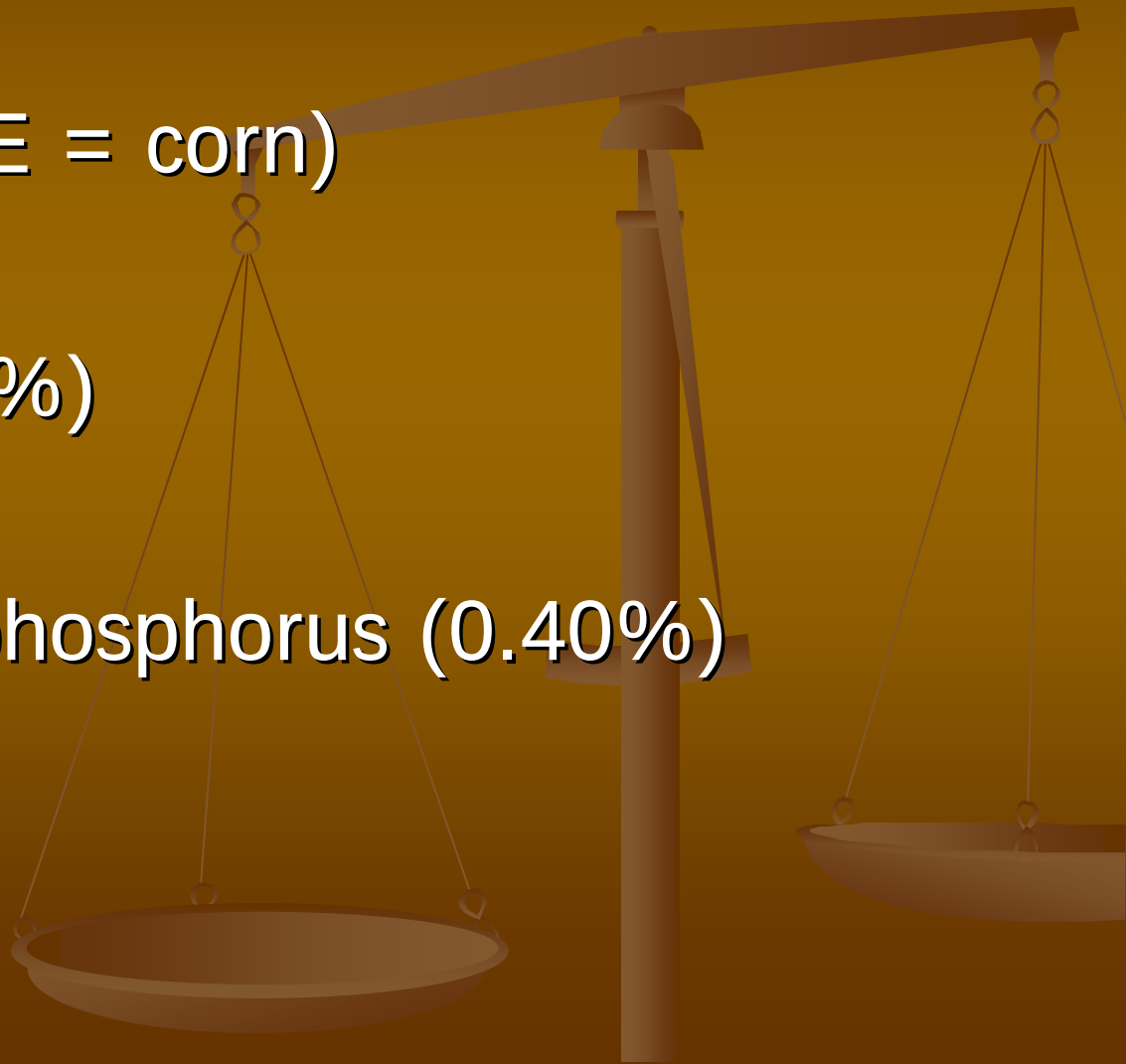
Use of U.S. Corn DDGS in Practical Swine Diet Formulations

Dr. Jerry Shurson and Jenna Pomerenke
Professor, Research Assistant
Department of Animal Science
University of Minnesota

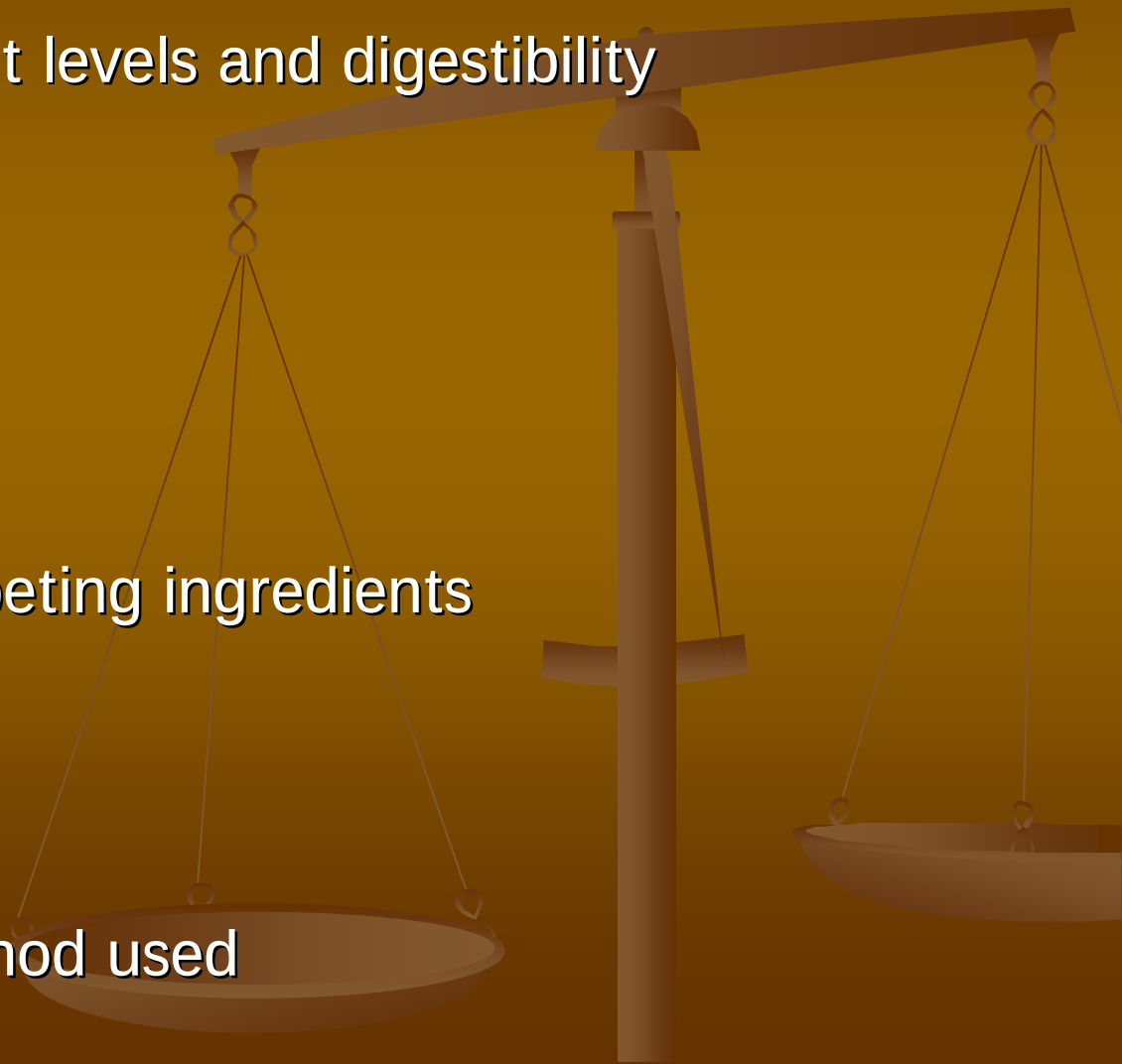
U.S. DDGS is an Excellent Feed Ingredient to Use in Swine Diets



- High energy (ME = corn)
- Mid-protein (27%)
- High available phosphorus (0.40%)

Pig Performance and Diet Cost Savings from Feeding DDGS Depends on…

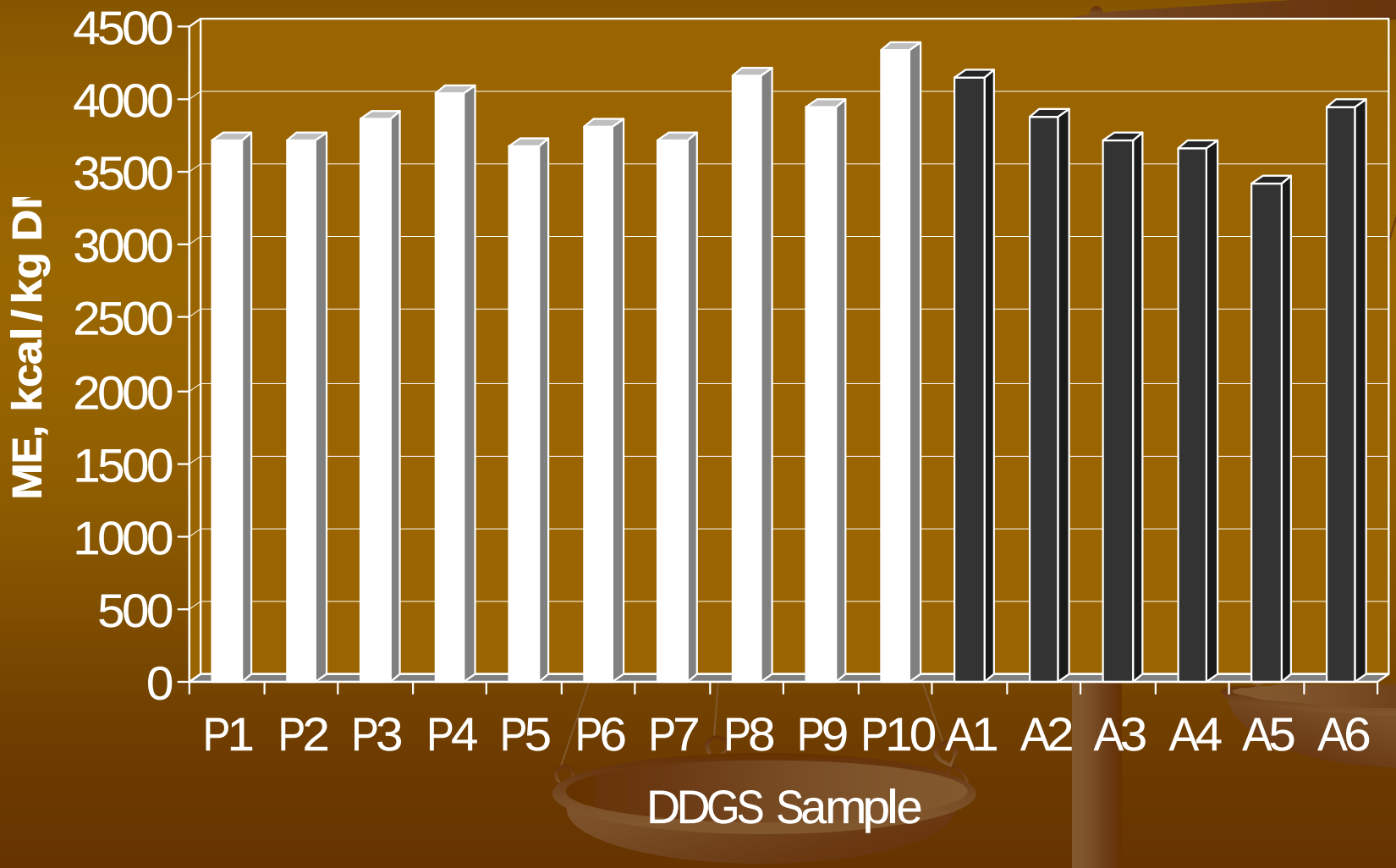
- Knowledge of nutrient levels and digestibility
  - Energy
  - Amino acids
  - Phosphorus
- Dietary inclusion rate
- Relative cost of competing ingredients
  - Corn
  - Soybean meal
  - Inorganic phosphate
- Diet formulation method used



DDGS Nutrient Levels and Digestibility

Variation in ME content of DDGS Sources

(Pedersen et al., 2007; Anderson et al., 2008)



Prediction of DE, ME, or NE from Feed Components

- Drennan & Maguire, 1970 (DE)
- Harris et al., 1972 (ME)
- Morgan et al., 1975 (DE, ME)
- King & Taverner, 1975 (ME)
- Henry, 1976 (DE)
- Kirchgessner & Schneider, 1978 (NE_{fat})
- Batterham et al., 1980 (DE)
- Jorgensen, 1980 (ME)
- Perez et al., 1980 (DE)
- Wiseman & Cole, 1979 (DE, ME)
- Eeckhout & Moermans, 1981 (DE, ME, NE_{growth})
- Kirchgessner & Roth, 1981 (ME)
- Wenk, 1982 (DE)
- Just et al., 1984 (DE, ME, NE)
- Noblet & Perez, 1993 (DE, ME)
- Noblet et al., 1994 (DE, ME, NE)
- Adedokun & Adeola, 2005 (ME for M&B)
- Pederson et al., 2007 (DE, ME)

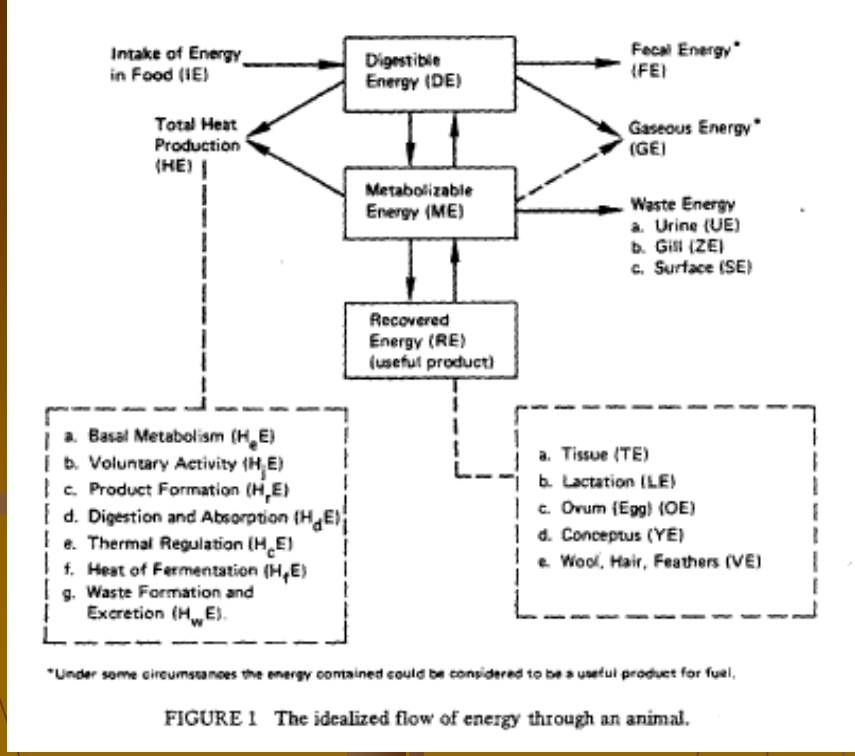


FIGURE 1 The idealized flow of energy through an animal.

Factors Affecting Energy Estimates

- DE = 1,161 + (0.749 × GE) – (4.3 × Ash) – (4.1 × NDF)
- ME = (0.997 × DE) – (0.68 × CP) + (0.23 × EE)
  - ME/DE × 100 = 99.7 – (0.18 × %CP) **Morgan et al., 1975**
- NE = (0.726 × ME) + (1.33 × EE) + (0.39 × ST) – (0.62 × CP) – (0.83 × ADF

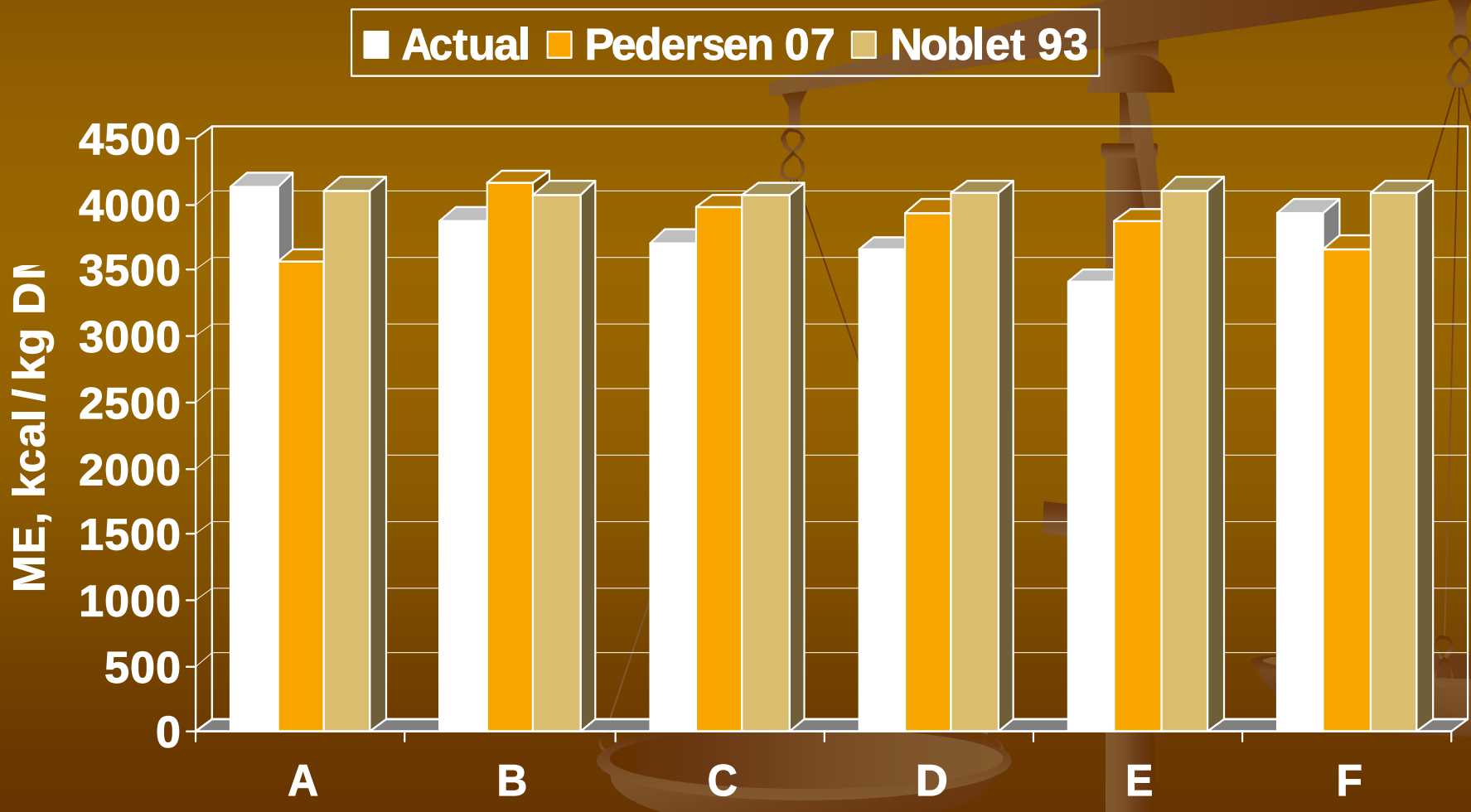
Noblet & Perez, 1993 / JAS 71:3389
Noblet et al., 1994 / JAS 72:344

Prediction of ME in DDGS Sources

Actual in vivo estimates (Anderson et al. , 2008 unpublished)

ME = -11,128 – (124.99×ash)+ (35.76×CP) – (63.40×EE) – (150.92×ADF) + (14.85×NDF) + (3.023×GE) [Pedersen et al., 2007/JAS 85:1168]

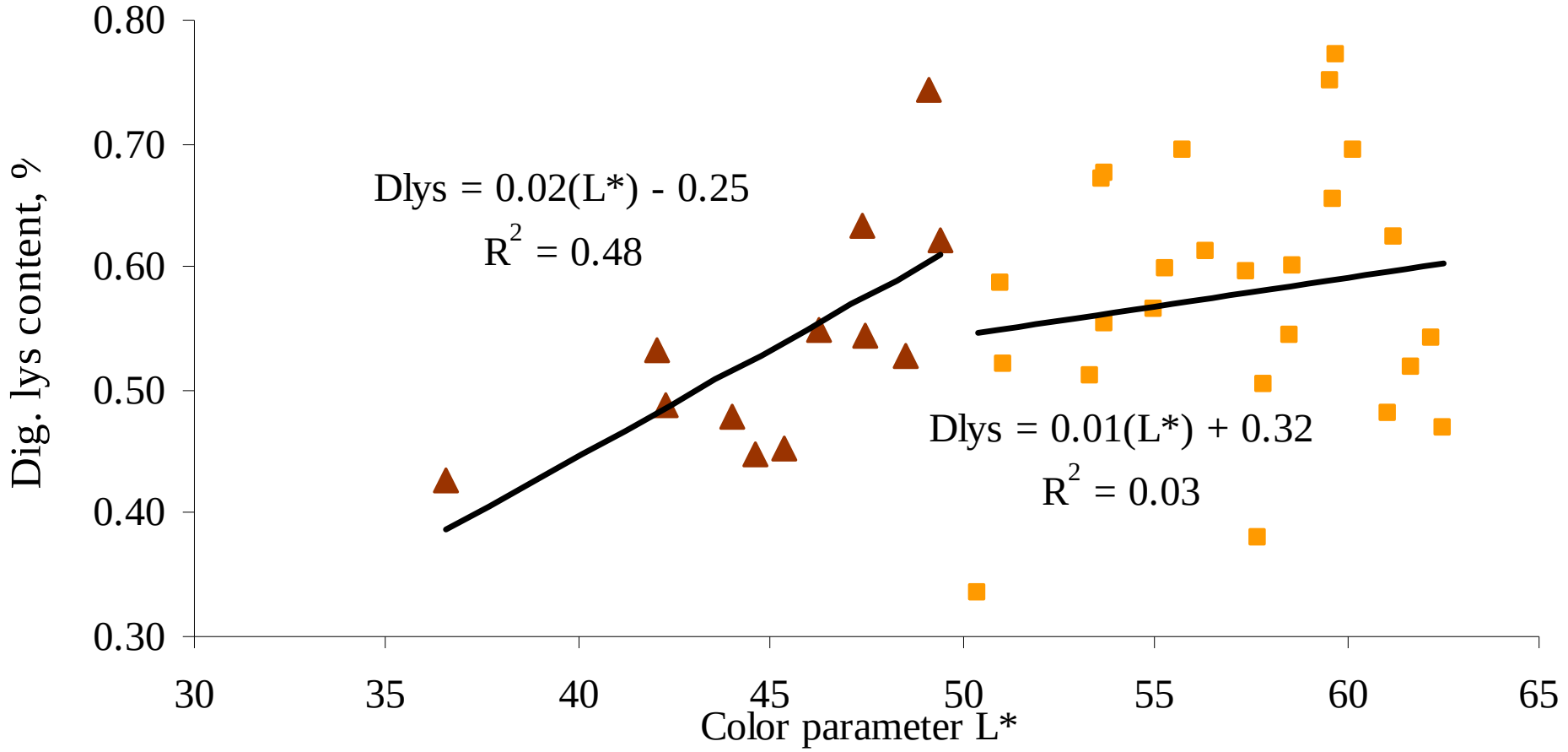
ME = 4,194 – (9.2× ash) + (1.0×CP) + (4.1×EE) – (3.5×NDF) [Noblet & Perez, 1993/JAS 71:3389]



Variation in Total and SID Amino Acid Content of DDGS Sources (As-fed Basis)

Amino acid	Average	Range
Lysine, %	0.80	0.54 – 0.98
SID lysine, %	0.49	0.29 – 0.68
Methionine, %	0.55	0.46 – 0.69
SID methionine, %	0.46	0.35 – 0.58
Threonine, %	0.99	0.83 – 1.16
SID threonine, %	0.70	0.60 – 0.84
Tryptophan, %	0.21	0.11 – 0.27
SID Tryptophan, %	0.14	0.09 – 0.18

Relationship Between Lightness of Color (L*) and Digestible Lysine Content of Corn DDGS



Variation in Total and Digestible Phosphorus Among DDGS Sources

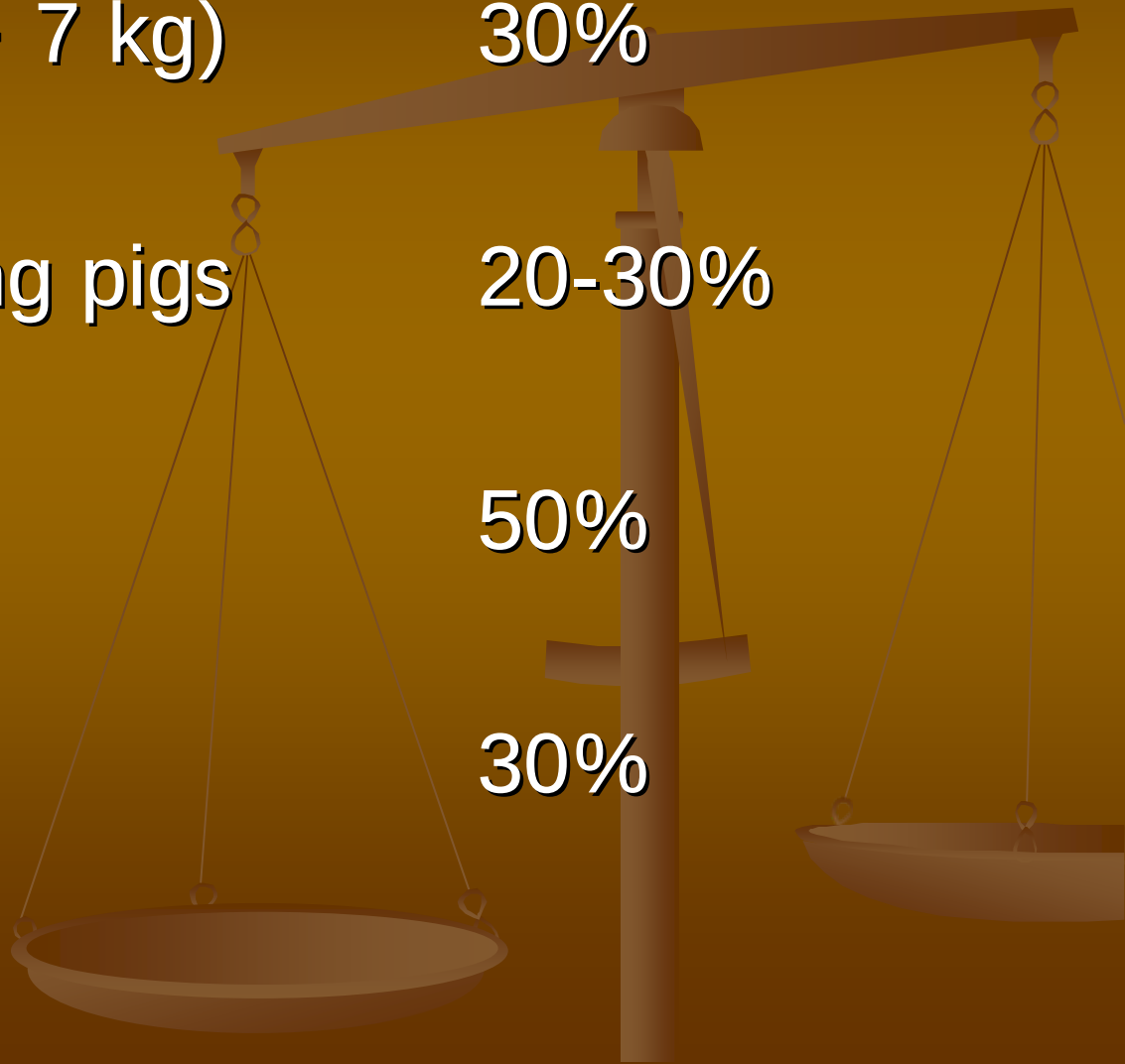
	Average	Range
Total P, %	0.66	0.37 – 0.87
Apparent digestible P, %	0.39	0.28 – 0.47

Diet Composition When 18.8% DDGS and Phytase are Added to a Swine Grower Diet

Ingredient	Corn-SBM-1.5 kg Lysine	18.8% DDGS + Phytase
Corn, kg	798.3	636.3
Soybean meal 44%, kg	176.9	159.4
DDGS, kg	0.0	188
Dicalcium phosphate, kg	11.6	0.0
Limestone, kg	7.2	9.8
Salt, kg	3.0	3.0
L-lysine HCl, kg	1.5	1.5
VTM premix, kg	1.5	1.5
Phytase, 500 FTU/kg	0.0	0.5
TOTAL, kg	1000.0	1000.0

Maximum Recommended Dietary Inclusion of DDGS for Swine

- Weaned pigs (> 7 kg) 30%
- Growing finishing pigs 20-30%
- Gestating sows 50%
- Lactating sows 30%



Summary of Growth Performance Responses from Feeding Levels up to 30% DDGS in Grower-Finisher Diets

Performance Measure	Number of Published Studies	Increased	Reduced	Not Changed
ADG	25	1	6	18
ADFI	23	2	6	15
Gain/Feed	25	4	5	16

Effect of Formulating G-F Diets on a Digestible Amino Acid Basis, with Increasing Levels of DDGS, on Overall Growth Performance

	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Initial wt., kg	22.5	22.8	22.5	22.5
Final wt., kg	114	115	114	113
ADG, kg/d	0.92	0.92	0.92	0.91
ADFI, kg/d[a]	2.57	2.55	2.49	2.46
F/G[a]	2.79	2.76	2.71	2.70

[a] Linear effect of DDGS level

Data from 64 pens, 16 pens/treatment (Xu et al., 2007)

Relative Cost of Competing Ingredients

Quick Calculation of Feed Cost Savings

Thumb rule:

Additions / 1000 kg diet

+ 100 kg DDGS	x	_____	$/kg =	$_____
+ 1.5 kg limestone	x	_____	$/kg =	$_____
TOTAL ADDITIONS (A)				$_____

Subtractions / 1000 kg diet

- 88.5 kg corn	x	_____	$/kg =	$_____
- 10 kg SBM (44%)	x	_____	$/kg =	$_____
- 3 kg dical. phos.	x	_____	$/kg =	$_____
TOTAL SUBTRACTIONS (S)				$_____

(S – A) = Feed cost savings / ton by adding 10% DDGS to the diet

Diet Formulation Methods Affect Pig Performance and Cost

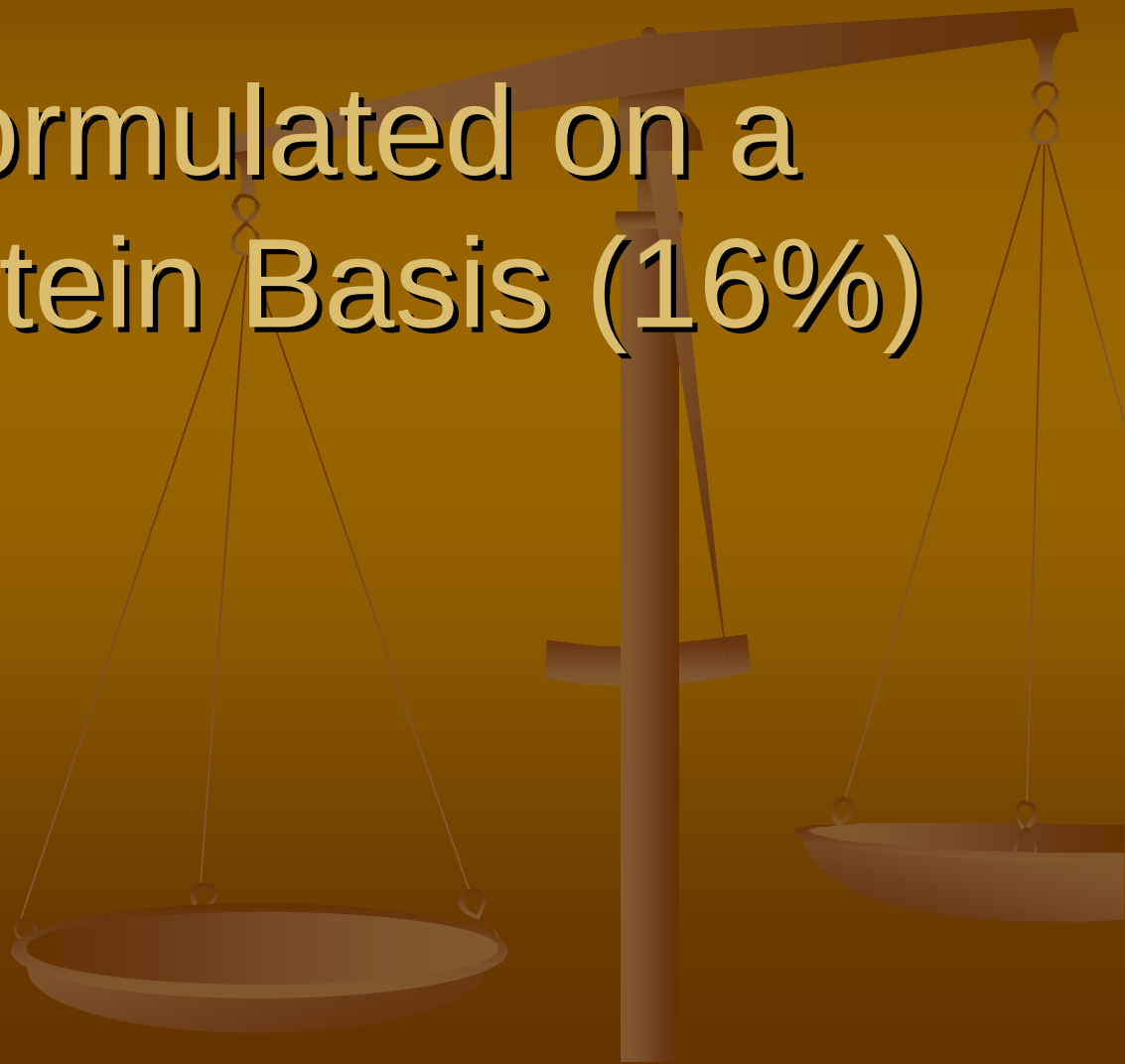
- Energy systems
  - DE
  - ME
  - NE
- Protein systems
  - CP
  - Total lysine (amino acids)
  - SID lysine (amino acids)
  - Ideal amino acid rations
  - Lys:Kcal ME
- Phosphorus systems
  - Total P
  - Available P
  - Available P + phytase

Diet Formulation Assumptions

- 50 kg growing pig fed *ad libitum*
- Based on requirements as defined by NRC (1998)

ME content of diet, kcal/kg	3265
Crude Protein, %	15.5
Lysine, %	0.75
Methionine, %	0.20
Threonine, %	0.51
Tryptophan, %	0.14
Calcium, %	0.50
Phosphorus, %	0.45

Diets Formulated on a Crude Protein Basis (16%)



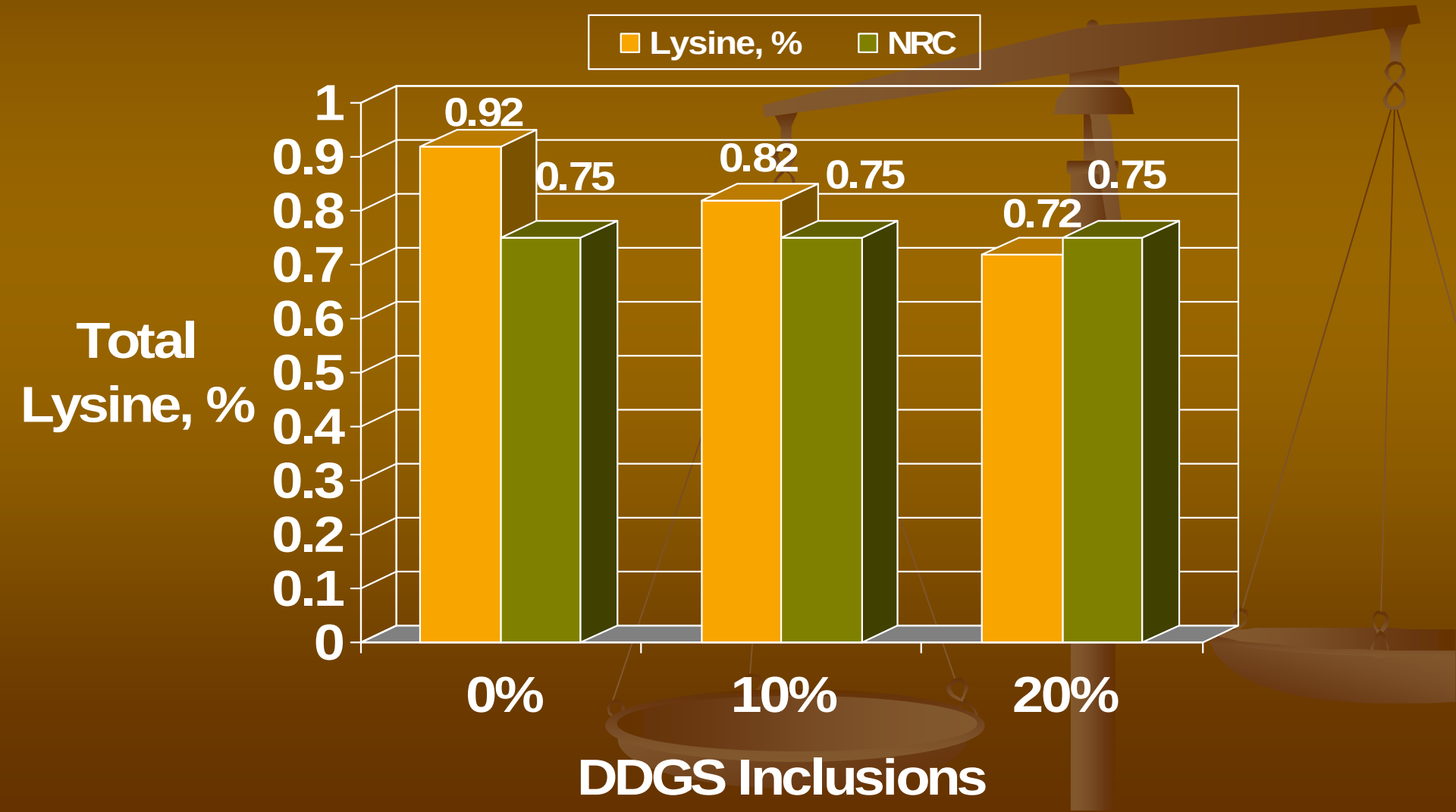
Diet Composition When Formulating on a Crude Protein Basis

Ingredient	0 % DDGS	10 % DDGS	20 % DDGS
DDGS, %	0	10	20
Corn, %	78.1	73.0	67.9
Soybean meal 47%, %	19.7	14.8	9.8
Dicalcium phosphate, %	0.52	0.35	0.20
Limestone, %	0.83	0.90	0.98
Salt, %	0.30	0.30	0.30
L-lysine HCL, %	0.15	0.15	0.15
VTM premix, %	0.20	0.20	0.20
TOTAL, %	100	100	100

Diet Nutrient Profile

Nutrients	0 % DDGS	10 % DDGS	20 % DDGS
Crude Protein, %	16.00	16.00	16.00
ME Swine, Kcal/kg	3372	3316	3261
Lysine, %	0.92	0.82	0.72
Methonine, %	0.26	0.27	0.28
Threonine, %	0.59	0.58	0.57
Tryptophan, %	0.18	0.16	0.15
Calcium, %	0.50	0.50	0.50
Phosphorus, %	0.45	0.45	0.45
Ca:P Ratio	1.11	1.11	1.11
Salt, %	0.37	0.41	0.44
Fat, %	3.65	4.14	4.64

Total Lysine Content When Formulating on a Crude Protein Basis



Diet Formulation Based on a Total Lysine Basis

Diet Composition When Formulating on a Total Lysine Basis

Ingredient	0% DDGS	10% DDGS	20% DDGS	Adjusted 20% DDGS
DDGS, %	0	10.0	20.0	20.0
Corn, %	79.6	74.8	67.3	61.1
Soybean Meal 47%, %	18.4	13.5	11.0	17.1
Dicalcium phosphate, %	0.54	0.39	0.18	0.24
Limestone, %	0.82	0.85	0.99	0.90
Salt, %	0.30	0.30	0.30	0.30
VTM Premix, %	0.20	0.20	0.20	0.20
L-lysine HCL, %	0.15	0.15	0.15	0.15
L-tryptophan, %	0	0	0	0.15
TOTAL, %	100	100	100	100

Total Lysine Levels are Acceptable… But

Nutrients	0% DDGS	10% DDGS	20% DDGS	Adjusted 20% DDGS
Lysine, %	0.88	0.78	0.75	0.92
SID Lysine, %	0.66	**0.55**	**0.51**	0.66
Methonine, %	0.26	0.27	0.29	0.32
SID Methonine, %	0.23	0.23	0.24	0.27
Threonine, %	0.57	0.56	0.59	0.68
SID Threonine, %	0.49	0.45	0.46	0.54
Tryptophan, %	0.17	0.16	0.16	0.35
SID Tryptophan, %	0.15	0.12	**0.10**	0.13

Diet Formulation Based on Standardized Ileal Digestible Basis (SID) for Lysine (0.66%)

Diet Composition When Formulating on a SID Lysine Basis

Ingredient	0% DDGS	10% DDGS	20% DDGS	30% DDGS
DDGS, %	0	10.0	20.0	30.0
Corn, %	79.6	70.5	61.3	51.9
Soybean Meal 47%, %	18.3	17.6	17.0	16.4
Dicalcium phosphate, %	0.54	0.29	0.03	0.00
Limestone, %	0.82	0.92	1.01	0.99
Salt, %	0.30	0.30	0.30	0.30
L-lysine HCL, %	0.15	0.15	0.15	0.15
VTM Premix, %	0.20	0.20	0.20	0.20
TOTAL, %	100	100	100	100

Diet Nutrient Profile

Nutrients	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Crude Protein, %	15.48	17.17	18.86	20.55
ME Swine, Kcal/kg	3371	3317	3262	3205
Calcium, %	0.50	0.50	0.50	0.50
Phosphorus, %	0.45	0.45	0.45	0.49
Ca:P Ratio	1.11	1.11	1.11	1.02
Salt, %	0.37	0.41	0.44	0.48
Fat, %	3.66	4.54	4.58	5.04

Total and SID Amino Acid Profile

Nutrients	0 % DDGS	10 % DDGS	20 % DDGS	30 % DDGS
Lysine, %	0.88	0.90	0.92	0.94
SID Lysine, %	0.66	0.66	0.66	0.66
Methonine, %	0.26	0.29	0.32	0.35
SID Methonine, %	0.23	0.25	0.27	0.29
Threonine, %	0.57	0.63	0.68	0.74
SID Threonine, %	0.48	0.51	0.54	0.57
Tryptophan, %	0.17	0.18	0.20	0.21
SID Tryptophan, %	0.15	0.14	0.13	0.12

Example South American DDGS Diets

Ingredient	0% DDGS	10% DDGS	20% DDGS	30% DDGS
DDGS, %	0.0	10.0	20.0	30.0
Corn, %	22.5	20.0	16.3	12.5
Sorghum, %	55.5	49.8	44.3	38.7
Soybean Meal 47%, %	20.0	18.2	17.5	16.8
Dicalcium phosphate, %	0.55	0.50	0.45	0.45
Limestone, %	0.80	0.85	0.90	0.95
Salt, %	0.30	0.30	0.30	0.30
L-lysine HCL, %	0.15	0.15	0.15	0.15
VTM Premix, %	0.20	0.20	0.20	0.20
TOTAL, %	100	100	100	100

South American DDGS Diet Nutrient Profile

Nutrient	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Crude Protein, %	16.6	16.6	17.5	18.5
ME, kcal/kg	3327	3272	3217	3160
Lysine, %	0.90	0.89	0.91	0.93
SID Lysine, %	0.69	0.66	0.66	0.66
Methionine, %	0.27	0.29	0.32	0.35
SID Methionine, %	0.24	0.25	0.27	0.29
Threonine, %	0.61	0.64	0.70	0.75
SID Threonine, %	0.52	0.53	0.56	0.58
Tryptophan, %	0.20	0.20	0.22	0.23
SID Tryptophan, %	0.17	0.16	0.15	0.14

Example Asian DDGS Diets

Ingredient	0 % DDGS	10 % DDGS	20 % DDGS	30 % DDGS
DDGS, %	0.0	10.0	20.0	30.0
Corn, %	70.8	64.4	55.0	45.5
Soybean meal 47%, %	20.0	17.3	16.6	16.0
Wheat bran, %	5.0	5.0	5.0	5.0
Fish meal, %	1.8	1.8	1.8	1.8
Dicalcium phosphate, %	0.25	0.00	0.00	0.00
Limestone, %	0.82	0.87	0.93	1.03
Salt, %	0.30	0.30	0.30	0.30
L-lysine HCL, %	0.15	0.15	0.15	0.15
VTM Premix, %	0.20	0.20	0.20	0.20
Total, %	100	100	100	100

Asian DDGS Diet Nutrient Profile

Nutrient	0 % DDGS	10 % DDGS	20 % DDGS	30 % DDGS
Crude Protein, %	17.5	18.4	20.1	21.8
ME, kcal/kg	3311	3258	3196	3134
Lysine, %	1.03	0.99	1.01	1.03
SID Lysine, %	0.71	0.66	0.66	0.66
Methionine, %	0.30	0.32	0.35	0.38
SID Methionine, %	0.24	0.25	0.27	0.29
Threonine, %	0.65	0.68	0.73	0.79
SID Threonine, %	0.51	0.51	0.54	0.57
Tryptophan, %	0.20	0.20	0.22	0.23
SID Tryptophan, %	0.16	0.14	0.13	0.12

Example Western Canadian DDGS Diets

Ingredient	0% DDGS	10% DDGS	20% DDGS	30% DDGS
DDGS, %	0.0	10.0	20.0	30.0
Wheat, %	47.3	41.0	35.0	30.0
Barley, %	25.0	23.5	21.3	17.5
Soybean Meal 47%, %	15.5	15.4	15.4	14.9
Canola Meal, %	10.4	8.5	6.7	5.9
Dicalcium phosphate, %	0.25	0.00	0.00	0.00
Limestone, %	1.00	0.95	1.05	1.08
Salt, %	0.30	0.30	0.30	0.30
L-lysine HCL, %	0.15	0.15	0.15	0.15
VTM premix, %	0.20	0.20	0.20	0.20
Total, %	100	100	100	100

Western Canada DDGS Diet Nutrient Profile

Nutrient	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Crude Protein, %	20.2	21.3	22.3	23.5
ME, kcal/kg	3069	3055	3030	3005
Lysine, %	1.05	1.05	1.04	1.04
SID Lysine, %	0.66	0.66	0.66	0.66
Methionine, %	0.32	0.34	0.36	0.38
SID Methionine, %	0.20	0.22	0.24	0.27
Threonine, %	0.71	0.75	0.78	0.82
SID Threonine, %	0.44	0.48	0.51	0.54
Tryptophan, %	0.25	0.26	0.26	0.27
SID Tryptophan, %	0.15	0.14	0.13	0.13

U of M DDGS Web Site www.ddgs.umn.edu

We have developed a DDGS web site featuring:

* research summaries
  - swine, poultry, dairy, & beef
  - DDGS quality
* presentations given
* links to other DDGS related web sites
* international audiences
* nutrient profiles of DDGS sources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