Production, Nutritional Value, and Physical Characteristics of High Quality U.S. Corn DDGS

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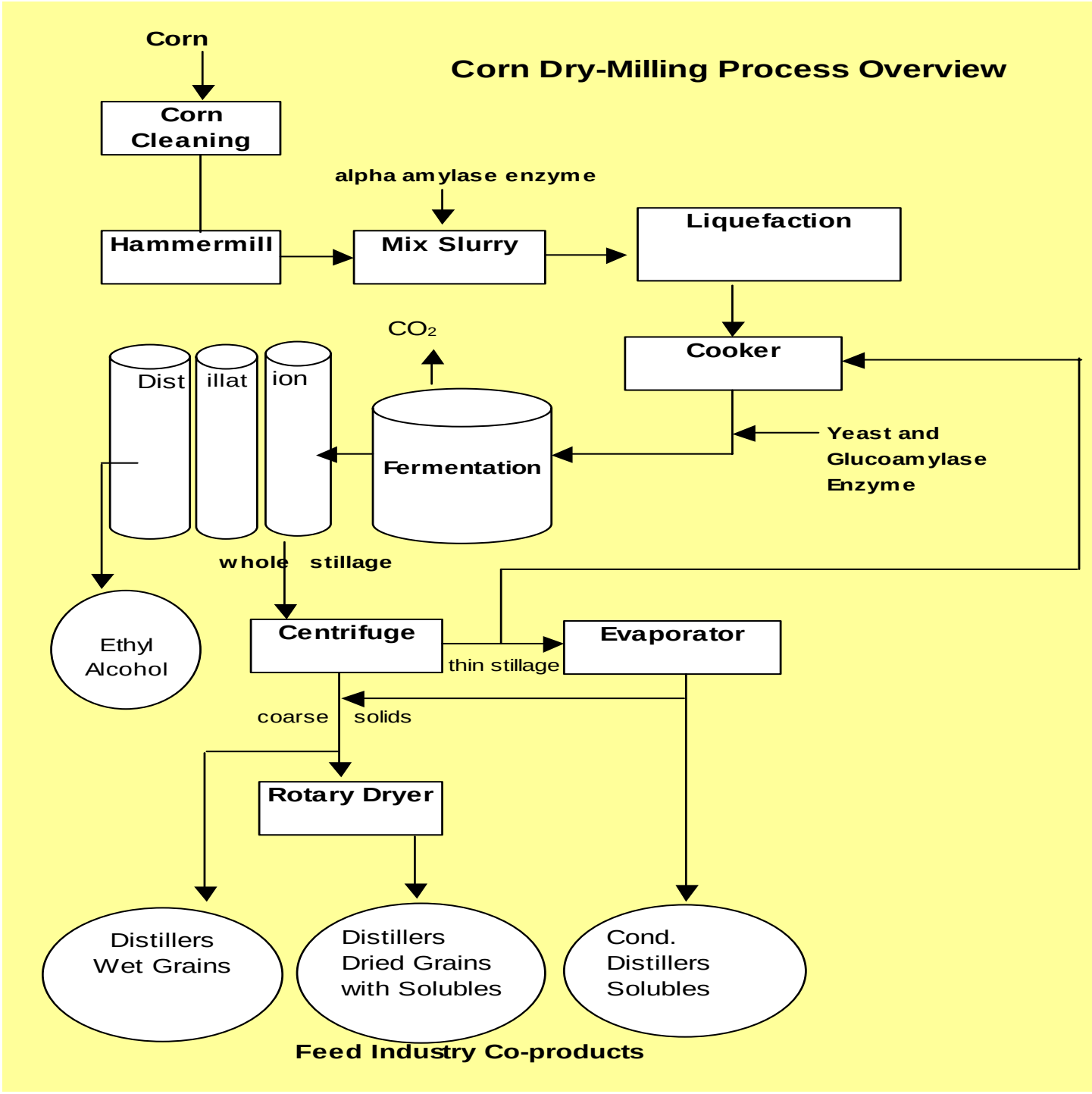
Overview – Part 1

- Overview of DDGS production process
- Trends in DDGS production, domestic consumption, and exports
- DDGS nutrient composition and comparison among various sources and other grain co-products
- Physical characteristics
- Quality characteristics

What is DDGS?

- By-product of the dry-milling ethanol industry
  - **Corn (maize) DDGS - Midwestern US**
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS - Spain


Corn
Corn Dry-Milling Process Overview
Corn Cleaning
alpha amylase enzyme
Hammermill
Mix Slurry
Liquefaction
CO_2
Cooker
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

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

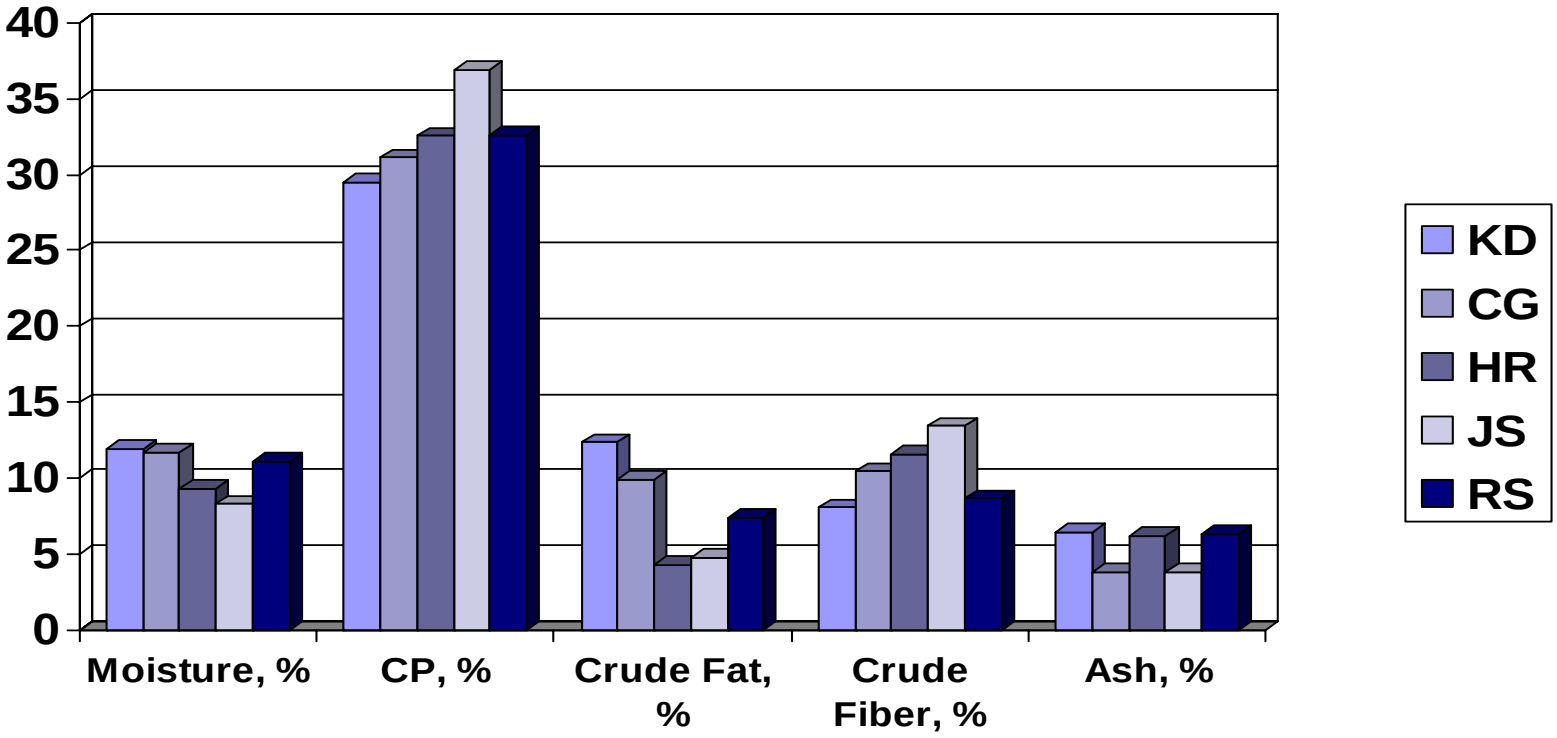
- Ethanol 10.2 liters
- DDGS 8.2 kg
- CO_2 8.2 kg

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

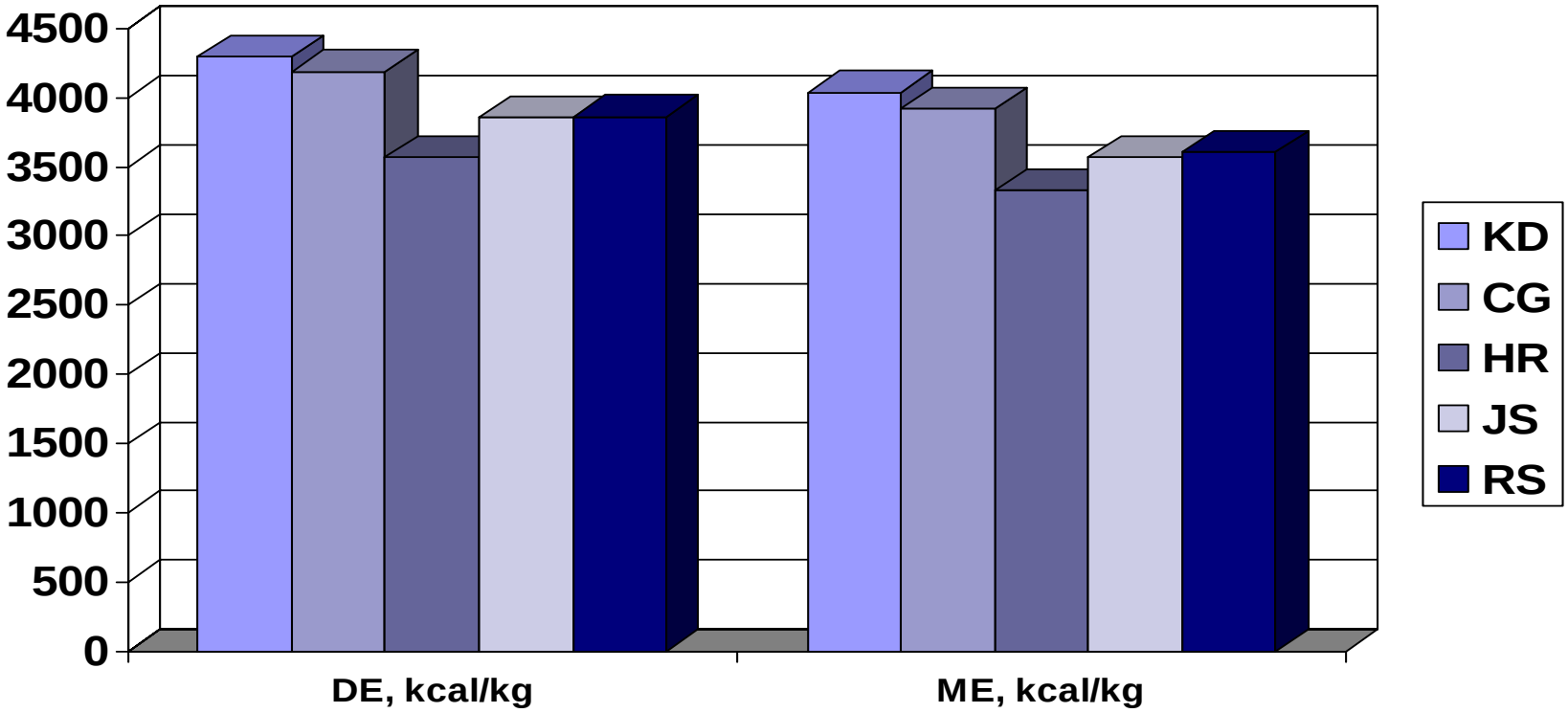
Comparison of “New Generation” Corn DDGS to Other DDGS Sources and Other Grain By-products

High Quality U.S. Corn DDGS vs. Chinese DDGS

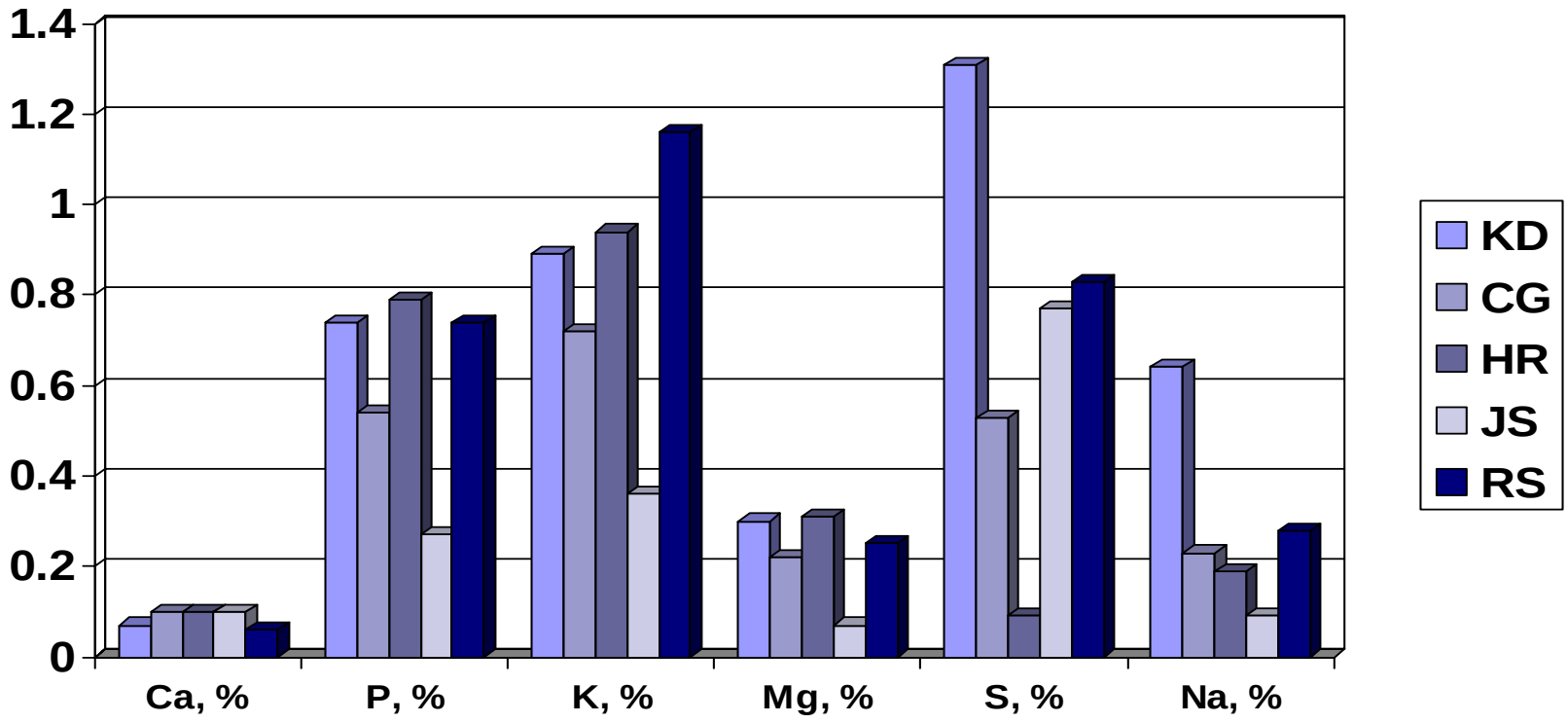
Comparison of Proximate Analysis Values Among Chinese DDGS Sources (100% Dry Matter Basis)



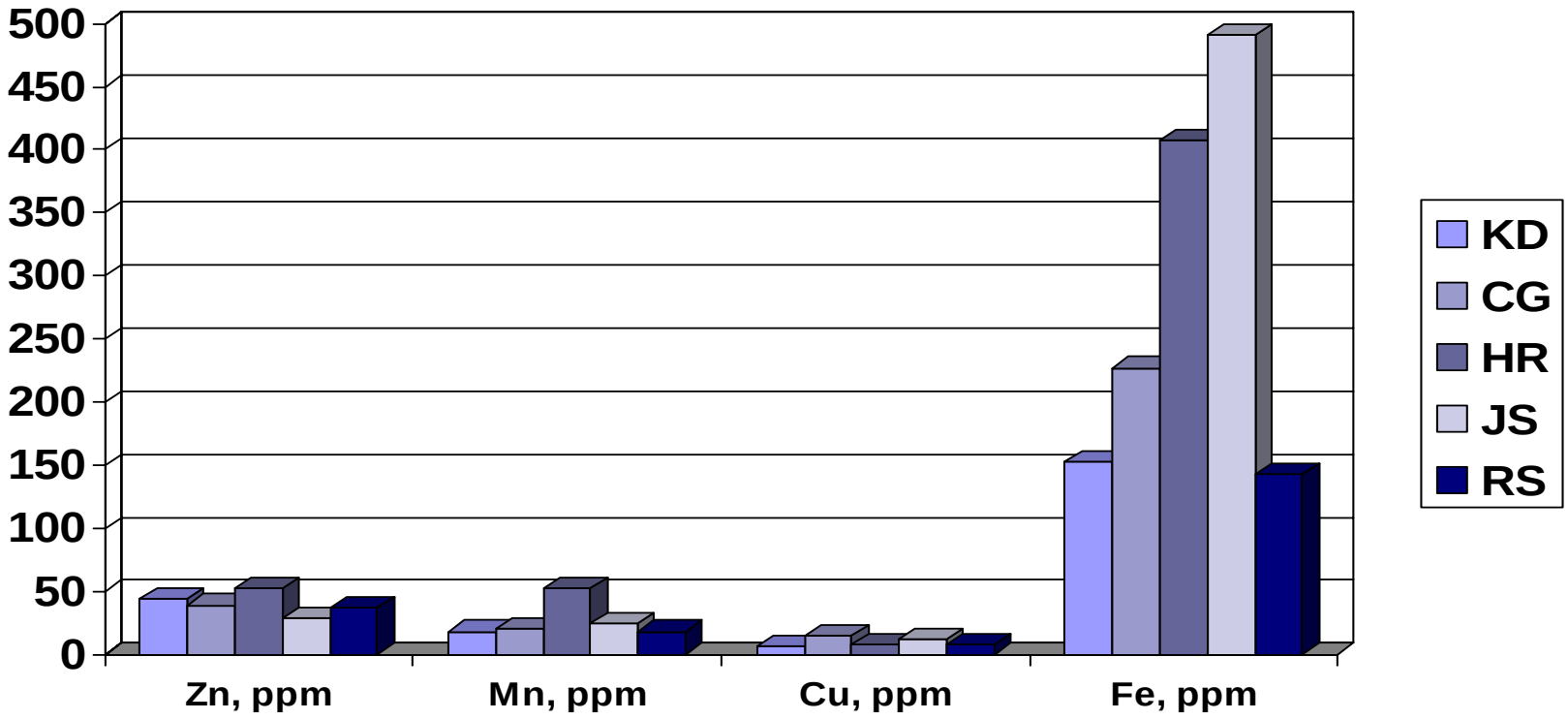
Comparison of Calculated Digestible Energy (DE) and Metabolizable Energy (ME) Values for Swine Among Chinese DDGS Sources (100% Dry Matter Basis)



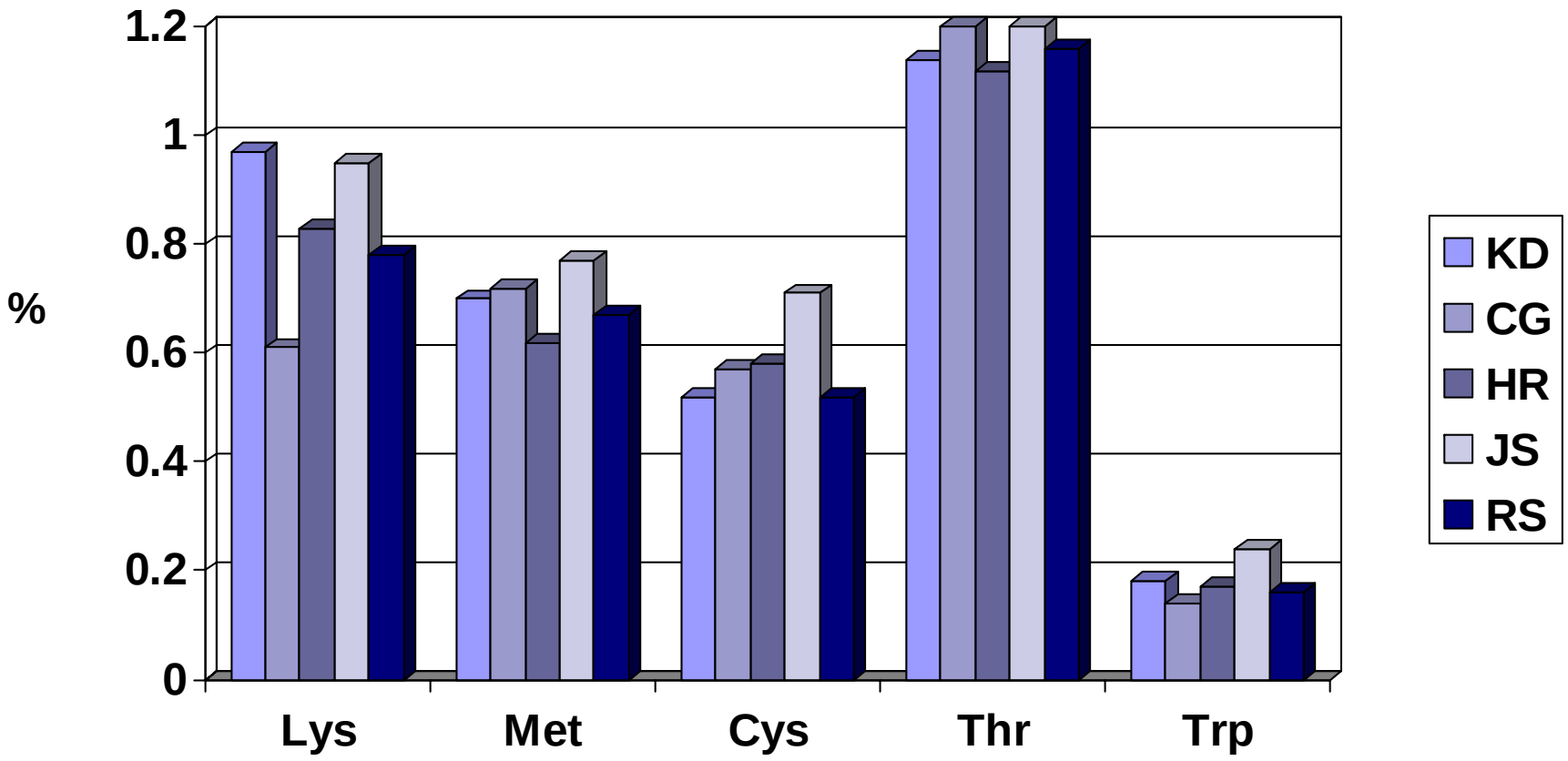
Comparison of Macro Minerals Concentrations Among 5 Chinese DDGS Sources (100% Dry Matter Basis)



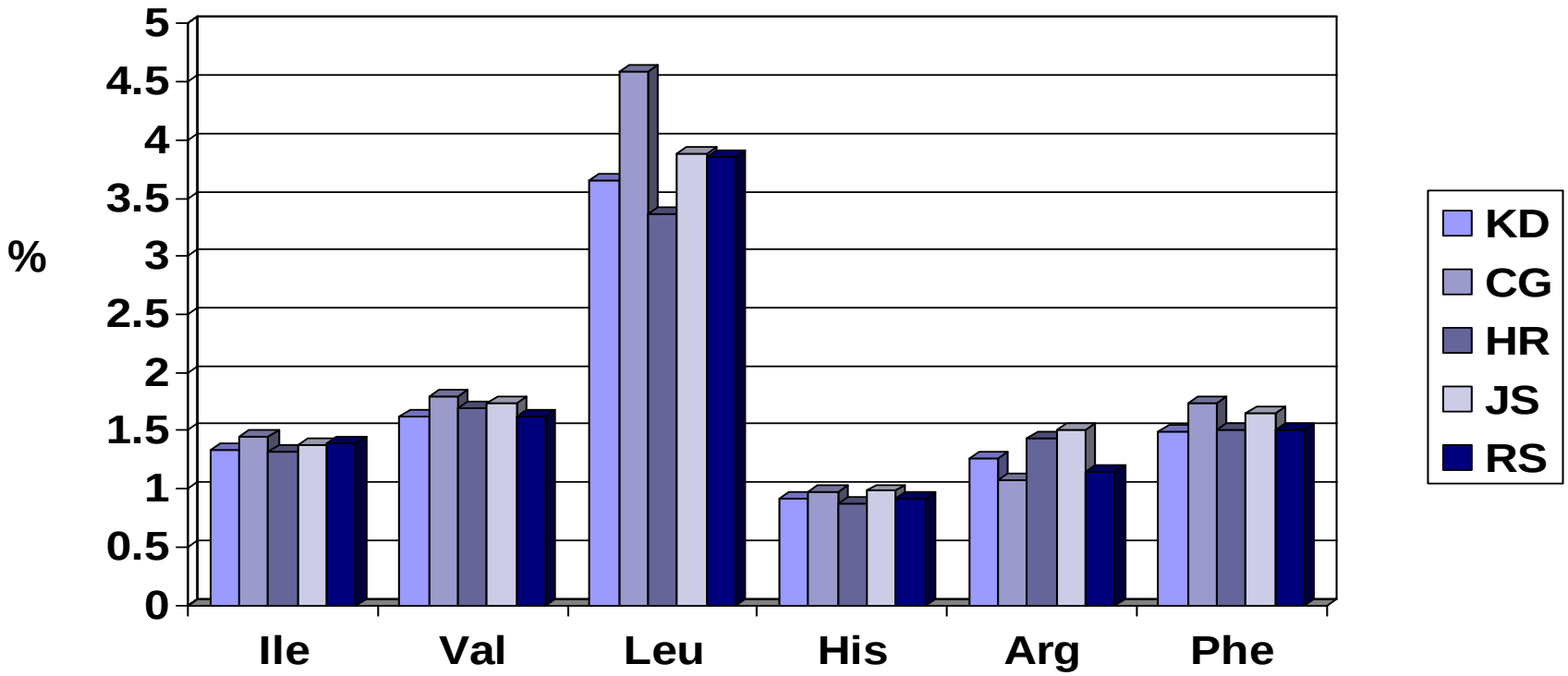
Comparison of Micro Minerals Concentrations Among 5 Chinese DDGS Sources (100% Dry Matter Basis)



Comparison of Lysine, Methionine, Cystine, Threonine, and Tryptophan Concentrations Among 5 Chinese DDGS Sources (100% Dry Matter Basis)



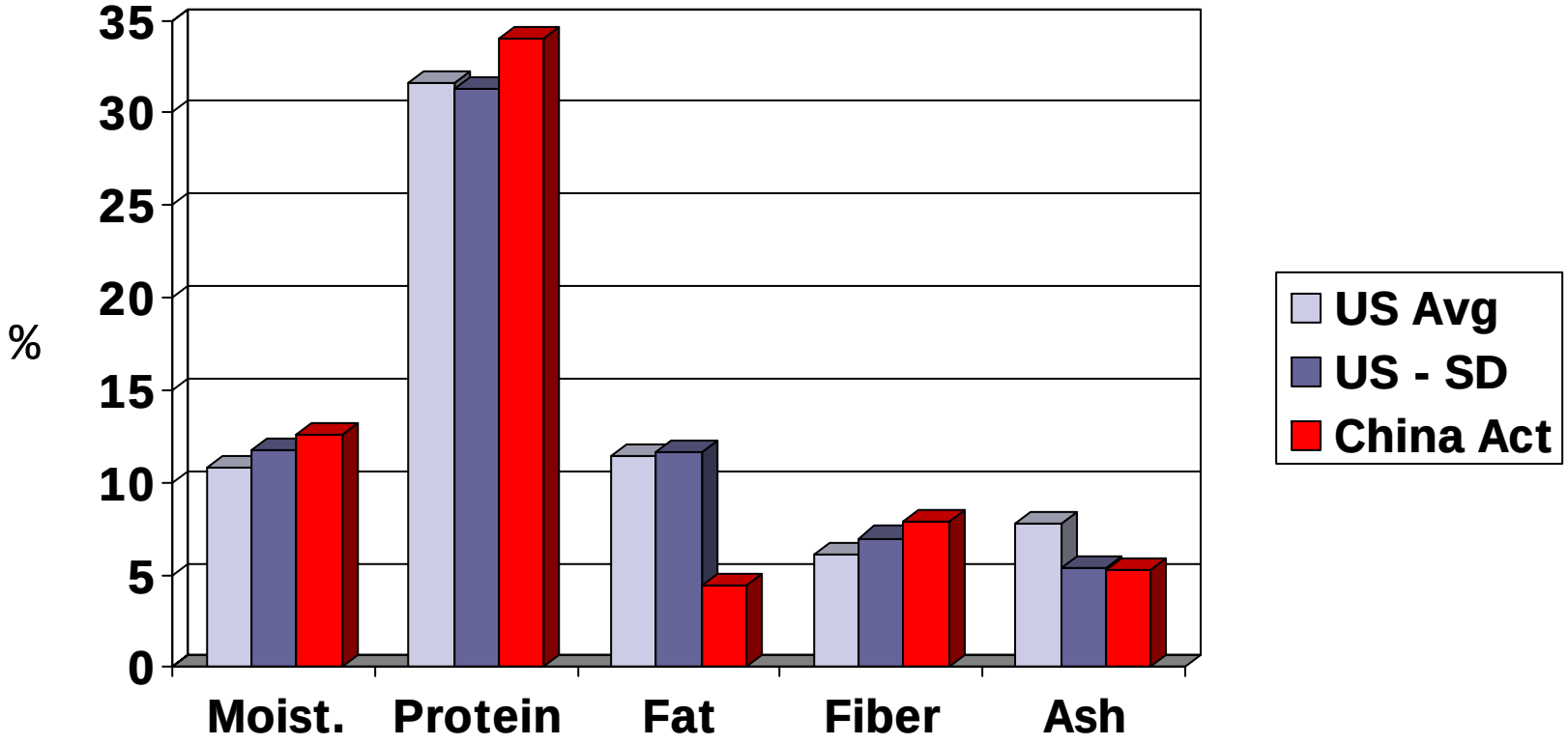
Comparison of Isoleucine, Valine, Leucine, Histidine, Arginine, and Phenylalanine Concentrations Among 5 Chinese DDGS Sources (100% Dry Matter Basis)



Levels of Mycotoxins Present in 5 Sources of Chinese DDGS

DDGS Source	Aflatoxin, ppb	DON, ppm	Zearalenone, ppb	Fumonisin, ppm
KD	< 5	2.6	129.4	4.7
CG	< 5	0.8	< 100	< 0.5
HR	< 5	2.6	< 100	0.5
JS	7.8	0.5	340.9	5.9
RS	< 5	1.9	< 100	< 0.5

Comparison of Proximate Analysis of U.S. DDGS to Chinese DDGS (100% Dry Matter Basis)

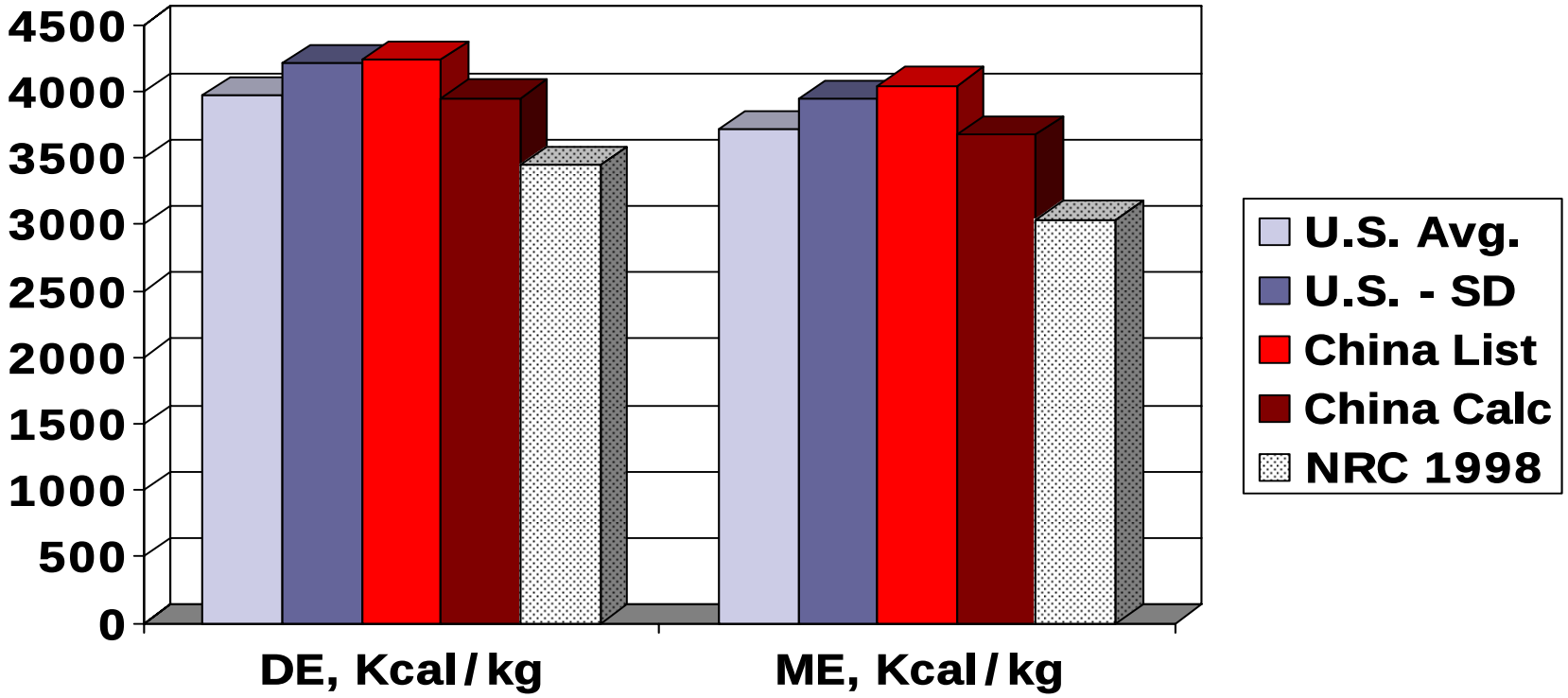


U.S. Avg. = average of values obtained from samples from 9 "New Generation" dry-mill ethanol plants (Shurson and Whitney, 2004)

U.S. – SD = actual analyzed values of DDGS produced by a South Dakota ethanol plant that was exported to Taiwan in 2003.

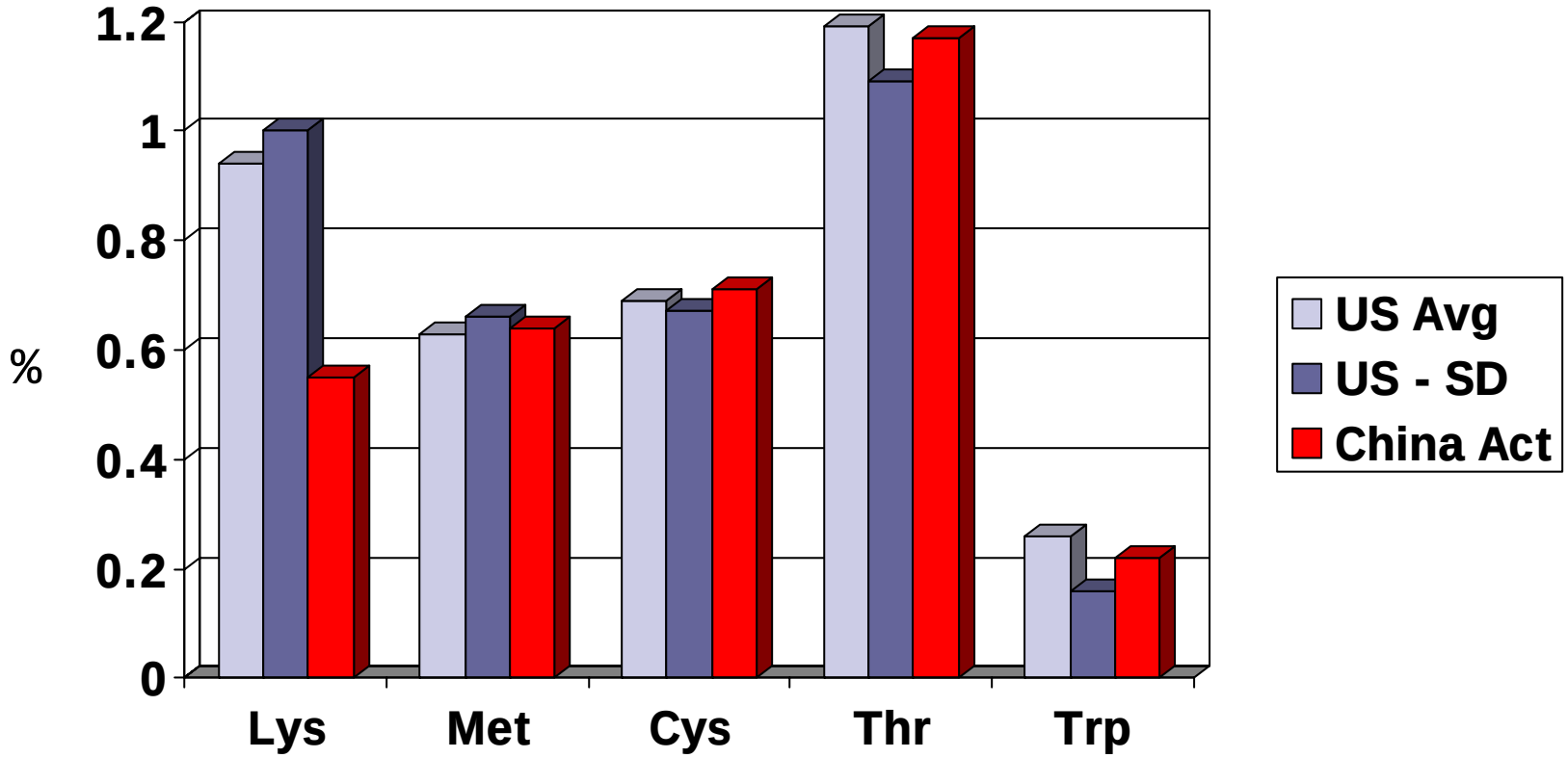
China Act = actual analyzed values of a sample of Chinese DDGS obtained from Taiwan

Comparison of Calculated DE, ME Values for Swine Between U.S. DDGS and 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)
U.S. – SD = calculated values from actual proximate analysis of DDGS produced by a S. Dakota plant that was exported to Taiwan
China List = published energy values from Chinese DDGS nutrient specification sheet
China Calc = calculated values from actual proximate analysis of a sample of Chinese DDGS obtained from Taiwan
NRC 1998 = published values from the National Research Council (1998), Nutrient Requirements of Swine, 10th Rev. Ed.

Comparison of Amino Acid Analysis of U.S. DDGS to Chinese DDGS (100% Dry Matter Basis)



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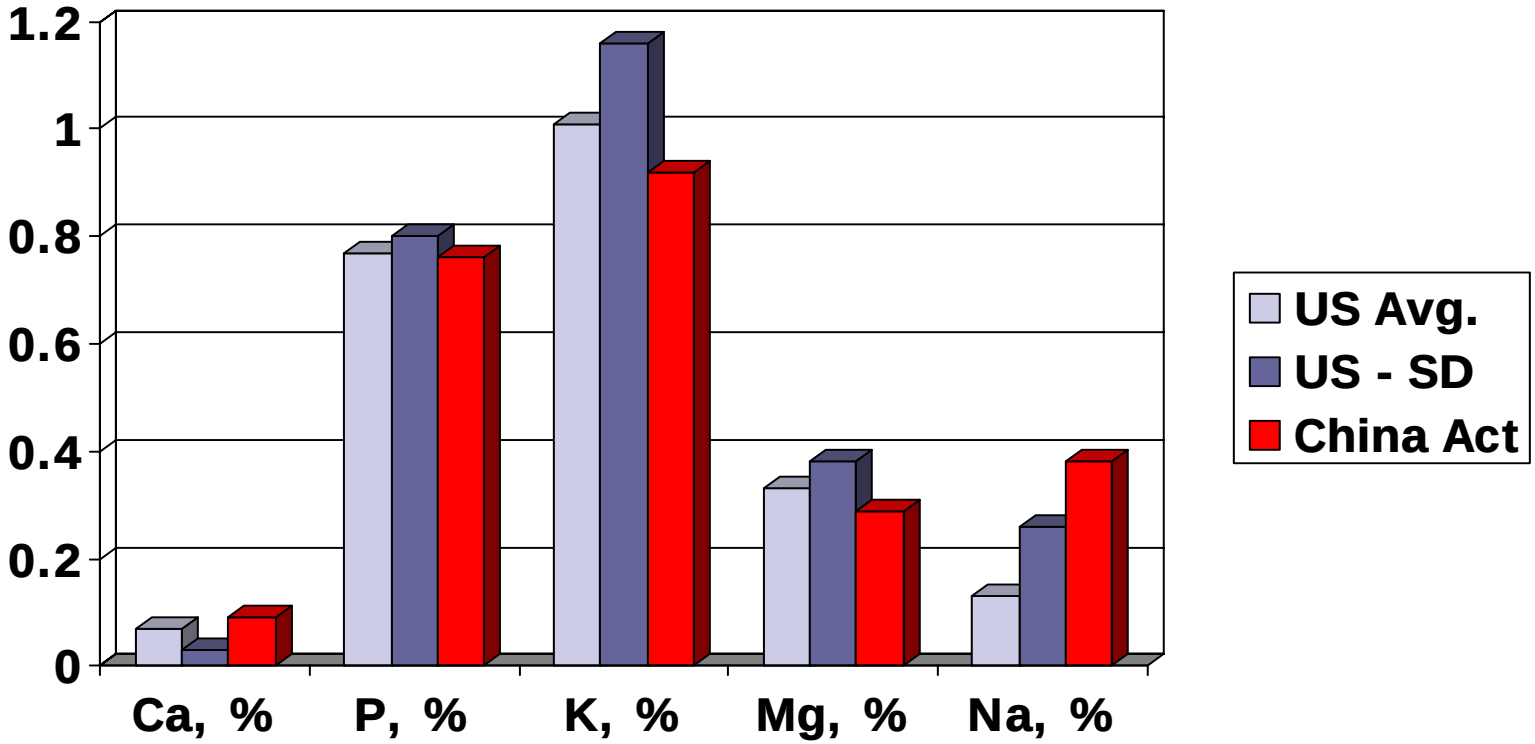
Comparison of Macro-mineral Analysis of U.S. DDGS to Chinese DDGS (100% Dry Matter Basis)



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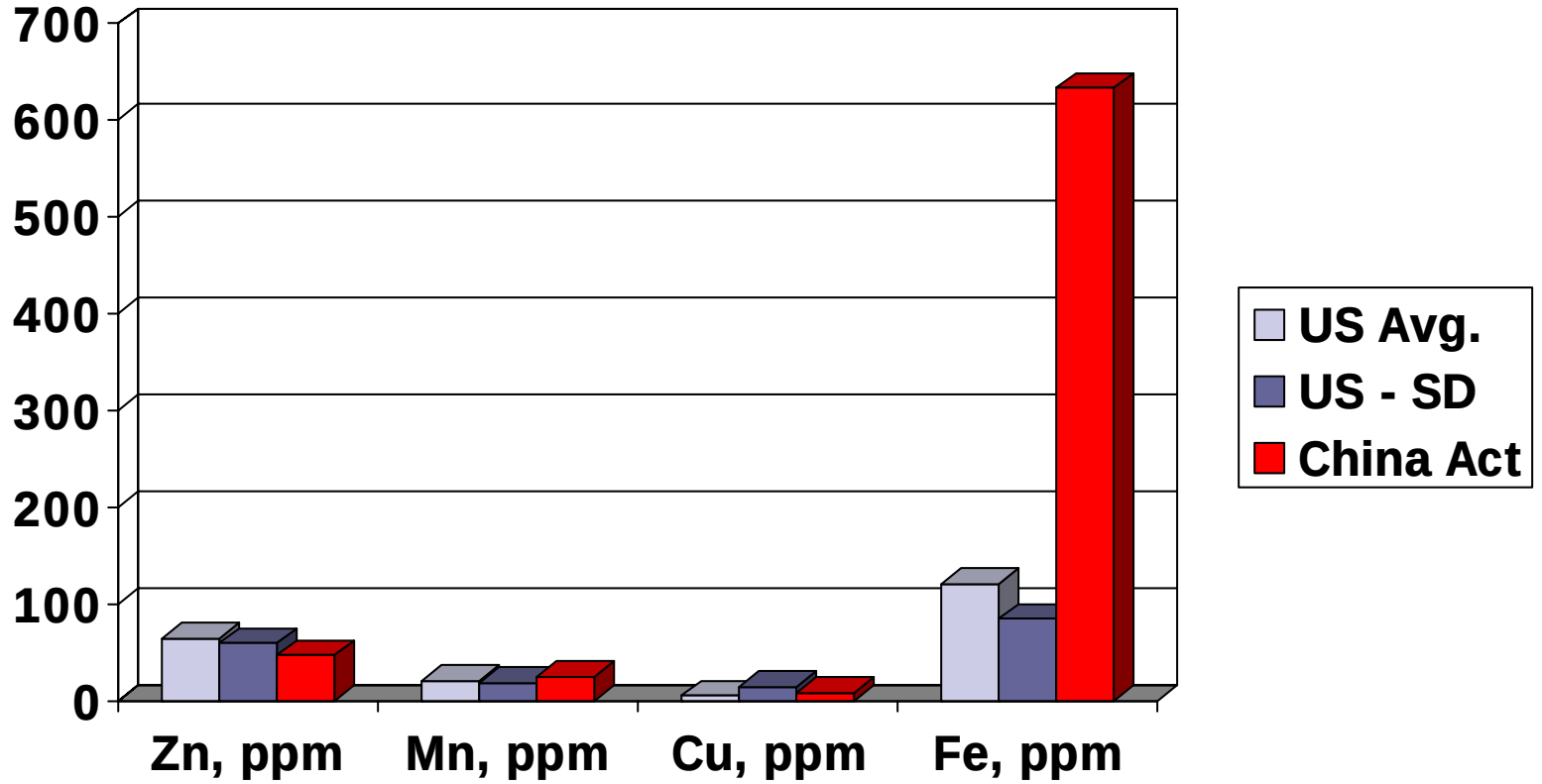
Comparison of Trace Mineral Analysis of U.S. "New Generation" DDGS to Chinese DDGS (100% Dry Matter Basis)



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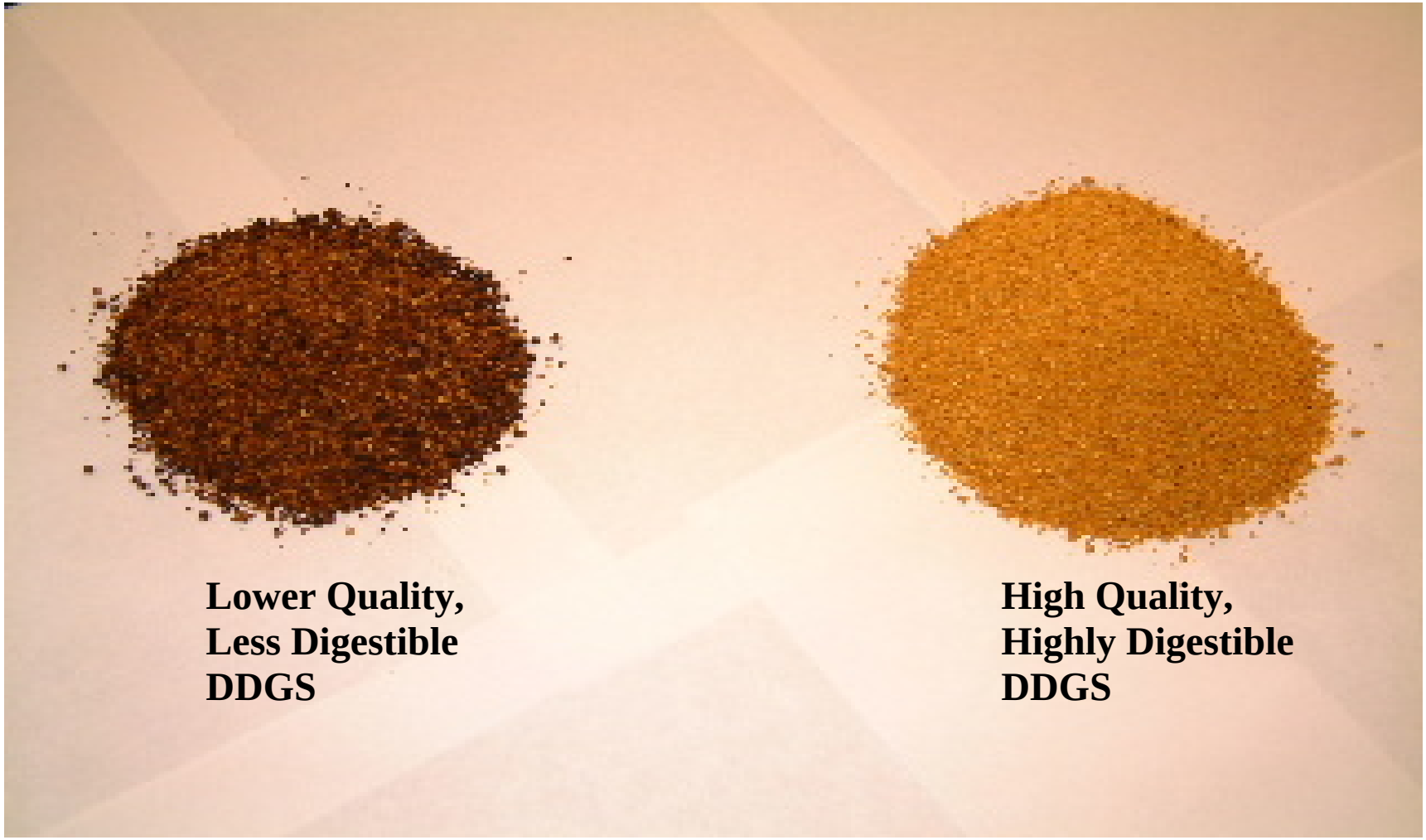
Comparison of Nutrient Composition (Dry Matter Basis) of "New Generation" DDGS to Corn Gluten Feed, Corn Gluten Meal, Corn Germ Meal, and Brewer's Dried Grains

	"New Generation" 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

DDGS Color and Digestibility Varies Among DDGS Sources



Proximate Analysis of High Quality Corn DDGS (100% Dry Matter Basis)

Nutrient	%
Dry matter	89.2
Crude protein	31.6
Fat	11.5
Crude fiber	6.2
Ash	7.8
NFE	42.8
ADF	11.2

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

	High Quality DDGS Calculated	High Quality DDGS Trial avg.	Lower Quality DDGS Calculated	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 Amino Acid Composition of DDGS (88% dry matter basis)

	High Quality DDGS	Lower Quality 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

Comparison of Apparent Ileal Digestible Amino Acid Composition of DDGS for Swine (88% dry matter basis)

	High Quality DDGS	Lower Quality DDGS	DDGS (NRC, 1998)
Lysine, %	0.39	0.00	0.27
Methionine, %	0.28	0.21	0.34
Threonine, %	0.55	0.32	0.49
Tryptophan, %	0.13	0.13	0.12
Valine, %	0.81	0.45	0.77
Arginine, %	0.79	0.53	0.77
Histidine, %	0.45	0.26	0.40
Leucine, %	2.26	1.62	1.85
Isoleucine, %	0.63	0.37	0.64
Phenylalanine, %	0.78	0.60	0.96

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

	DDGS		DDGS NRC (1998)	Corn NRC (1998)
Total P, %	0.78 Range 0.62-0.87		0.73	0.25
P Availability, %	90 Range 88-92		77	14
Available P, %	0.70		0.56	0.03


CORNHUSKER BOD
CORNHUSKER BOD

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

Quality Assessment of DDGS

- NIR
- Smell
- Color
- Mycotoxins
- Fat stability

NIR Calibrations for DDGS

Nutrient	R	Rmsep, %	R^2	CV, %
Lysine	0.89	0.064	.79	16.2
Methionine	0.81	0.044	.66	14.2
Threonine	0.73	0.046	.53	6.2
Energy	0.87	37	.76	1.9

R = correlation between actual and predicted values
Rmsep = prediction error
R^2 = proportion of the total variation explained by calibrations
CV, % = coefficient of variation among DDGS samples

DDGS Color and Smell

- Color varies among sources
  - ranges from dark to golden
  - 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
  - high quality DDGS has a sweet, fermented smell
  - smell may affect palatability

Samples of High Quality DDGS from Various Ethanol Plants

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

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

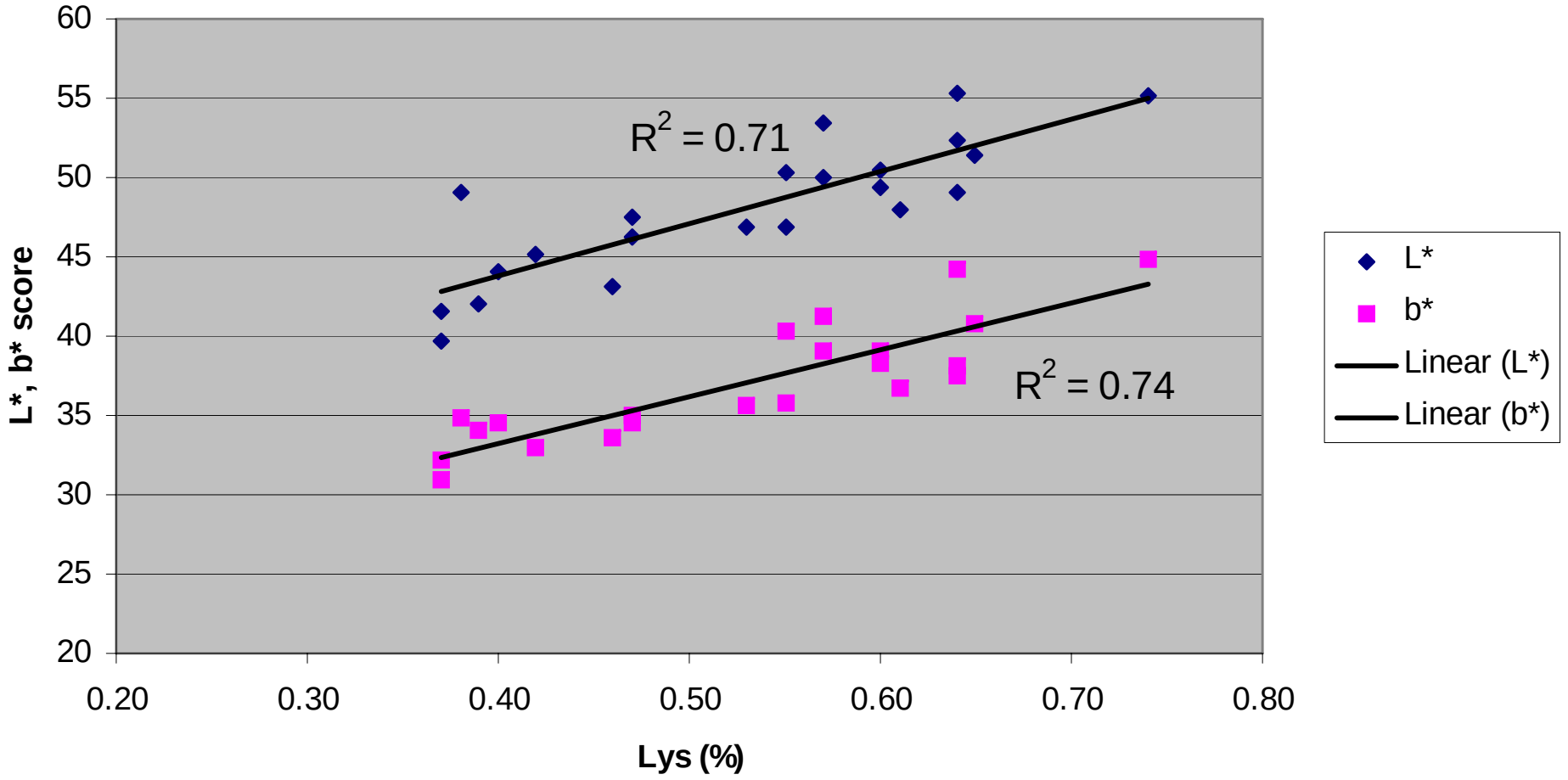


Fig. 2. Regression of digestible cys (%) and color (L*, b*)

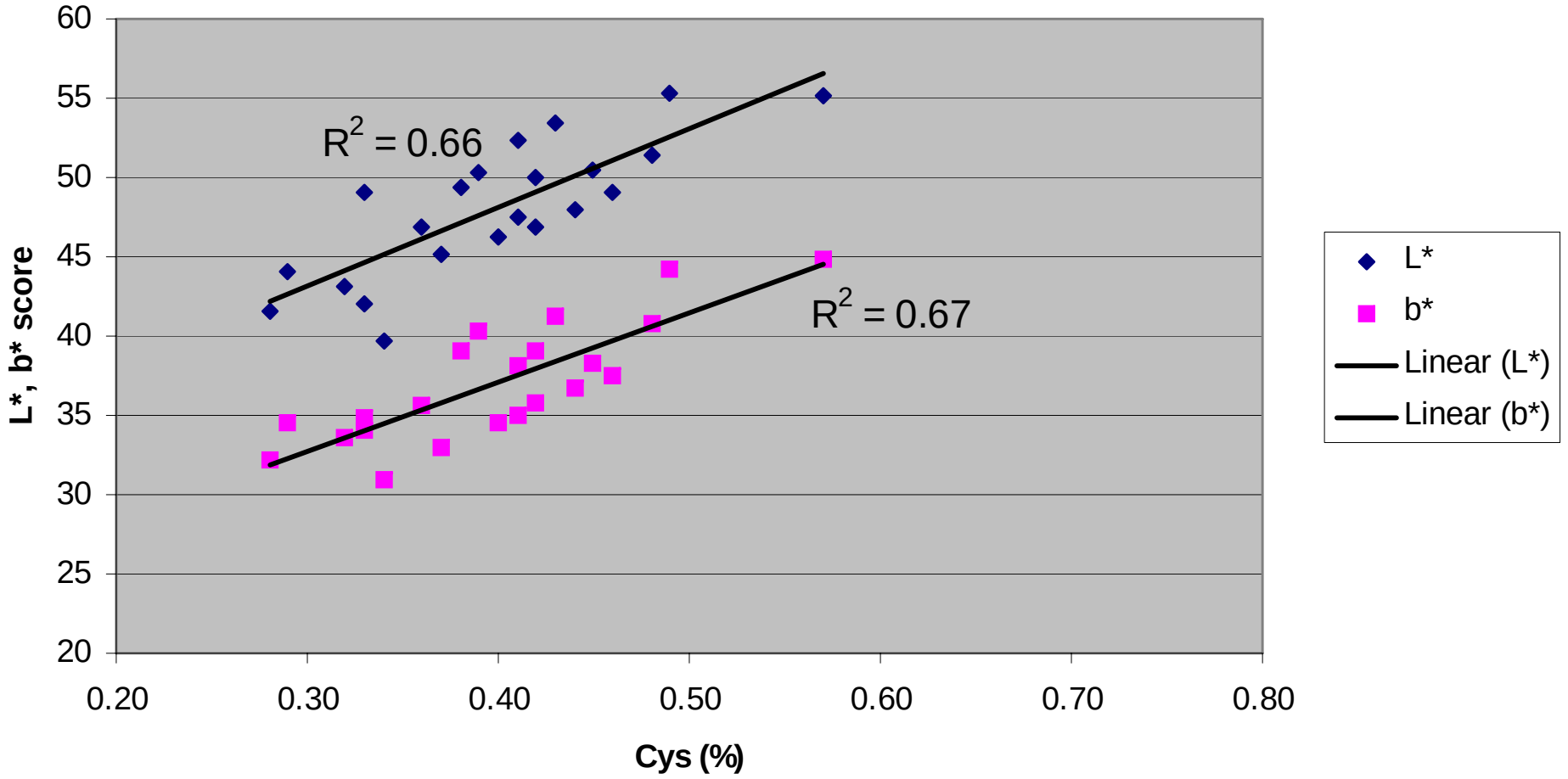
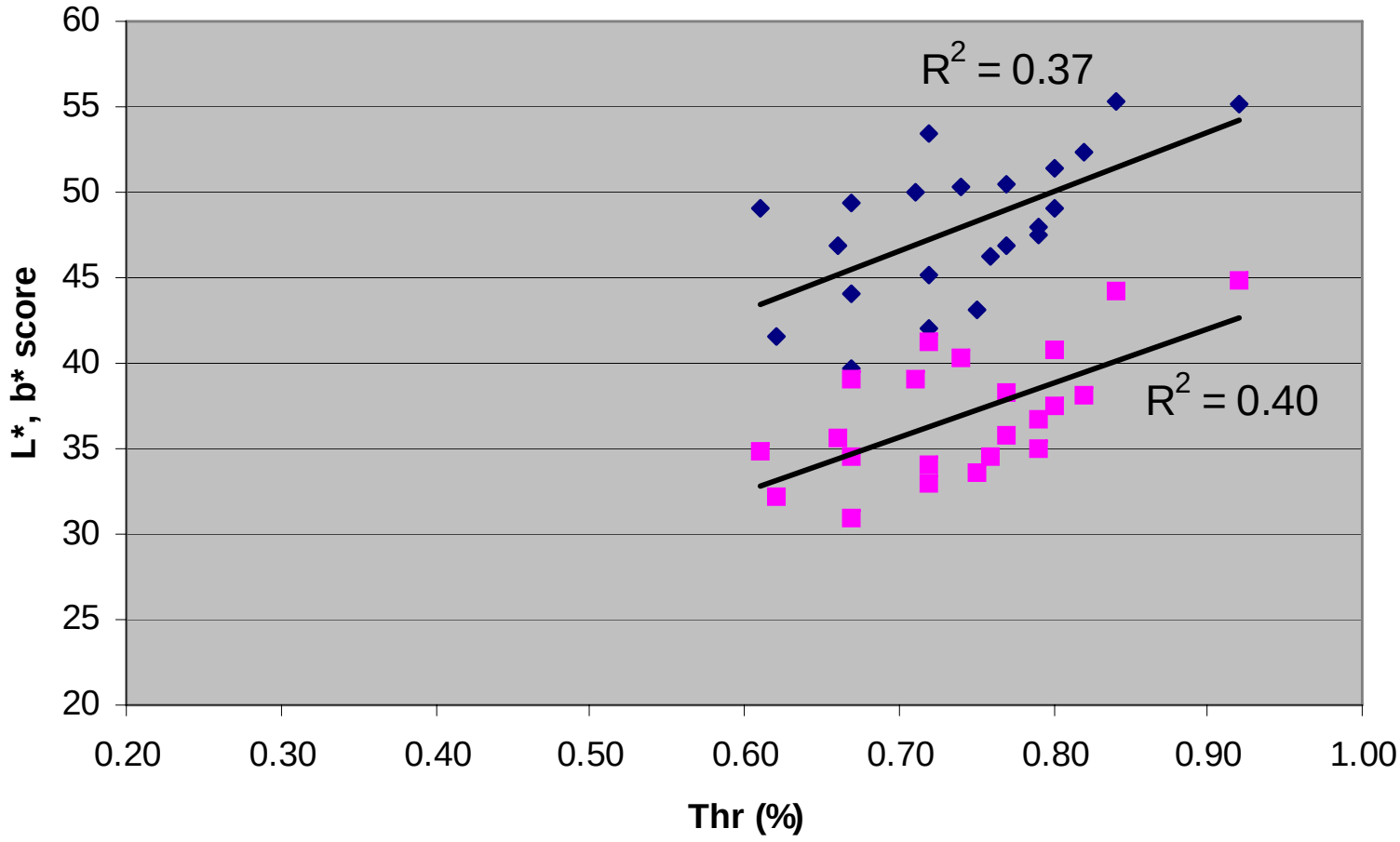


Fig. 3. Regression of digestible thr (%) and color (L*, b*)



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 upper Midwest is has a low risk for mycotoxins
- Must use thin layer chromatography (TLC) or HPLC for testing mycotoxins in DDGS
  - ELISA and other methods result in false positives

Fat Stability of DDGS

- Limited data
- Mexico
  - 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

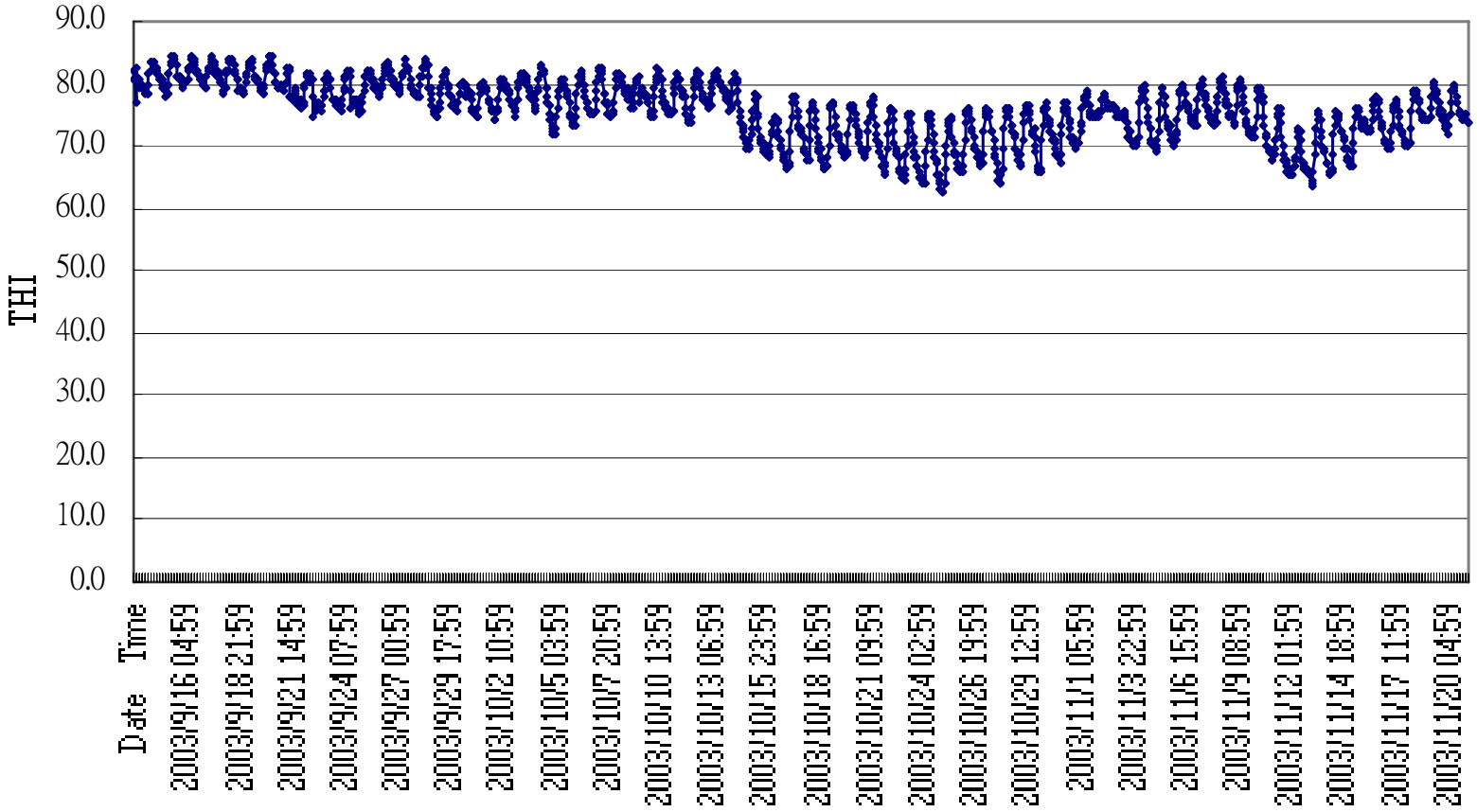
Fat Stability of DDGS in Taiwan

- Study conducted at Lin-Fong-Ying Dairy Farm
  - a commercial dairy farm located about 20 km south of the Tropic of Cancer
  - DDGS was shipped from Watertown, SD to Taiwan in a 40 ft. container
  - upon arrival in Taiwan, DDGS was re-packaged in 50 kg feed bags with a plastic lining
  - DDGS bags were stored in a covered steel pole barn for 10 weeks during the course of the dairy feeding trial

Dr. Yuan-Kuo Chen discussing DDGS sampling procedures from storage bags with his research assistant.

Inside of the covered, steel pole barn used to store bags of DDGS and other forage and feed ingredients at LFY Dairy.

Temperature-Humidity-Index (THI) During the Taiwan DDGS Fat Stability Trial



Fat Stability of DDGS in Taiwan

Analysis	Week 1	Week 10
Peroxide value, mEq/kg	0.70	0.60
Free fatty acids, % as oleic	11.2	16.2

Peroxide values < 5 mEq/kg are considered acceptable for fat quality and there is no oxidative rancidity.