

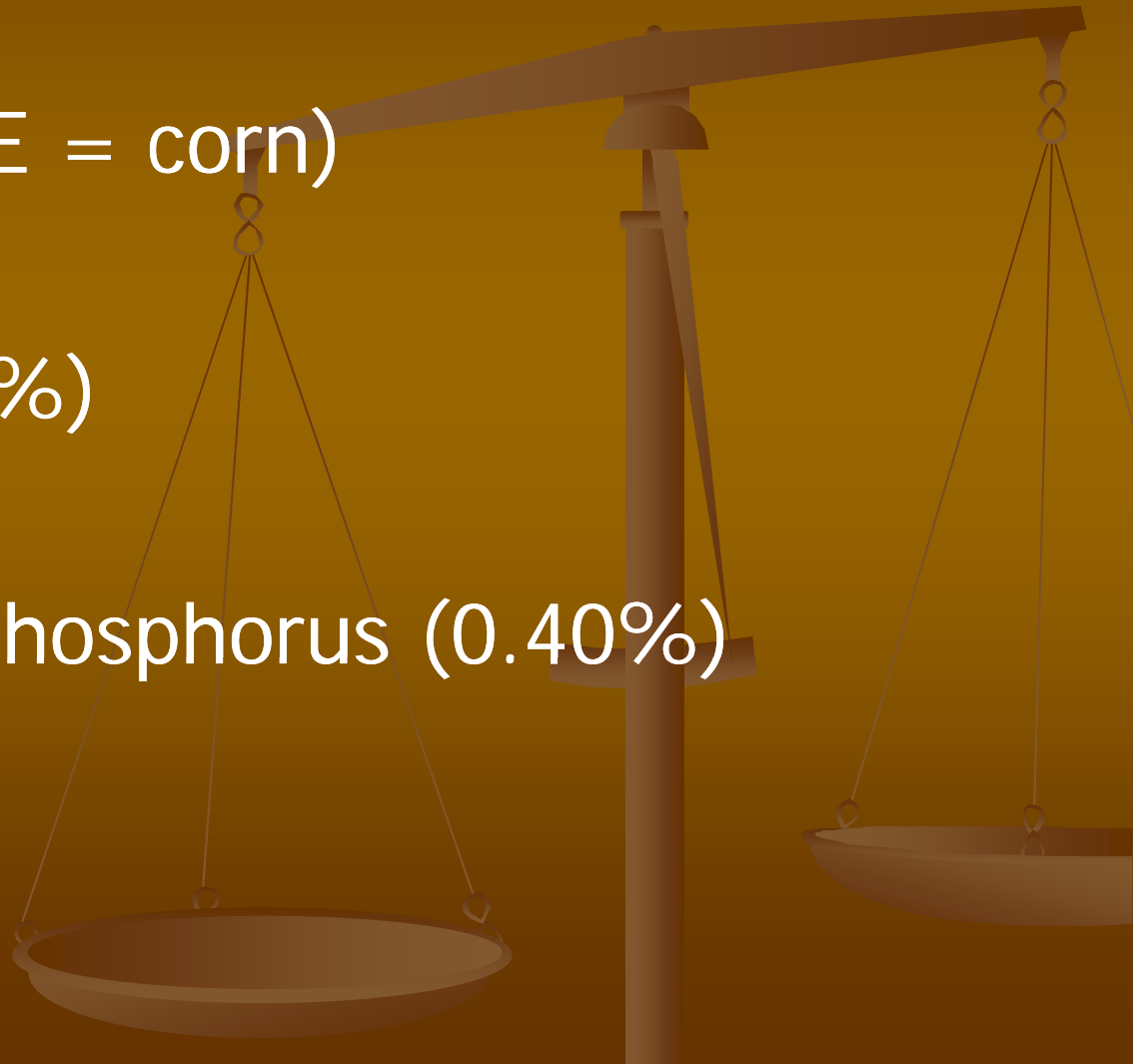


Use of U.S. Corn DDGS in Practical Swine Diet Formulations

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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

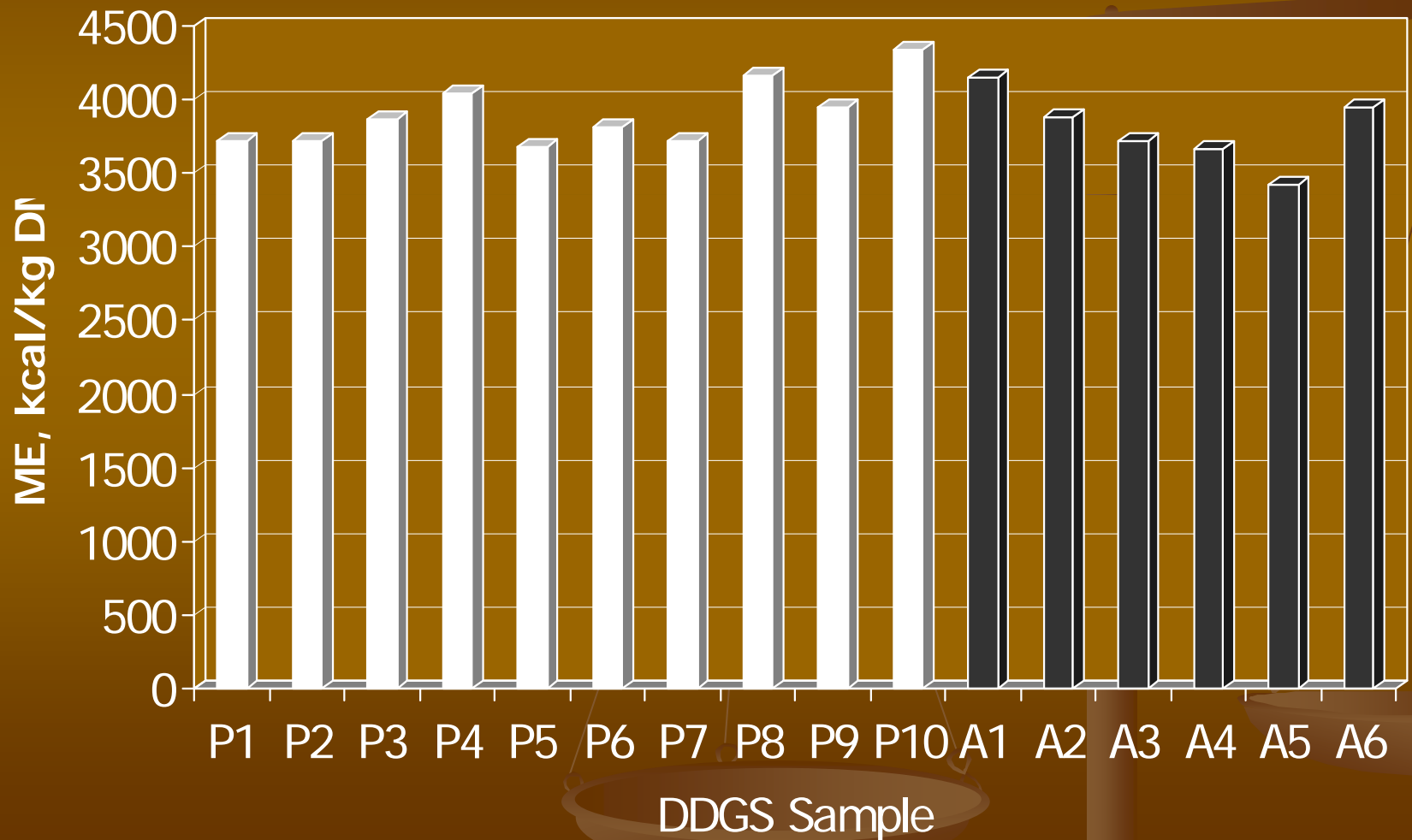


DDGS Nutrient Levels and Digestibility



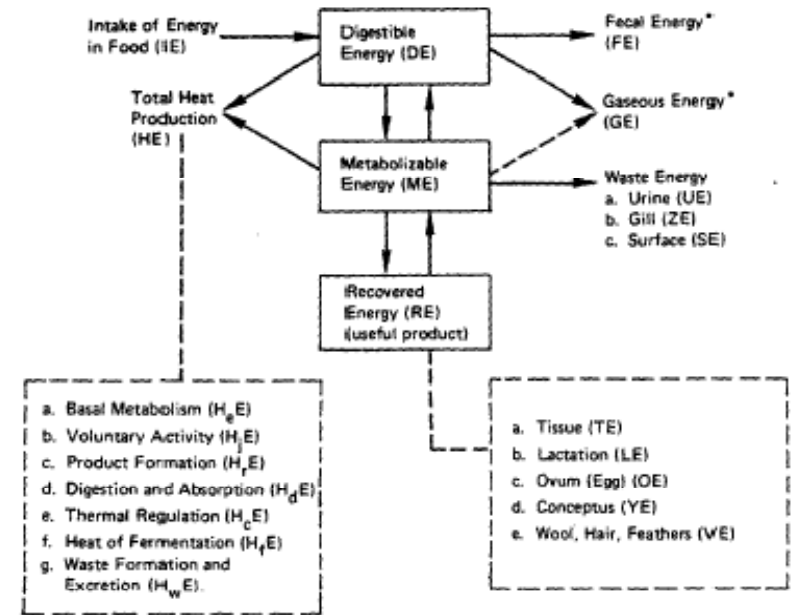
Variation in ME content of DDGS Sources

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



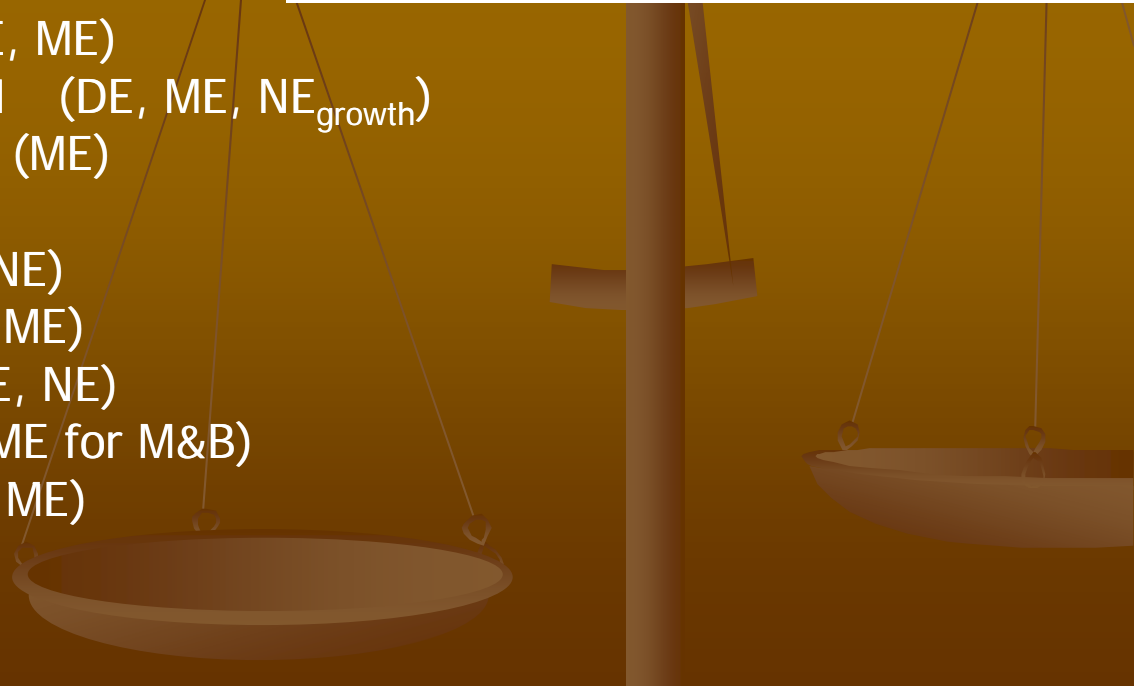
Prediction of DE, ME, or NE from Feed Components

- 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)



*Under some circumstances the energy contained could be considered to be a useful product for fuel.

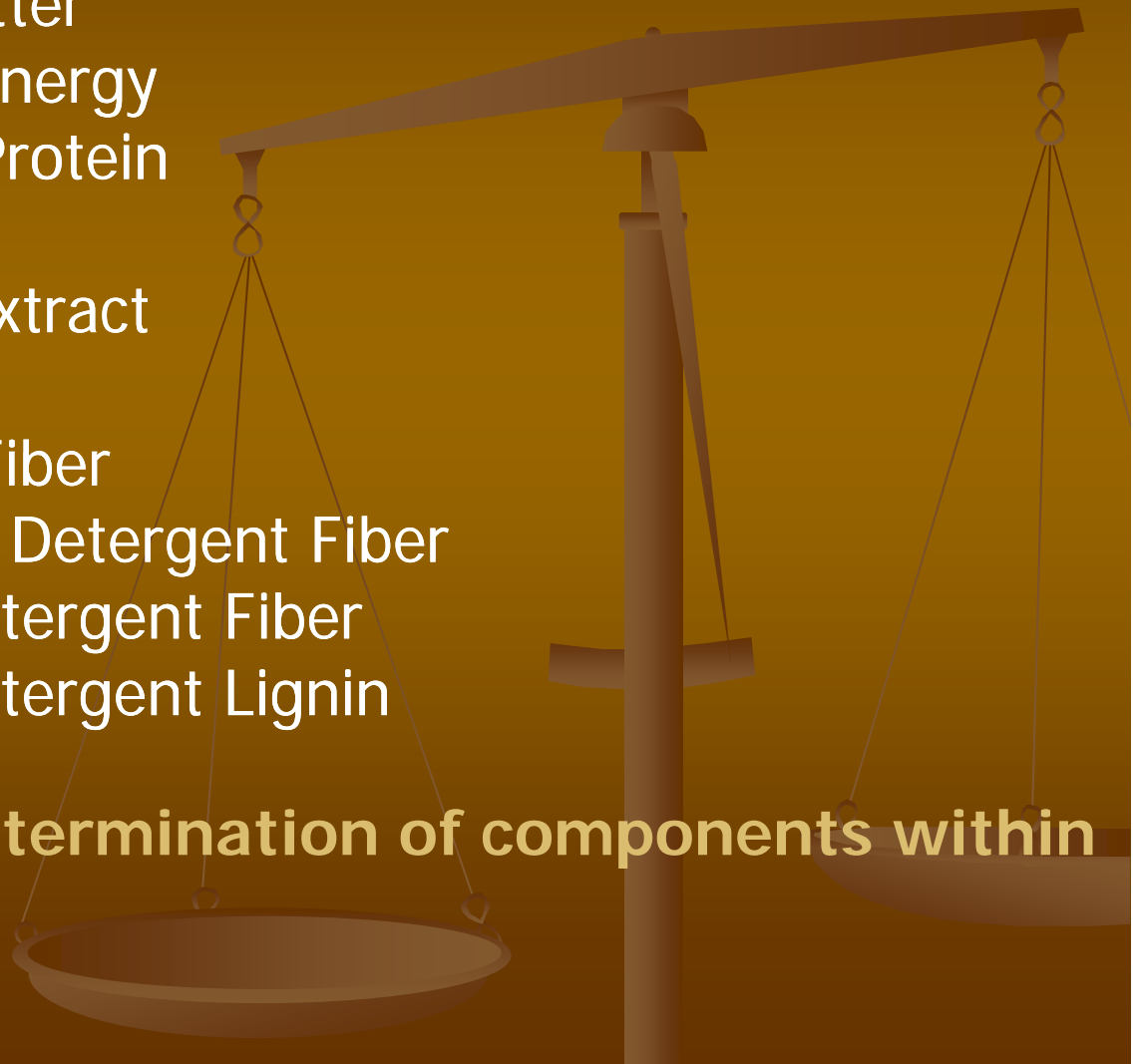
FIGURE 1 The idealized flow of energy through an animal.



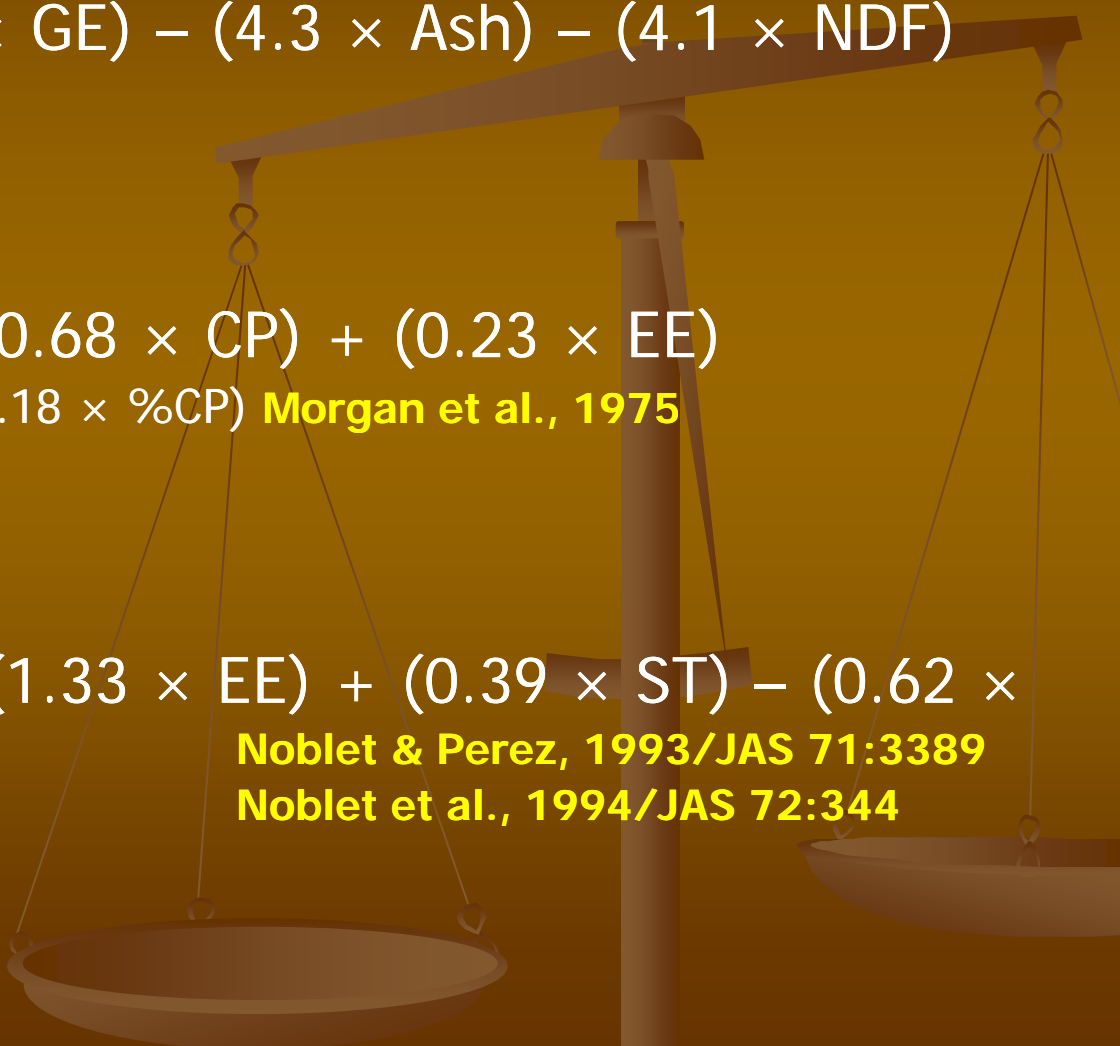
Nutrient Analysis Needed for Use in Energy Prediction Equations

- Dry Matter
- Gross Energy
- Crude Protein
- Starch
- Ether Extract
- Ash
- Crude Fiber
- Neutral Detergent Fiber
- Acid Detergent Fiber
- Acid Detergent Lignin

There is variation in determination of components within a feedstuff.



Factors Affecting Energy Estimates

- $DE = 1,161 + (0.749 \times GE) - (4.3 \times \text{Ash}) - (4.1 \times \text{NDF})$
 - $ME = (0.997 \times DE) - (0.68 \times \text{CP}) + (0.23 \times \text{EE})$
 - $ME/DE \times 100 = 99.7 - (0.18 \times \%CP)$ **Morgan et al., 1975**
 - $NE = (0.726 \times ME) + (1.33 \times \text{EE}) + (0.39 \times \text{ST}) - (0.62 \times \text{CP}) - (0.83 \times \text{ADF})$
 - **Noblet & Perez, 1993/JAS 71:3389**
 - **Noblet et al., 1994/JAS 72:344**
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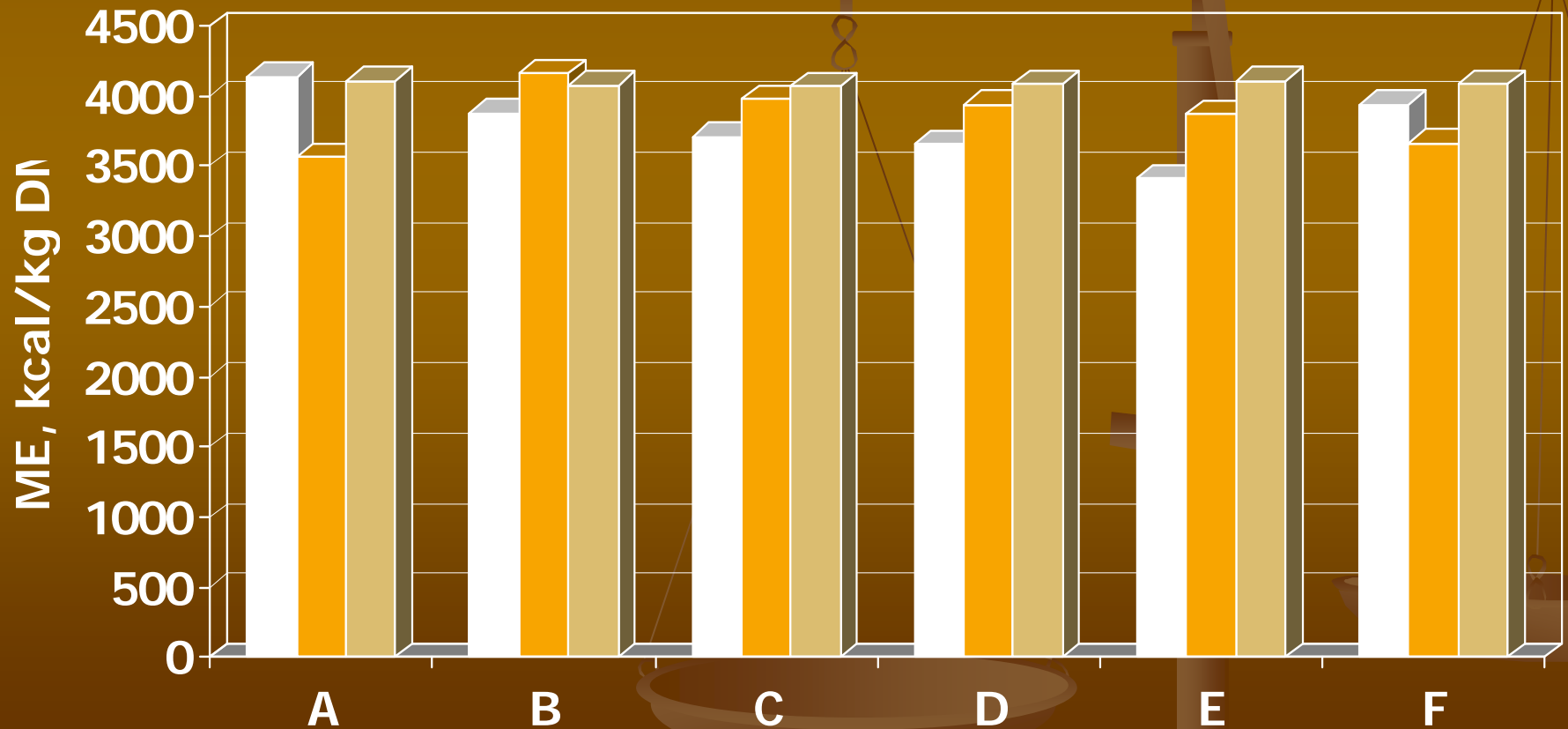
Prediction of ME in DDGS Sources

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

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

$$ME = 4,194 - (9.2 \times \text{ash}) + (1.0 \times \text{CP}) + (4.1 \times \text{EE}) - (3.5 \times \text{NDF}) \text{ [Noblet & Perez, 1993/JAS 71:3389]}$$

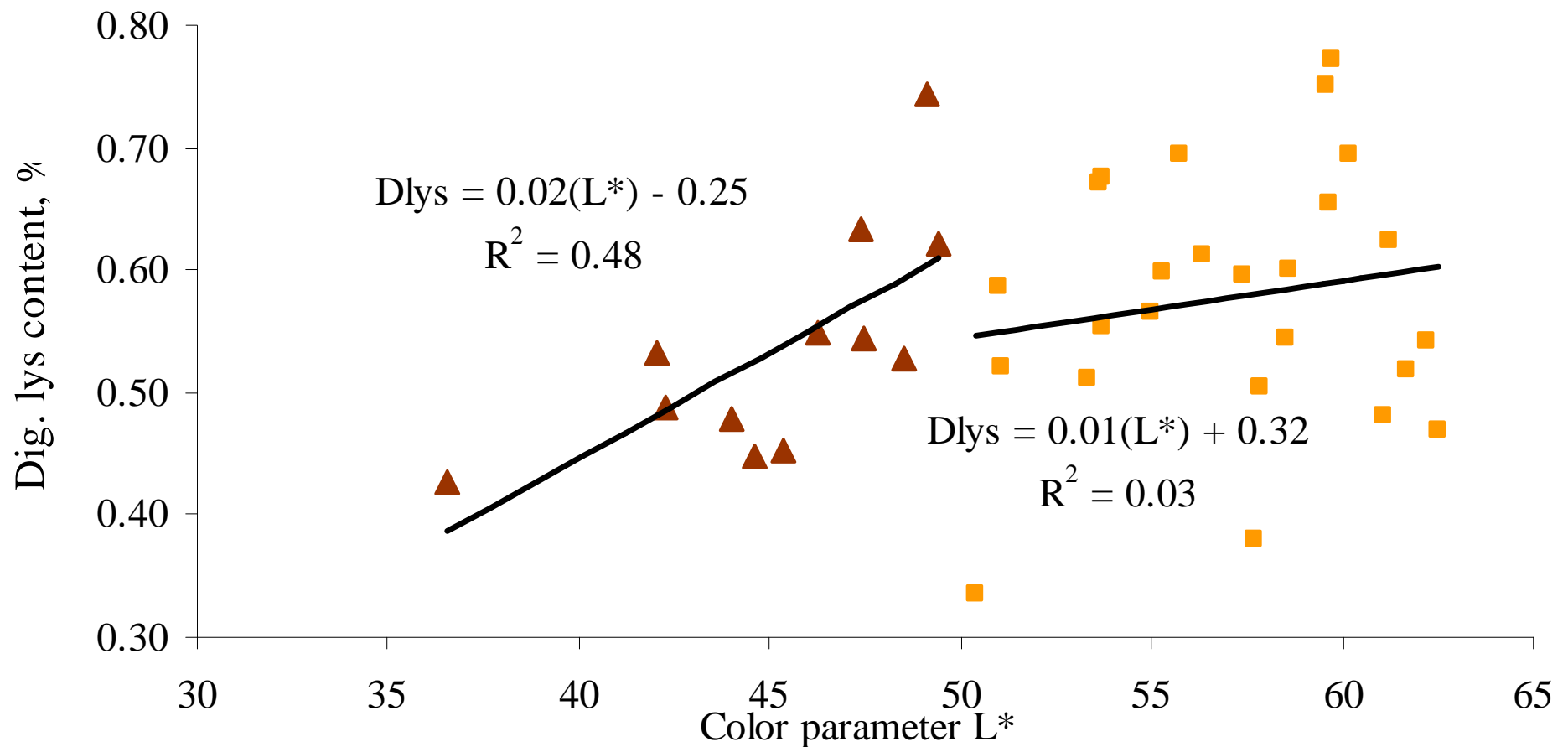
■ Actual ■ Pedersen 07 ■ Noblet 93



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



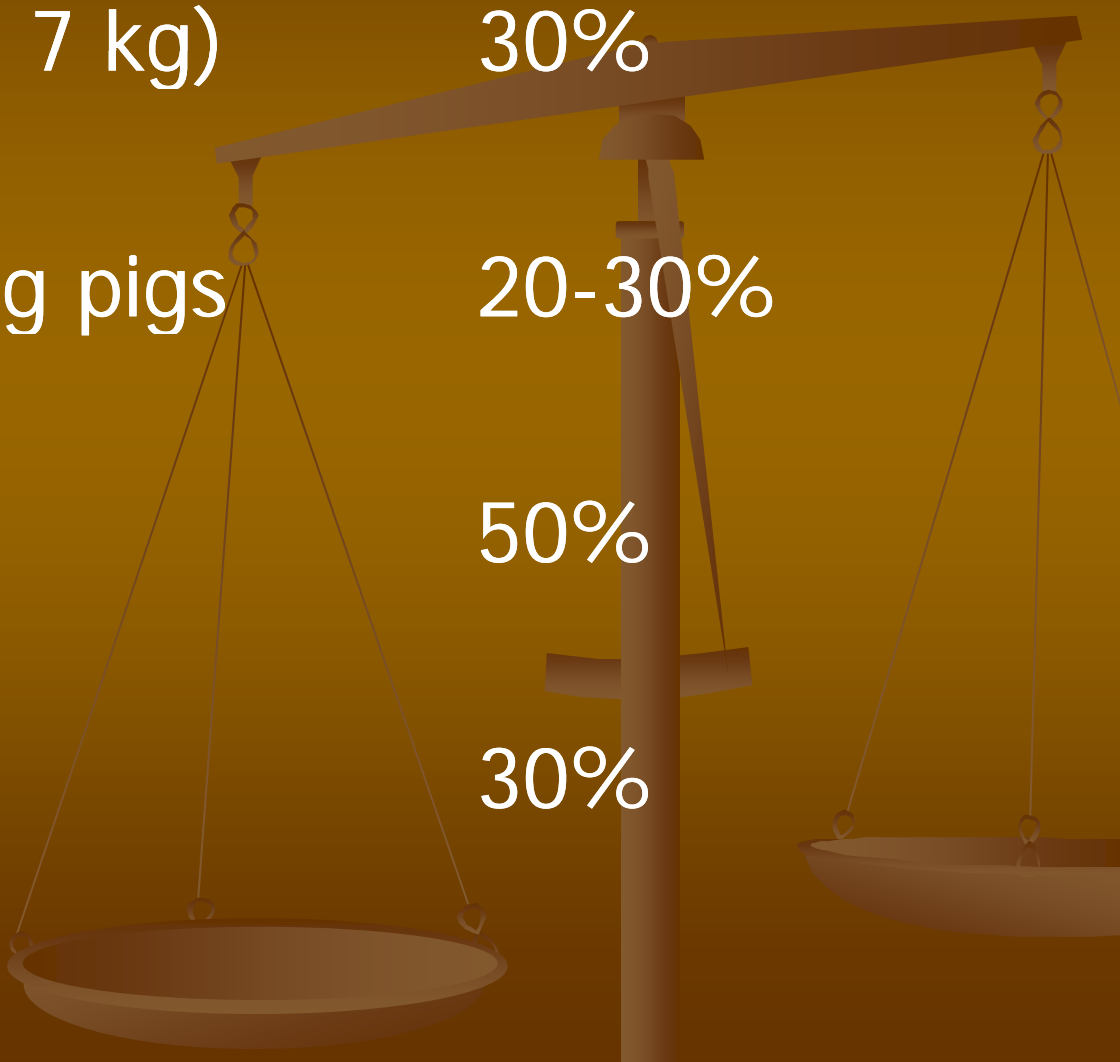
Variation in Total and Digestible Phosphorus Among DDGS Sources

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

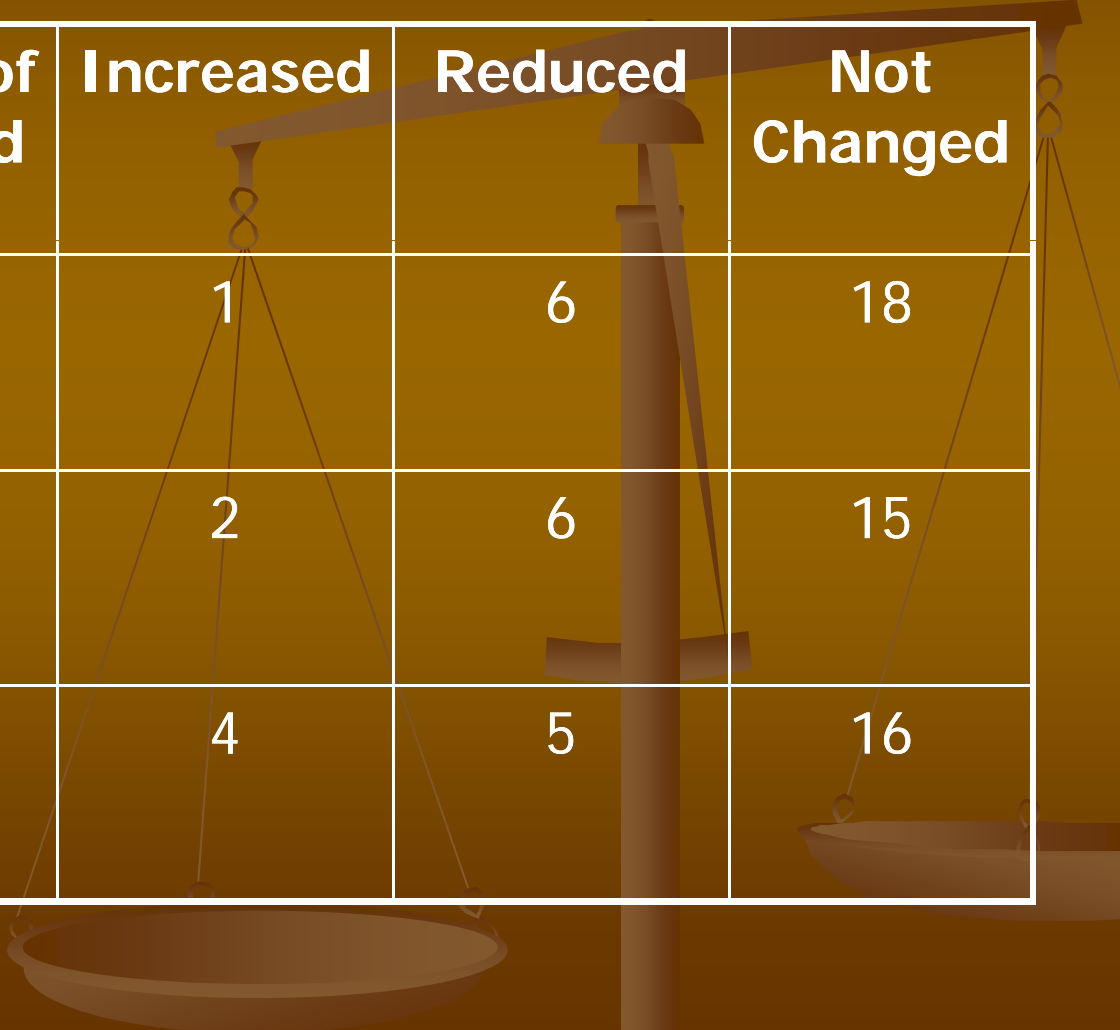
Diet Composition When 18.8% DDGS and Phytase are Added to a Swine Grower Diet

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:

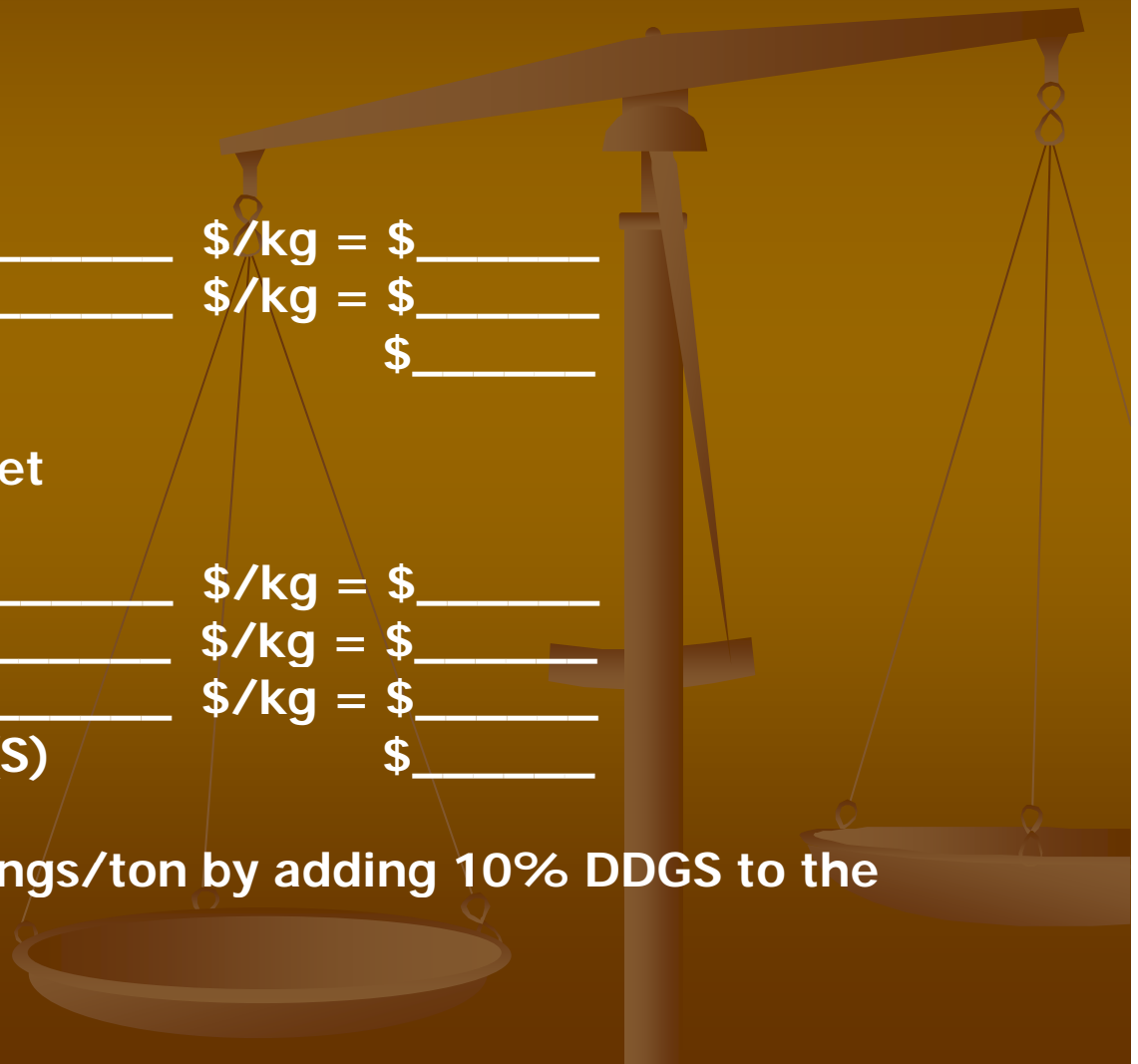
Additions/1000 kg diet

+ 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



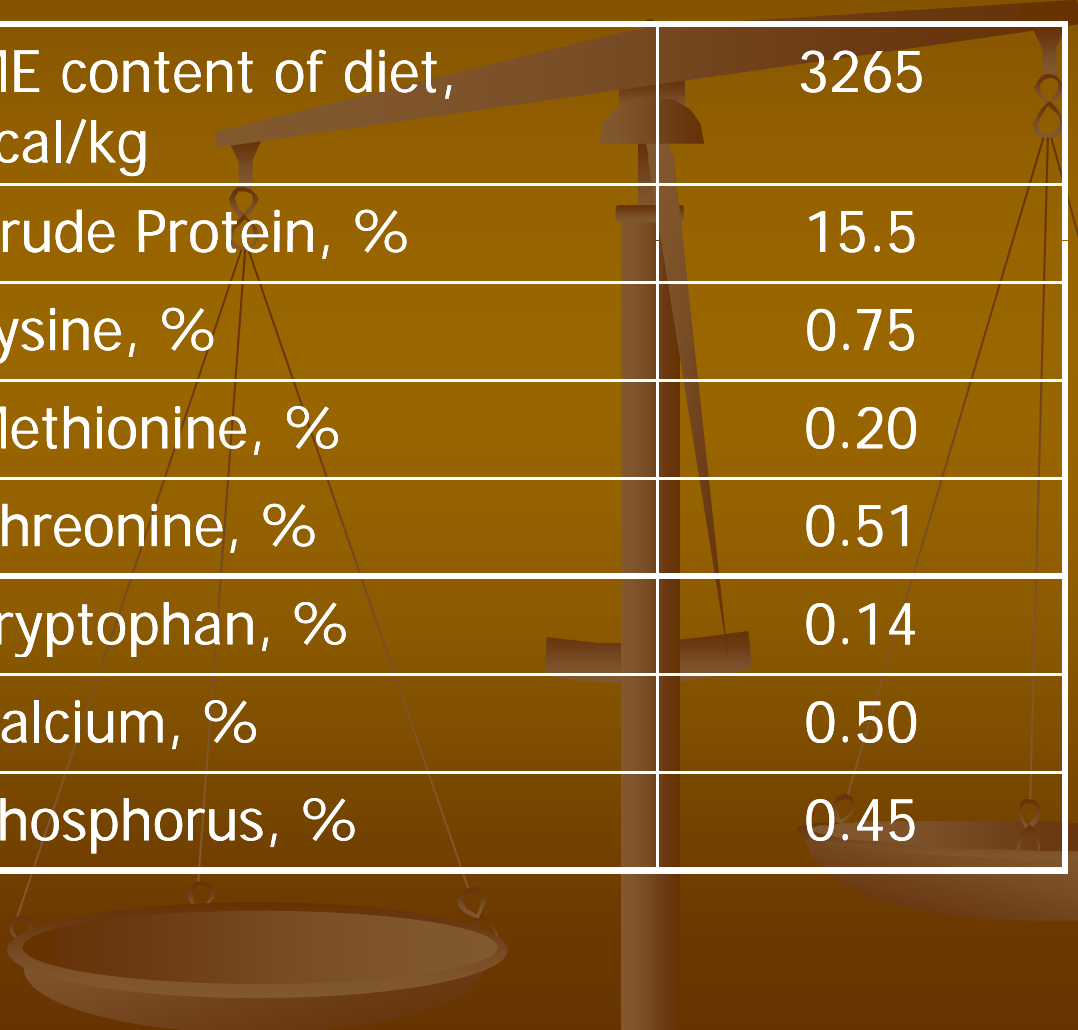
Diet Formulation Methods Affect Pig Performance and Cost

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



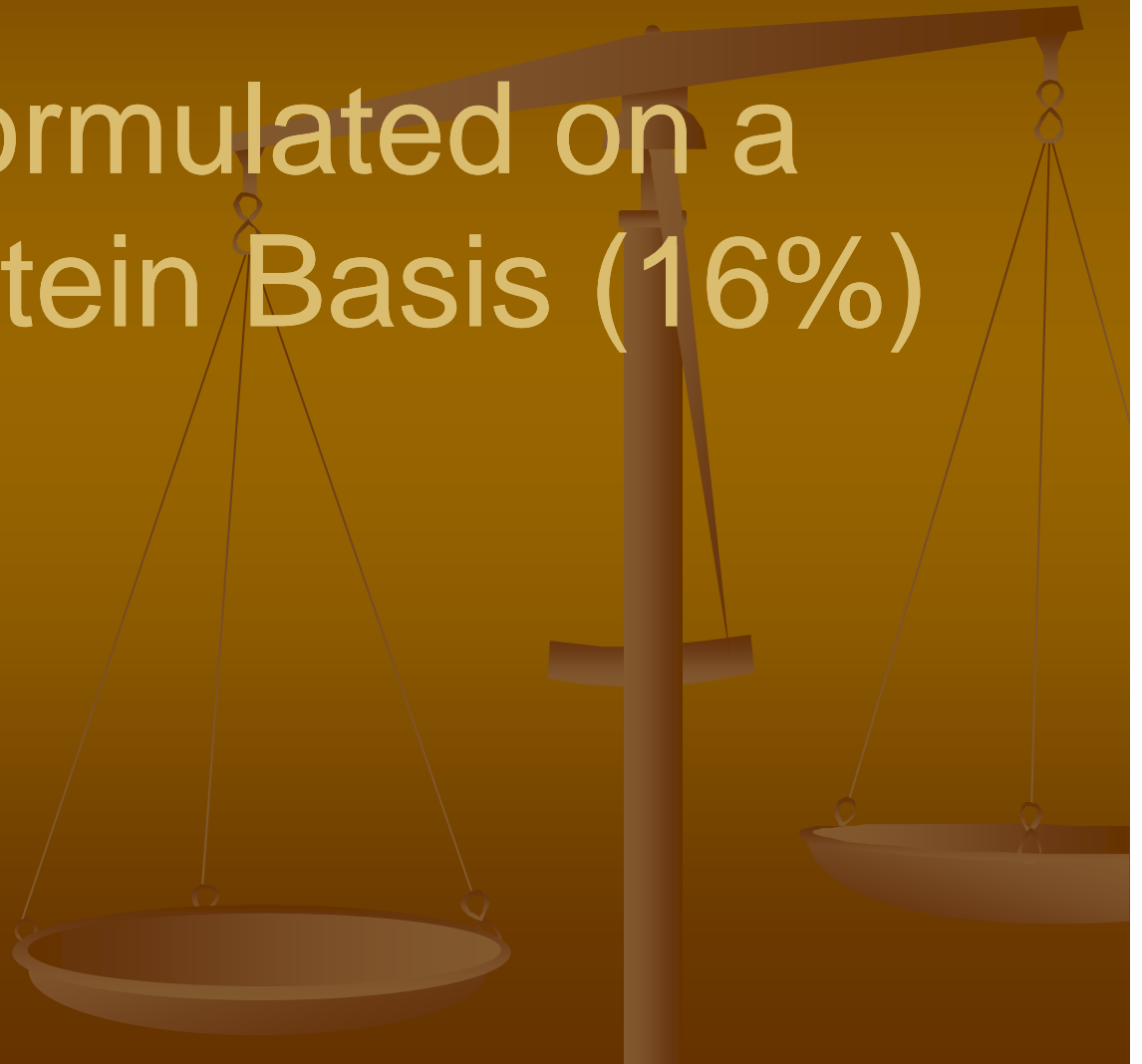
Diet Formulation Assumptions

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

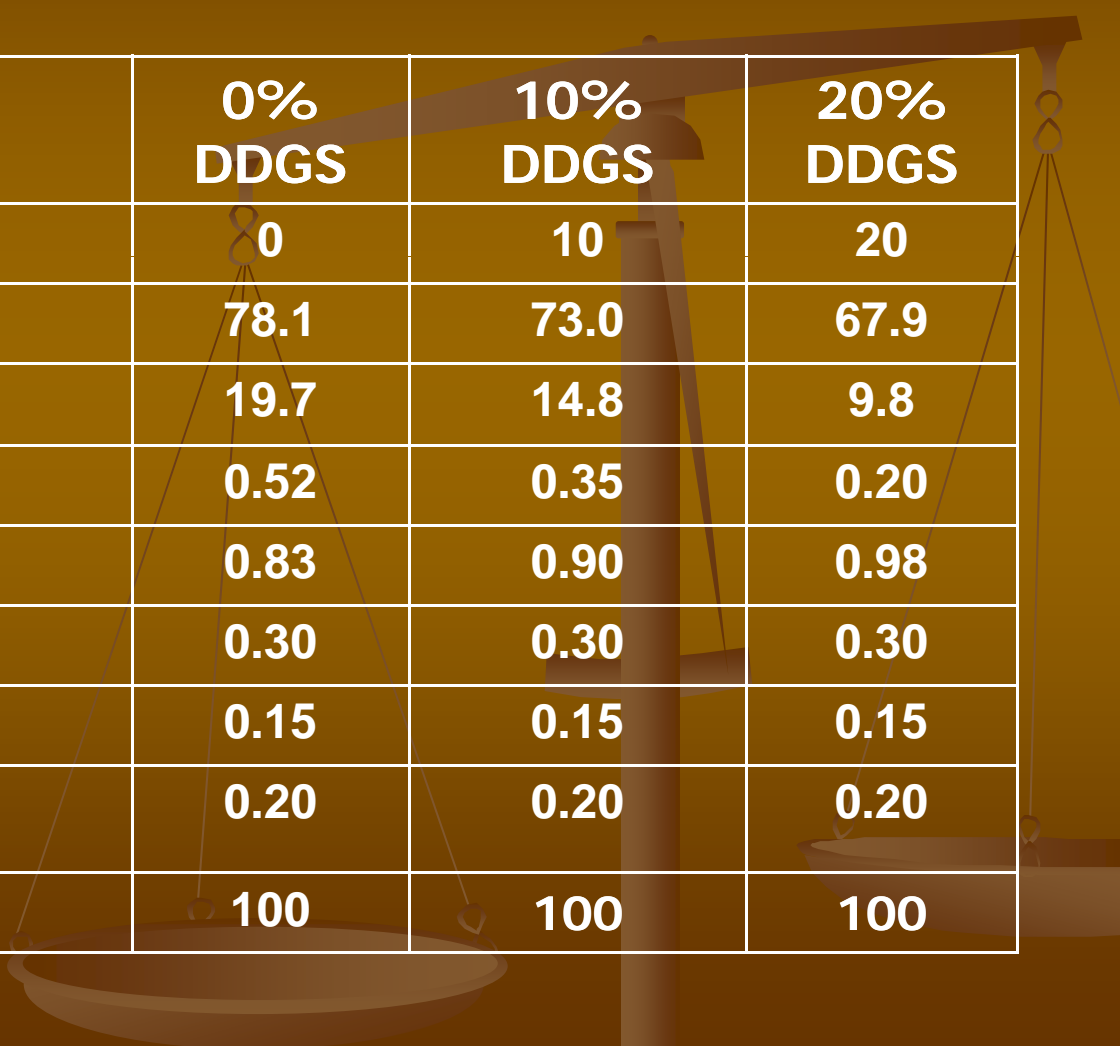


ME content of diet, kcal/kg	3265
Crude Protein, %	15.5
Lysine, %	0.75
Methionine, %	0.20
Threonine, %	0.51
Tryptophan, %	0.14
Calcium, %	0.50
Phosphorus, %	0.45

Diets Formulated on a Crude Protein Basis (16%)



Diet Composition When Formulating on a Crude Protein Basis

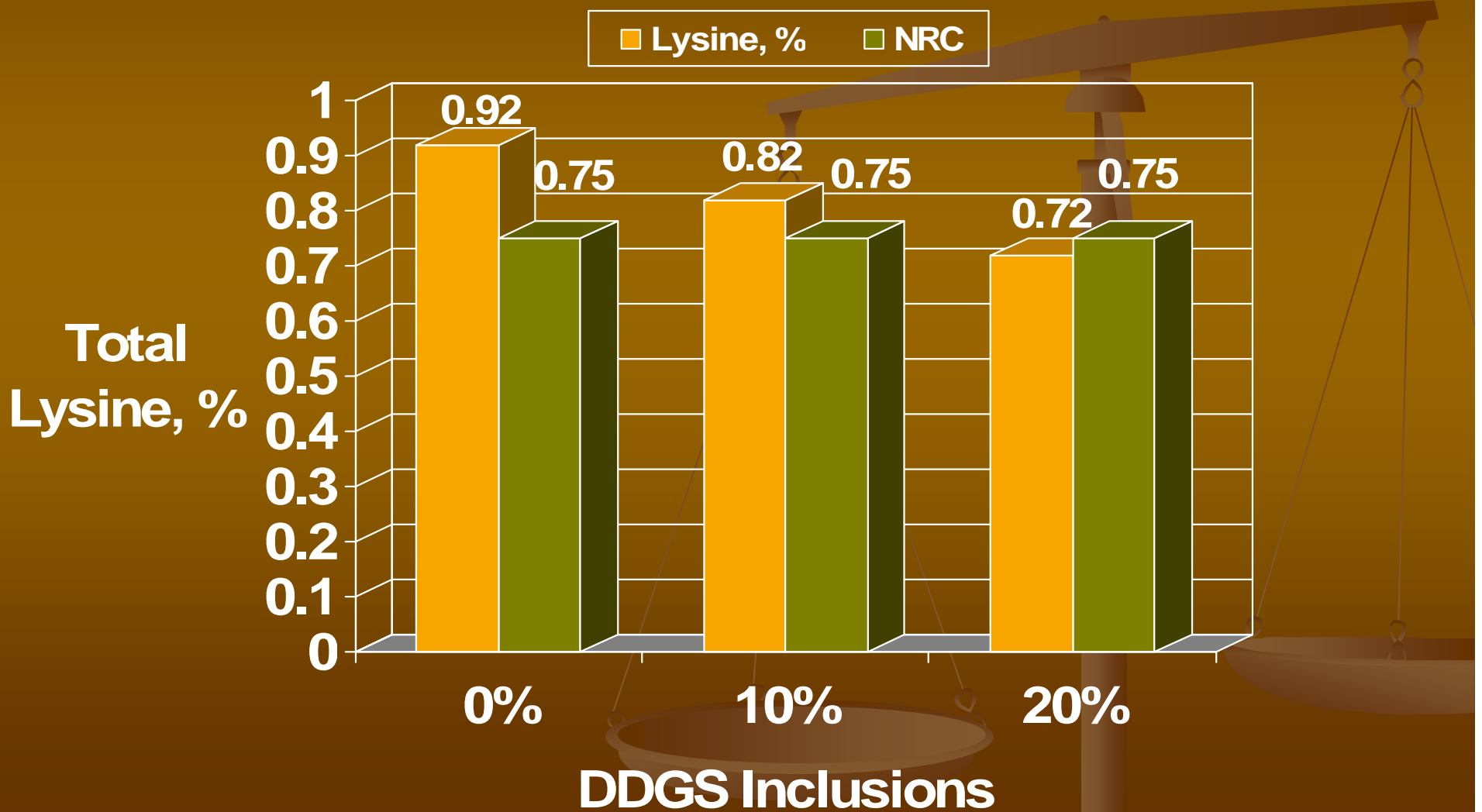


Ingredient	0% DDGS	10% DDGS	20% DDGS
DDGS, %	0	10	20
Corn, %	78.1	73.0	67.9
Soybean meal 47%, %	19.7	14.8	9.8
Dicalcium phosphate, %	0.52	0.35	0.20
Limestone, %	0.83	0.90	0.98
Salt, %	0.30	0.30	0.30
L-lysine HCL, %	0.15	0.15	0.15
VTM premix, %	0.20	0.20	0.20
TOTAL, %	100	100	100

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
Methionine, %	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



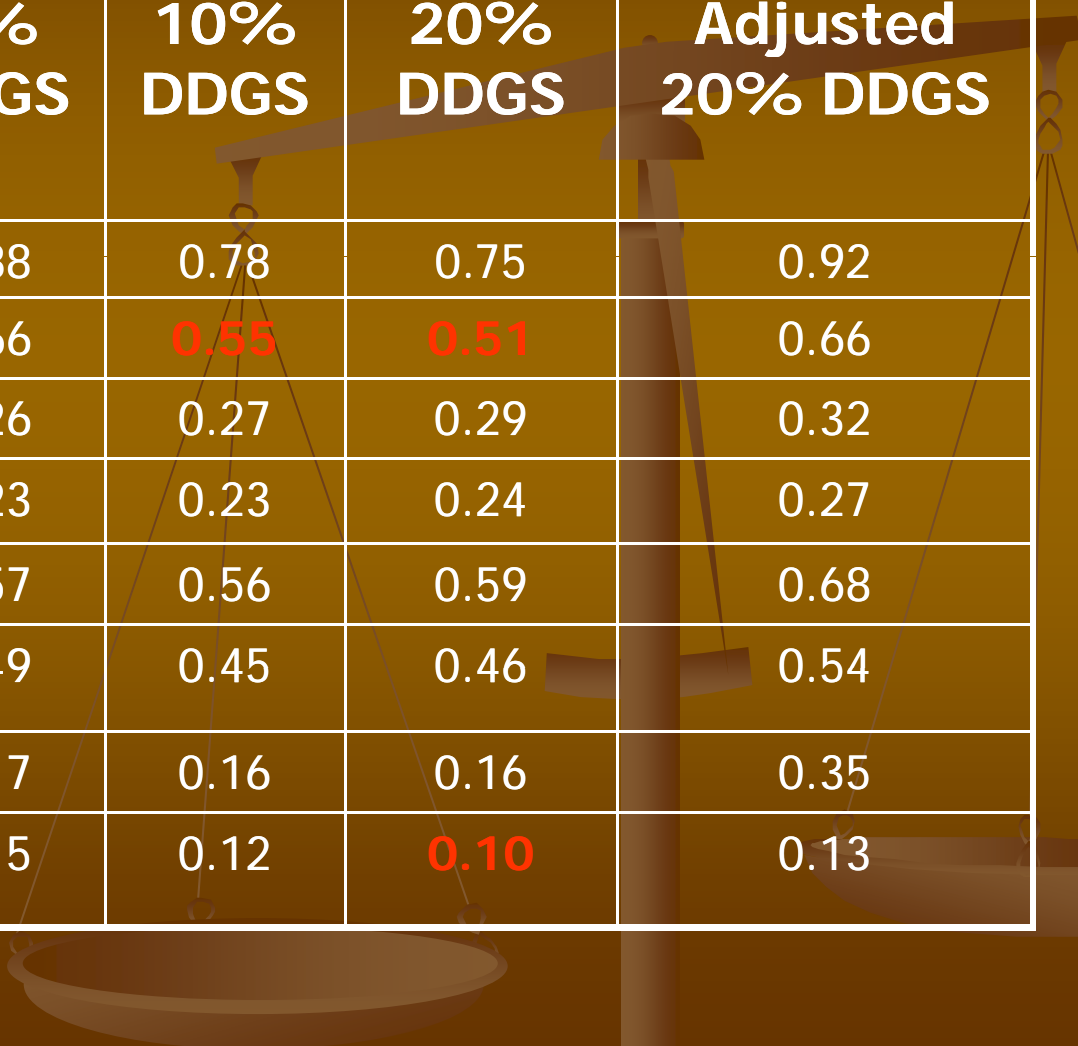
Diet Formulation Based on a Total Lysine Basis



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

