Overview of Production and Nutrient Content of DDGS

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What is DDGS?

- **Distiller's dried grains with solubles (DDGS)**
  - By-product of the **dry-milling** ethanol industry
- Nutrient composition is **different** between dry-mill, wet-mill and beverage alcohol by-products
  - DDGS – fuel ethanol
  - DDGS - whiskey distilleries
  - Corn gluten feed – wet mill
  - Corn gluten meal – wet mill
  - Brewer's dried grains – beer manufacturing
- Nutrient content depends on the grain source used
  - **Corn DDGS - Midwestern US**
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS

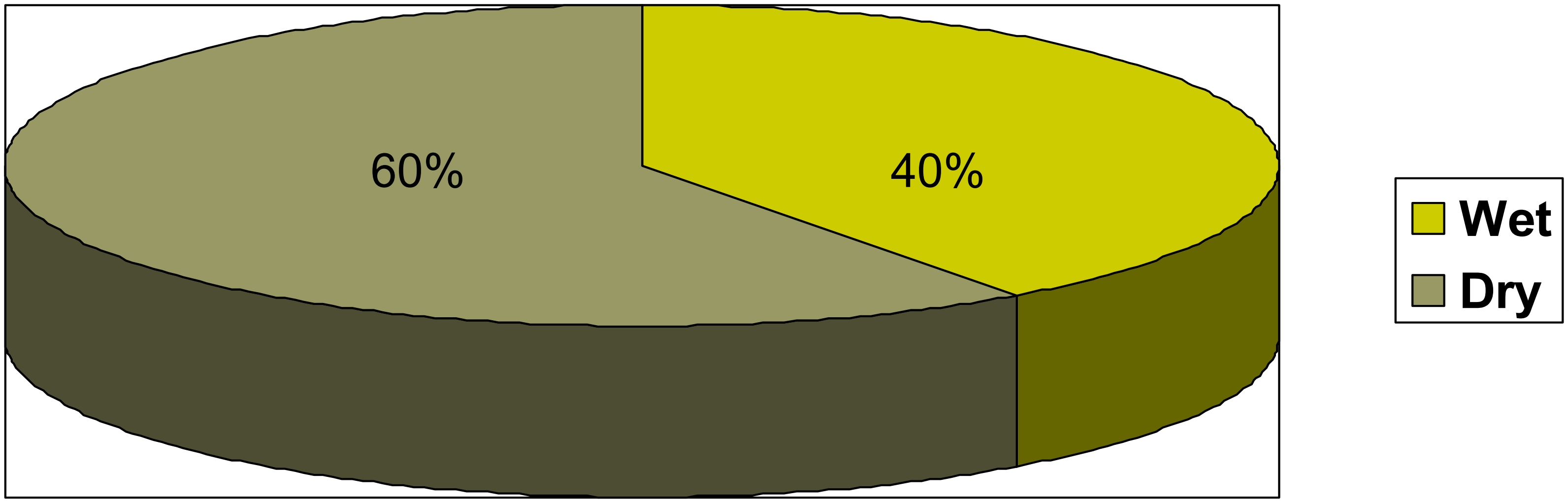
Comparison of Nutrient Composition (100% Dry Matter Basis) of Golden DDGS to Corn Gluten Feed, Corn Gluten Meal, Corn Germ Meal, and Brewer's Dried Grains

	Golden DDGS (UM)	Corn Gluten Feed (NRC)	Corn Gluten Meal (NRC)	Corn Germ Meal (Feedstuffs)	Brewer's Dried Grains (NRC)
Protein, %	30.6	23.9	66.9	22.2	28.8
Fat, %	*10.7*	3.3	3.2	1.1	7.9
NDF, %	43.6	37.0	9.7	No data	52.9
DE, kcal/kg	*4011*	3322	4694	No data	2283
ME, kcal/kg	*3827*	2894	4256	3222	2130
Lys, %	0.83	0.70	1.13	1.00	1.17
Met, %	0.55	0.39	1.59	0.67	0.49
Thr, %	1.13	0.82	2.31	1.22	1.03
Trp, %	0.24	0.08	0.34	0.22	0.28
Ca, %	0.06	0.24	0.06	0.33	0.35
Available P, %	*0.80*	0.54	0.08	0.17	0.21

Types of Distiller's By-Products from Dry-Grind Ethanol Plants

- Wet distiller's grains
  - Primarily beef, some dairy
- Dry distiller's grains
  - Beef and dairy
- Wet distiller's grains with solubles
  - Beef and dairy
- Dried distiller's grains with solubles
  - Dairy, swine, poultry, some beef
- Modified wet cake (blend of wet and dry distiller's grains)
  - Primarily beef, some dairy
- Condensed distiller's solubles
  - Beef and dairy
  - Ontario, Canada - swine liquid feeding systems

Proportion of Distiller's Grains Marketed Wet vs Dry



Samples of High Quality, Golden Corn DDGS

VeraSun - Aurora, SD

CVEC - Benson, MN

Al-Corn - Claremont, MN

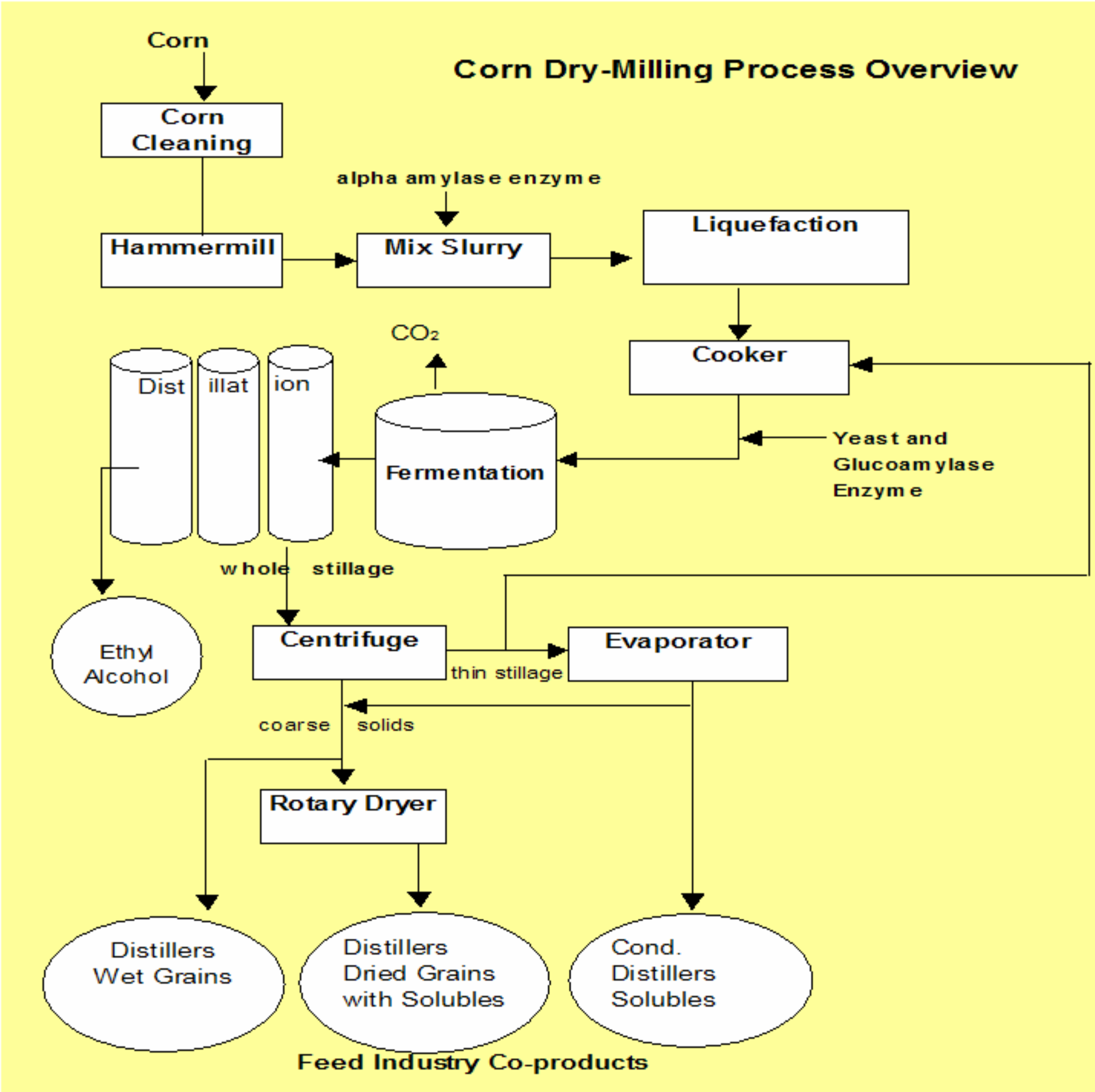
MGP – Lakota, IA

CMEC - Little Falls, MN

Agri-Energy - Luverne, MN

LSCP - Marcus, IA

DENCO – Morris, MN

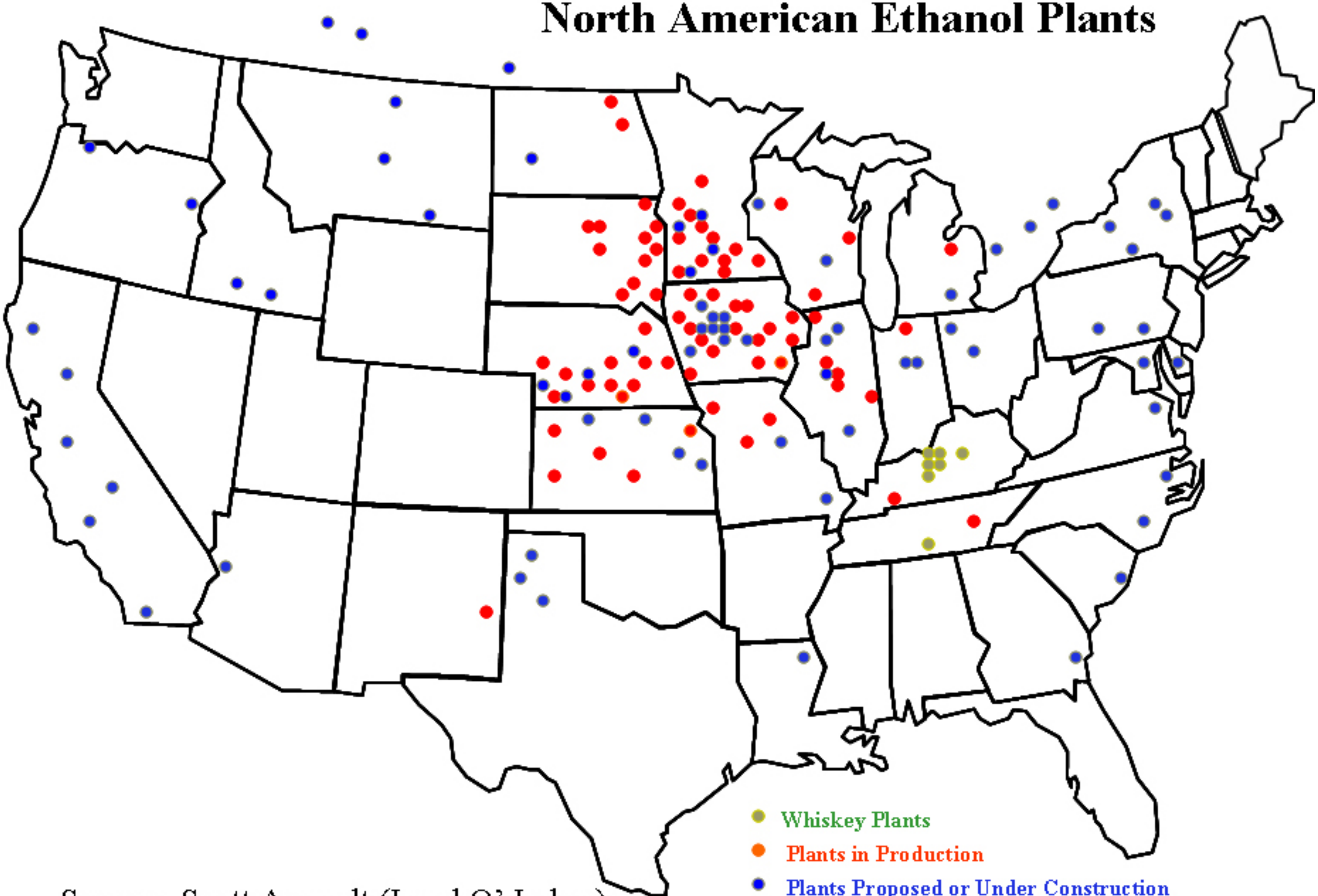

Corn Dry-Milling Process Overview
Corn
Corn Cleaning
Hammermill
alpha amylase enzyme
Mix Slurry
Liquefaction
Cooker
CO2
Distillation
Fermentation
Yeast and Glucoamylase Enzyme
whole stillage
Ethyl Alcohol
Centrifuge
thin stillage
Evaporator
coarse solids
Rotary Dryer
Distillers Wet Grains
Distillers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

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

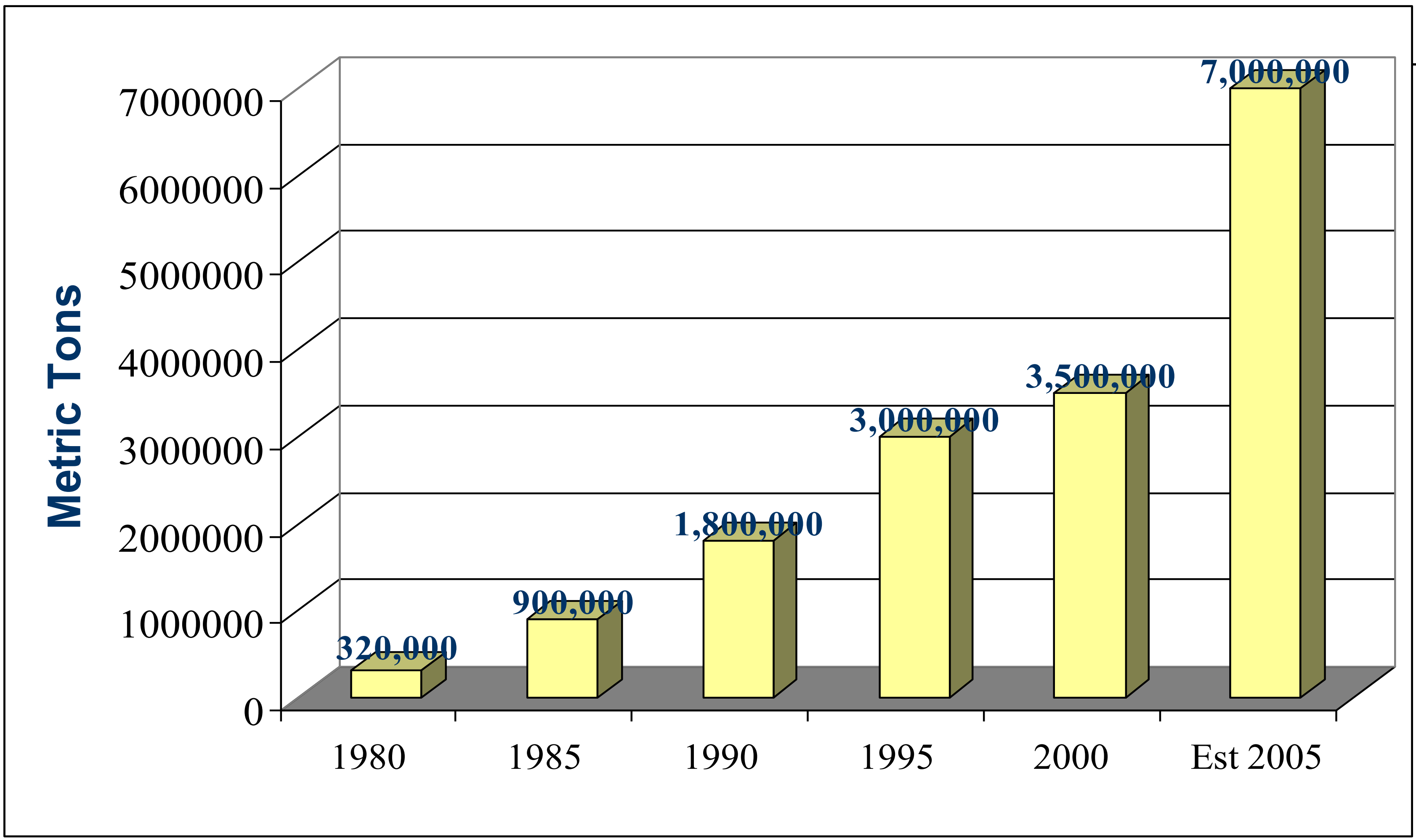
Slide courtesy of Ms. Kelly Davis, CVEC, Benson, MN

North American Ethanol Plants



Source: Scott Amendt (Land O' Lakes)

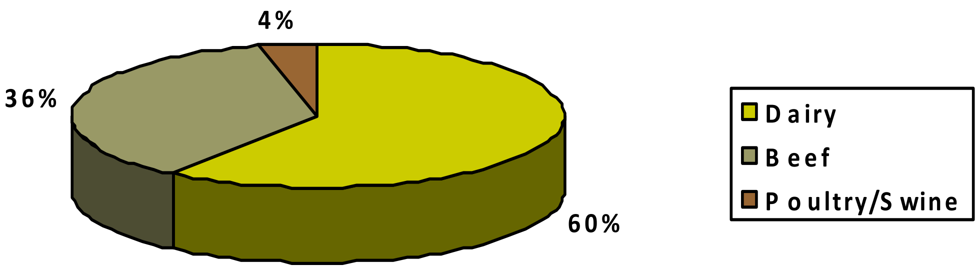
U.S. DDGS Production



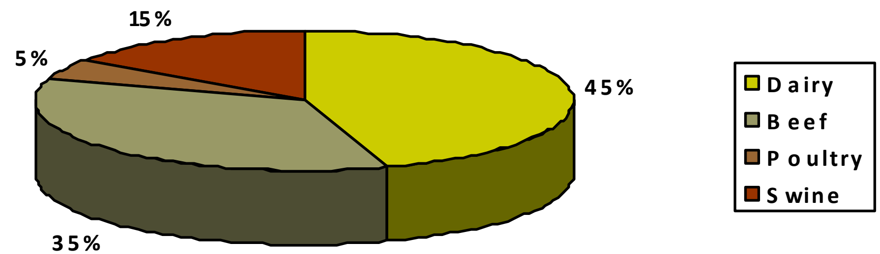
Source: Steve Markham – Commodity Specialists Company

U.S. DDGS Consumption

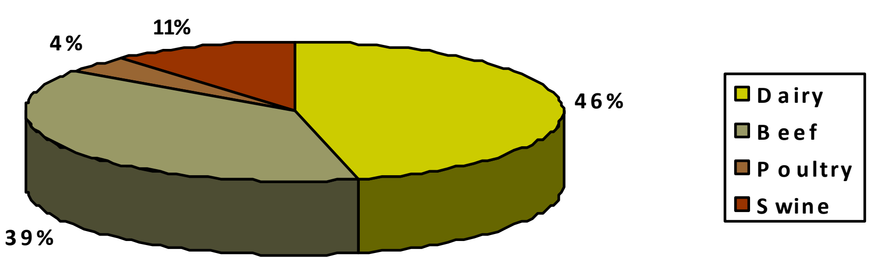
Estimate 2001



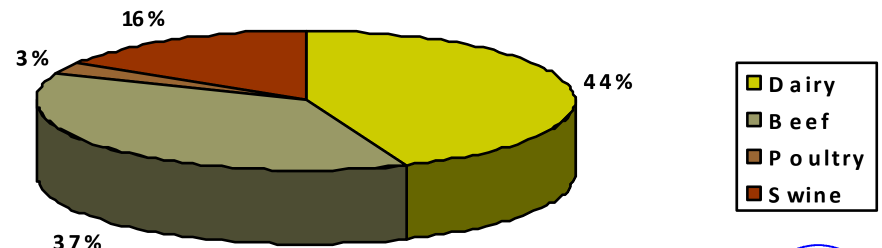
Estimate 2002



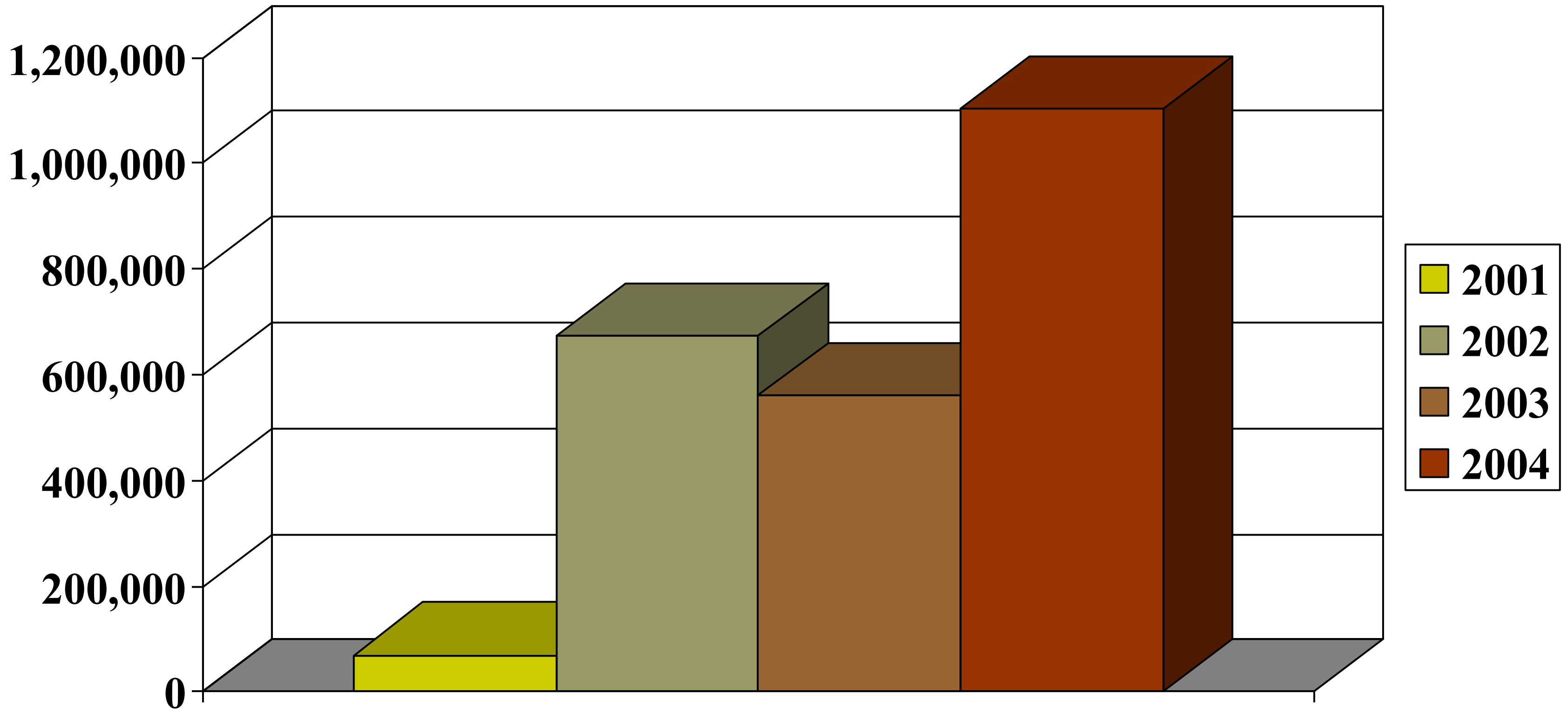
Estimate 2003



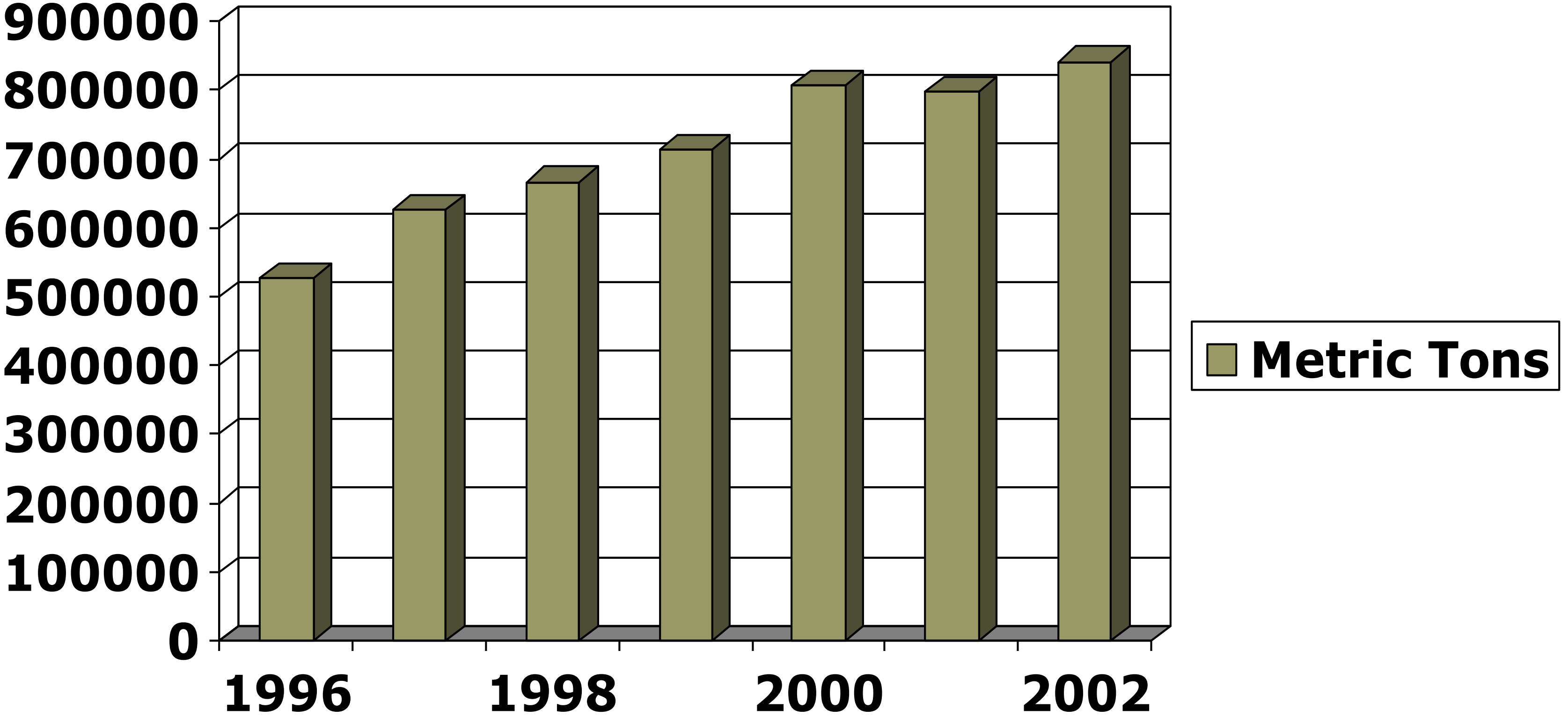
Estimate 2004



Estimated DDGS Usage in U.S. Swine Feeds 2001-2004 (Metric Tonnes)

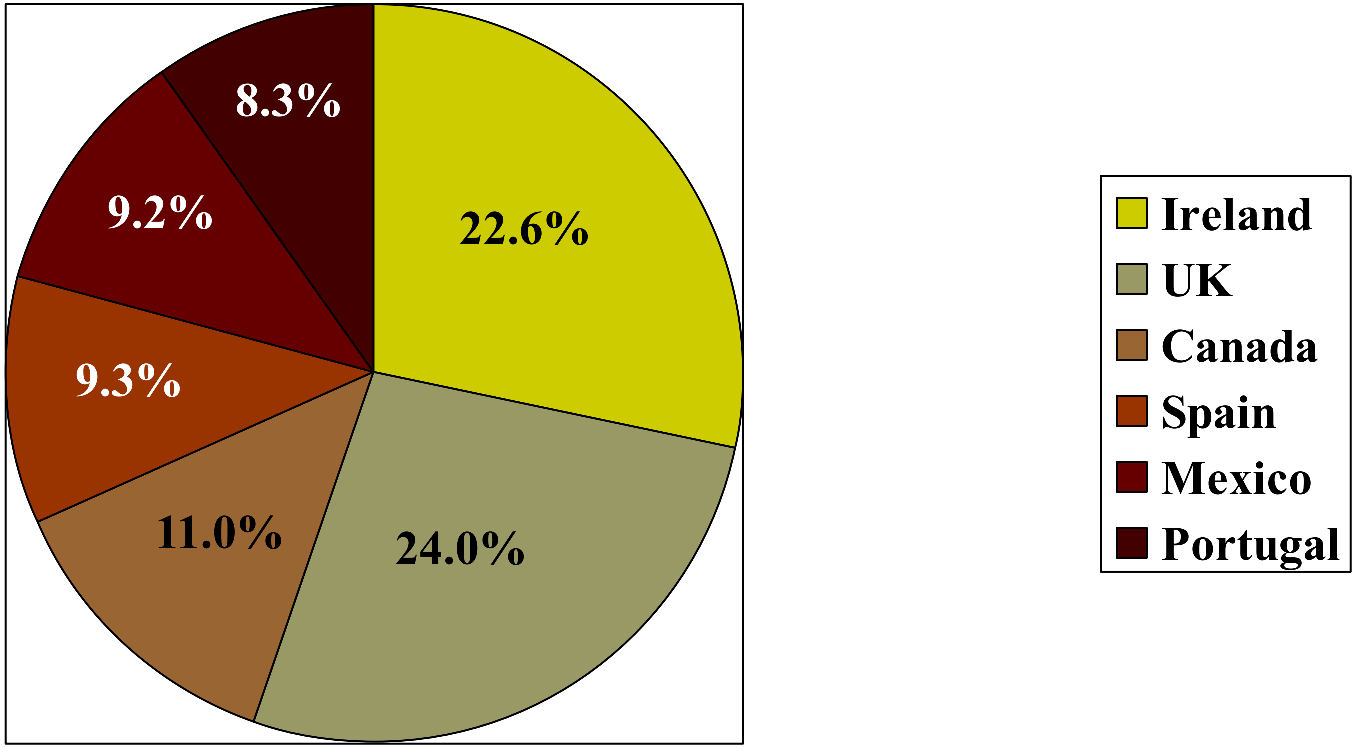


U.S. DDGS Exports Are Increasing

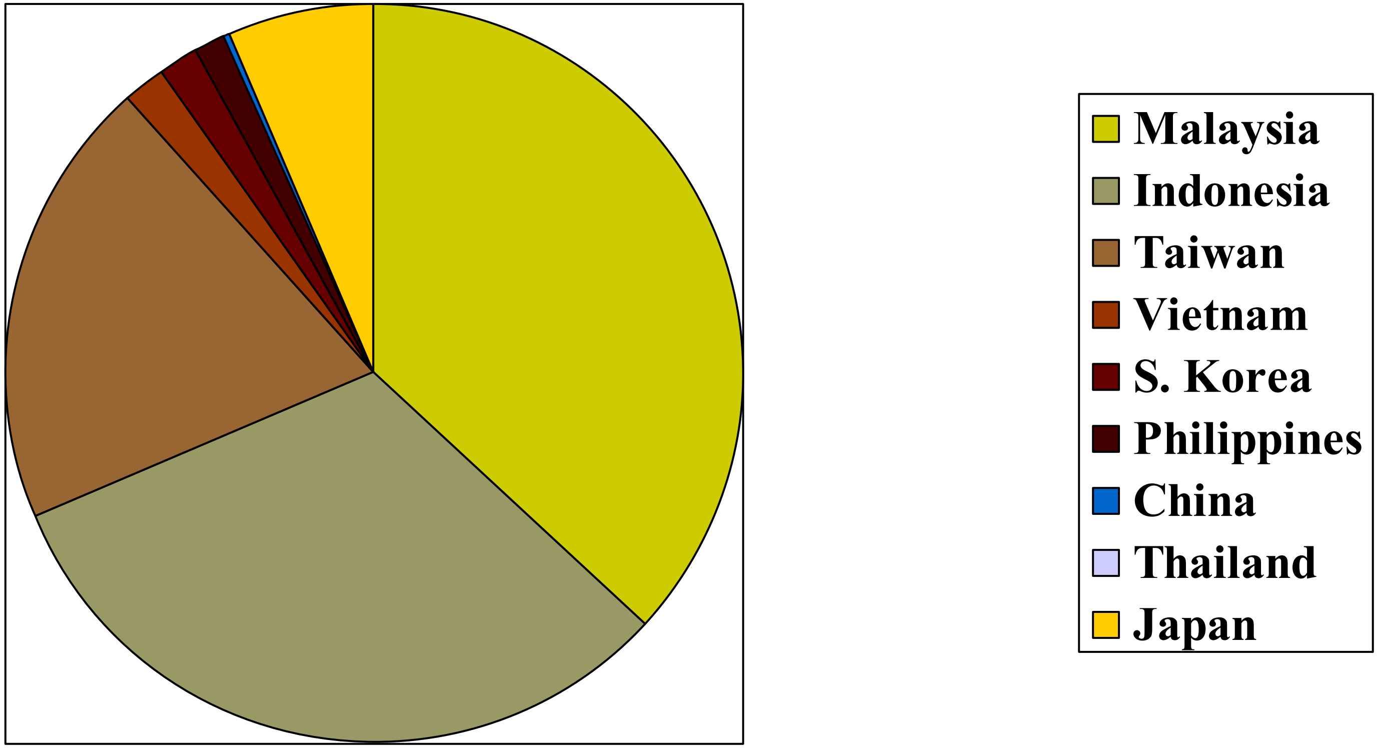


Source: Commodity Specialists Company

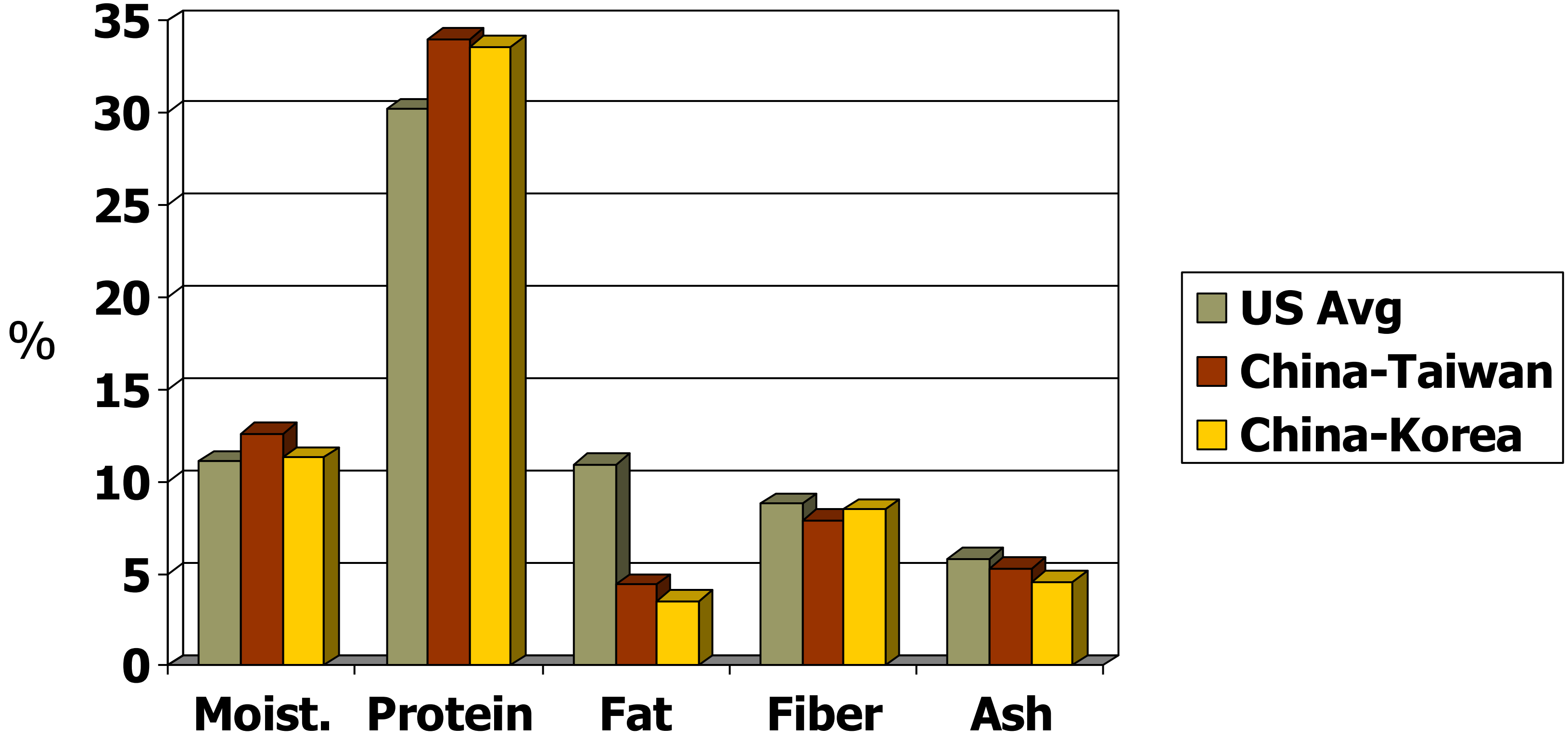
Major U.S. DDGS Importing Countries (84% of Total Exports)



Asian Countries Importing U.S. DDGS (4.5% of Total Exports)



Comparison of Proximate Analysis of High Quality U.S. Golden Corn DDGS with Chinese DDGS (100% Dry Matter Basis)

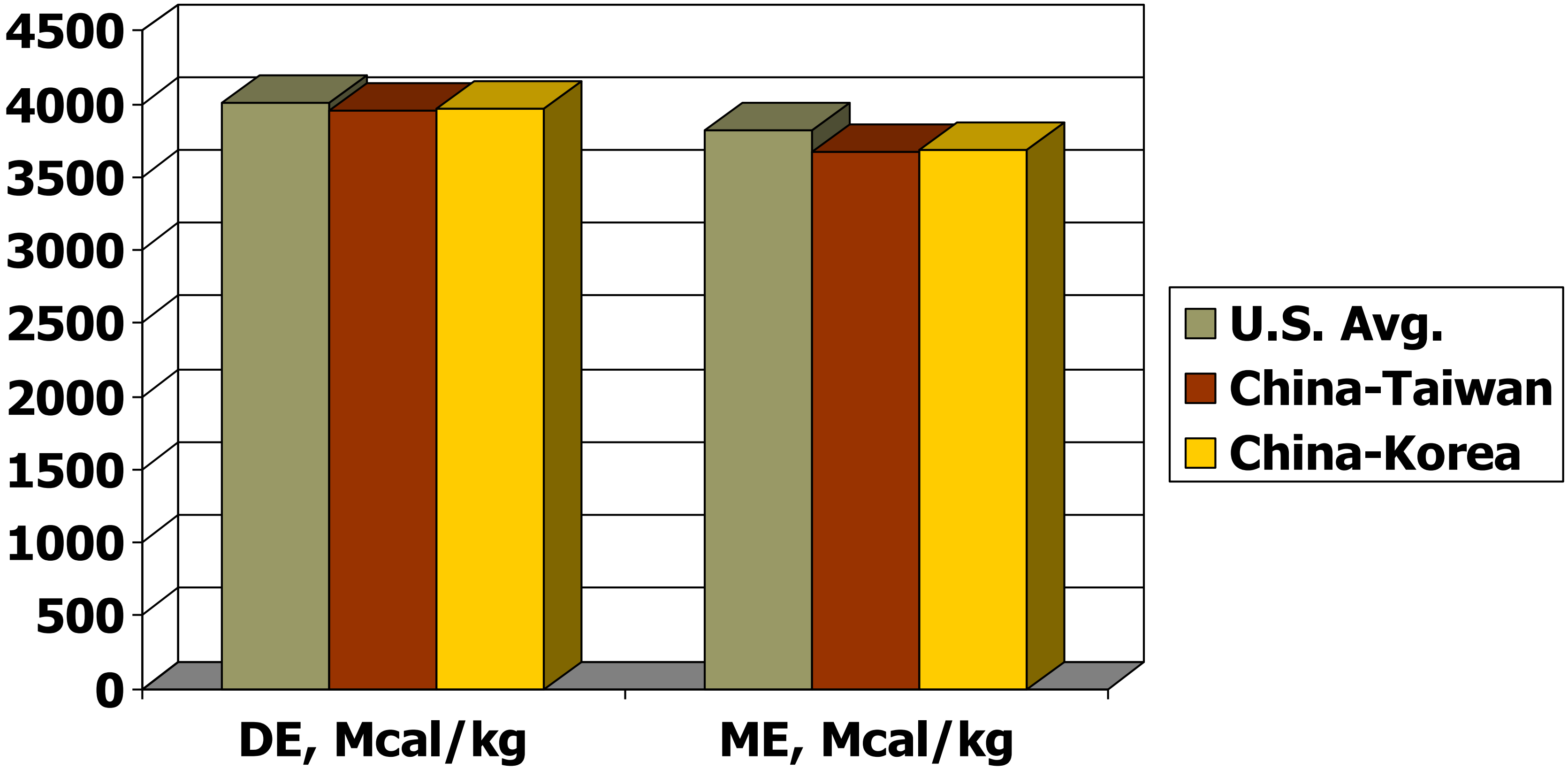


U.S. Avg. = average of values obtained from samples from 10 "New Generation" dry-mill ethanol plants (Spiehs et al., 2002)

China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003

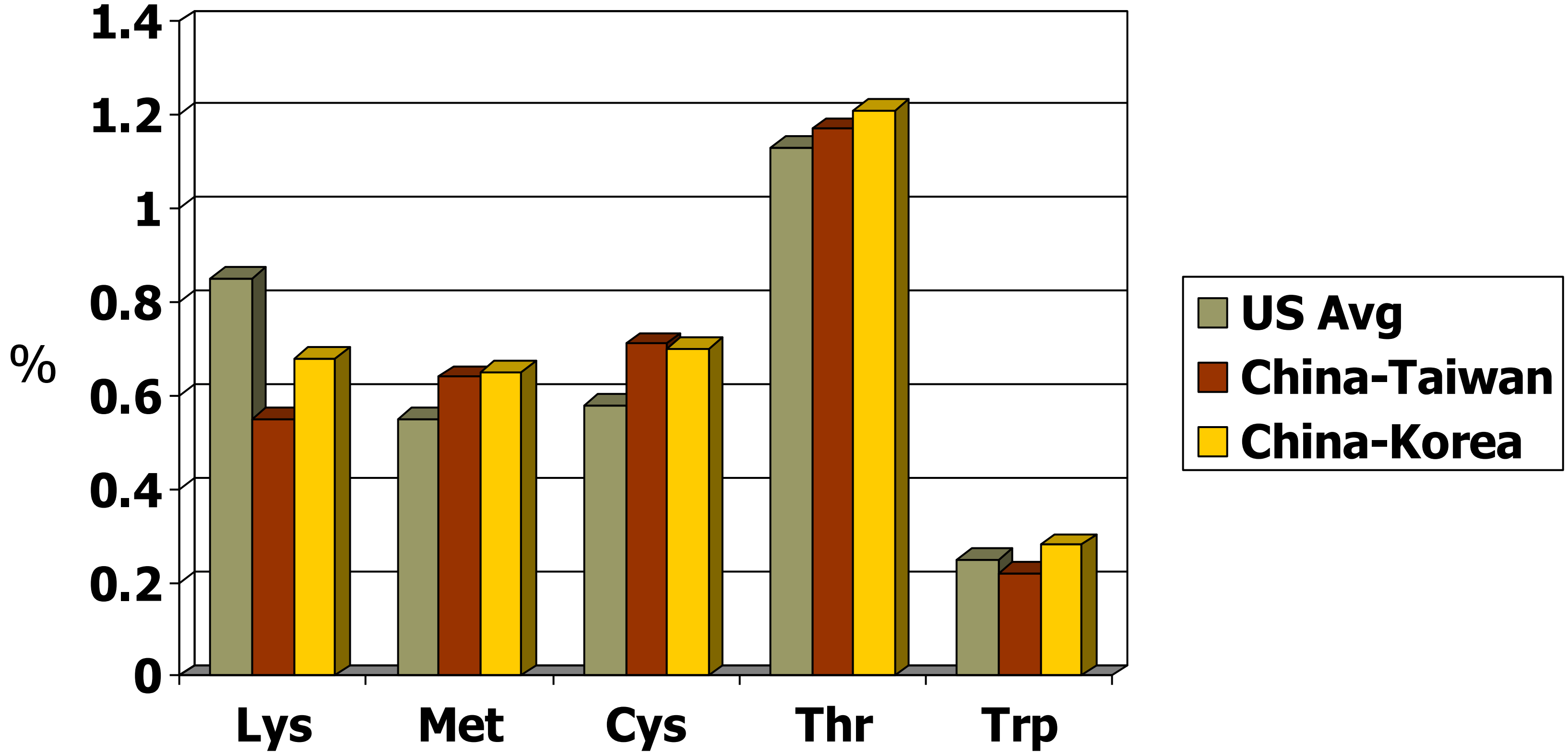
China-Korea = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005

Comparison of Calculated Digestible Energy, Metabolizable Energy for Swine of U.S. "New Generation" DDGS to Chinese DDGS (100% Dry Matter Basis)



U.S. Avg. = average of calculated values obtained from DDGS samples from 10 "New Generation" ethanol plants (Spiehs et al., 2002)
China-Taiwan = calculated values from actual proximate analysis of a sample of Chinese DDGS obtained from Taiwan in 2003
China-Korea = calculated values from actual proximate analysis of a sample of Chinese DDGS obtained from S. Korea in 2005

Comparison of Amino Acid Analysis of U.S. "New Generation" DDGS with Chinese DDGS (100% Dry Matter Basis)

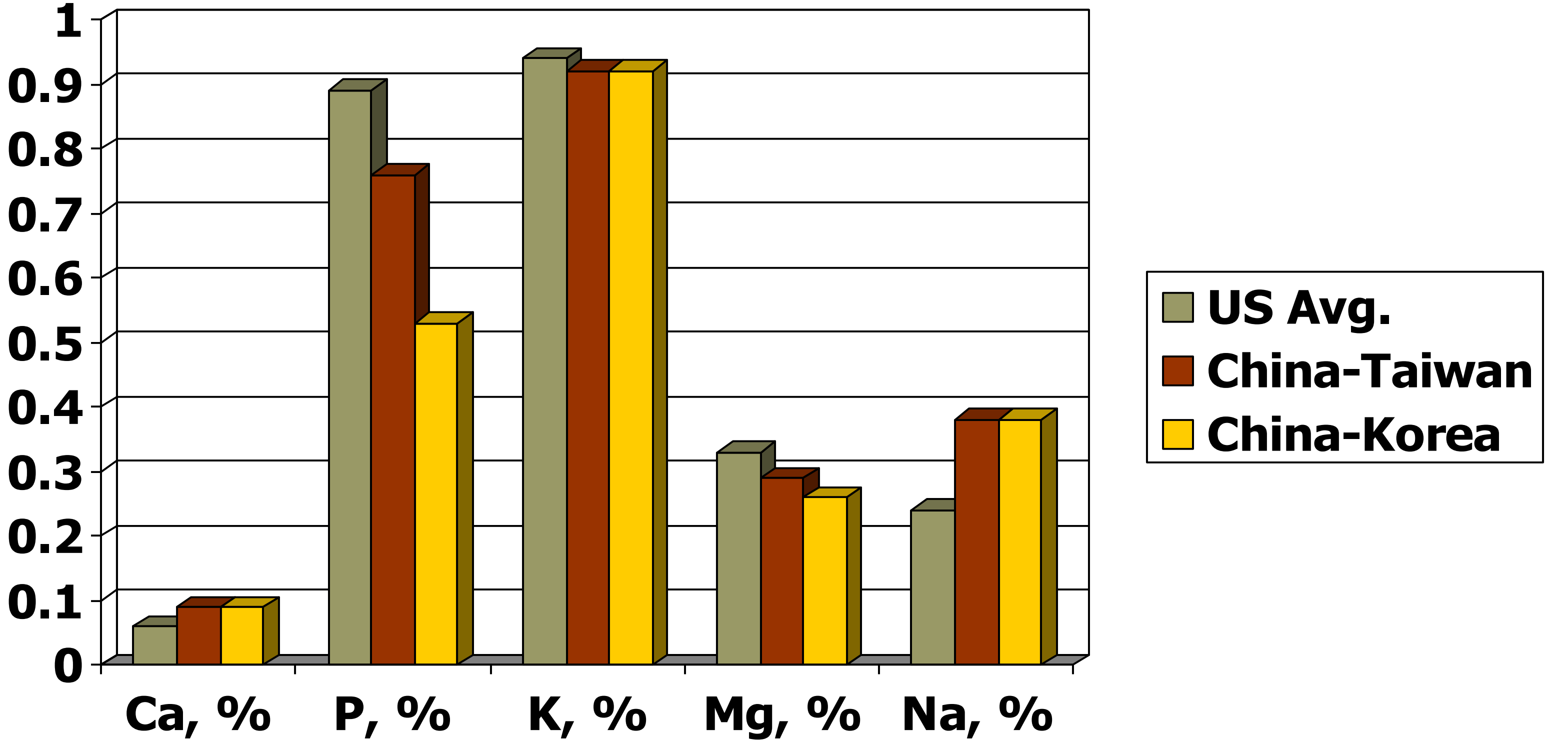


U.S. Avg. = average of values obtained from samples from 10 "New Generation" dry-mill ethanol plants (Spiehs et al., 2002)

China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003

China-Korea = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005

Comparison of Macro-mineral Analysis of U.S. "New Generation" DDGS with Chinese DDGS (100% Dry Matter Basis)

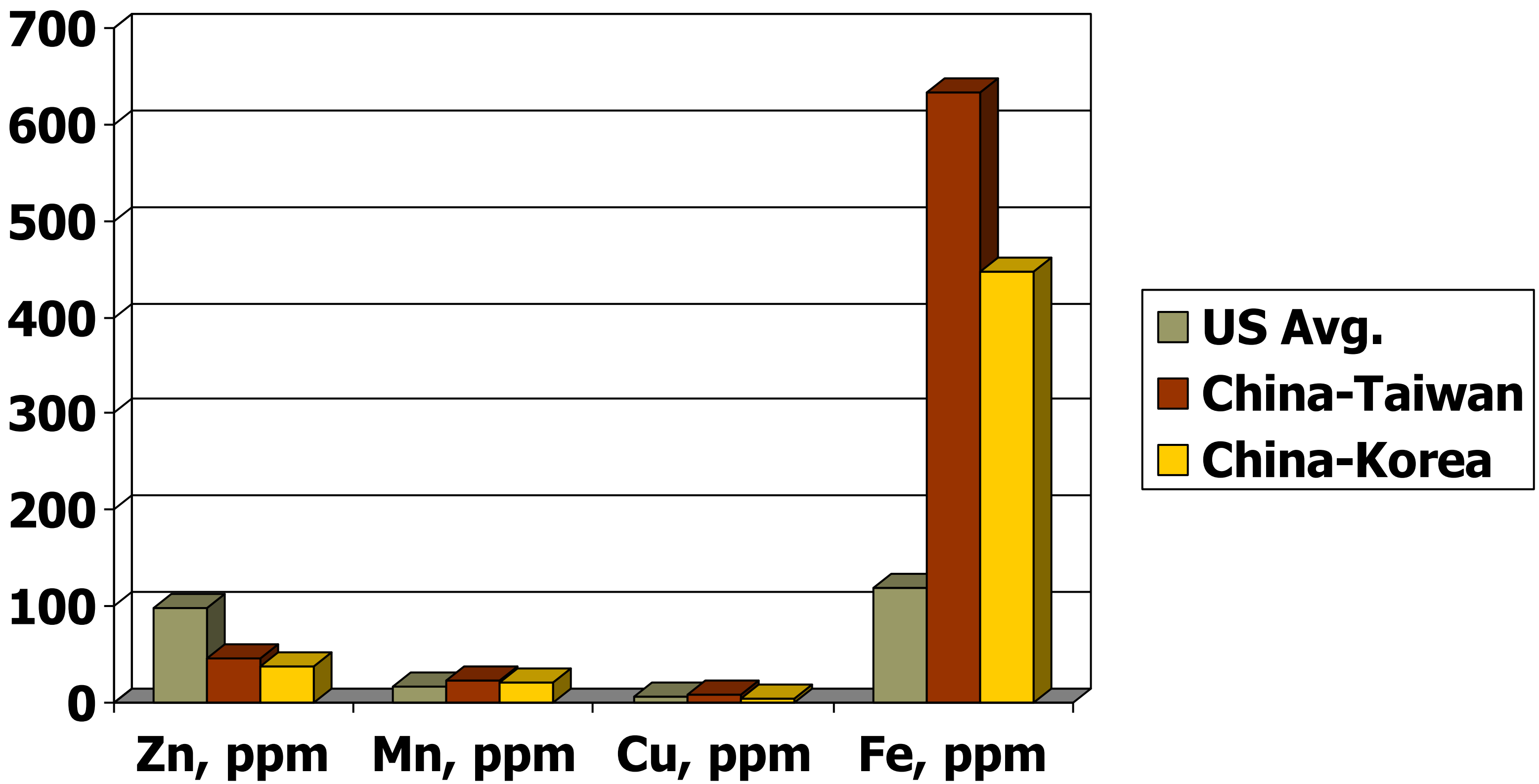


U.S. Avg. = average of values obtained from samples from 10 "New Generation" dry-mill ethanol plants (Spiehs et al., 2002)

China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003

China-Korea = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005

Comparison of Trace Mineral Analysis of U.S. "New Generation" DDGS with Chinese DDGS (100% Dry Matter Basis)



U.S. Avg. = average of values obtained from samples from 10 "New Generation" dry-mill ethanol plants (Spiehs et al., 2002)

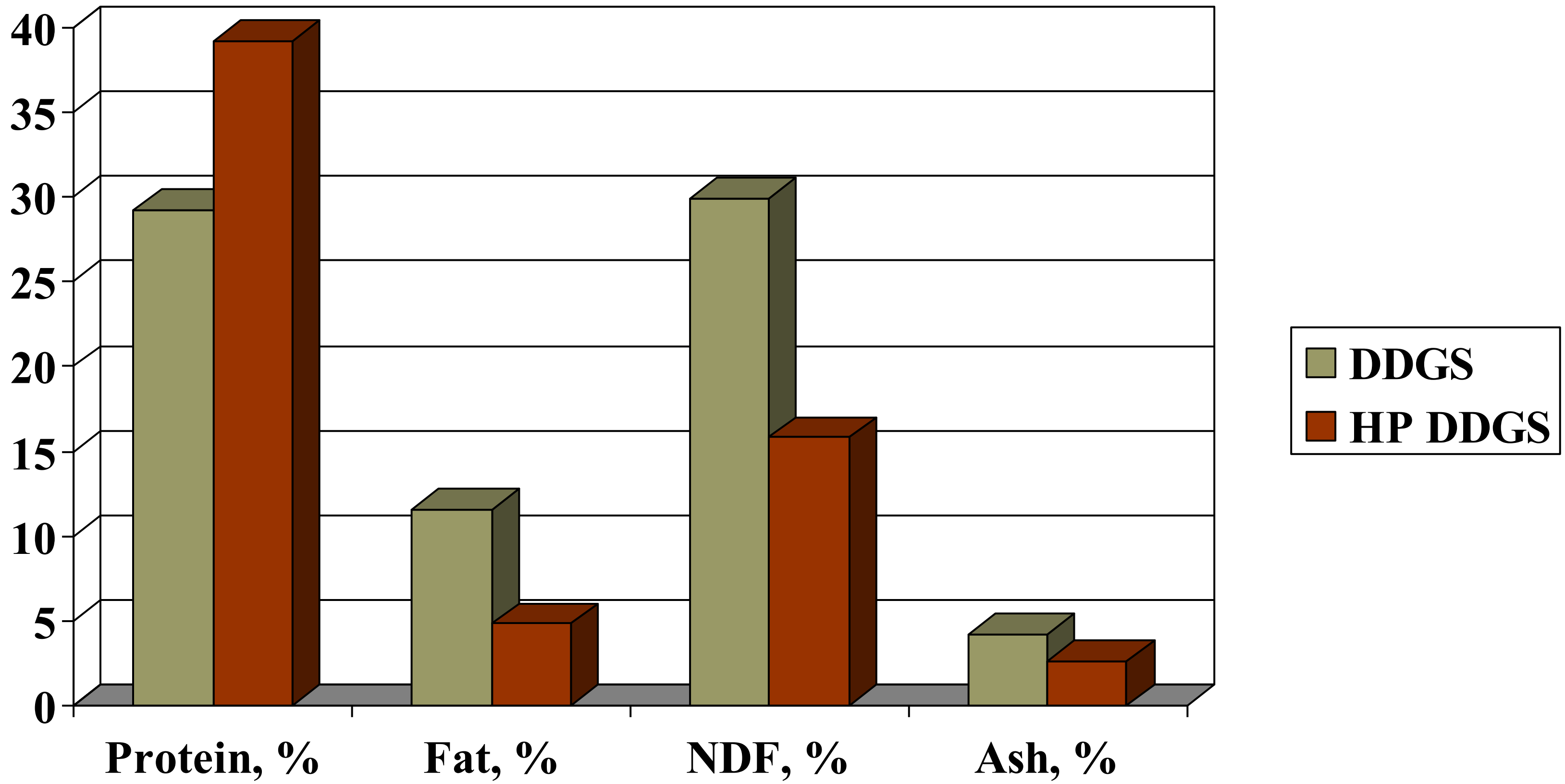
China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003

China-Korea = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005

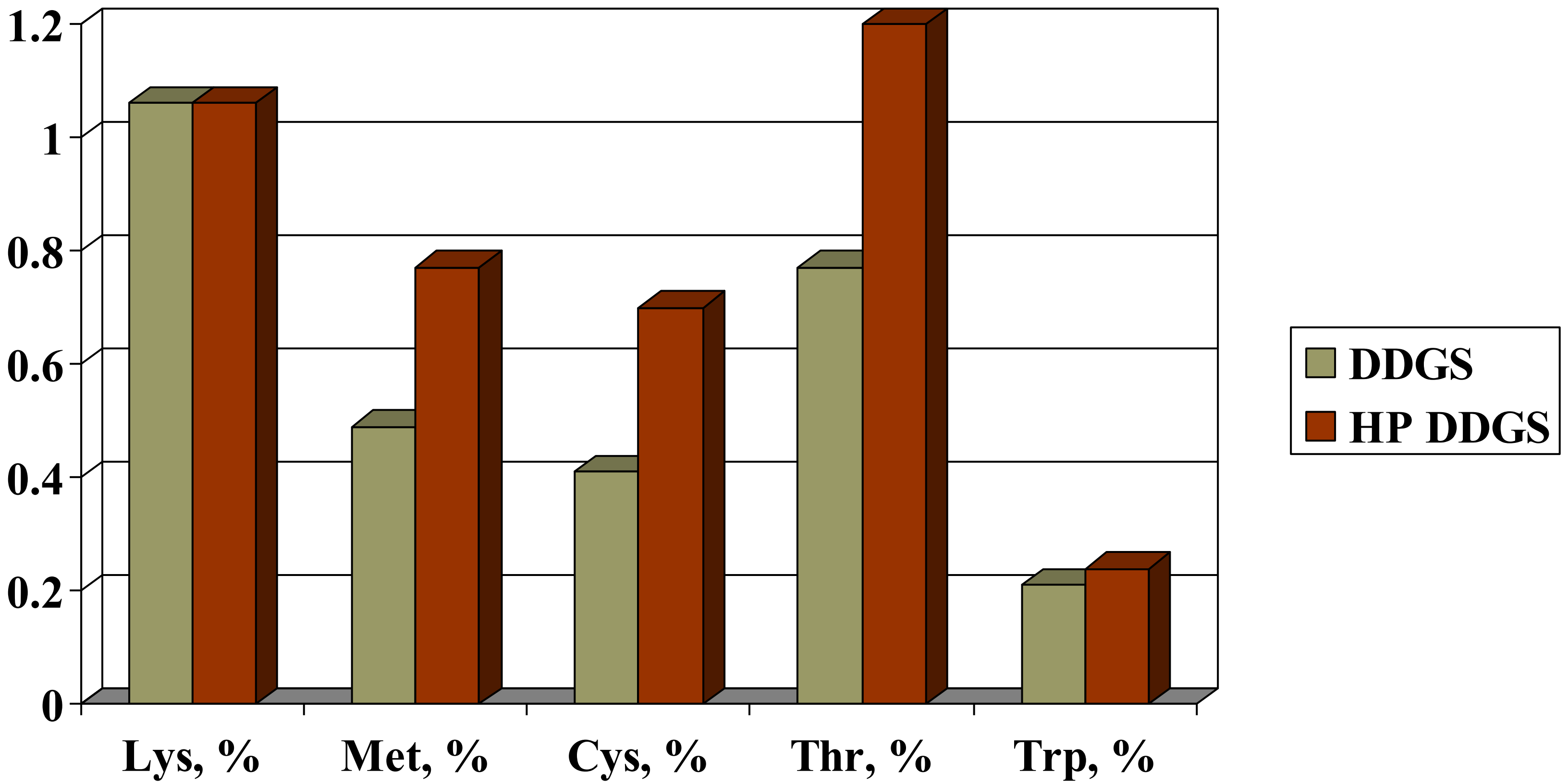
Ethanol Plants are Developing New Distiller’s By-Products

- DDG – Winnebago
- High protein DDGS – Dakota Commodities
- De-germed or partial de-germed DDGS
- “Quick fiber”
- Removing P
- Others

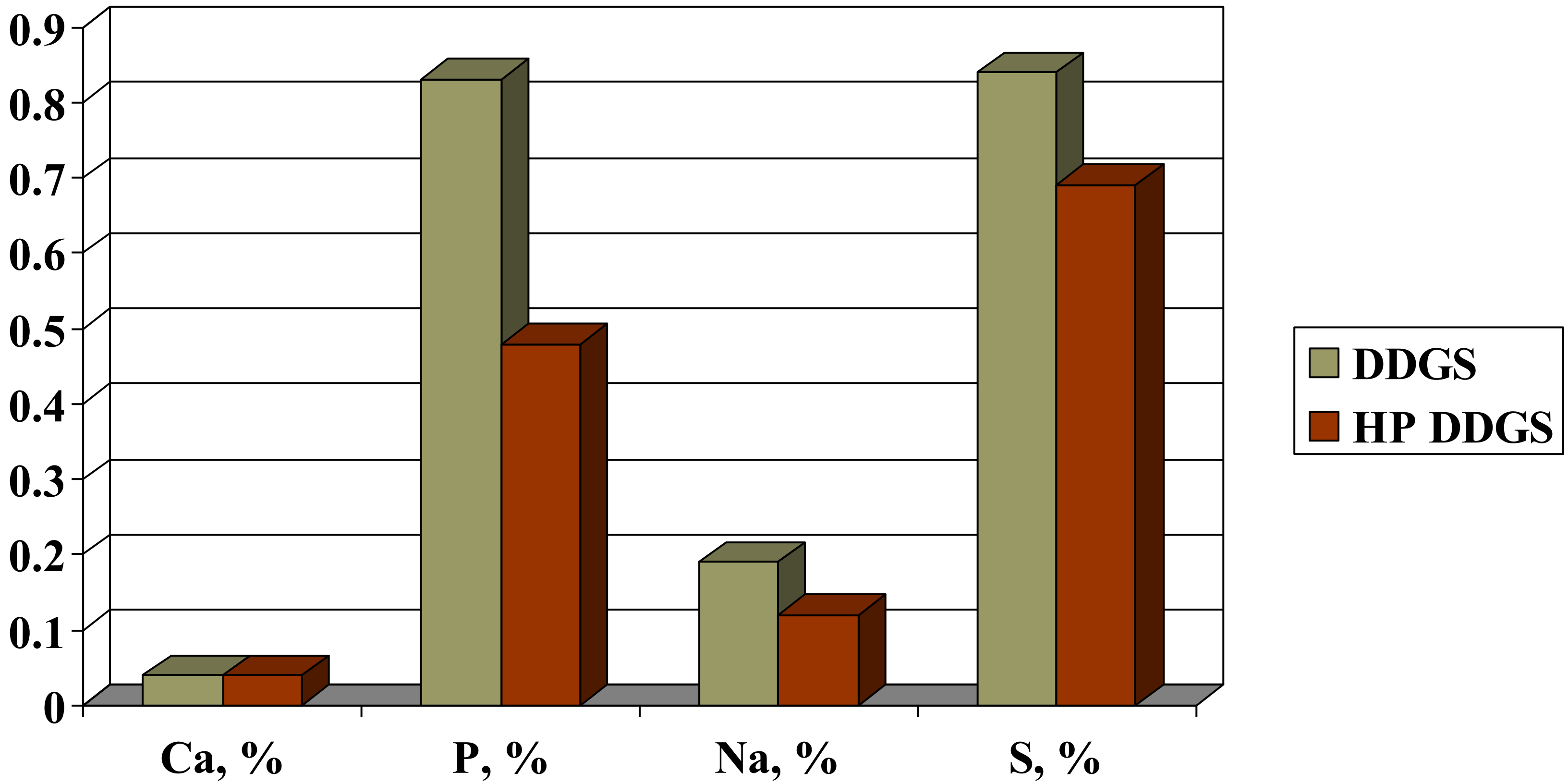
Comparison of Nutrient Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)



Comparison of Amino Acid Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)



Comparison of Mineral Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)



Proximate Analysis and Calculated Swine Energy Values Among 27 U.S. DDGS Sources (100% Dry Matter Basis)

Nutrient	Average	Range
Dry matter, %	89.3	87.3 – 92.4
Crude protein, %	31.0	28.7 – 32.9
Fat, %	10.6	8.8 – 12.4
Fiber, %	7.2	5.4 – 10.4
Ash, %	6.1	3.0 – 9.8
ADF, %	13.6	8.0 – 18.1
Swine DE, kcal/kg	4053	3737 – 4319
Swine ME, kcal/kg	3790	3504 – 4048

Amino Acid Analysis Averages and Ranges Among 27 U.S. DDGS Sources (100% Dry Matter Basis)

Nutrient	Average	Range
Arg, %	1.31	1.01 – 1.48
His, %	0.84	0.71 – 0.98
Ile, %	1.17	1.01 – 1.31
Leu, %	3.58	2.91 – 3.96
Lys, %	0.89	0.61 – 1.06
Met, %	0.65	0.54 – 0.76
Cys, %	0.68	0.61 – 0.76
Phe, %	1.51	1.36 – 1.72
Thr, %	1.15	1.01 – 1.28
Trp, %	0.25	0.18 – 0.28
Val, %	1.58	1.31 – 1.80

Mineral Analysis Averages and Ranges Among 27 U.S. DDGS Sources (100% Dry Matter Basis)

Nutrient	Average	Range
Ca, %	0.08	0.02 – 0.12
P, %	**0.75**	**0.42 – 0.99**
K, %	0.96	0.45 – 1.27
Mg, %	0.29	0.14 – 0.38
S, %	0.62	0.34 – 1.05
Na, %	0.15	0.04 – 0.52
Zn, ppm	62	38 – 105
Mn, ppm	19	9 – 27
Cu, ppm	6	3 – 10
Fe, ppm	133	77 – 239

Nutrient Composition of High Quality U.S. Corn DDGS for Ruminants

Nutrient	**% of Dry Matter**
Crude protein	30.1
Ruminally undegradable protein (% of CP)	55.0
$NE_{maintenance}$ (Mcal/kg)	2.07
NE_{gain} (Mcal/kg)	1.41
$NE_{lactation}$ (Mcal/kg)	2.26
NDF	41.5
ADF	16.1
Ether extract	10.7

Comparison of Energy Values of DDGS for Swine (88% DM Basis)

	Golden DDGS Calculated U of M	Golden DDGS Trial avg. U of M	Traditional DDGS Calculated U of M	DDGS NRC (1998)
DE, kcal/kg	3488 Range 3418-3537	3528 Range 2975-4086	3409	3449
ME, kcal/kg	3162 Range 3087-3215	3367 Range 2820-3916	3098	2672

Corn (NRC, 1998): DE (kcal/kg) = 3484
ME (kcal/kg) = 3382

Comparison of DE and ME Estimates of DDGS for Swine (88% DM)

	DE, Mcal/kg	ME, Mcal/kg	NE, Mcal/kg
U of M – Golden DDGS (1999)	3.49	3.37	No data
U of M – Traditional (1999)[1]	3.41	3.10	No data
KSU – New Generation (2004)[2]	3.87	3.49 – 3.70	2.61
KSU – "Old Generation" (2004)[3]	3.73	3.13 – 3.59	2.45
Hanor-Hubbard-Ajinomoto (2004)[4]	No data	3.25	2.42
NRC (1998)	3.45	2.67	No data

[1] Calculated values
[2] Determined by growth and metabolism trials (source Dakota Gold)
[3] Not DDGS but corn gluten from a NE ethanol plant
[4] Determined by growth trials (source Dakota Gold)

Comparison of Energy Values of Golden Corn DDGS for Poultry (88% DM Basis)

	Golden DDGS	NRC (1994)
AME, kcal/kg	2260 Range 2090-2418	2480
TME, kcal/kg	2850 Range 2650 - 3082	3097

Source: Noll and Parsons. 2003. Unpublished data.

Comparison of Amino Acid Composition of DDGS (88% dry matter basis)

	Golden DDGS	Traditional DDGS	DDGS (NRC, 1998)
Lysine, %	0.75 (17.3)	0.47 (26.5)	0.59
Methionine, %	0.63 (13.6)	0.44 (4.5)	0.48
Threonine, %	0.99 (6.4)	0.86 (7.3)	0.89
Tryptophan, %	0.22 (6.7)	0.17 (19.8)	0.24
Valine, %	1.32 (7.2)	1.22 (2.3)	1.23
Arginine, %	1.06 (9.1)	0.81 (18.7)	1.07
Histidine, %	0.67 (7.8)	0.54 (15.2)	0.65
Leucine, %	3.12 (6.4)	2.61 (12.4)	2.43
Isoleucine, %	0.99 (8.7)	0.88 (9.1)	0.98
Phenylalanine, %	1.29 (6.6)	1.12 (8.1)	1.27

Values in ( ) are CV's among plants

Standardized Ileal True Digestible Amino Acid Levels and Coefficients of Corn DDGS for Swine (10 Sources of Golden DDGS)

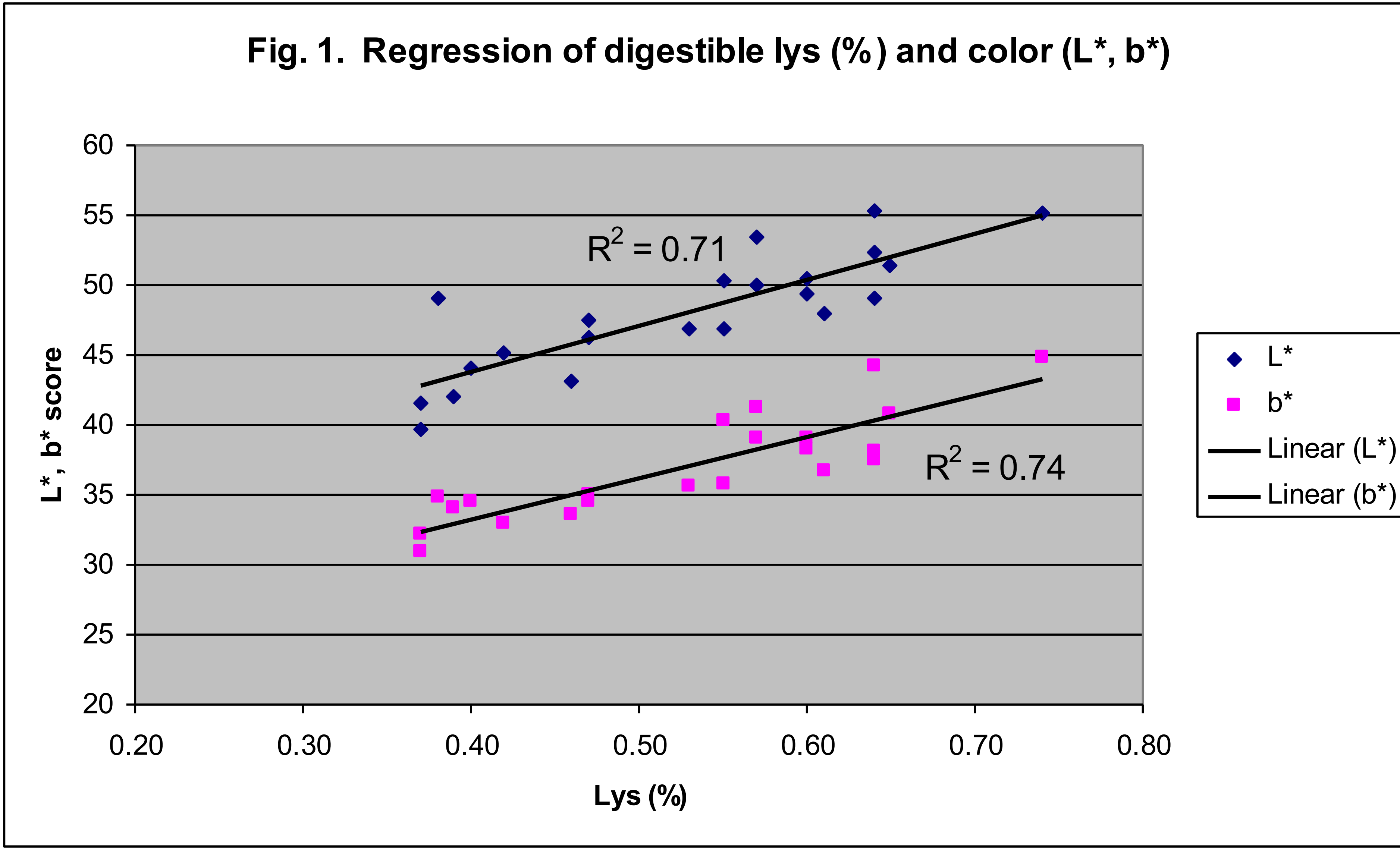
Amino acid	True Dig. Amino Acid, %	Digestibility Coefficient, %	Average
Lysine	0.30 – 0.54	44 – 61	57
Methionine	0.48 – 0.60	74 – 85	79
Threonine	0.61 – 0.76	62 – 71	67
Tryptophan	0.13 – 0.14	74 – 80	77

Source: Stein et al., 2005. Unpublished data.

True Digestible Amino Acid Levels of Golden Corn DDGS for Poultry (5 Sources)

Amino acid	True Dig. Amino Acid, %	Average	Digestibility Coefficient, %	Average
Methionine	0.35 – 0.53	0.43	86 - 90	88
Cystine	0.28 – 0.57	0.40	66 - 85	76
Lysine	0.37 – 0.74	0.53	59 - 83	71
Arginine	0.73 – 1.18	0.93	80 - 90	86
Tryptophan	0.14 – 0.21	0.18	76 - 87	82
Threonine	0.61 – 0.92	0.74	67 - 81	75

Source: Noll and Parsons. 2003. Unpublished data.



Source: Dr. Sally Noll (2003)

Fig. 2. Regression of digestible cys (%) and color (L*, b*)

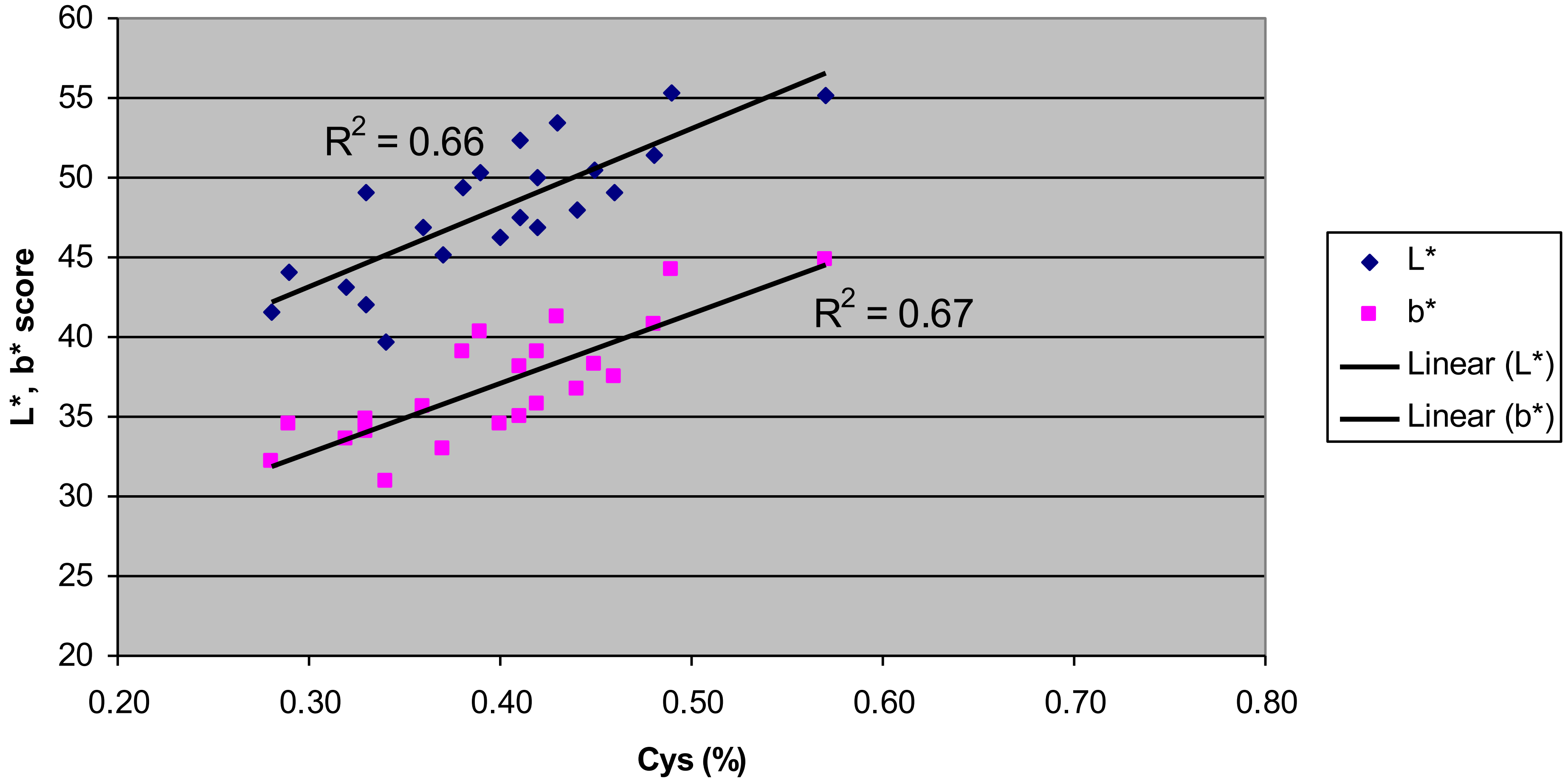
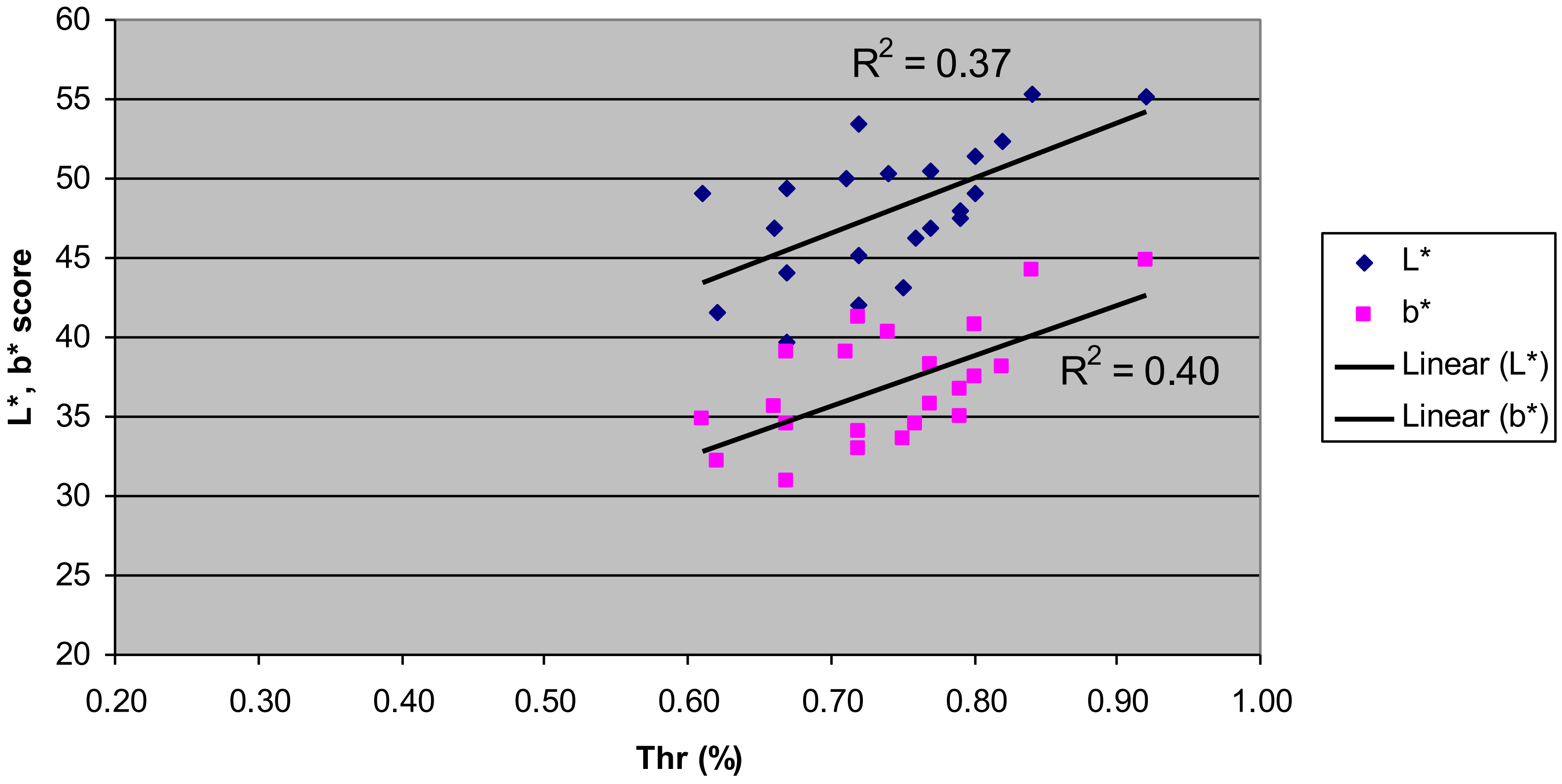


Fig. 3. Regression of digestible thr (%) and color (L*, b*)



Comparison of Phosphorus Level and Relative Availability of DDGS for Swine (88% dry matter basis)

	Golden DDGS	Traditional DDGS	DDGS NRC (1998)	Corn NRC (1998)
Total P, %	0.78 Range 0.62-0.87	0.79	0.73	0.25
P Availability, %	90 Range 88-92	No data	77	14
Available P, %	0.70	No data	0.56	0.03

Comparison of Phosphorus Level and Relative Availability of DDGS for Poultry (88% dry matter basis)

	Golden DDGS	NRC (1994)
Total P, %	0.74	0.72
P Availability, %	61 Range 54 - 68	54
Available P, %	0.45	0.39

Source: 2003 Lumpkins, Dale, and Batal, University of Georgia. Abstract.

Relative Value of DDGS Differs Depending on Species

Assumptions:

- Corn $2.00 / bu
- SBM $175.00 / ton
- Urea $360.00 / ton
- Non-ruminant diets corn/SBM
- Ruminant diets typical diets with competing by-products.

Feed	Dollars/ ton
Dairy Lactation	$114.24
Poultry Finisher	$100.09
Layer Diet	$104.66
Swine G-F Diet	$96.34
Beef Feedlot	$108.00

Source: Tilstra, Land O' Lakes