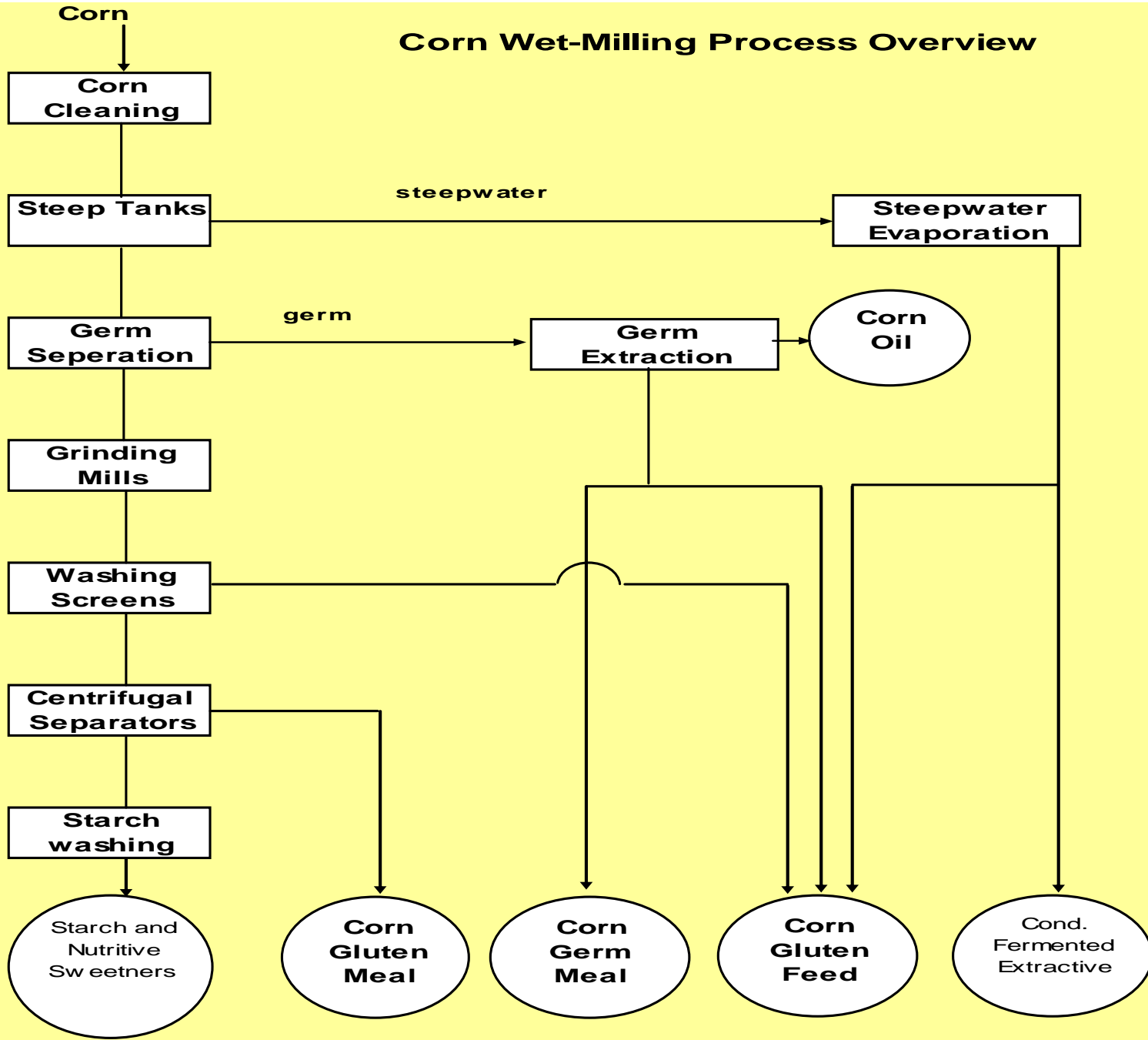


Corn By-Product Diversity and Feeding Value to Non-Ruminants

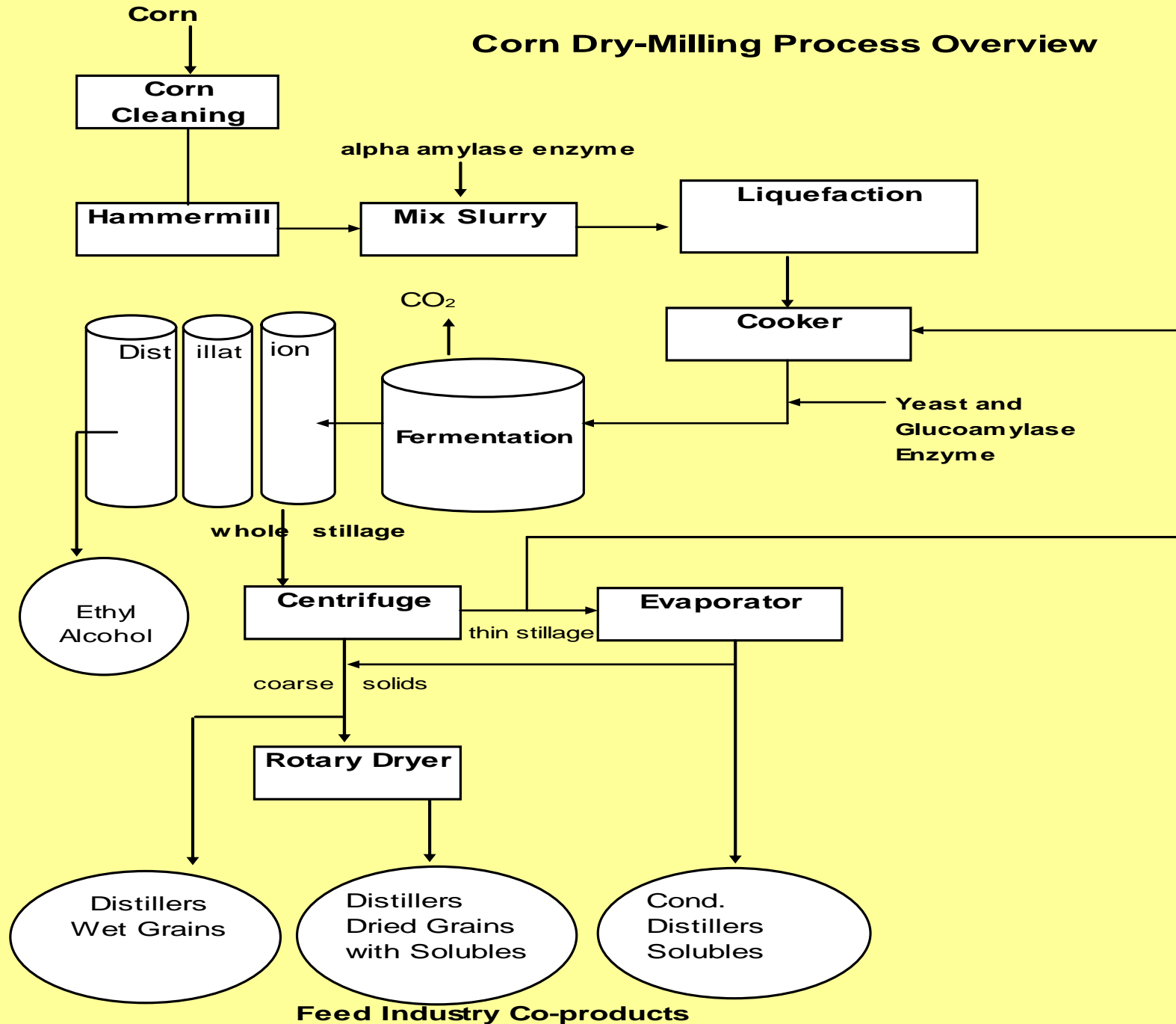
Jerry Shurson¹, Sally Noll¹, and John Goihl²
Dept. of Animal Science¹ and Agri-Nutrition Services²

Corn Wet-Milling Process Overview



Feed Industry Co-Products

Corn Dry-Milling Process Overview





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, %	<i>10.7</i>	3.3	3.2	1.1	7.9
NDF, %	43.6	37.0	9.7	No data	52.9
DE, kcal/kg	<i>4011</i>	3322	4694	No data	2283
ME, kcal/kg	<i>3827</i>	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, %	<i>0.80</i>	0.54	0.08	0.17	0.21



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

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



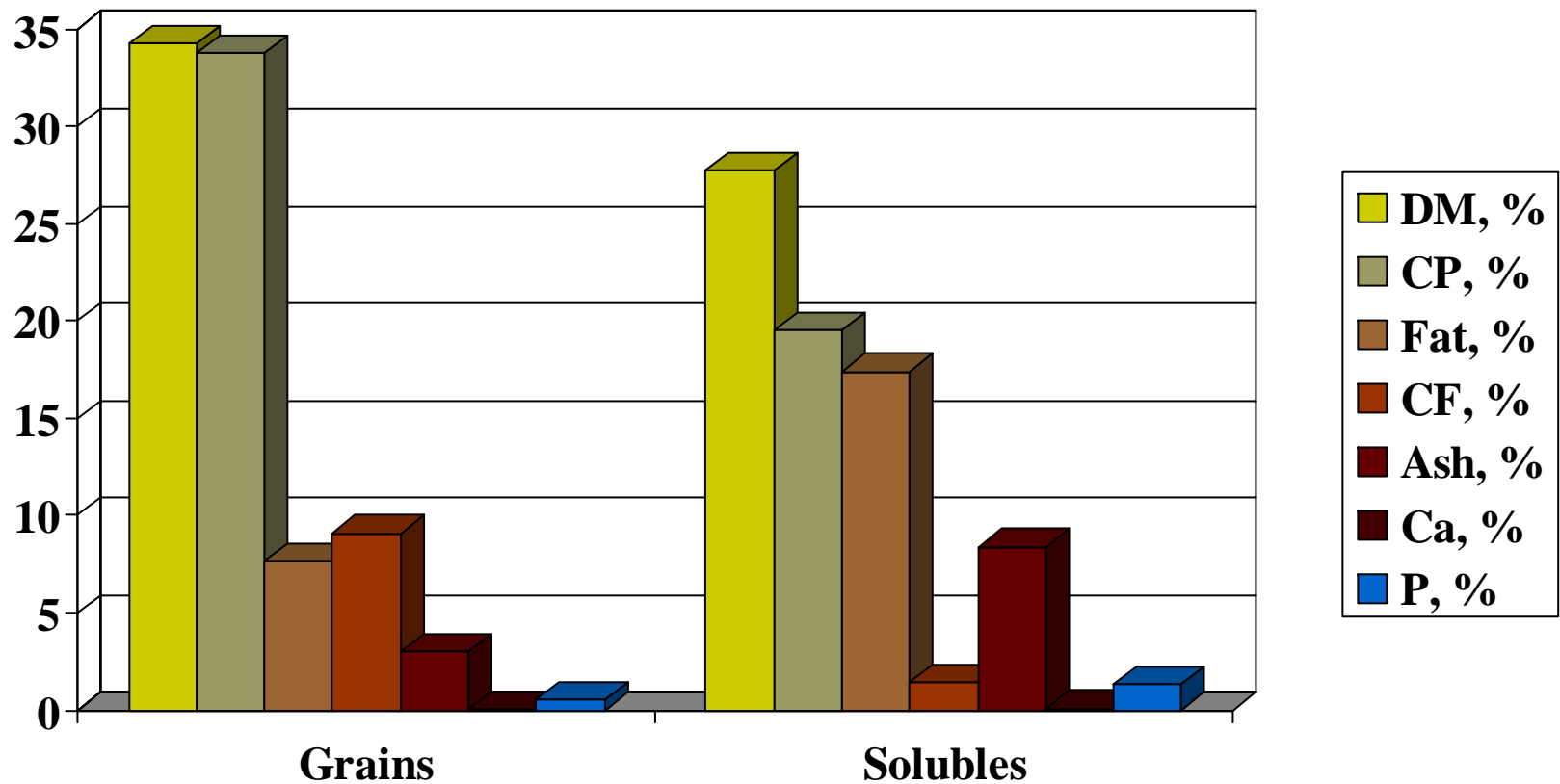
Distillers Products Definitions

- 27.6 ____ **Distillers Dried Grains with Solubles** is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or a grain mixture by condensing and drying at least $\frac{3}{4}$ of the solids of the resultant whole stillage and drying it by methods employed in the grain distilling industry. The predominating grain shall be declared as the first word in the name.

Averages and Ranges of Selected Nutrients Among 32 U.S. DDGS Sources (100% Dry Matter Basis)

Nutrient	Average	Range
Dry matter, %	89.3	87.3 – 92.4
Crude protein, %	30.9 (4.7)	28.7 – 32.9
Crude fat, %	10.7 (16.4)	8.8 – 12.4
Crude fiber, %	7.2 (18.0)	5.4 – 10.4
Ash, %	6.0 (26.6)	3.0 – 9.8
Swine ME, kcal/kg	3810 (3.5)	3504 – 4048
Lysine, %	0.90 (11.4)	0.61 – 1.06
Phosphorus, %	0.75 (19.4)	0.42 – 0.99

Comparison of the Nutrient Content of Corn Distiller's Grains and Corn Condensed Distiller's Solubles



Color Extremes of DDGS



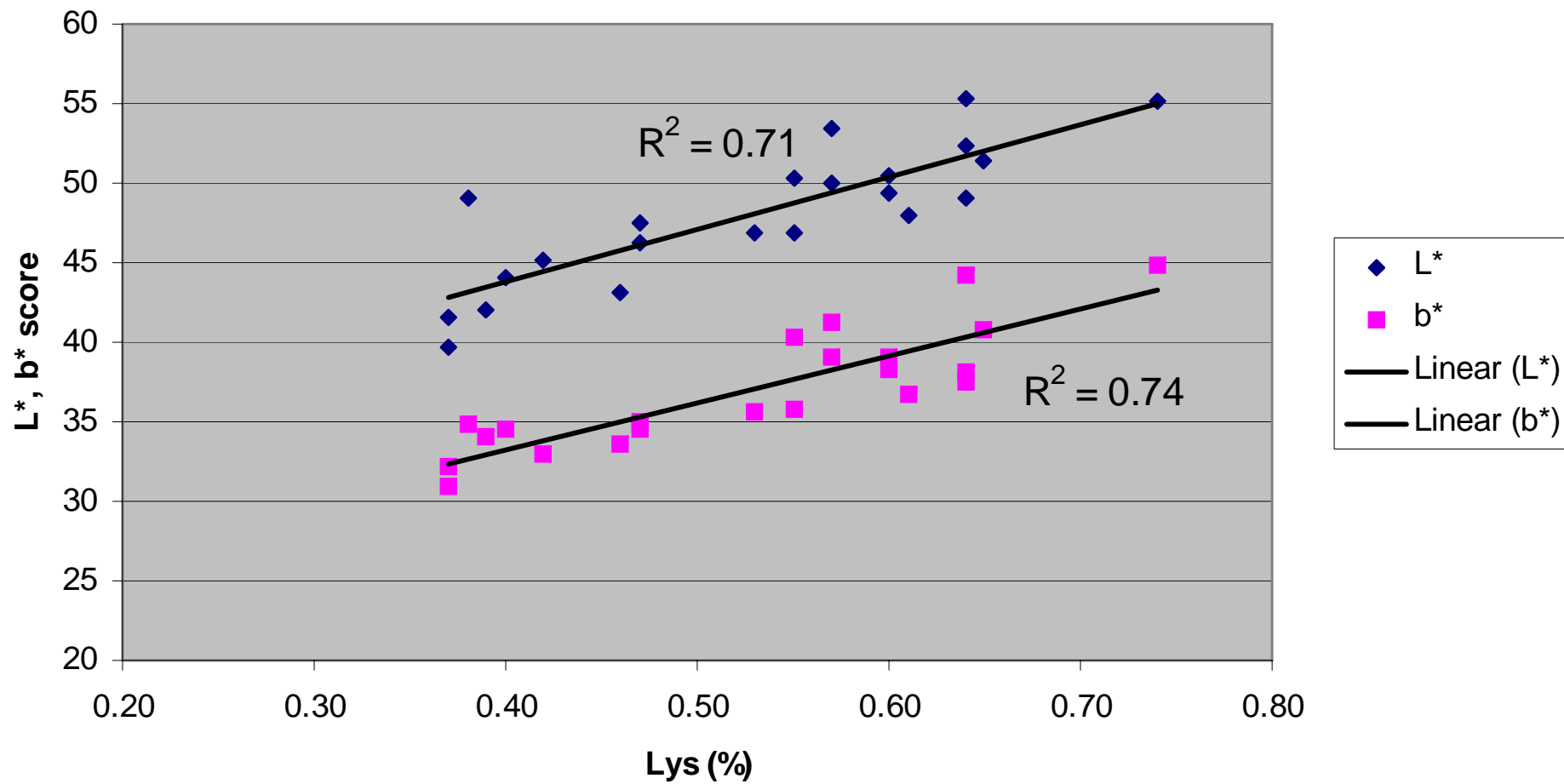
**Lower Quality,
Less Digestible
DDGS**

**High Quality,
Highly Digestible
DDGS**

DDGS Varies Nutrient Content and Digestibility, Color, and Particle Size Among U.S. Sources



Fig. 1. Regression of digestible lys (%) and color (L*, b*)



Source: Dr. Sally Noll (2003)

Comparison of Nutrient Composition of Golden DDGS to Other “DDGS Sources” (100% Dry Matter Basis)

	Golden Corn DDGS	“DDGS”	High Fat DDGS	Partial De-germed DDGS	Whiskey DDGS	Pelleted DDGS
Protein, %	31.8	29.3	31.6	30.1	29.9	27.0
Fat, %	11.3	3.5	15.3	8.9	8.8	9.00
Crude fiber, %	6.3	7.9	No data	7.8	10.6	15.10
ADF, %	12.4	11.8	17.9	21.0	20.2	No data
Ash, %	6.9	5.3	4.6	7.3	3.7	4.28
DE, kcal/kg*	4053	3808	No data	3796	No data	No data
ME, kcal/kg*	3781	3577	No data	3560	3789	No data
Lys, %	0.92	0.61	0.90	0.83	0.99	No data
Met, %	0.62	0.54	0.54	0.66	0.61	No data
Thr, %	1.17	1.01	1.04	1.13	1.10	No data
Trp, %	0.25	0.18	0.23	0.25	0.27	No data
Ca, %	0.07	0.12	0.06	0.51	0.04	0.17
P, %	0.77	0.78	0.89	0.68	0.57	0.62

*Calculated energy values for swine

Benefits and Limitations of DDGS for Swine

Benefits

- Energy value = corn
- High available P
 - Reduce diet P supplementation
 - Reduce manure P excretion
- Commonly fed at 10% of diet
 - Higher levels can be used if amino acids are supplemented
- Only “golden” DDGS should be used
 - High amino acid digestibility
- Appears to reduce gut health problems due to ileitis
- May increase litter size weaned when fed at high levels to sows

Limitations

- Low protein (lysine) quality
 - add other supplements high in lys and trp
- Manure N excretion increases
- Belly firmness and pork fat quality may become an issue when > 20% in the diet
- Mycotoxin free grain should be used to produce ethanol and DDGS
- Short-term feed intake may be reduced when feeding high DDGS diets to sows

Benefits and Limitations of DDGS for Poultry

Benefits

- Good energy and amino acid source when limited to < 15% of the diet
- Source of highly available P
 - Reduce manure P
- May improve egg yolk and skin color (xanthophyll)
- Source of “unidentified growth factors” ?
- “Golden” DDGS gives best performance
- Highly palatable

Limitations

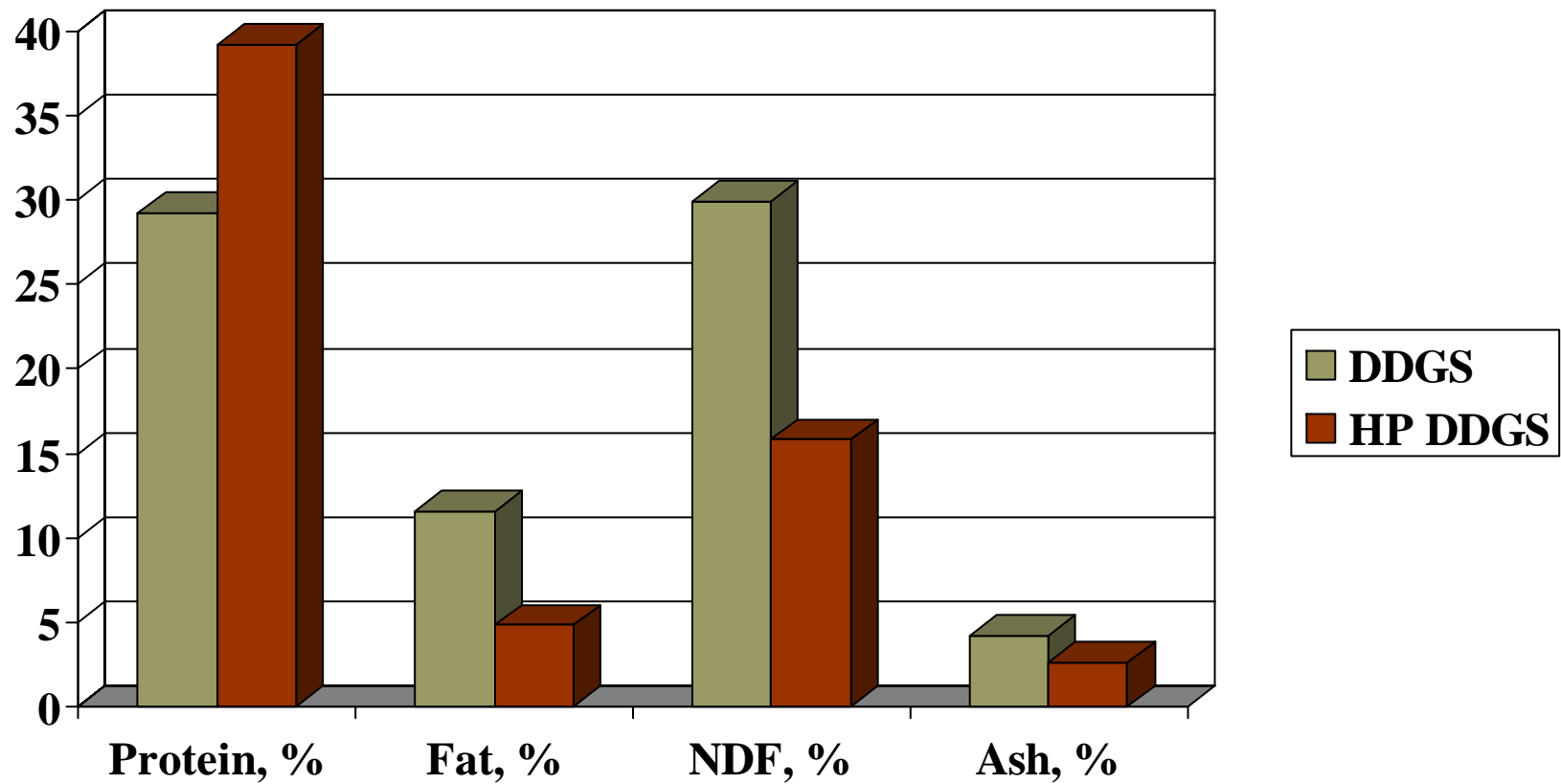
- Energy value ~ 84% of corn
- Low protein quality
 - add other supplements high in lys, arg, trp
- Sources high in sodium may increase litter moisture if adjustments to dietary salt levels are not made



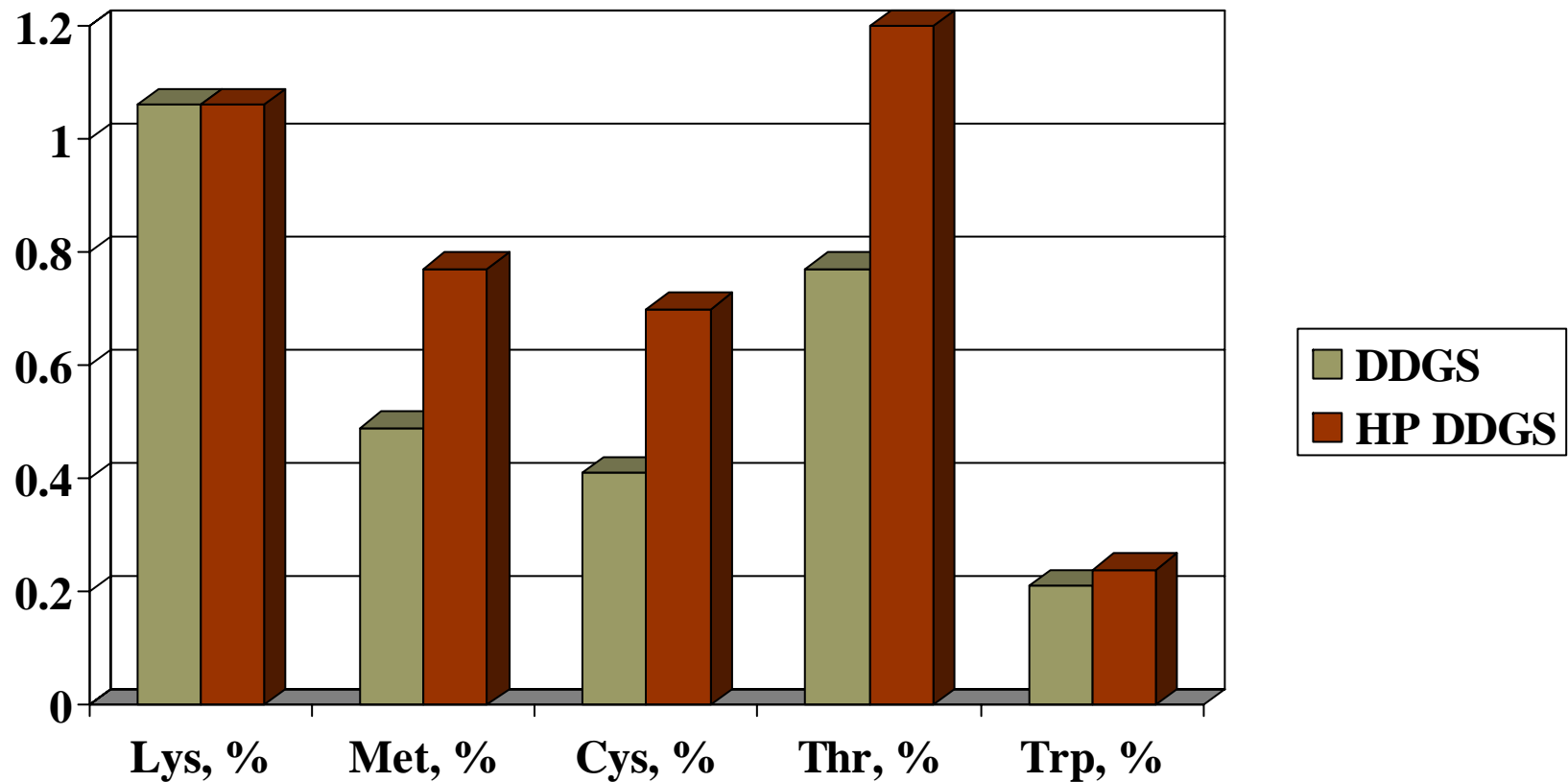
New Distiller's Grains By-Products

- Examples of modified processes
 - Use of new enzyme technology to increase DDGS protein
 - Removal of bran and/or germ prior to fermentation
 - Removal of phosphorus

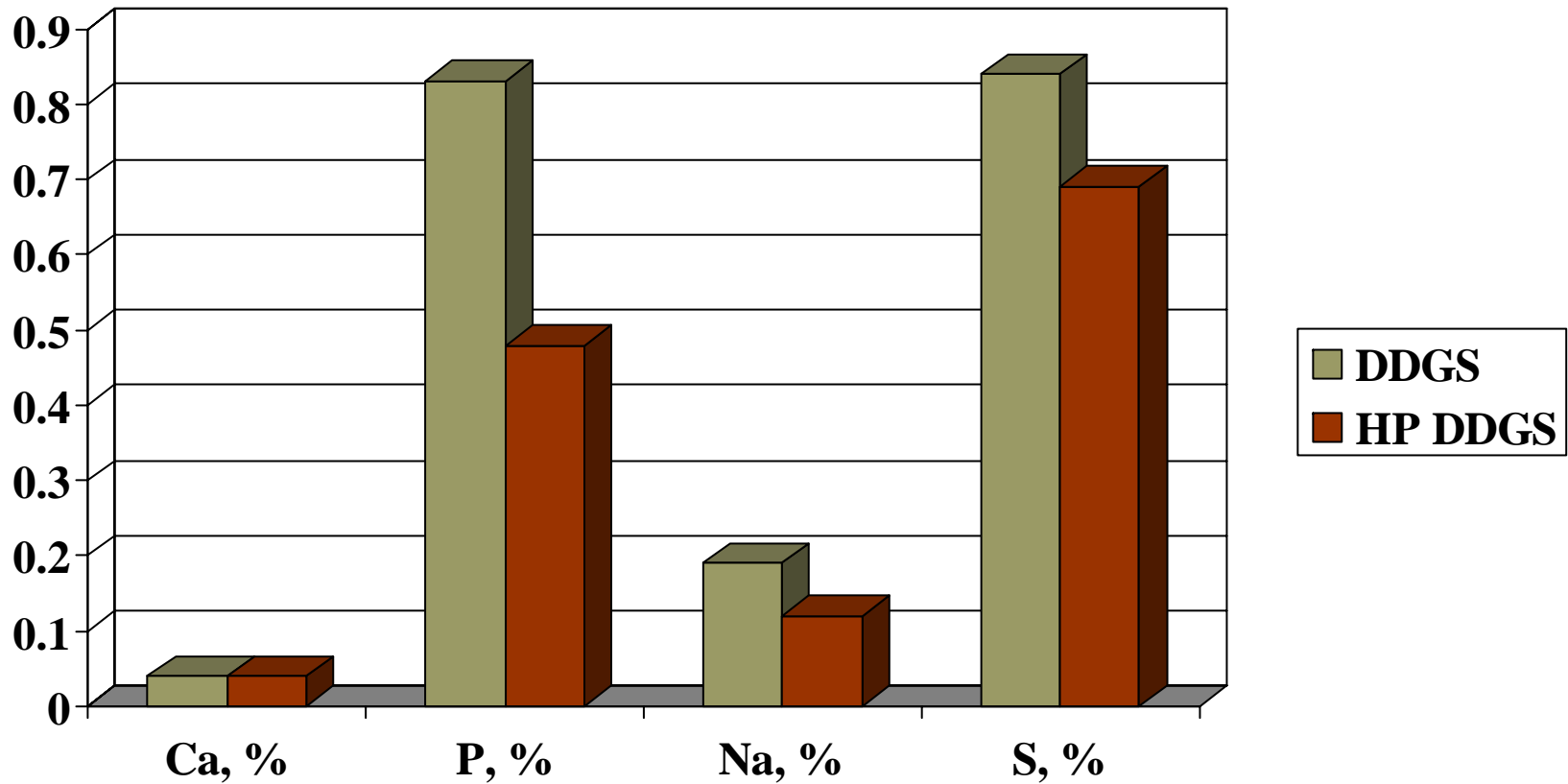
Comparison of Nutrient Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)



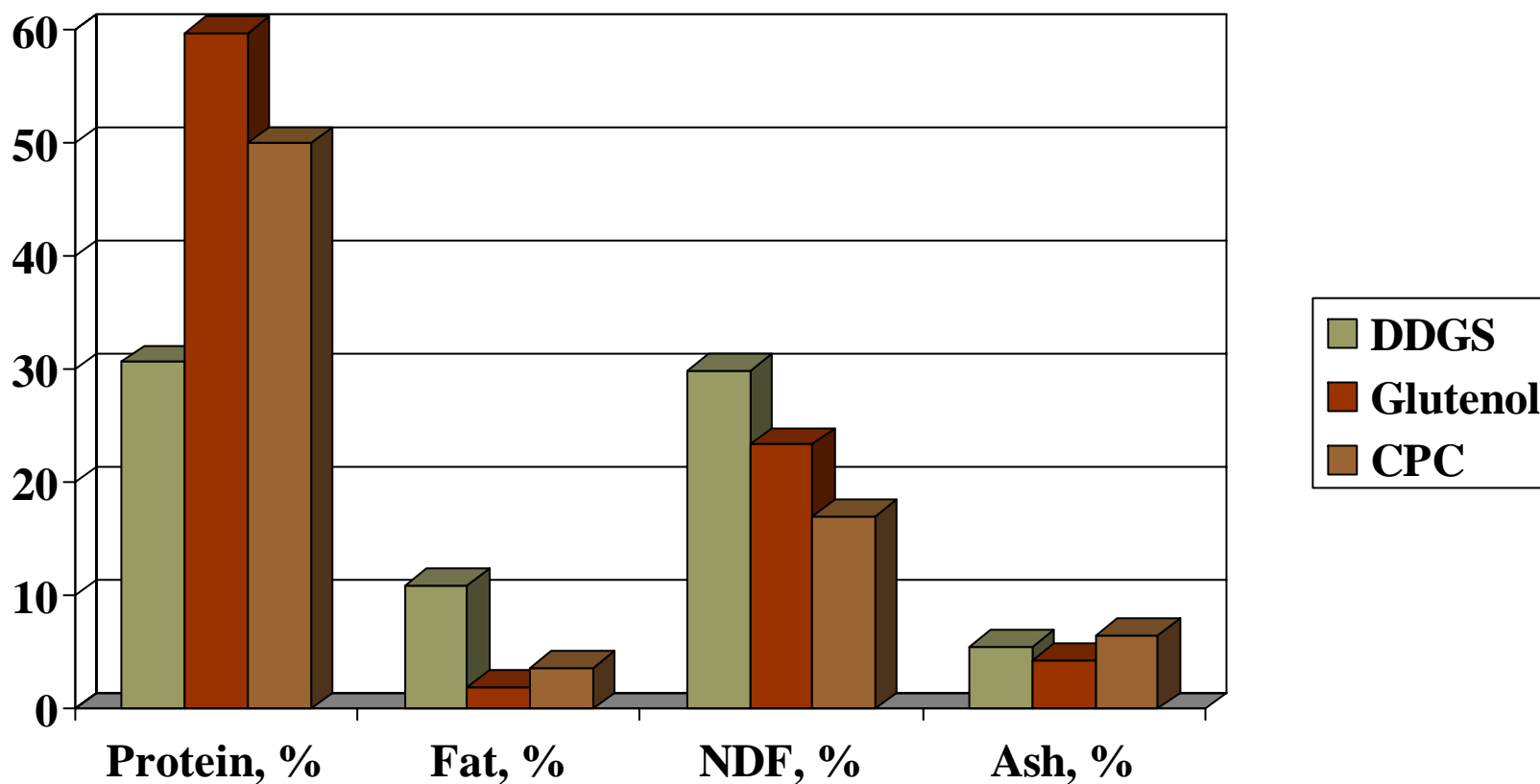
Comparison of Amino Acid Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)



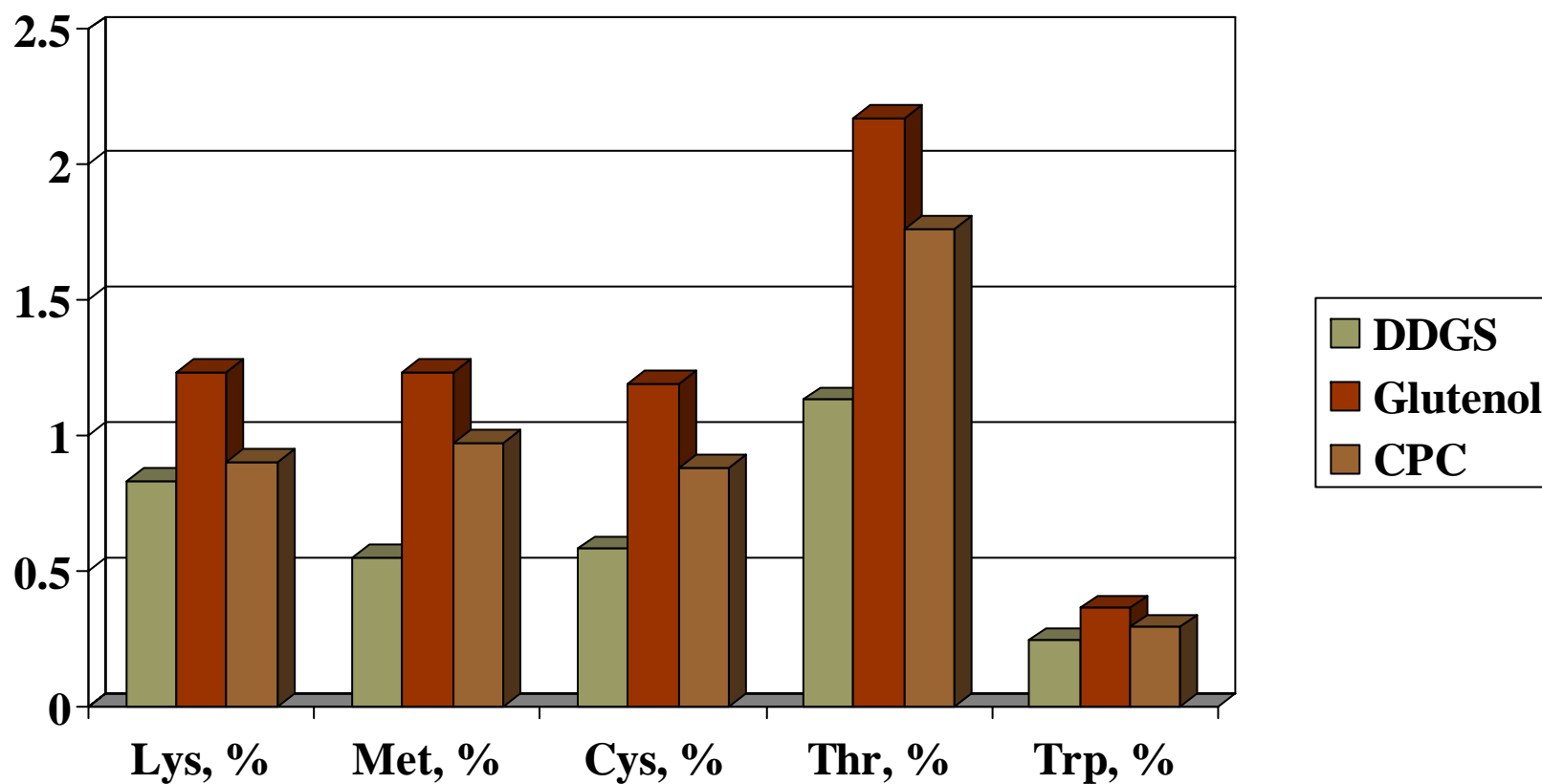
Comparison of Mineral Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)



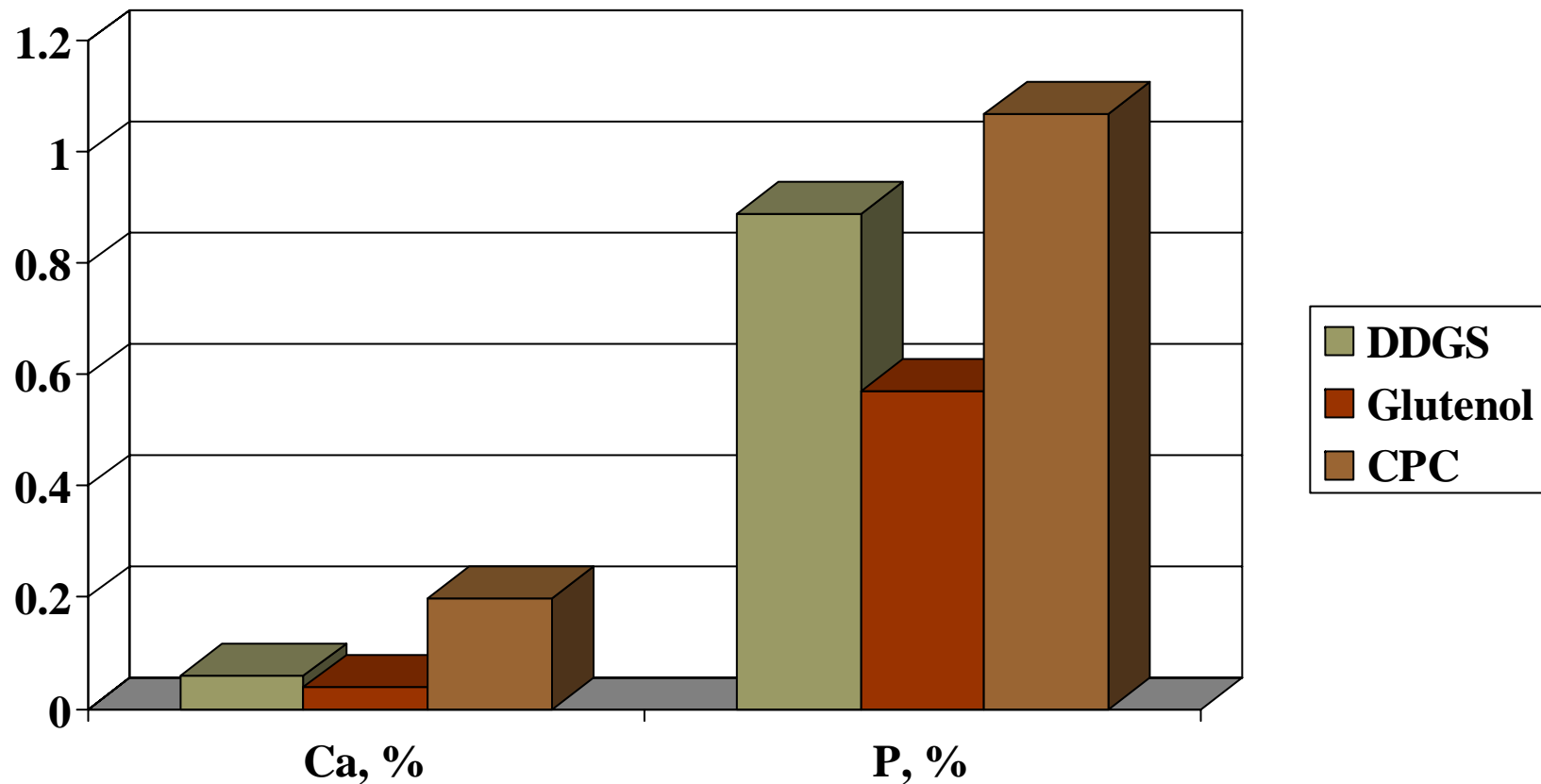
Comparison of Nutrient Content of DDGS with Glutenol and CPC (100% DM Basis)



Comparison of Amino Acid Content of DDGS with Glutenol and CPC (100% DM Basis)



Comparison of Calcium and Phosphorus Content of DDGS with Glutenol and CPC (100% DM Basis)



Ingredient Price Assumptions

Ingredient	\$/cwt
Corn	3.50
Soybean meal (47)	10.50
DDGS	4.00
Choice white grease	17.00
Dicalcium phosphate	13.00
Limestone	2.00
Salt	6.00
L-lysine HCl	80.00
L-threonine	145.00
DL-methionine	120.00
VTM premix	1.00



Swine Grower Diet Formulation

Assumptions

- Assumed lower ME values
 - High protein DDGS – 1300 kcal/lb
 - Glutenol – 1200 kcal/lb
 - CPC – 1258 kcal/lb
- Assumed the same amino acid digestibility coefficients for all distiller's by-products
 - Lys – 53%
 - Trp – 64%
 - Thr – 55%
 - Met+cys – 52%
- Assumed available P in all distiller's by-products was 85%

Swine Grower Diet Formulation

Assumptions

- All diets contained:
 - 1553 kcal ME/lb
 - 1.0% total lys
 - Min. 0.84% dig. lys
 - Min. 0.48% dig. thr
 - Min. 0.14% dig. trp
 - Synthetic amino acids were used to meet minimum digestible amino acid levels as needed
 - L-lysine HCl (78.8%)
 - DL-methionine (99%)
 - L-threonine (98.5%)
 - Minimum ratios of digestible amino acids relative to digestible lysine were:
 - Met+cys – 55%
 - Thr – 55%
 - Trp – 16.6%
 - 0.58% Ca
 - 0.26% avail. P
 - Equivalent salt, vitamins, and trace minerals



Turkey Grower Tom Diet Formulation

Assumptions

- All diets contained:
 - 1428 kcal ME/lb
 - Min. 1.15% dig lys
 - Min. 0.74% dig met+cys
 - Min. 0.74% dig thr
 - Synthetic amino acids were used to meet minimum digestible amino acid levels as needed
 - L-lysine HCl (78.8%)
 - DL-methionine (99%)
 - 1.12% Ca
 - 0.56% available P
 - Equivalent vitamins and minerals

Opportunity Costs of Corn By-Products in Swine and Poultry Diets

	DDGS Spec. 1	DDGS Spec. 2	HP DDGS	Glutenol	CPC
Swine	\$80.00	\$78.00	\$51.00	\$63.40	\$61.60
Poultry	\$80.00	\$75.20	\$53.00	\$75.20	\$43.00



Key Points for Evaluating and Using DDGS and New Distiller's By-Products in Monogastric Diets

- Remember the primary components that affect nutritional and economic value
 - Metabolizable energy
 - Level and digestibility of amino acids
 - Level and availability of P

- Minimize variability in nutrient content by limiting the number of sources used

- Question generic nutrient specification values provided by the supplier when formulating diets



Key Points for Evaluating and Using DDGS and New Distiller's By-Products in Monogastric Diets

- Request current, complete nutrient profiles from source(s) being considered
 - www.ddgs.umn.edu

- Request evidence of consistent quality and nutrient content from each source

- Although higher protein distiller's by-products may initially appear to have higher value, they are:
 - generally lower in fat and P content
 - still have inferior protein quality

