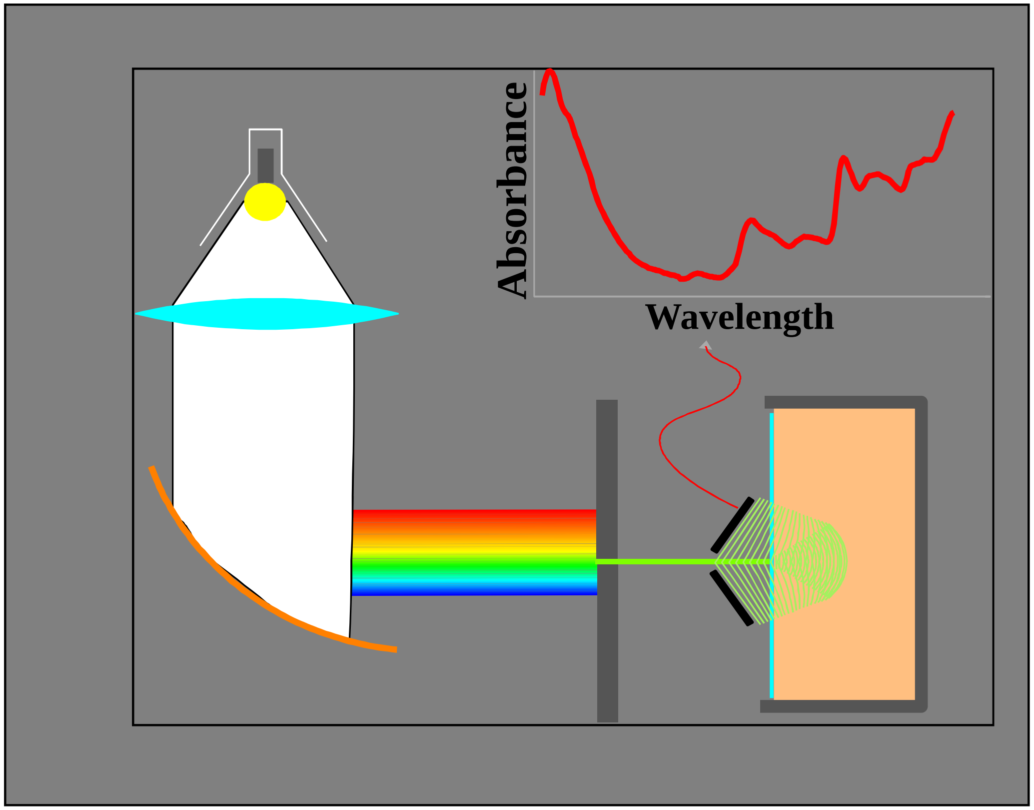
Figure 7. Results of the 80 DDGS samples displayed relative to the loss of rLys/CP, using the highest found result as reference. Almost half of the marketed qualities contain >20% less reactive lysine than best batches.

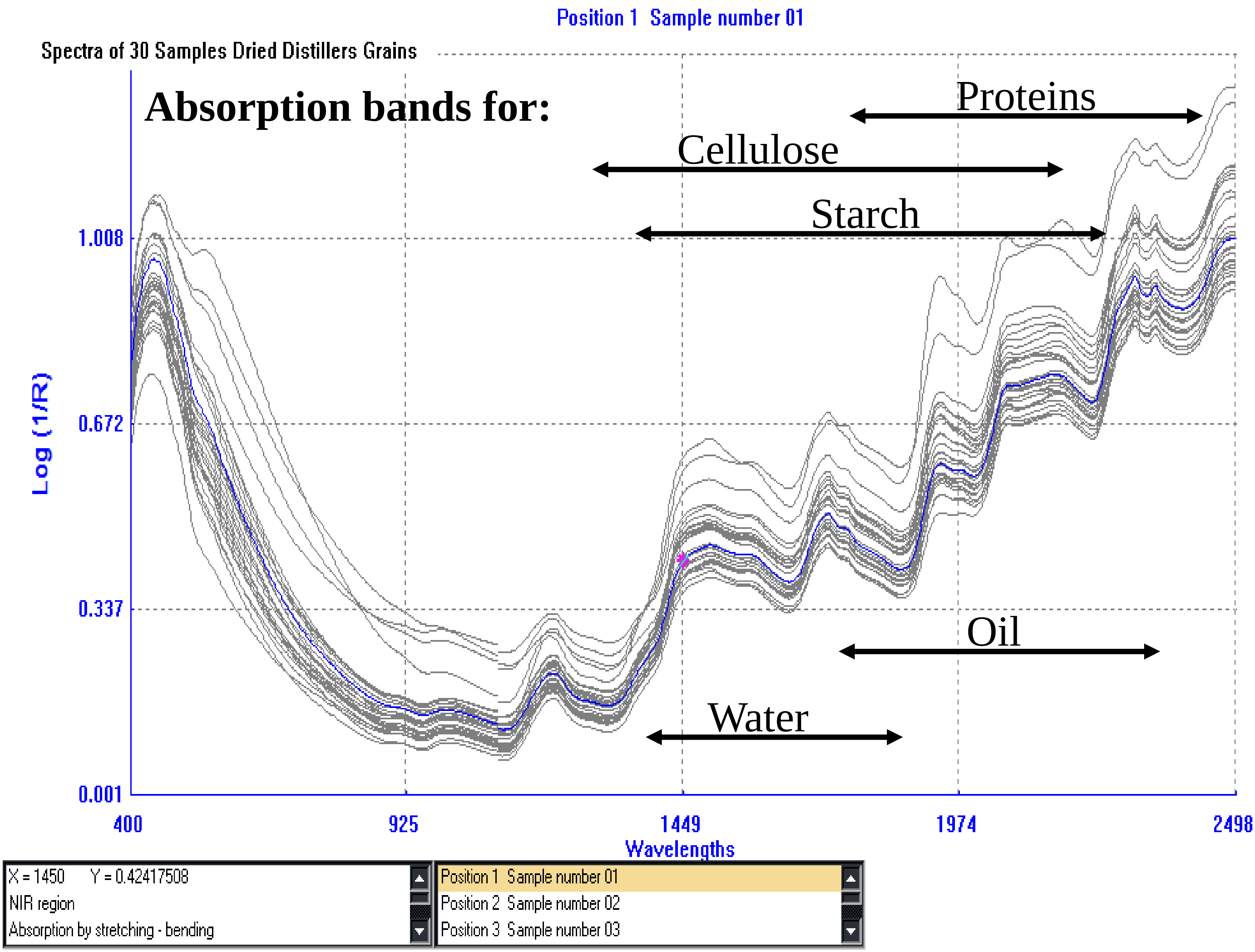
(Fontaine et al. 2007)

Solutions

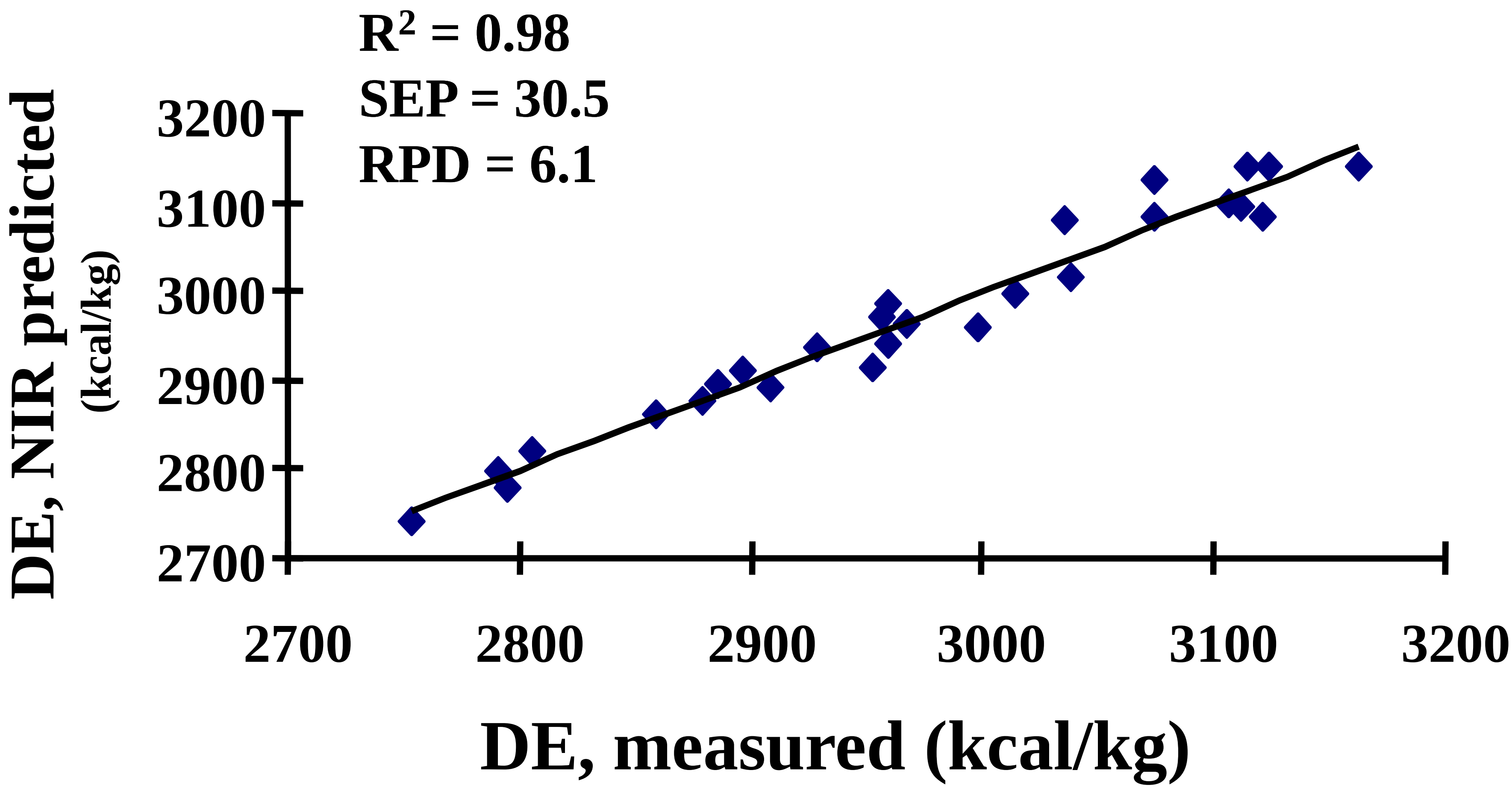
Rapid methods for estimation of energy values of feedstuffs for pigs

Near Infra-red Reflectance Spectroscopy



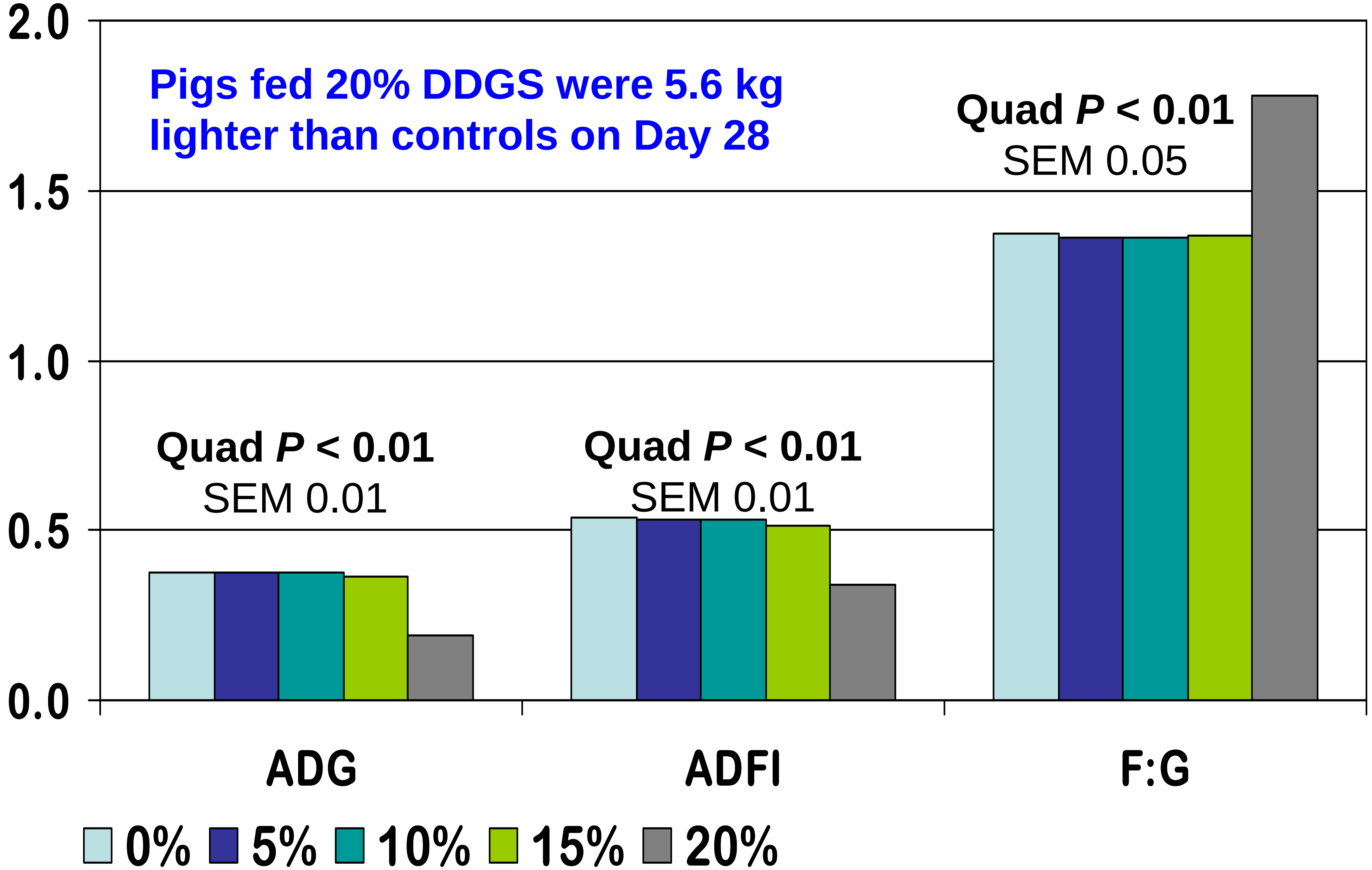

Position 1 Sample number 01
Spectra of 30 Samples Dried Distillers Grains
Absorption bands for:
Proteins
Cellulose
Starch
Oil
Water
Log (1/R)
1.008
0.672
0.337
0.001
400
925
1449
1974
2498
Wavelengths
X = 1450 Y = 0.42417508
NIR region
Absorption by stretching - bending
Position 1 Sample number 01
Position 2 Sample number 02
Position 3 Sample number 03

Calibration DE – Within feedstuff
(barley)



(Zijlstra et al., 2010)

Wheat DDGS for Weaned Pigs

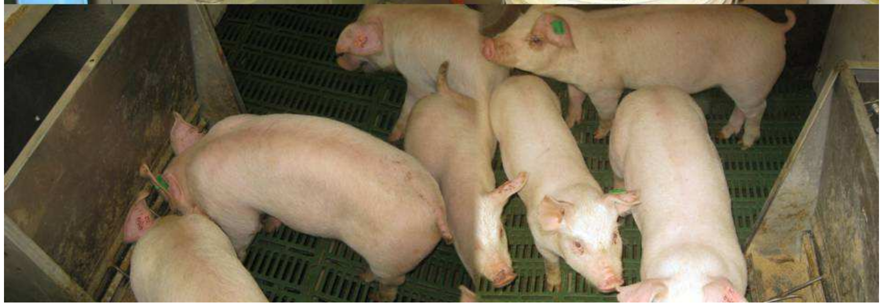


Avelar et al. 2010; Anim Feed Sci Technol

Canola

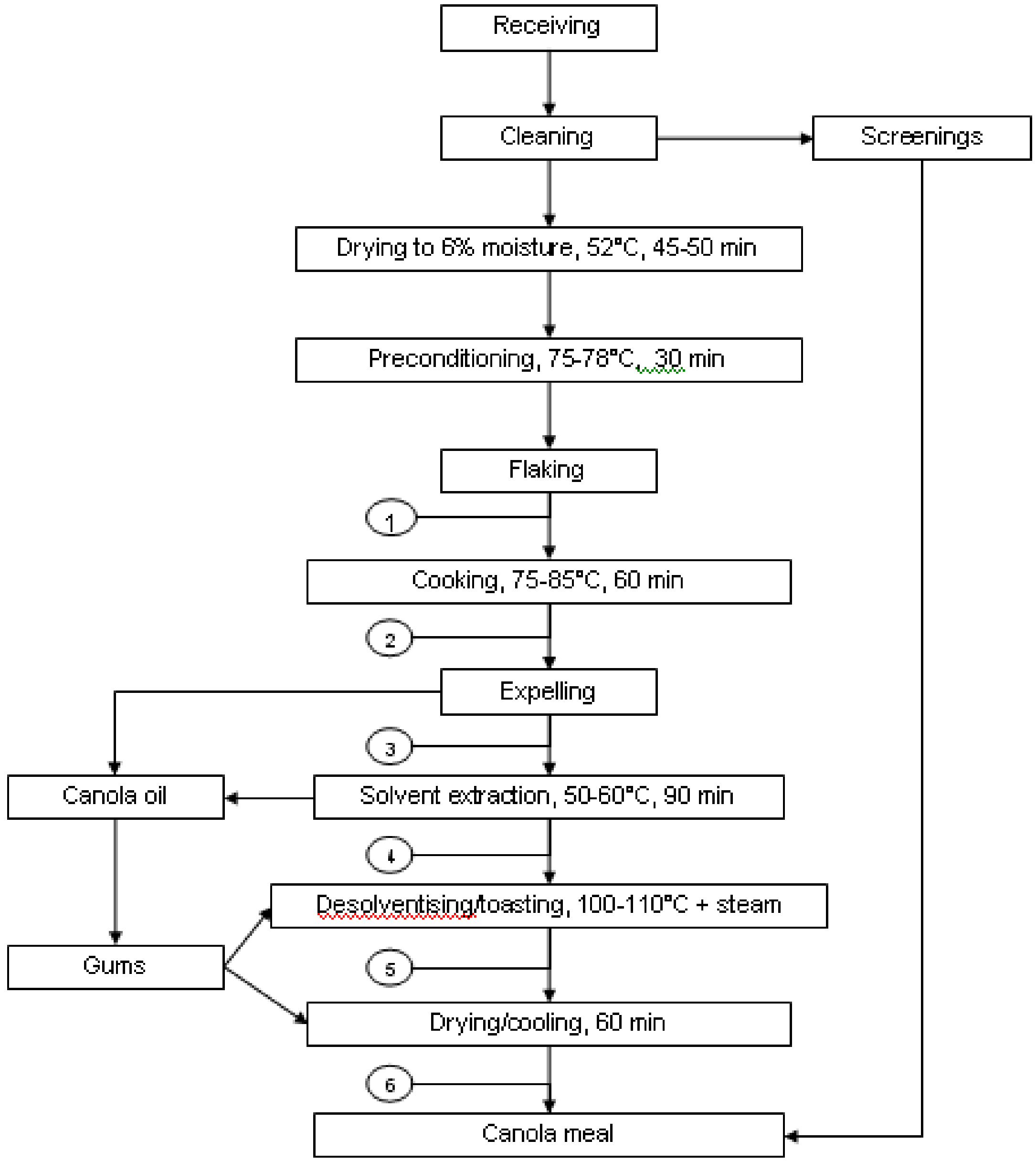
aka low glucosinolate, low erucic acid rapeseed
Canola seed contains >40% canola oil

- **Solvent oil extraction**
  - Canola meal
  - 2-stage; hexane
- **Expeller oil extraction**
  - Expeller-pressed canola meal
  - Conditioning
- **Cold press oil extraction**
  - Canola press cake
  - Without conditioning

Canola Oil Production

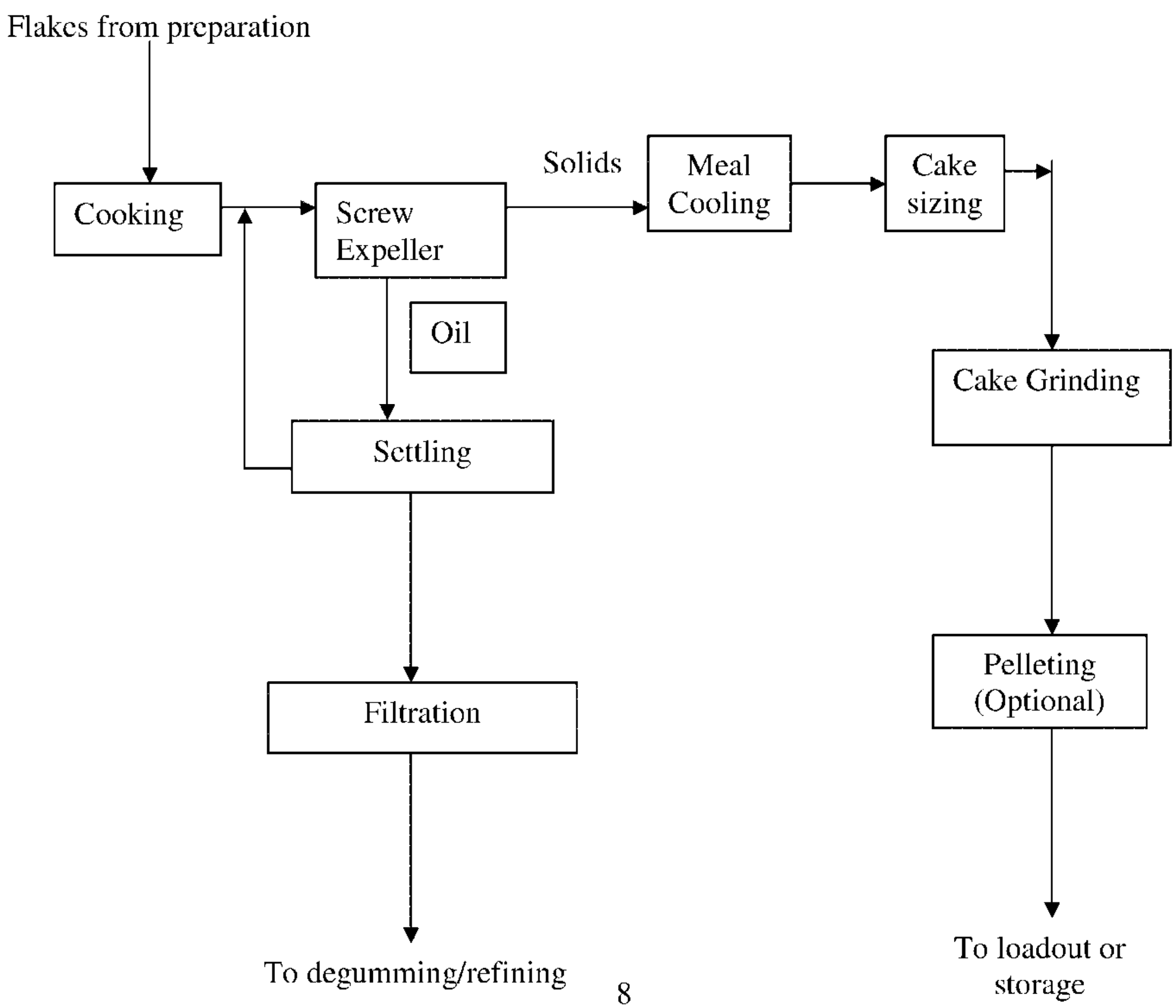
Co-product Canola Meal



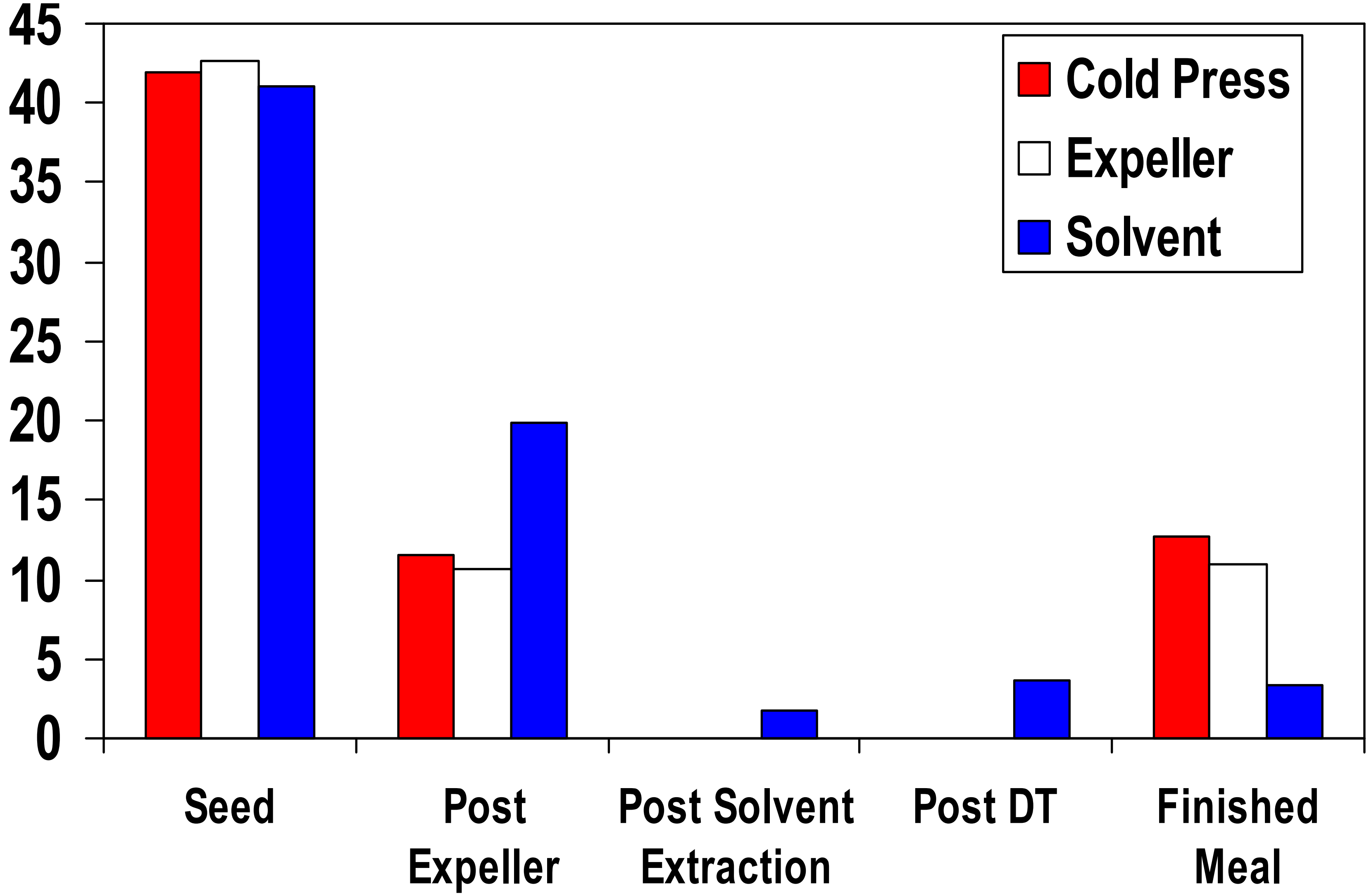
Canola Oil Production

Co-product Expeller-Pressed Canola Meal

Figure 2: Pre-treated Steam Expeller



Residual Oil



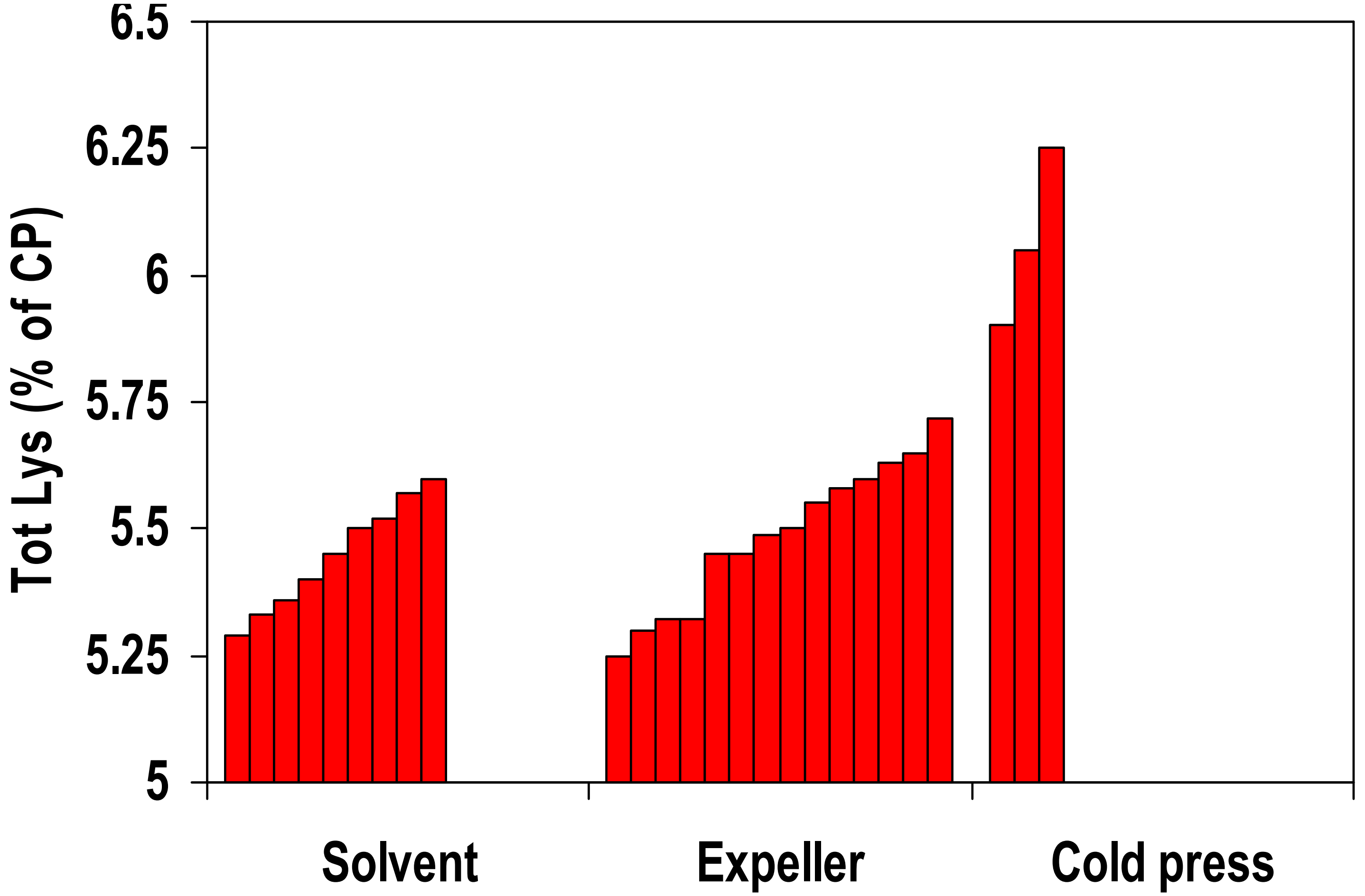
(Spragg and Mailer 2007)

Variability in Characteristics

Item, as is	Average	SD	Lowest	Highest
CP, EXP	36.3	2.62	31.6	41.7
% CM	37.3	1.87	33.3	42.5
EE, EXP	11.1	1.55	8.5	17.0
% CM	3.4	0.7	1.8	4.8
NDF, EXP	24.1	1.88	20.9	28.1
% CM	24.1	0.90	21.7	27.2
Glucos., EXP	5.26	1.72	2.36	8.92
µmol/g CM	1.73	0.79	0.49	3.09

(Spragg and Mailer 2007)

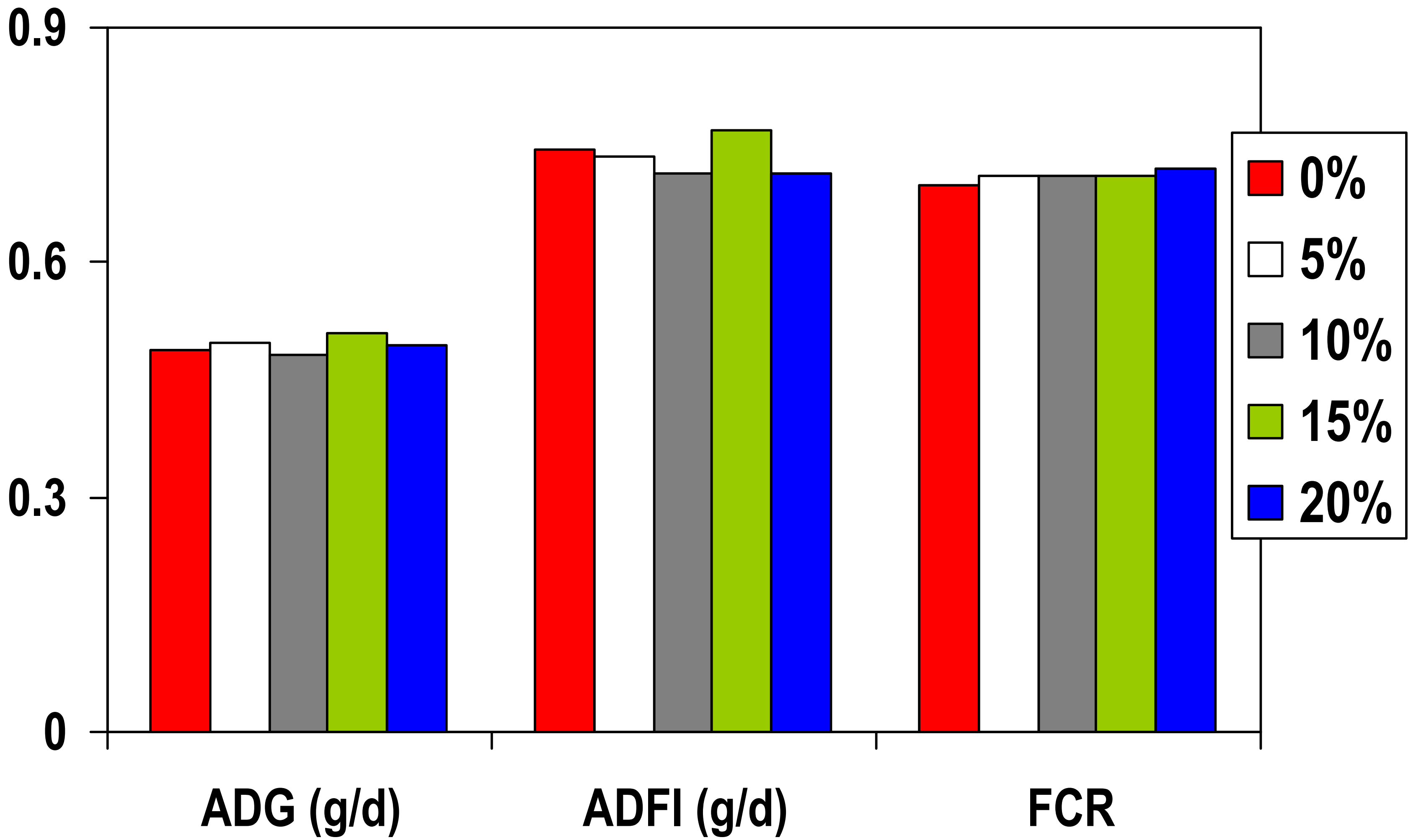
Variability in Lys



Reactive LYS 76.5% 79.0% 86.1%

(Spragg and Mailer 2007)

Solvent-Extracted Canola Meal for Weaned Pigs

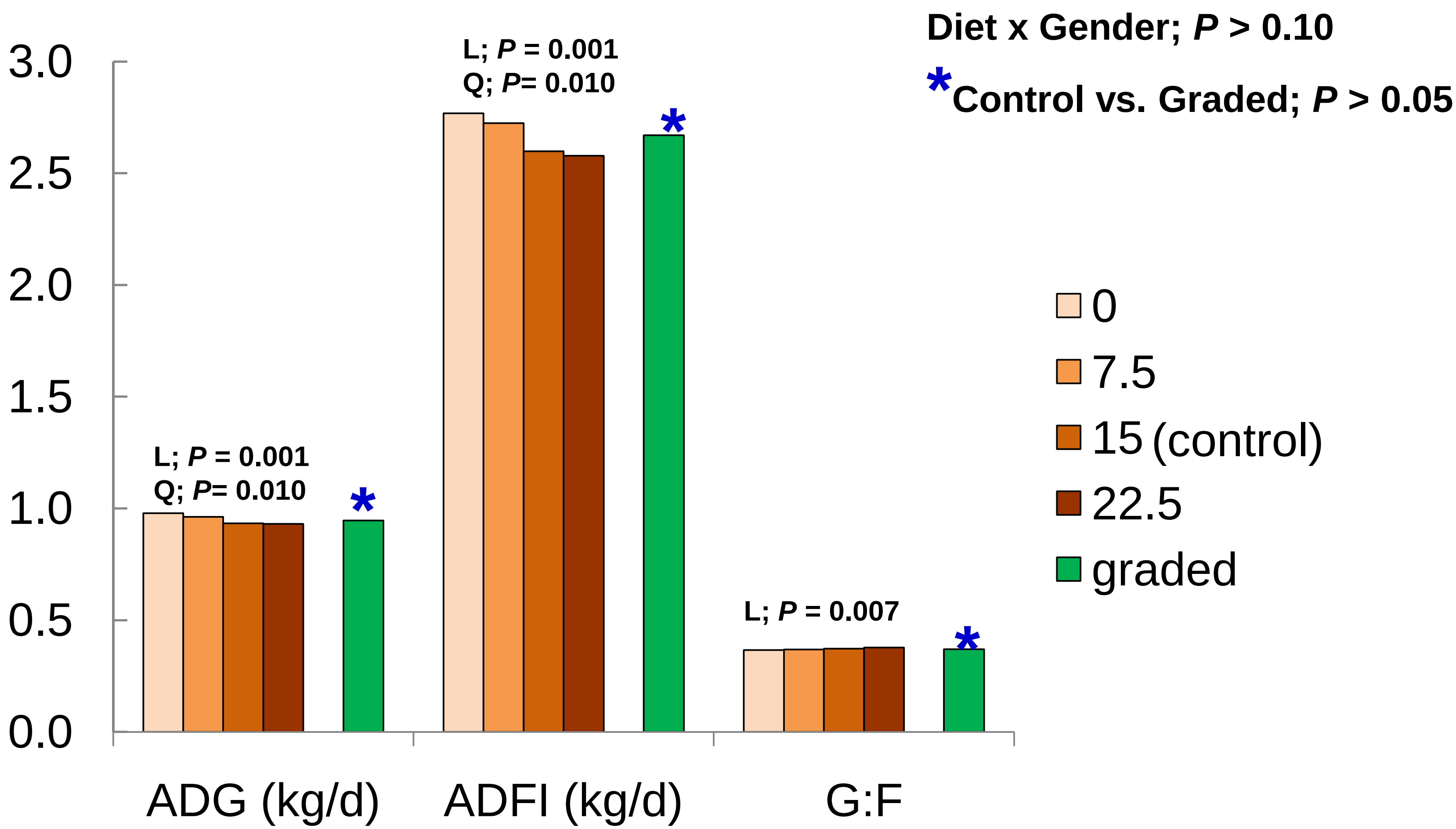


Canola meal replaced soybean as protein source for weaned pigs

Diets formulated using NE and SID AA

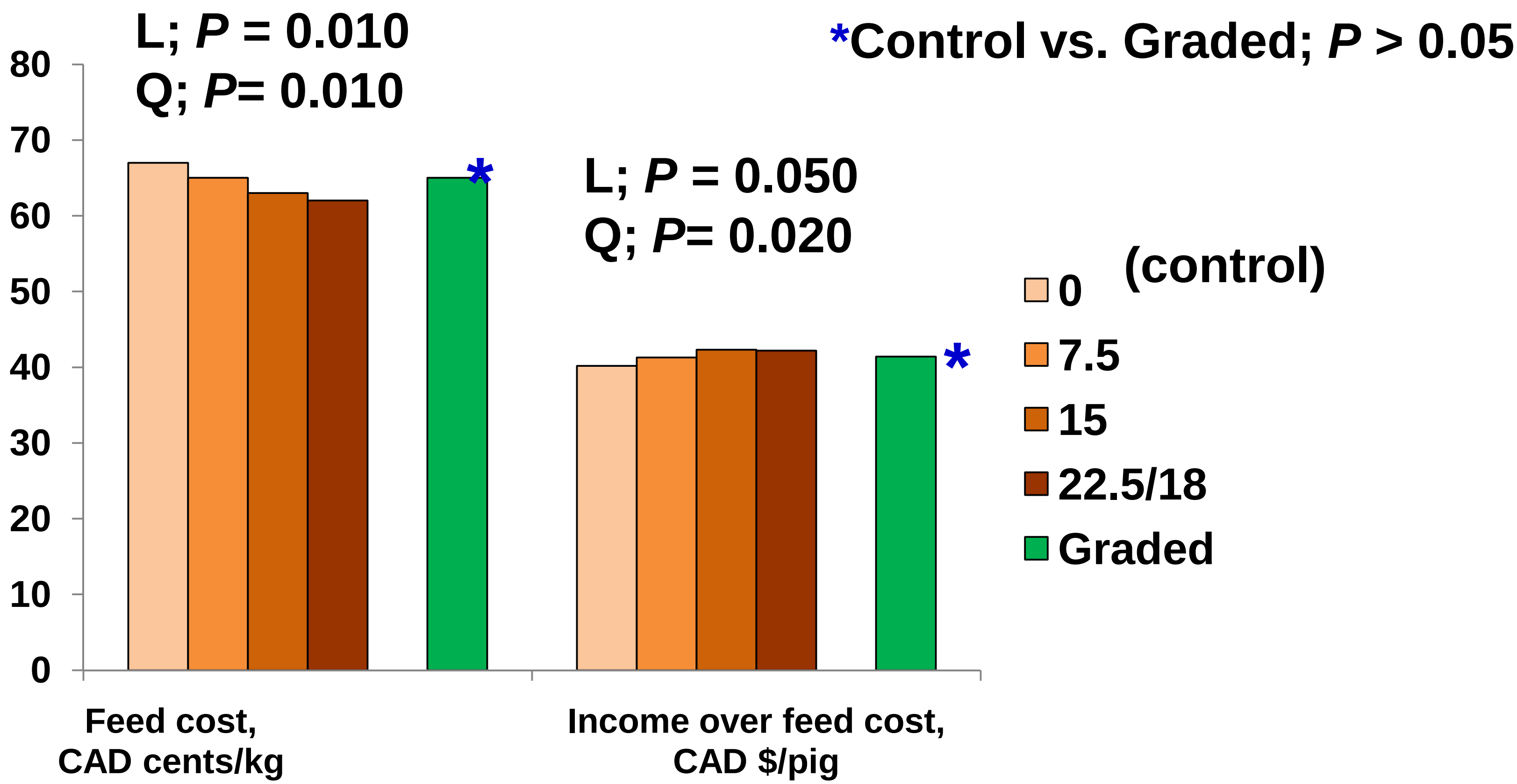
(Landero et al. 2010)

Expeller-Pressed Canola Meal Grower-Finisher Pigs



(Seneviratne et al. 2010; J Anim Sci)

Expeller-Pressed Canola Meal Feed Cost; Grower-Finisher Pigs



	EPCM, %						*P*- value	
Item	0	7.5	15	22.5/18	Graded[1]	SEM	L	Q
Carcass weight, kg	95.7	94.8	93.8	93.1	94.8	0.87	0.02	0.01

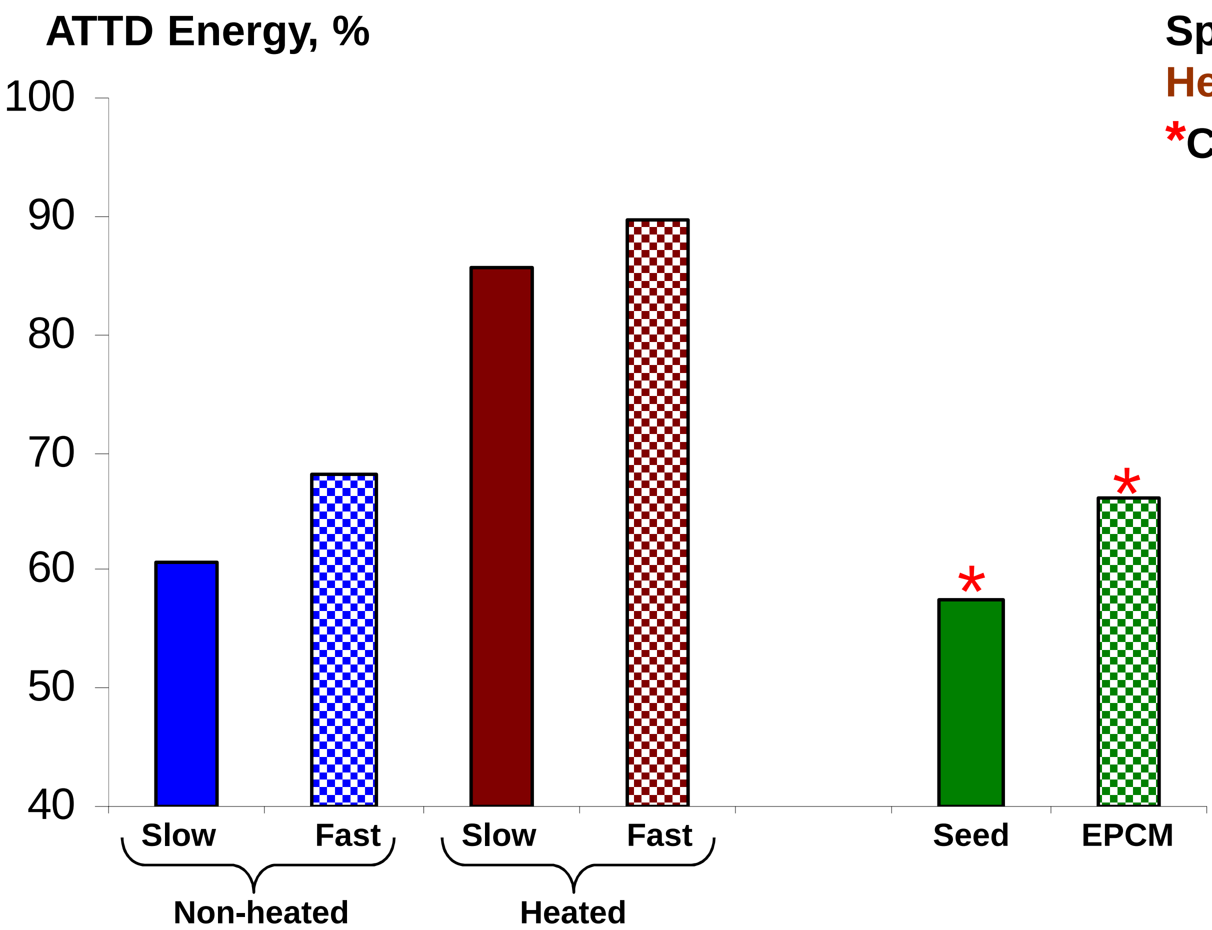
Dressing percentage reduced due to higher fiber; market pigs heavier

Cold-Pressed Canola Cake ATTD of Energy

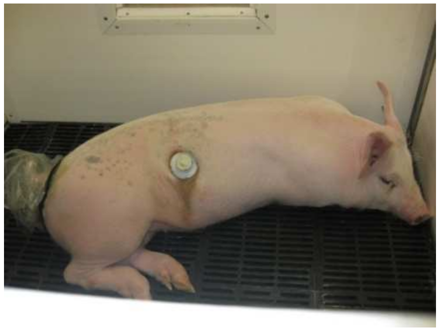
Speed x Heat; *P* > 0.05

Heat ; *P* < 0.05

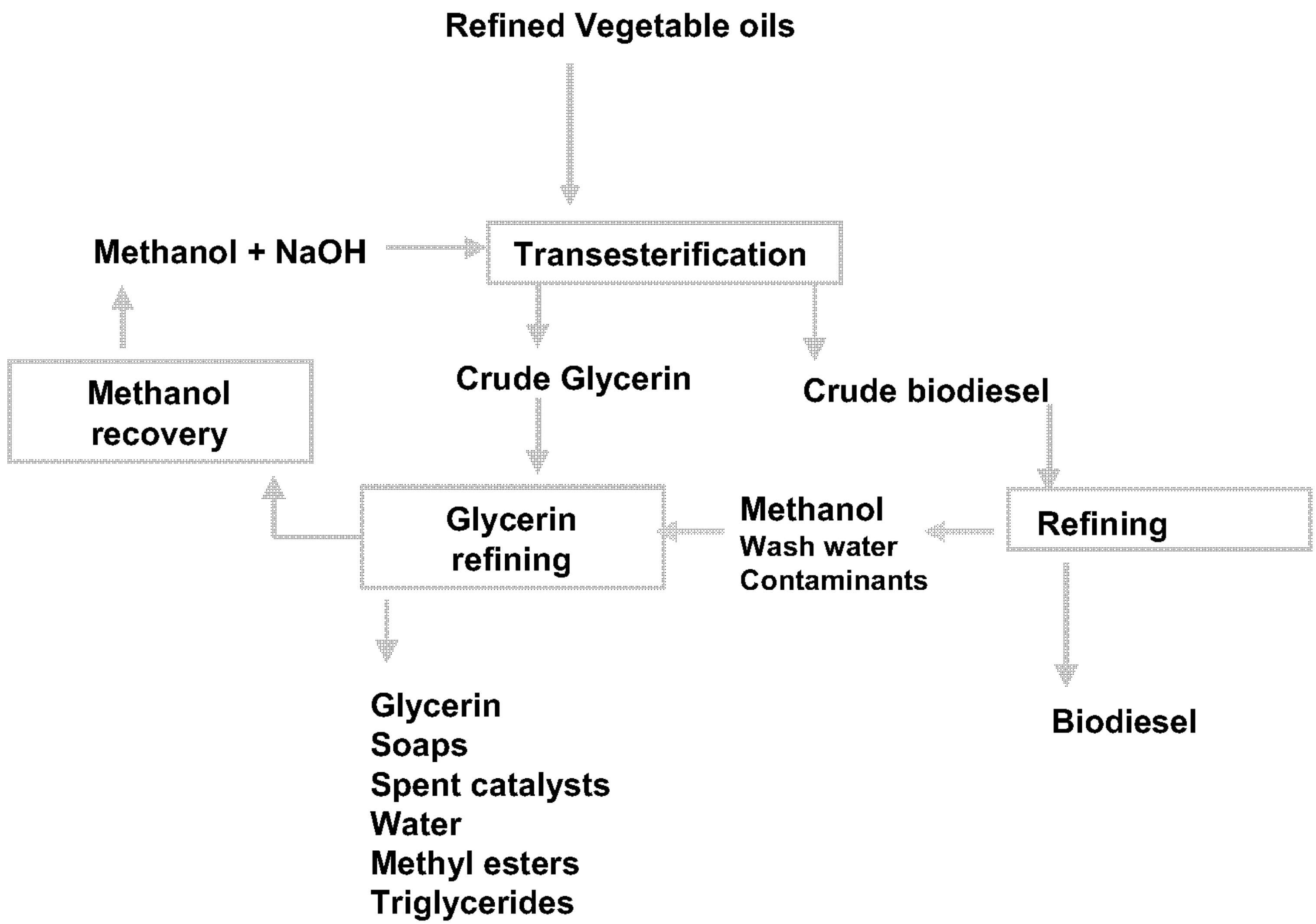
*Controls vs. test; *P* < 0.05



Fat digestibility increased by heat application (Dänicke et al., 1998; Mujahid et al., 2003)



Crude Glycerol

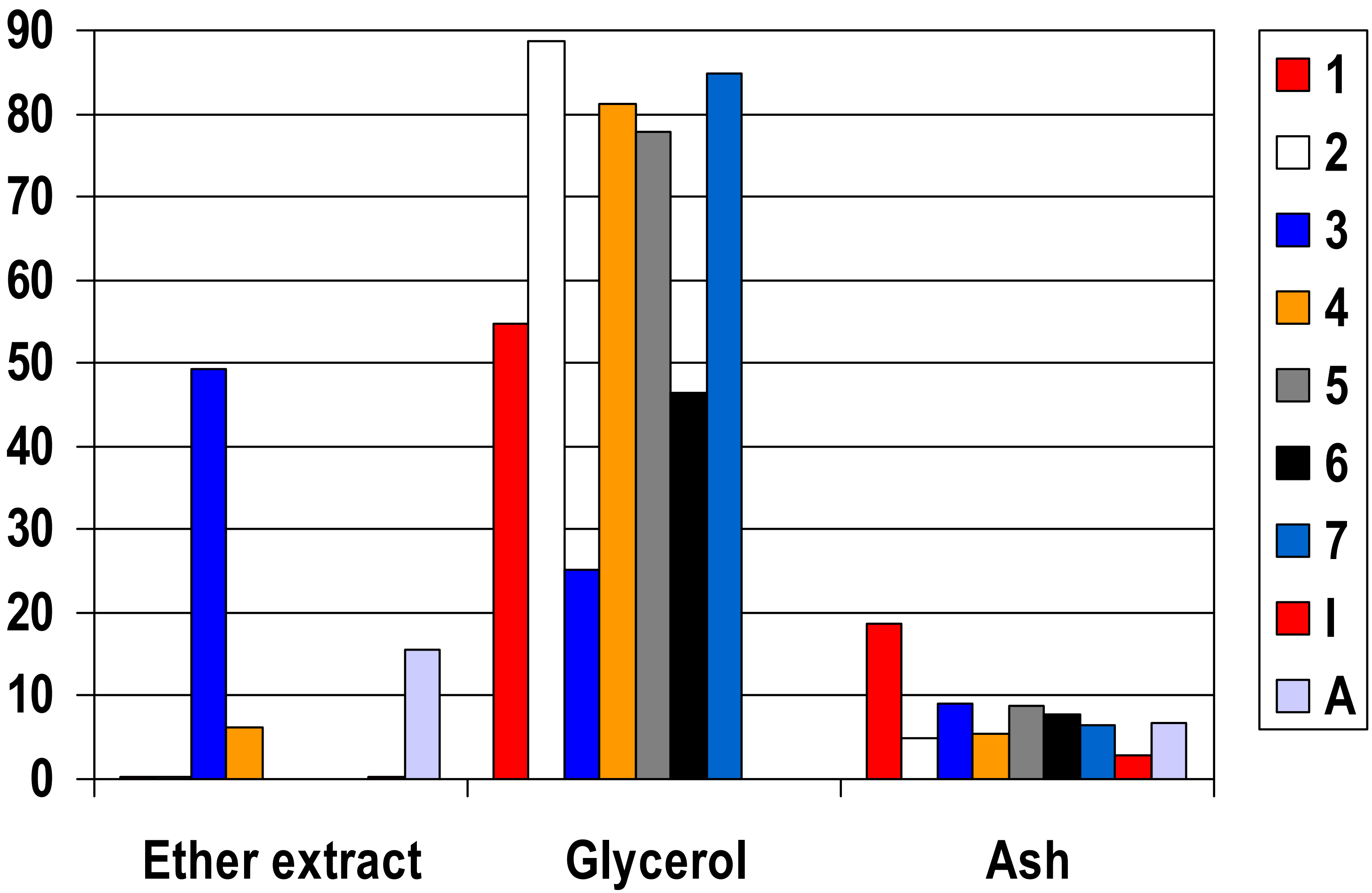


Crude glycerol may contain excess Na or K and residual methanol

Crude Glycerol

Crude glycerol also has logistical considerations

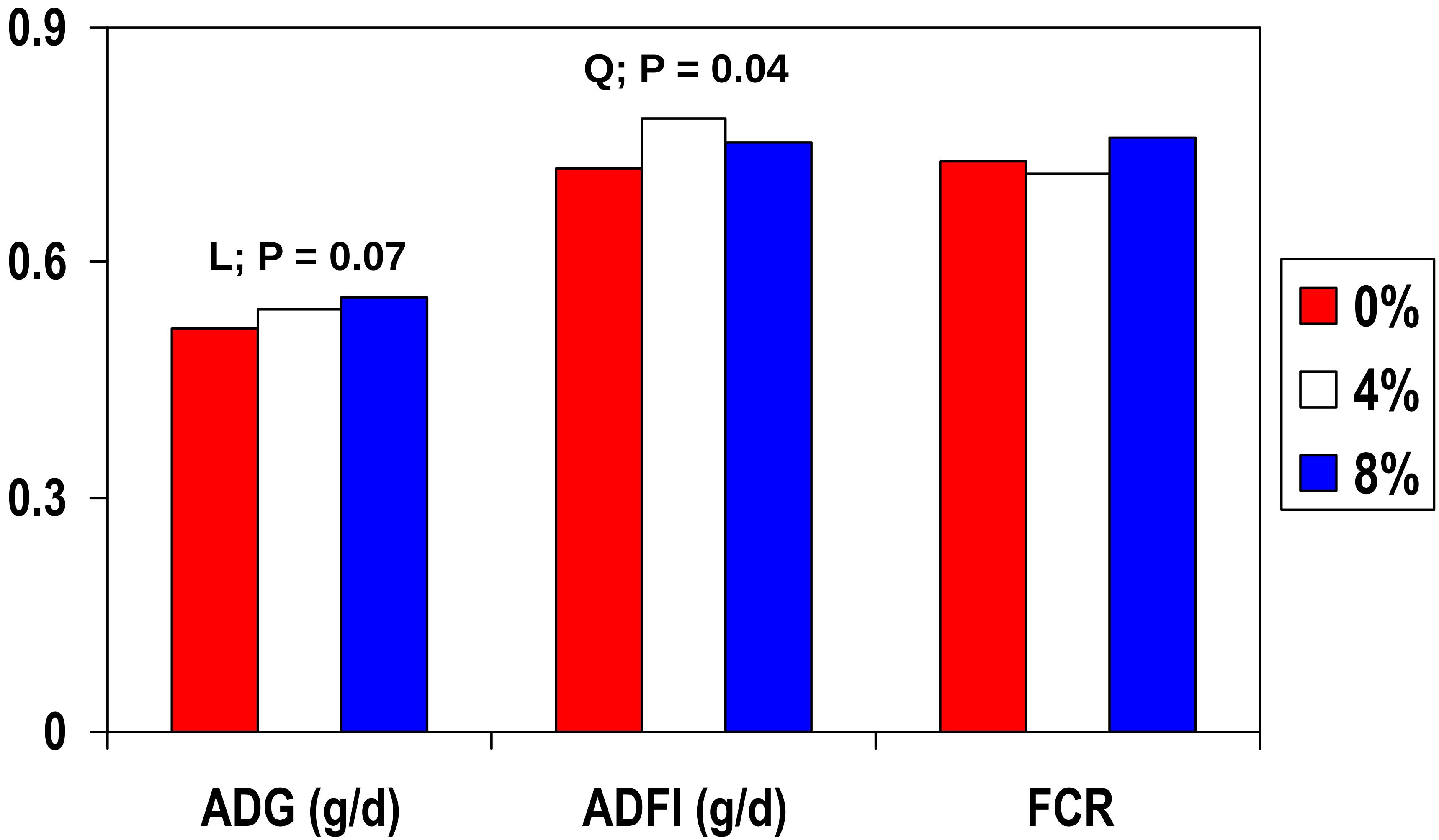
Crude Glycerol - Characteristics



Crude glycerol may contain excess Na or K and residual methanol

(Kijora and Kupsch 1996; Lammers et al. 2008; Zijlstra et al. 2009)

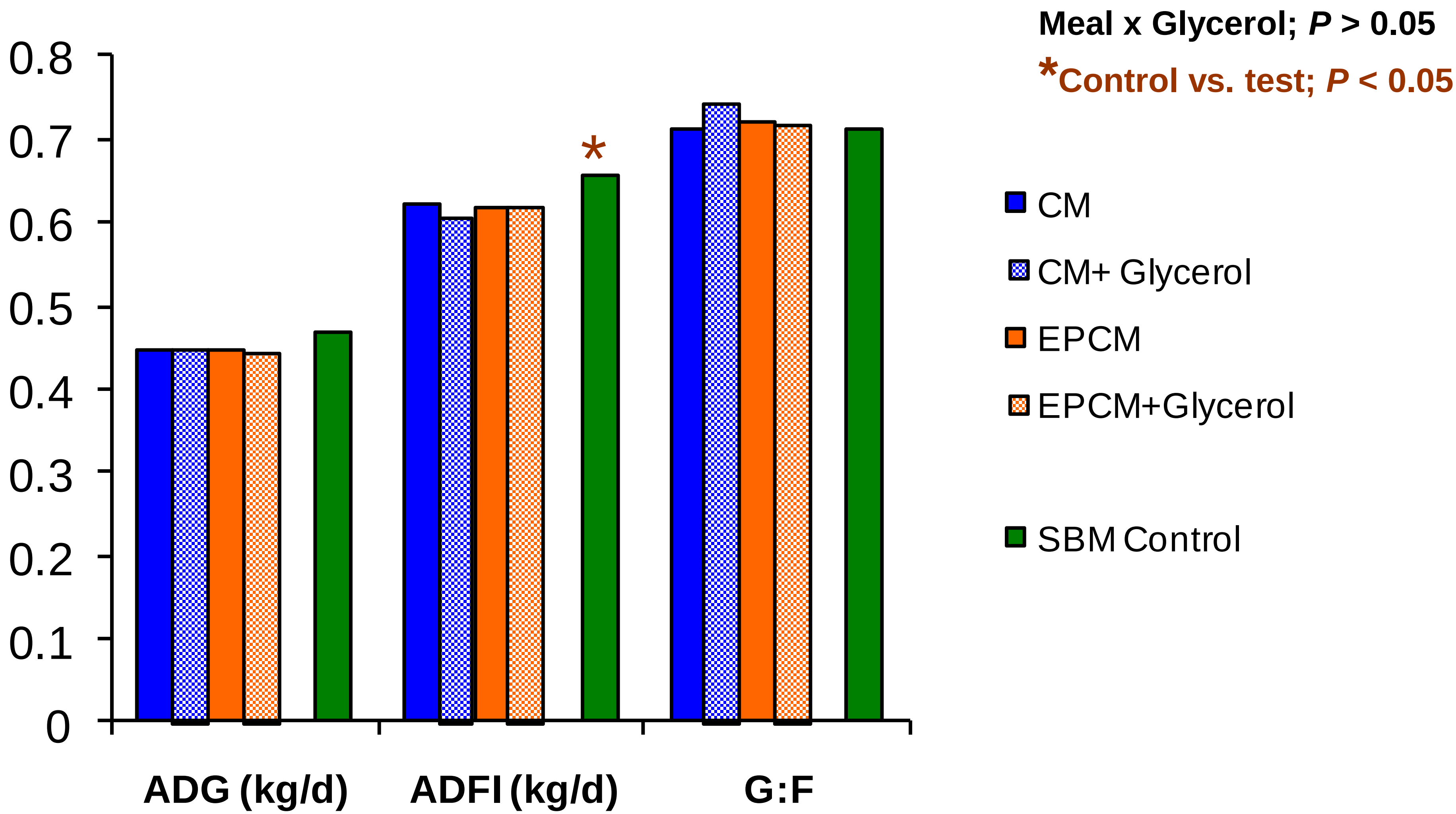
Crude Glycerol
Weaned Pigs



Crude glycerol replaced wheat as energy source for weaned pigs

(Zijlstra et al. 2009; Can J Anim Sci)

Canola Co-Products
Weaned Pigs

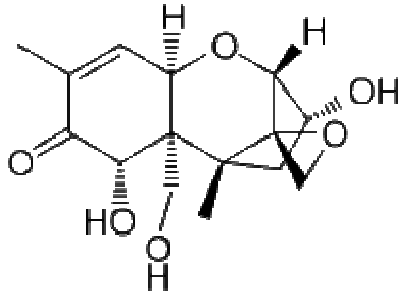


Canola meal partially replaced SBM and wheat
Crude glycerol replaced wheat as energy source for weaned pigs

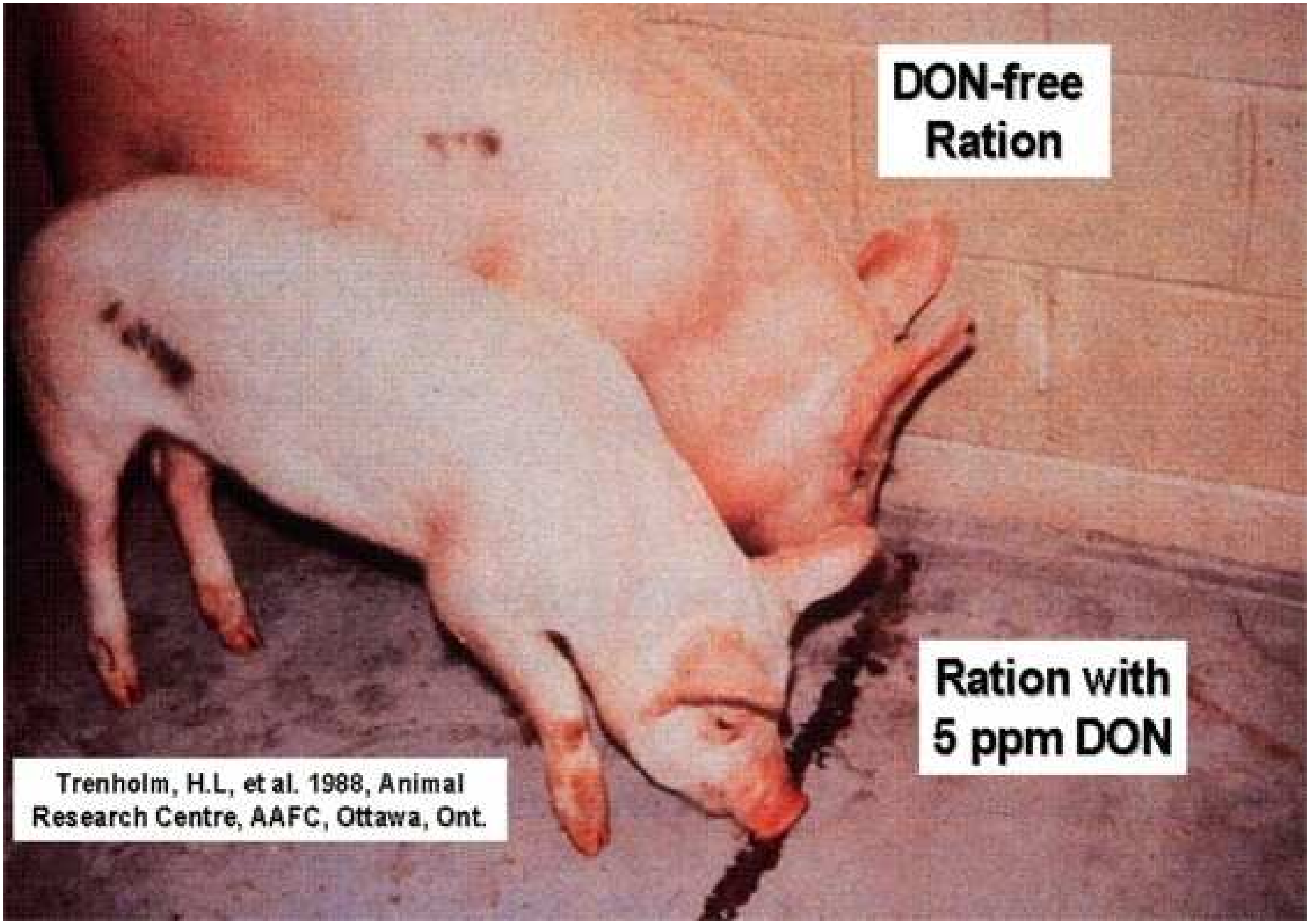
(Seneviratne et al. 2010)

Mycotoxins

- Deoxynivalenol (DON) aka vomitoxin
  - Produced by fungi, e.g., Fusarium *graminarum*
- Agricultural products contaminated with DON
  - Corn, barley, wheat, oats and rye
  - Rice, sorghum and triticale can also be infected
- DON survives production process
  - Thus, concentrates like nutrients
- Pigs extremely sensitive (1 ppm)
  - Only concern in wet years

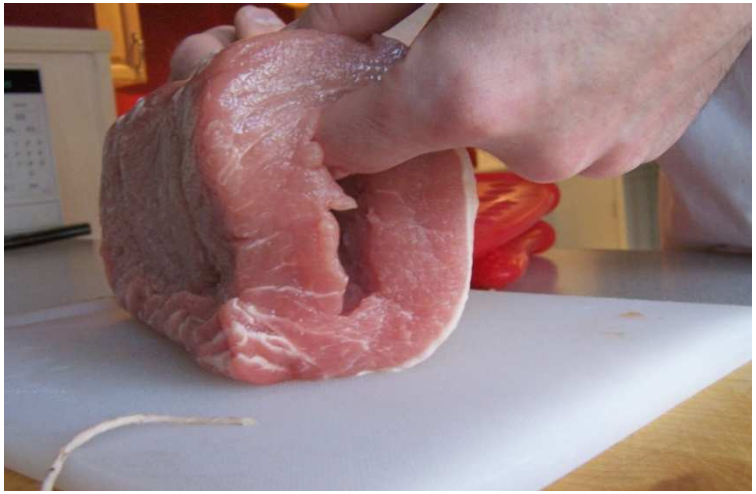


DON Effects


DON-free
Ration
Ration with
5 ppm DON
Trenholm, H.L, et al. 1988, Animal
Research Centre, AAFC, Ottawa, Ont.

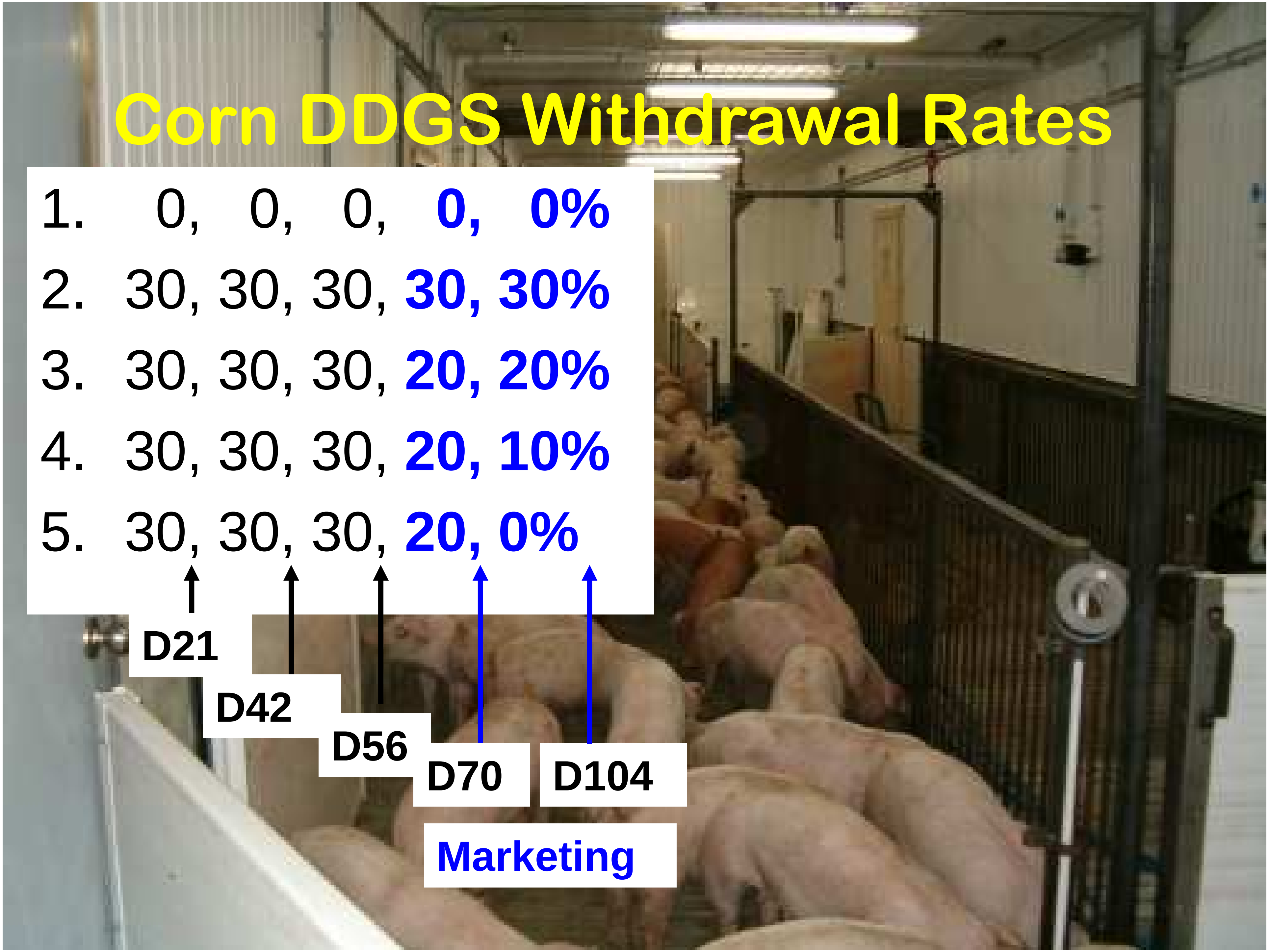
Corn DDGS and Pork Quality

- High in unsaturated linoleic acid
- Feeding DDGS may soften pork fat
- Canada is a large pork exporter
- Packers concerns:
  - Loin firmness
  - Bacon slices may stick and gel together
  - Sausage may appear oily, runny
  - Reduced pork shelf life
- Genotype and gender exacerbate the problem

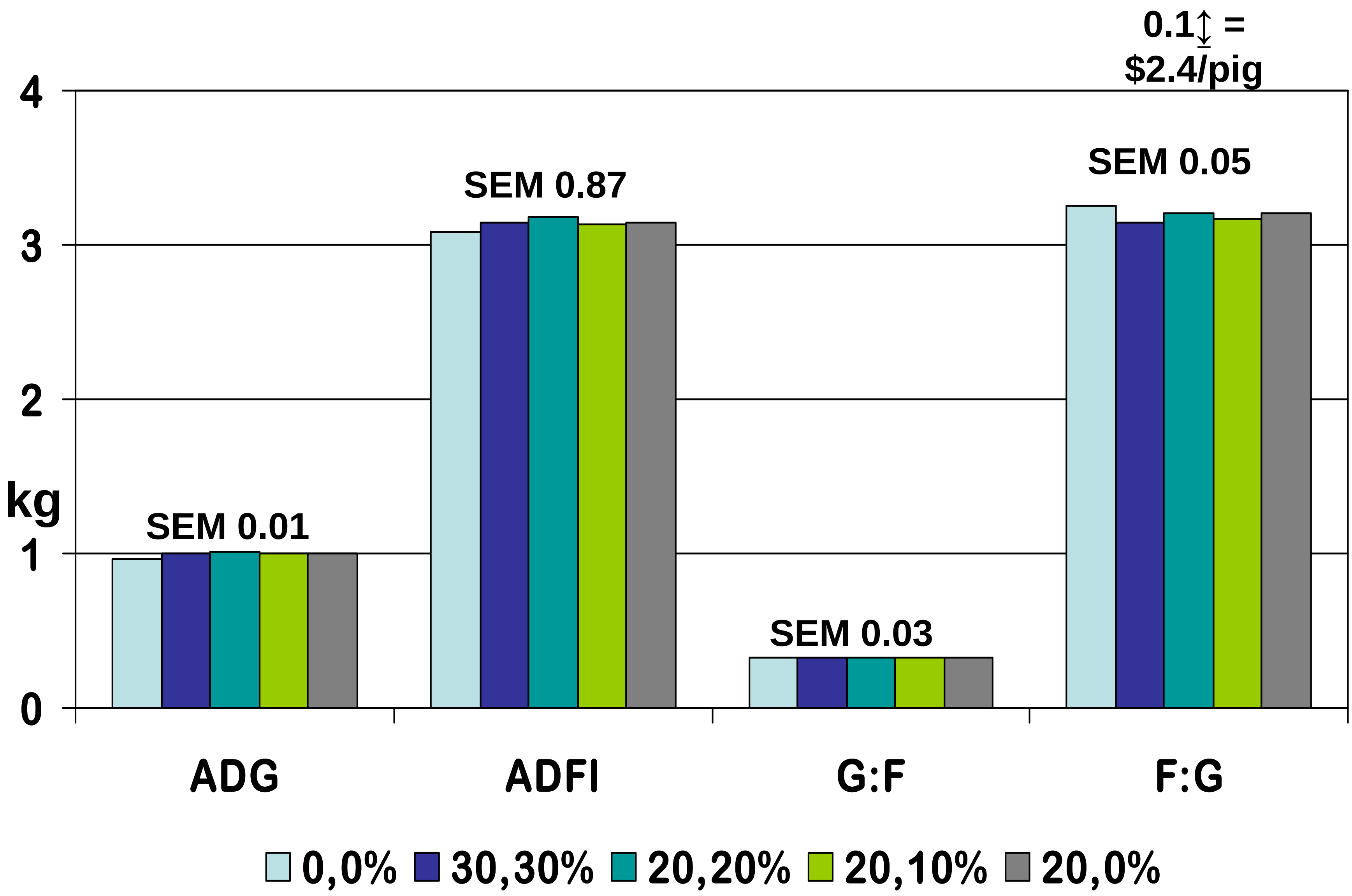


Corn DDGS Withdrawal Rates

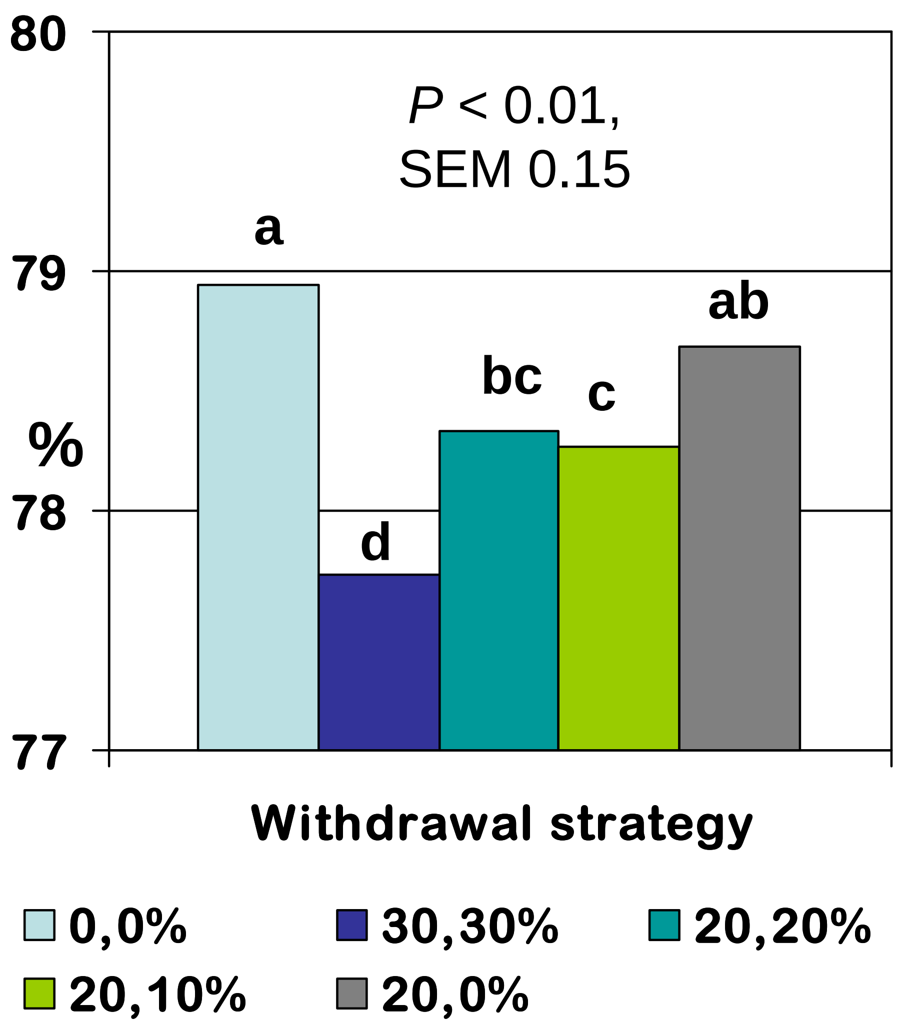
1. 0, 0, 0, **0, 0%**
2. 30, 30, 30, **30, 30%**
3. 30, 30, 30, **20, 20%**
4. 30, 30, 30, **20, 10%**
5. 30, 30, 30, **20, 0%**



Corn DDGS Withdrawal Rates on Hog Growth Performance



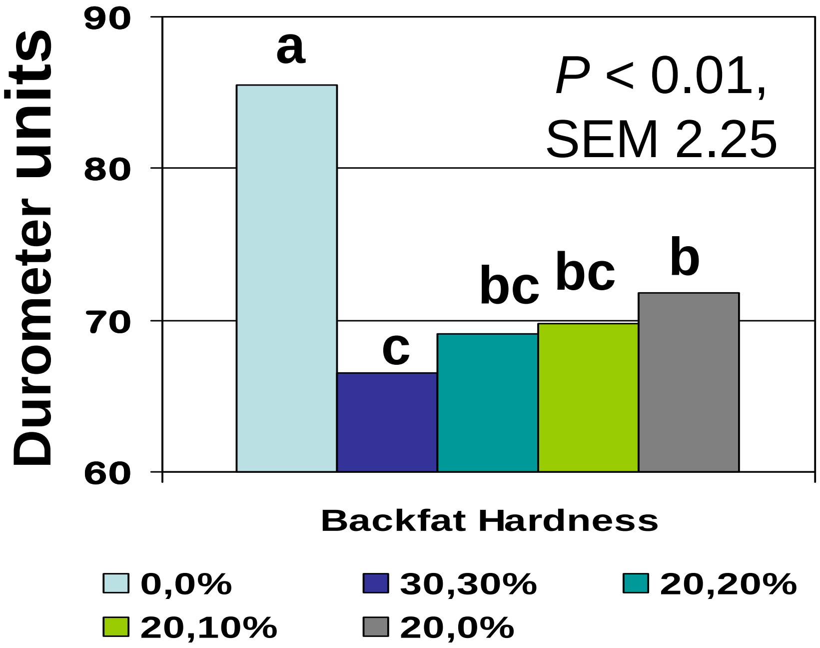
Corn DDGS Withdrawal on Dressing %



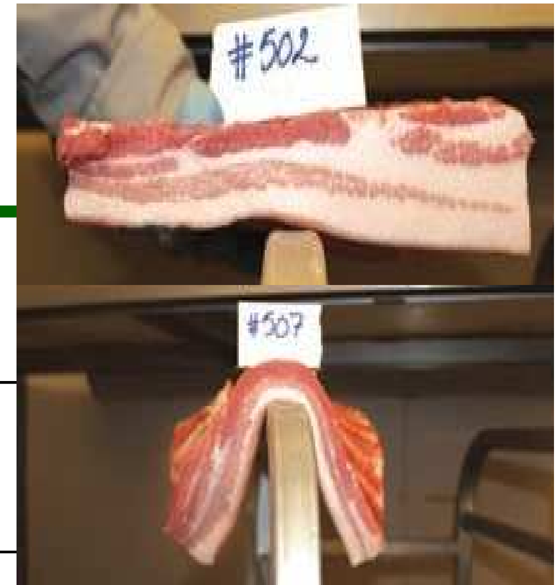
- For each 10% DDGS dressing declined 0.4%
- Negative effect of fiber

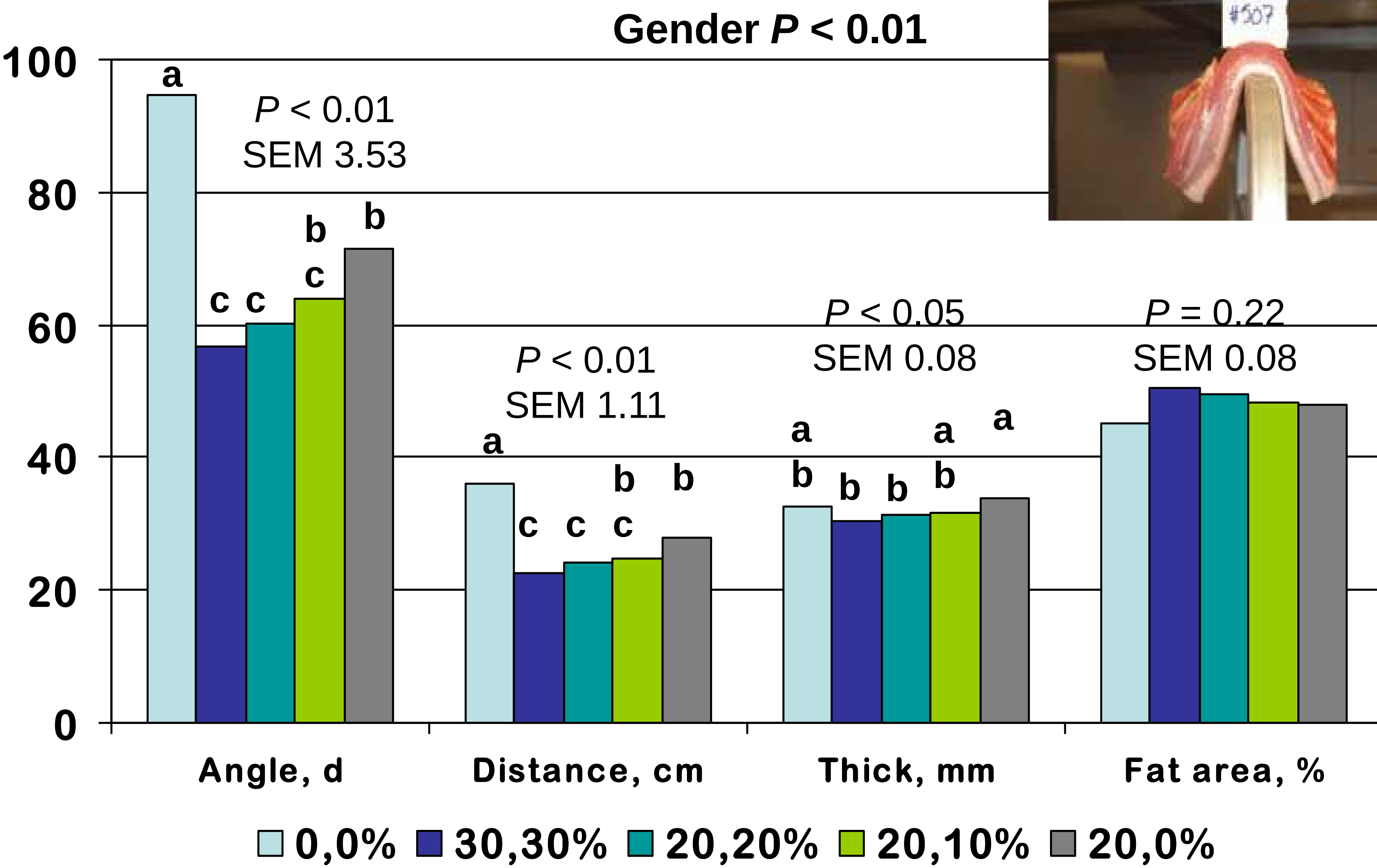
- Withdrawal strategies mitigated the problem

Corn DDGS Withdrawal Rates on Backfat Hardness

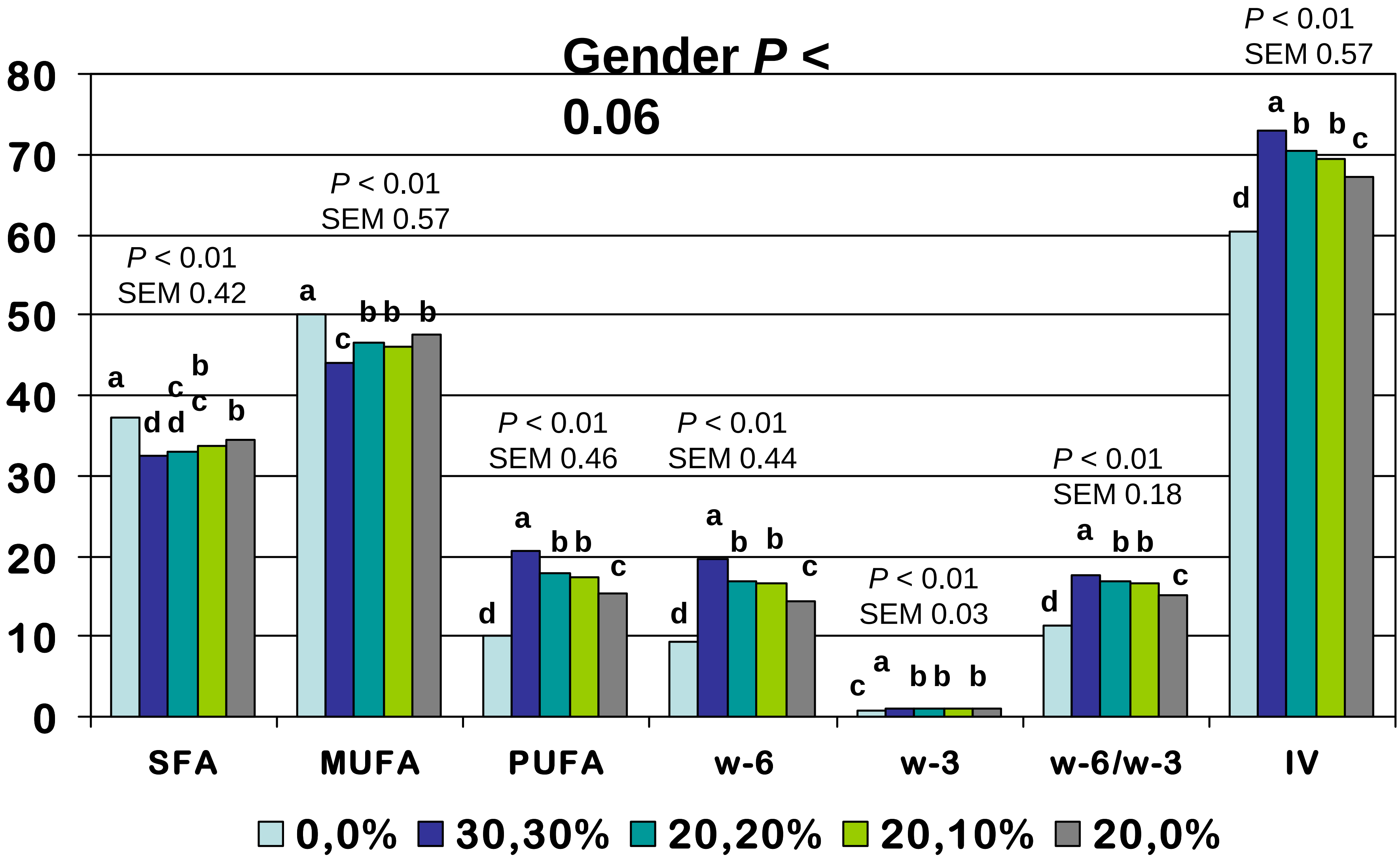


Corn DDGS Withdrawal on Belly Measurements



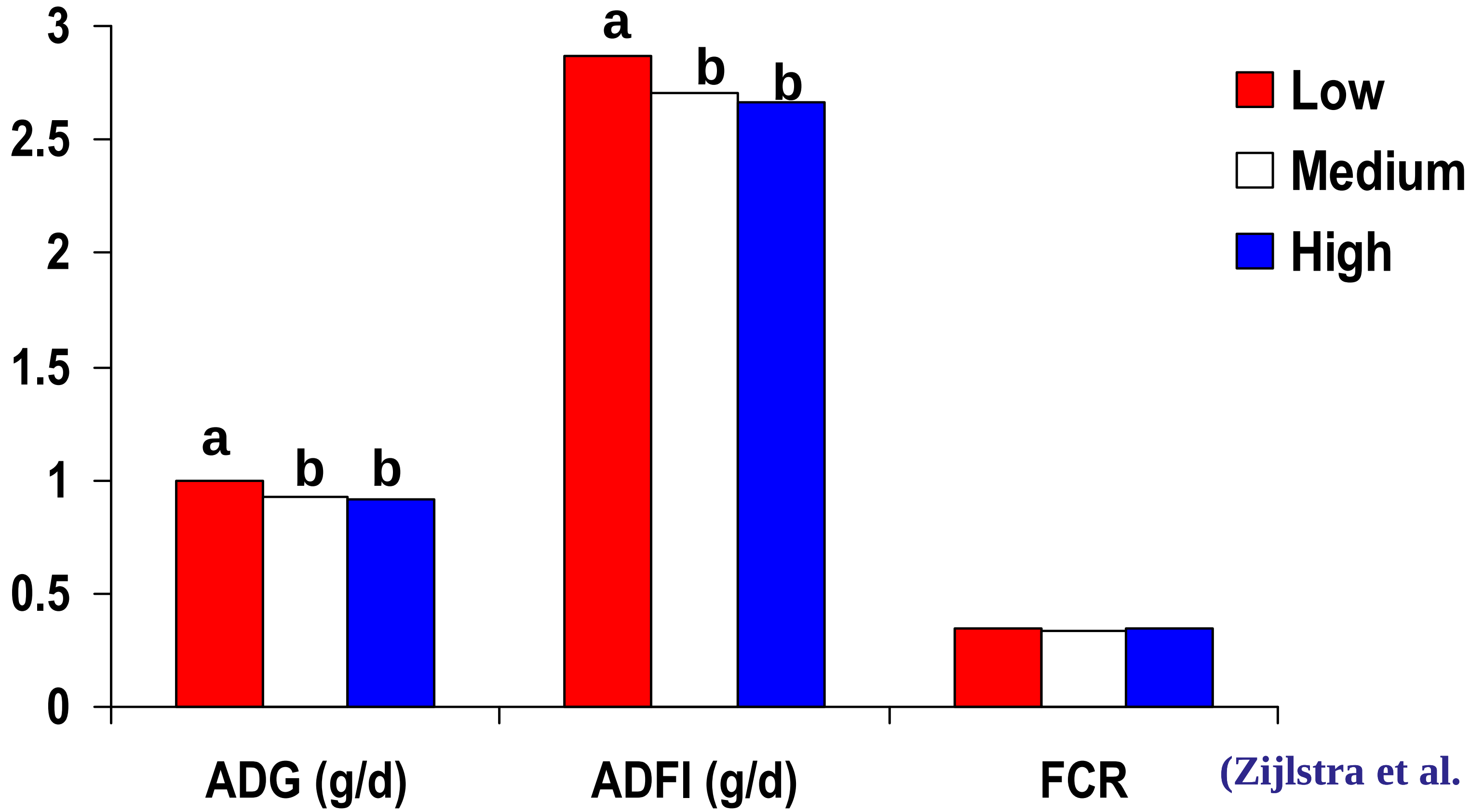


Corn DDGS Withdrawal Rates on % Belly Fatty Acid Composition



Validation studies

Grow-finish; co-product inclusion



(Zijlstra et al. 2009)

Variable	Low	Medium	High
Feed costs, CDN$/kg gain	0.842 a	0.788 b	0.747 b
Income over feed, CDN$/pig	39.5 a	39.9 a	42.4 b

Summary and Conclusions

- **Biofuel Co-Products**
  - **Are important feedstuffs**
  - **Manage risk with proper FQE**
- **Variability in Quality**
  - **Is large; will be important to manage**
- **Specific Risks**
  - **Mycotoxins & residues, occasionally important**
  - **Pork quality, is affected but payment might not be**
- **Conclusion**
  - **Biofuel co-products reduce feed costs/pork, but also provide challenges to achieve cost-effective, predict-able growth, carcass characteristics and pork quality**

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Evaluation and Use of Co-Products from the Biofuel Industry in Pigs

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Swine nutrition research

- Basic carbohydrate nutrition
- Feedstuff development
- Rapid feed quality evaluation