Corn DDGS Value in Swine & Poultry Feed Formulations

ASA Feed Formulation Workshop
November 2007

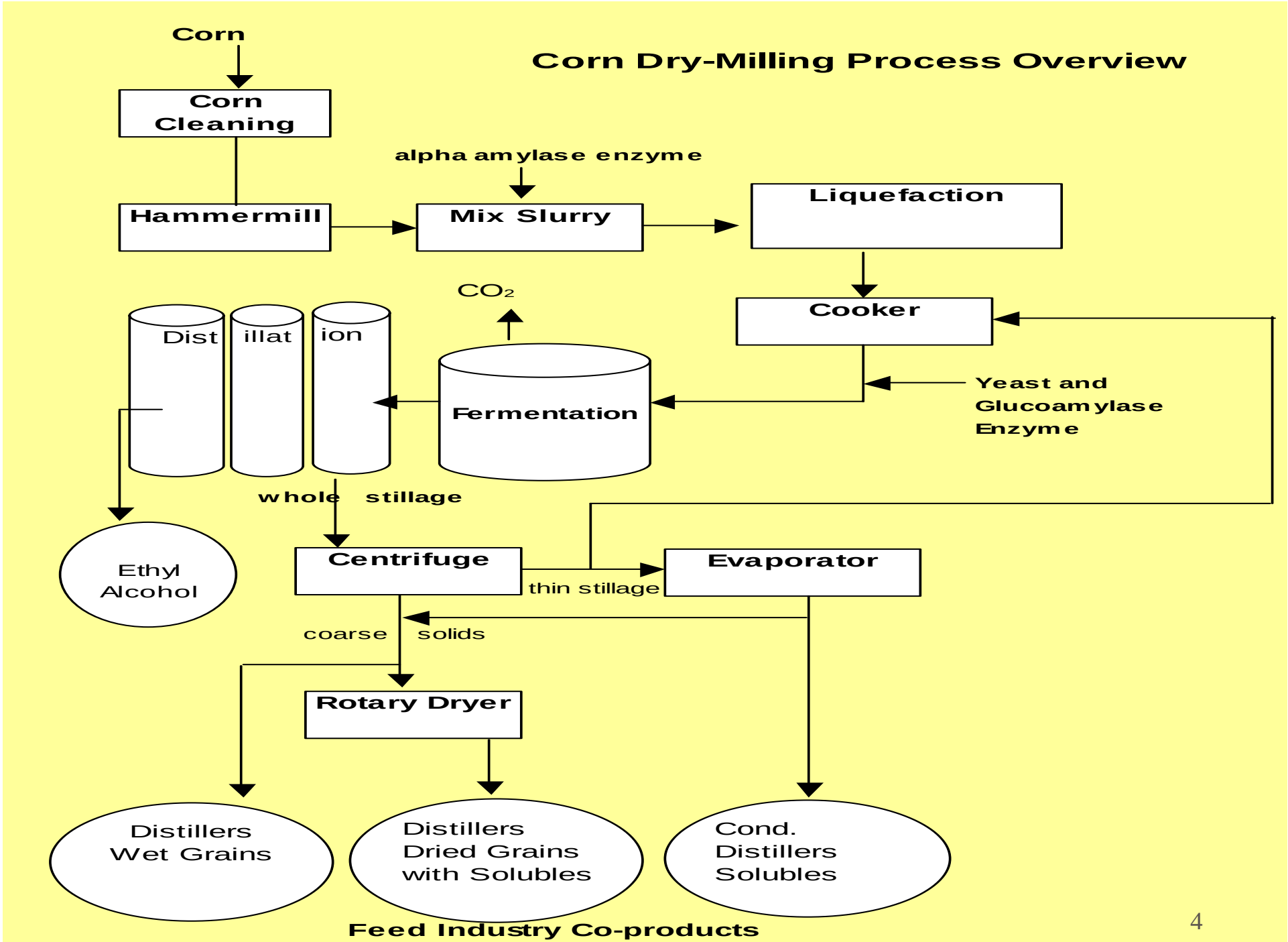
US Grains Council
Philippine Representative Office

Outline

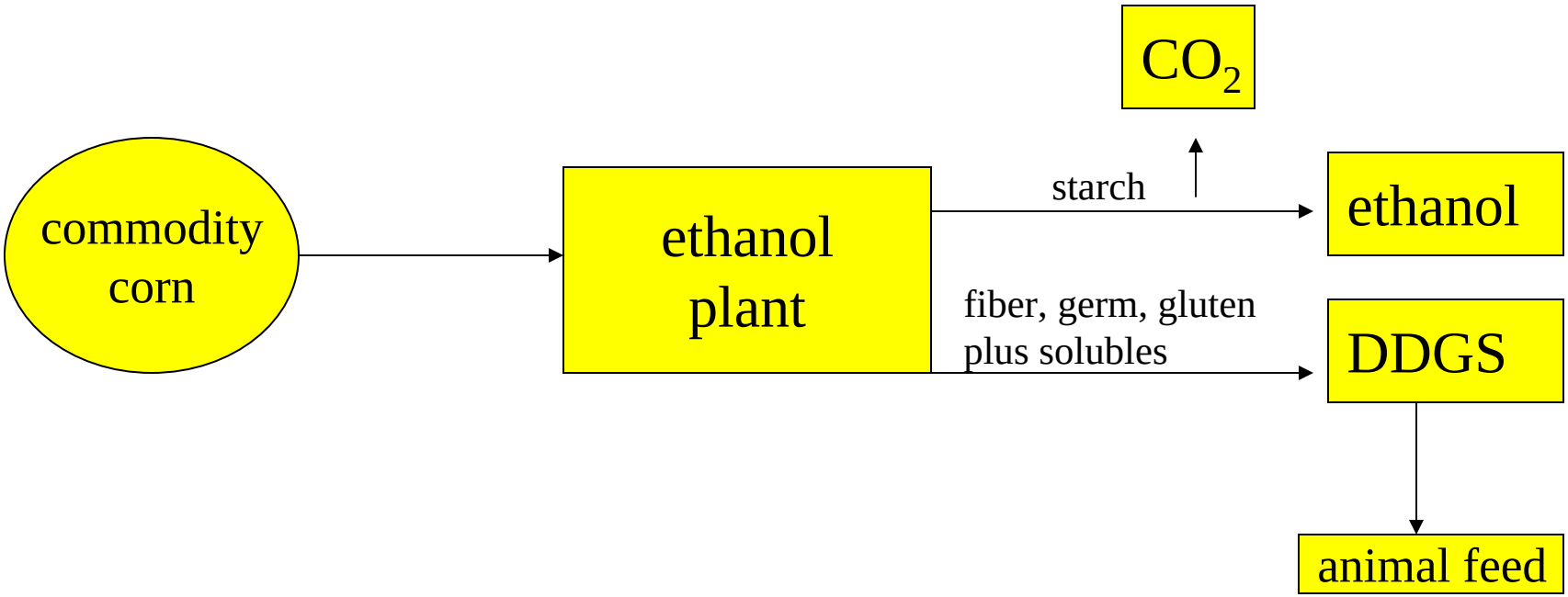
- Introduction
- Nutrient Composition
- Quality Considerations
- Sample Formulations
- Conclusion & Recommendations

What is DDGS?

- Distiller's Dried Grains & Solubles
- Co-product of the corn dry milling process employed by the ethanol industry
  - Cooking
  - Fermentation
  - Distillation
  - Drying


Corn Dry-Milling Process Overview
Corn
Corn Cleaning
alpha amylase enzyme
Hammermill
Mix Slurry
Liquefaction
Cooker
CO2
Dist
illat
ion
Fermentation
Yeast and Glucoamylase Enzyme
whole stillage
Ethyl Alcohol
Centrifuge
thin stillage
Evaporator
coarse solids
Rotary Dryer
Distillers Wet Grains
Distillers Dried Grains with Solubles
Cond. Distillers Solubles
Feed Industry Co-products

Ethanol and DDGS



Dry-Milling Average Ethanol Yield Per Bushel (25.4 kg) of Corn

- Ethanol 10.2 liters
- DDGS 8.2 kg
- CO_2 8.2 kg

Slide courtesy of Ms. Kelly Davis, CVEC, Benson, MN

U.S. DDGS Exports to Southeast Asia (MT)

	2004	2005	2006	Jan-Jun '07
Indonesia	11,516	46,523	43,764	31,323
Malaysia	12,475	34,475	29,970	16,971
Philippines	958	11,758	62,465	35,088
Thailand	10	12,802	38,140	18,871
Vietnam	633	19,869	17,979	27,092
TOTAL	**25,592**	**125,427**	**192,318**	**129,345**

Nutrient Specifications

Nutrient Contributions of DDGS in Food Animal Diets

- Energy
- Protein & Amino Acids
- Phosphorus
- Xanthophyll

Nutrient Specifications of DDGS

- Moisture- maximum 12%
- Crude protein- minimum 26.5%
- Crude fat- minimum 9.5%
- Crude Fiber- maximum 8%
- “Profat”- minimum 36%

Source: Shurson, 2005

Other Buyer Considerations with DDGS

- TPhos- minimum 0.55%
- ADF- maximum 12%
- NDF- maximum 40%
- TLys:CP- minimum 2.8%

Stein, 2007

Energy Value Prediction for DDGS, Swine

- **DE=** 4,151 - (122 x %ash) + (23 x %CP) + (38 x %Fat) - (64 x %Fiber)

- **ME=** DE x [1.003-(0.0021 x %CP)]

- **NE=** 328 + (0.599 x ME) - (15 x %Ash) -(30 x %ADF)

DE & ME, Noblet and Perez, 1993

NE, Ewan, 1989

Energy Value Prediction for DDGS, Swine

- **DE=** -9,229 - (180.38 x ash) + (106.82 x Fat) - (120.44 x ADF) + (3.202 x GE)

  R2=0.96

- **ME=** -7,803 - (223.19 x ash) + (61.3 x Fat) - (121.94 x ADF) + (1.911 x GE)

  R2=0.97

*In kcal/ kg DM

Pedersen et al, 2007

Determined ME, kcal/kg **of DDGS**

ME	Source
3032	NRC 1988
3370	Spiehs 1999
3592	Shurson 2002
3897	Pedersen et al. 2005
Equal to corn	Stein 2006

Sources: Thaler, 2002; Shurson, 2002; Pedersen, 2005; Stein 2006

TME_n Value Prediction for DDGS

- TME_n = 2957.1 + 43.8(EE) – 79.1(CF)

  R2=0.43

- TME_n = 2582.3 + 36.7(EE) – 72.4(CF) + 14.6(CP)

  R2=0.44

- TME_n = 2732.7 + 36.4(EE) – 76.3(CF) + 14.5(CP) – 26.2(Ash)

  R2=0.45

Dale and Batal, 2006

Determined TME_n, kcal/kg of DDGS

TME_n	Source
2480	NRC 1994
2834	Noll 2004
2864	Fastinger et al 2006
2820	Batal and Dale 2006
2899	Lumpkins and Batal 2005
2858	Parsons et al. 2006

Sources: Noll, 2005; Creswell, 2006; Waldroup, 2007

Amino acid prediction in DDGS, regression equations

Amino Acid	Equation	R^2
Arginine	y = 0.07926 + 0.03938*CP	0.48
Cystine	y = 0.11159 + 0.01610*CP + 0.00244*Fat	0.52
Isoleucine	y = -0.23961 + 0.04084*CP + 0.01227*Fat	0.86
Leucine	y = -1.15573 + 0.13082*CP + 0.06983*Fat	0.86
Lysine	y = -0.41534 + 0.04177*CP + 0.00913*Fiber	0.45
Methionine	y = -0.17997 + 0.02167*CP + 0.01299*Fat	0.78
TSAA	y = -0.12987 + 0.03499*CP – 0.00229*Fat^2 + 0.05344*Fat	0.73
Threonine	y = -0.05630 + 0.03343*CP – 0.00141*Fat^2 + 0.02989*Fat	0.87
Tryptophan	y = 0.01676 + 0.0073*CP	0.31
Valine	y = 0.01237 + 0.04731*CP + .00054185*Fat^2	0.81

Sources: Novus International, 2006 (Adapted from Waldroup, 2007)

Amino acid digestibility coefficients of DDGS, Poultry

Amino acid	N = 8	N = 47	N = 20	N = 5	Weighted average
Arginine %	84.1	85.2		88.3	85.3
Histidine %	84.1			85.3	84.5
Isoleucine %	83.3	81.8		84.1	82.2
Leucine %	88.6	89.3		90.2	89.3
Lysine %	69.6	65.9	71	76.5	68.5
Methionine %	86.8	86.1	88	88.5	86.8
Cystine %	73.9	77.6	77	81.6	77.3
Phenylalanine %	87.5			88.0	87.7
Threonine %	74.5	74.6	76	77.5	75.1
Tryptophan %	82.8	83.9		88.2	84.1
Valine %	79.3	81.8		81.4	81.4
Serine %	81.9			84.3	82.8

Sources: Batal and Dale, 2006; Fiene et al., 2006; Parsons et al. 2006; Fastinger et al. 2006 (Adapted from Waldroup, 2007)

Digestibility Coefficients of Amino Acids in DDGS, Swine

Amino Acid	Range	Avg	NRC
Lysine	44 – 78	63	59
Threonine	62 – 83	71	65
Methionine	74 – 89	82	75
Tryptophan	54 – 80	69	-
Isoleucine	67 – 83	76	79
Arginine	74 - 92	81	-
Valine	66 – 82	75	67

Source: Stein, 2007

Digestibility Coefficients of Amino Acids in DDGS, Swine

Amino Acid	%		Amino Acid	%
Lysine	62		Isoleucine	75
Threonine	71		Leucine	83
Methionine	82		Valine	75
Cystine	82		Arginine	-
Tryptophan	70		Phenylalanine	-

Source: KSU Swine Day, 2007

Mineral composition of DDGS

Nutrient	N = 118	N = 12	N = 20	N = 4	Weighted Average
Ca	0.05	0.29		0.03	0.07
P	0.79	0.68	0.73	0.73	0.77
K	0.84	0.91			0.85
Na	0.21	0.25		0.11	0.20

Sources : Spiehs et al., 2002; Batal and Dale 2003; Martinez , Amezcua et al. 2004; Parsons et al 2006 (from Waldroup, 2007)

Phosphorus availability in DDGS

Author	Year	Species	% Availabilty of Phos
Lumpkins and Batal	2005	poultry	68
			54
Martinez, Amezcua et al.	2005	poultry	62
			62
Widmer et al.	2007	swine	59
Pedersen et al	2007	swine	59

Source: Waldroup, 2007; Stein, 2007

Xanthophyll Content of Corn, Corn Gluten Meal and DDGS

- **Corn=** 5 to 25 mg/kg
- **Corn gluten meal=** 130 to 170 mg/kg
- **Corn DDGS=** 40 to 50 mg/kg

Suggested nutrient matrix for New Generation DDGS , Poultry				
Nutrient	**Amount**		**Nutrient**	**Amount**
Dry matter %	88.00		Calcium %	0.07
Crude protein %	27.00		Phosphorus %	0.77
Fat %	9.00		AvPhos, poultry %	0.47
Fiber %	8.00		Potassium %	0.85
ME Poultry, kcal/kg	2820		Sodium %	0.20
Arginine %	1.14		Dig Arginine %	0.97
Isoleucine %	0.97		Dig Isoleucine %	0.80
Leucine %	3.00		Dig Leucine %	2.67
Lysine %	0.79		Dig Lysine %	0.53
Methionine %	0.52		Dig Methionine %	0.45
Cystine %	0.57		Dig Cystine %	0.44
Threonine %	1.00		Dig Threonine %	0.75
Tryptophan %	0.21		Dig Tryptophan %	0.18
Valine %	1.33		Dig Valine %	1.08

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Nutrient	**Amount**		**Nutrient**	**Amount**
Dry matter %	88.00		Calcium %	0.07
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Fat %	9.00		Av Phos, Swine %	0.45
Fiber %	8.00		Potassium %	0.85
ME Swine, kcal/kg	3300		Sodium %	0.20
Arginine %	1.14		Dig Arginine %	0.93
Isoleucine %	0.97		Dig Isoleucine %	0.73
Leucine %	3.00		Dig Leucine %	2.49
Lysine %	0.79		Dig Lysine %	0.46
Methionine %	0.52		Dig Methionine %	0.39
Cystine %	0.57		Dig Cystine %	0.47
Threonine %	1.00		Dig Threonine %	0.65
Tryptophan %	0.21		Dig Tryptophan %	0.15
Valine %	1.33		Dig Valine %	0.89

Quality Considerations

Quality Assessment of DDGS

- Particle size
- Bulk density
- Smell
- Color
  - Amino acid digestibility
  - Variability
- Fat stability
- Mycotoxins

Physical Characteristics of DDGS

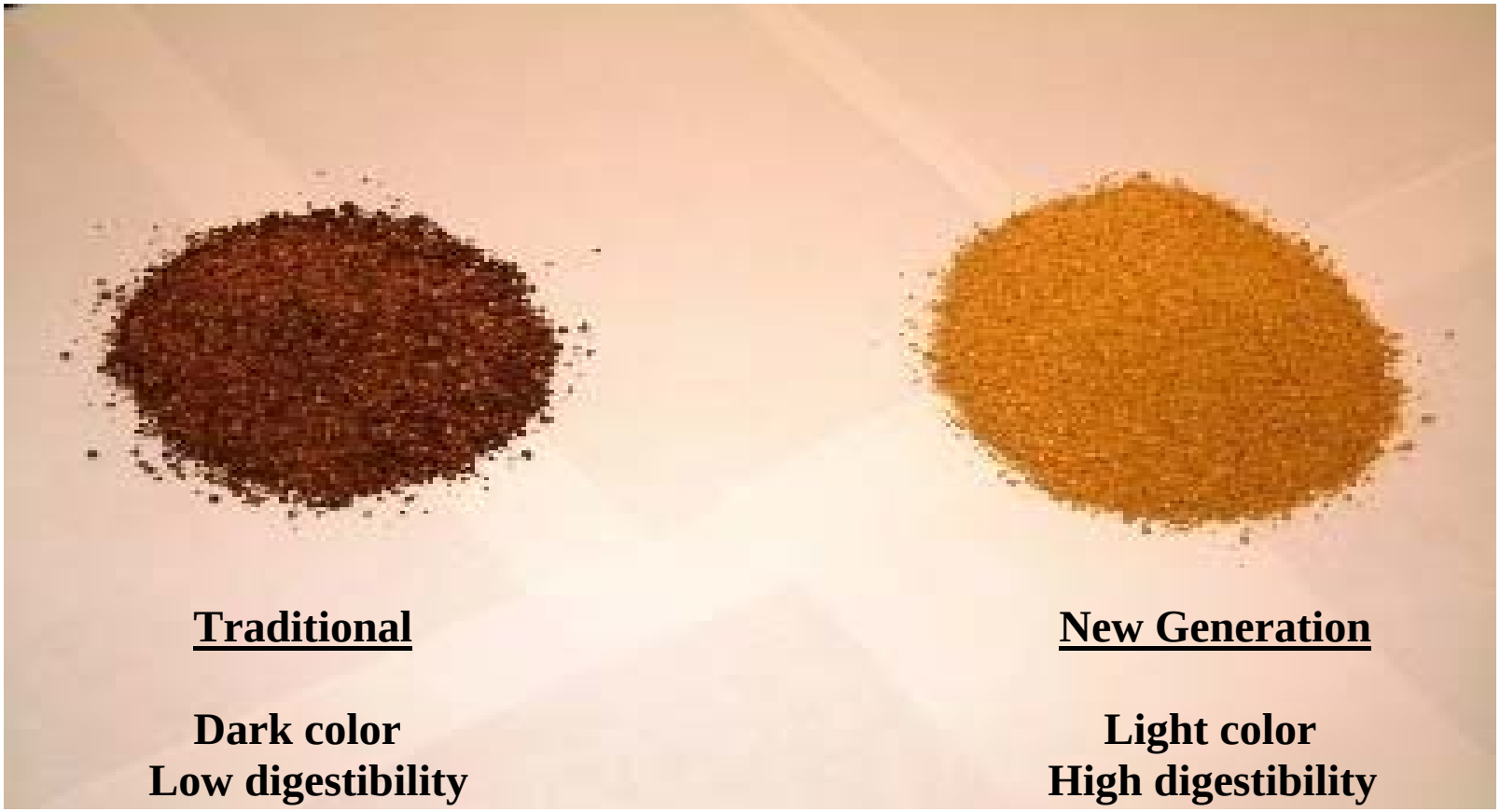
- Bulk density
  - 35.7± 2.79 lbs/ft^3
  - Range 30.8 to 39.3 lbs/ft^3

- Particle size
  - 1282± 305 microns
  - Range 612 to 2125 microns

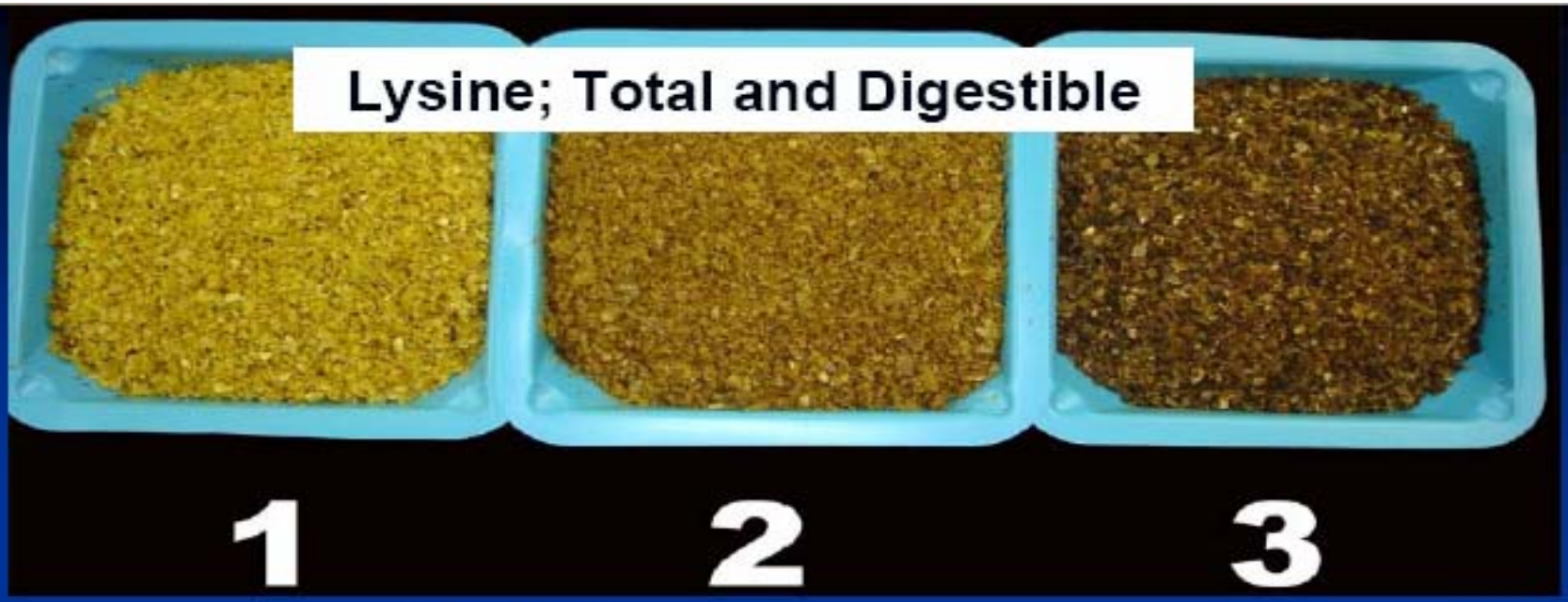
DDGS Color and Smell

- Color varies among sources
  - ranges from dark to golden (Cromwell et al., 1993)
  - golden color is correlated with higher amino acid digestibility in swine and poultry
- Smell varies among sources
  - ranges from burnt or smoky to sweet and fermented (Cromwell et al., 1993)
  - DDGS has a sweet, fermented smell

“Traditional” vs. “New Generation” DDGS



Lysine; Total and Digestible



Spl	Color			Total Lys	Lys Dig. Co	Dig. Lys
	L* (Lightness)	b* (Yellowness)	a* (Redness)			
1	60.3	25.9	5.0	0.86	76.8	0.66
2	57.7	18.3	6.2	0.82	72.1	0.59
3	50.4	7.41	5.2	0.39	45.8	0.18

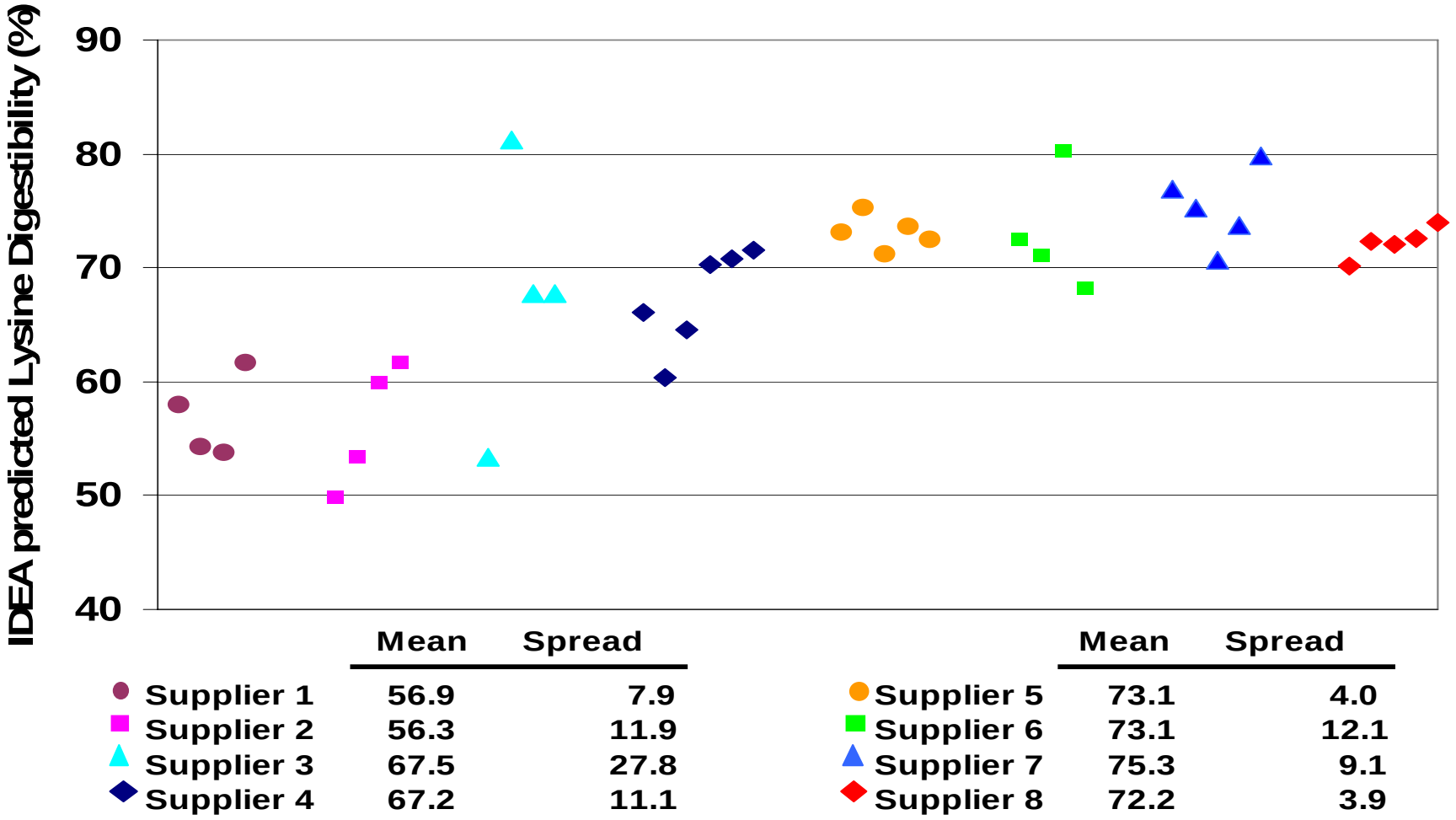
Color (L*, b*, a*) was measured with a Minolta Chroma Meter CR-300

Batal, 2007

Correlation Between DDGS Color and Amino Acid Digestibility (R^2)

Amino acid	**L***	**a***	**b***
Lysine	.71	NS	.74
Cystine	.66	NS	.67
Threonine	.37	NS	.40

Supplier Survey Shows Consistency of Lysine Digestibility Within Producer



	Mean	Spread
Supplier 1	56.9	7.9
Supplier 2	56.3	11.9
Supplier 3	67.5	27.8
Supplier 4	67.2	11.1

	Mean	Spread
Supplier 5	73.1	4.0
Supplier 6	73.1	12.1
Supplier 7	75.3	9.1
Supplier 8	72.2	3.9

Source: Novus International; Adapted: Waldroup, 2007

Fat Stability of DDGS

- Limited data
- Mexico trial
  - DDGS monitored during transit and storage for 16 weeks in a commercial feed mill in Jalisco, Mexico
    - Temperature ranged from 2 to 28 degrees C
    - Average high temperature 25 degrees C
    - Average low temperature was 8.4 degrees C
  - No rancidity was detectable

Mycotoxins

- Risk of mycotoxin contamination in “new generation” DDGS is very low
  - Poor quality corn = poor ethanol yields
  - Corn supplied to ethanol plants is produced locally
  - Corn produced in the upper Midwest has a low risk for mycotoxins

Mycotoxins

- Must use thin layer chromatography (TLC) or HPLC for testing mycotoxins in DDGS
  - ELISA and other methods result in false positives
  - May be due to salts and oxidizers that affect detection

Mycotoxins

- Trial conducted at Iowa State University Veterinary Diagnostic Laboratory using HPLC (Imerman,2006)
- Samples taken at ethanol plant, USA port and Taiwan port
- No Aflatoxins, Zearalenone/Zearalenol, or T-2 toxin were found in DDGS.
- Low level of Fumonisins and Vomitoxin present in DDGS.
- No real increase in toxin after shipment of DDGS in containers.

Suggested Inclusion Rates of DDGS in Poultry Diets

- Young broiler
  - from 5 to 10%
- Grow-finish broiler
  - from 10 to 15%
- Layer
  - From 5 to 15%

- formulate on a digestible amino acid and available phosphorus basis
- diets contain other by-products- rice bran, copra, wheat pollard, etc

Suggested Inclusion Rates of DDGS in Swine Diets

- Starter
  - Up to 10%
- Grower-finisher
  - Up to 15%
- Breeder
  - Up to 15%

- formulate on a digestible amino acid and available phosphorus basis
- diets contain other by-products- rice bran, copra, wheat pollard, etc

Keys to Using DDGS in Animal Diets

- Obtain analytical information from the supplier
  - nutrient variability between suppliers
  - establish nutrient matrix
- Choose the golden color
  - high amino acid digestibility

Keys to Using DDGS in Animal Diets

- Formulate on digestible amino acid basis
  - Pay attention to minimums for lysine, tsaa, threonine, tryptophan and arginine
- Maximize DDGS contribution by using available phosphorus values
- Introduce at lower levels in formulations, especially for young animals

Sample Formulations

Swine Grower

Ingredient	kg/mt	P/kg	Minimum nutrient specs	
Corn	378.9	11.5	ME	3100
Sbm US47	215.0	19.5	Protein	16.78
Coco oil	38.0	38.0	Fat	7.63
Copra	100.0	7.5	Fiber	5.02
Cassava meal	100.0	6.5	Calcium	0.84
Rice bran	100.0	8.5	Sodium	0.21
Molasses	30.0	6.5	AvPhos	0.44
MDCP	16.0	25.0	Dig lys	0.90
Limestone	13.0	1.3	Dig m+c	0.49
Salt	4.0	3.5	Dig threo	0.58
L-Lysine	2.9	80.0	Dig tryp	0.14
L-Threonine	1.4	135.0		
DL-Methionine	0.8	150.0		
				P 13,411/mt

Swine Grower w/ DDGS

Ingredient	kg/mt	P/kg	Minimum nutrient specs	
DDGS	100.0	13.5		
Corn	305.2	11.5	ME	3100
Sbm US47	192.0	19.5	Protein	17.78
Coco oil	35.0	38.0	Fat	7.63
Copra	100.0	7.5	Fiber	5.46
Cassava meal	100.0	6.5	Calcium	0.85
Rice bran	100.0	8.5	Sodium	0.23
Molasses	30.0	6.5	AvPhos	0.45
MDCP	15.0	25.0	Dig lys	0.90
Limestone	14.0	1.3	Dig m+c	0.49
Salt	4.0	3.5	Dig threo	0.58
L-Lysine	3.2	80.0	Dig tryp	0.14
L-Threonine	1.2	135.0		
DL-Methionine	0.4	150.0		

P 13,264/mt

Broiler Finisher

Ingredient	kg/mt	P/kg	Minimum nutrient specs	
Corn	693.7	11.5	ME	3148
Sbm US47	216.0	19.5	Protein	18.00
FMA	30.0	40.0	Fat	5.94
Coco oil	30.0	38.0	Fiber	3.42
Limestone	12.0	1.3	Calcium	0.81
MDCP	12.0	25.0	AvPhos	0.41
Salt	3.0	3.5	Dig lys	0.90
DL-Methionine	2.1	155.0	Dig meth	0.49
L-Lysine	0.8	80.0	Dig tsaa	0.74
L-Threonine	0.4	120.0	Dig threo	0.63
			Dig tryp	0.17

PhP 15,289/mt

Broiler Finisher w/ DDGS

Ingredient	kg/mt	P/kg	Minimum nutrient specs	
DDGS	100.0	13.5		
Corn	633.2	11.5	ME	3142
Sbm US47	178.0	19.5	Protein	18.40
FMA	30.0	40.0	Fat	6.57
Coco oil	30.0	38.0	Fiber	3.86
Limestone	12.0	1.3	Calcium	0.81
MDCP	10.0	25.0	AvPhos	0.40
Salt	3.0	3.5	Dig lys	0.90
DL-Methionine	1.8	155.0	Dig meth	0.47
L-Lysine	1.6	80.0	Dig tsaa	0.74
L-Threonine	0.4	120.0	Dig threo	0.63
			Dig tryp	0.16

PhP 15,171/mt

Layer 100

Ingredient	kg/mt	P/kg	Minimum nutrient specs	
Corn	557.4	11.5	ME	2700
Sbm US47	218.0	17.0	Protein	16.00
Coco oil	15.0	38.0	Fat	4.89
Oyster shell	50.0	3.50	Fiber	3.92
Limestone	52.0	1.3	Calcium	3.81
MDCP	15.0	25.0	AvPhos	0.40
Salt	3.5	3.5	Dig lys	0.77
DL-Methionine	2.5	155.0	Dig meth	0.47
L-Lysine	0.6	80.0	Dig tsaa	0.69
Rice bran	87.0	8.5	Dig threo	0.51
			Dig tryp	0.15

PhP 13,004/mt

Layer 100 w/ DDGS

Ingredient	kg/mt	P/kg	Minimum nutrient specs	
DDGS	100.0	13.5		
Corn	506.5	11.5	ME	2700
Sbm US47	169.0	17.0	Protein	16.00
Coco oil	15.0	38.0	Fat	5.54
Oyster shell	50.0	3.50	Fiber	4.36
Limestone	52.0	1.3	Calcium	3.78
MDCP	13.0	25.0	AvPhos	0.40
Salt	3.5	3.5	Dig lys	0.77
DL-Methionine	2.3	155.0	Dig meth	0.46
L-Lysine	1.7	80.0	Dig tsaa	0.69
Rice bran	87.0	8.5	Dig threo	0.50
			Dig tryp	0.14

PhP 12,841/mt

Summary of Diet Cost Savings when using DDGS

Diet	No DDGS	w/ DDGS	Savings/ MT
Hog Grower	13,411	13,264	147
Broiler Finisher	15,289	15,171	118
Layer 100	13,004	12,841	163

As of November 2007

Ingredient Formulation Changes when using DDGS in Animal Diets

- Reduced inclusion levels of:
  - Corn
  - Soybean meal
  - Fat/ Oil
  - Inorganic phosphate
  - DL-methionine
  - L-threonine

- Increased levels of:
  - L-lysine
  - Limestone

Nutrient Formulation Changes when using DDGS in Animal Diets

- Increase in levels of:
  - Protein
  - Fiber
  - Fat
  - Sodium
  - Total Amino Acids

Conclusions & Recommendations

- With the increasing production of ethanol, global supply of corn DDGS becomes more abundant
- DDGS has excellent nutritional value for swine and poultry; it is however variable
- DDGS variability calls for the establishment of a quality assessment system

Conclusions & Recommendations

- Utilization of DDGS presents the animal and feed sectors an opportunity to save on feed cost

- At current local ingredient prices, formulation savings can reach up to PhP150/ metric ton of feed when using DDGS at a maximum level of 10%

For inquiries regarding corn DDGS,

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