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

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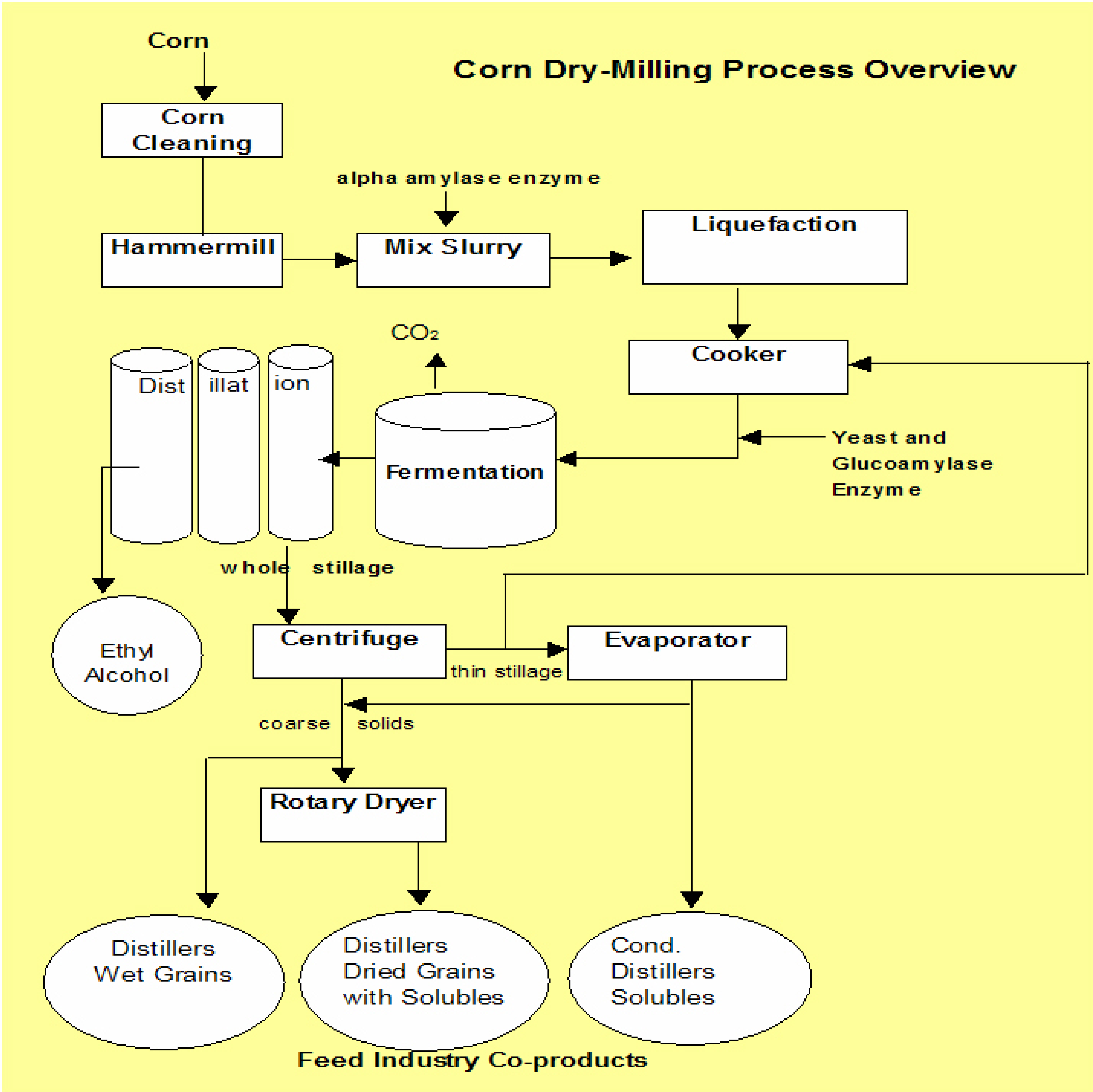
Overview – Part 1

- 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?

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

"New Generation" Corn DDGS vs. Canadian Wheat DDGS



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

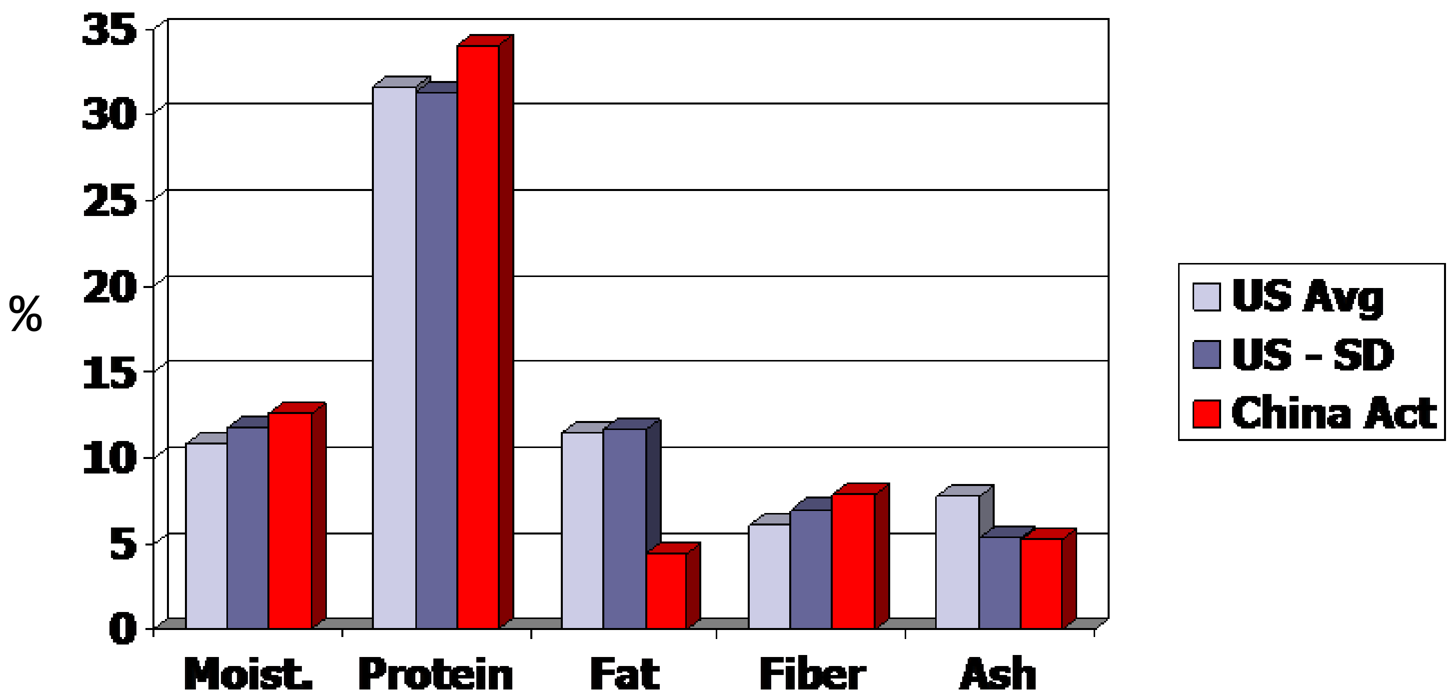
- Ethanol 10.2 liters
- DDGS 8.2 kg
- CO_2 8.2 kg

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

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

“New Generation” Corn DDGS vs. Chinese DDGS

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

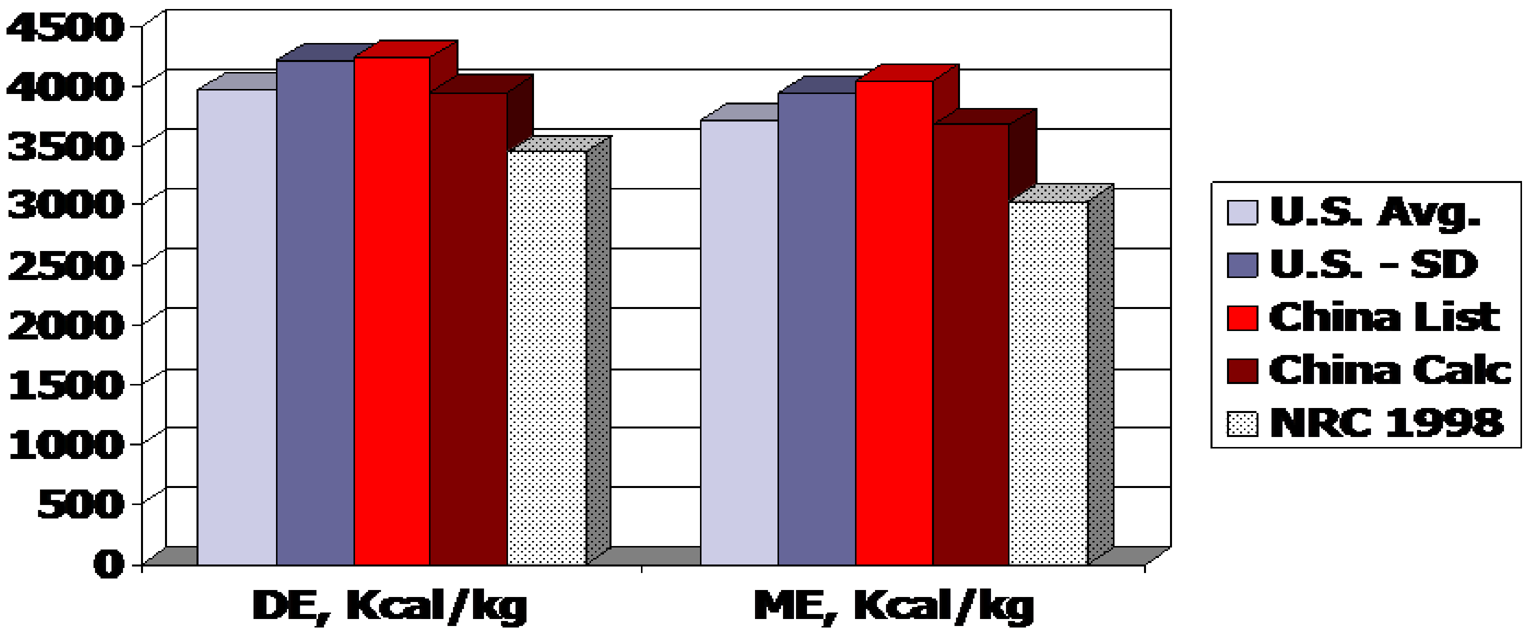


U.S. Avg. = average of values obtained from samples from 9 "New Generation" dry-mill ethanol plants (Shurson and Whitney, 2004)

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

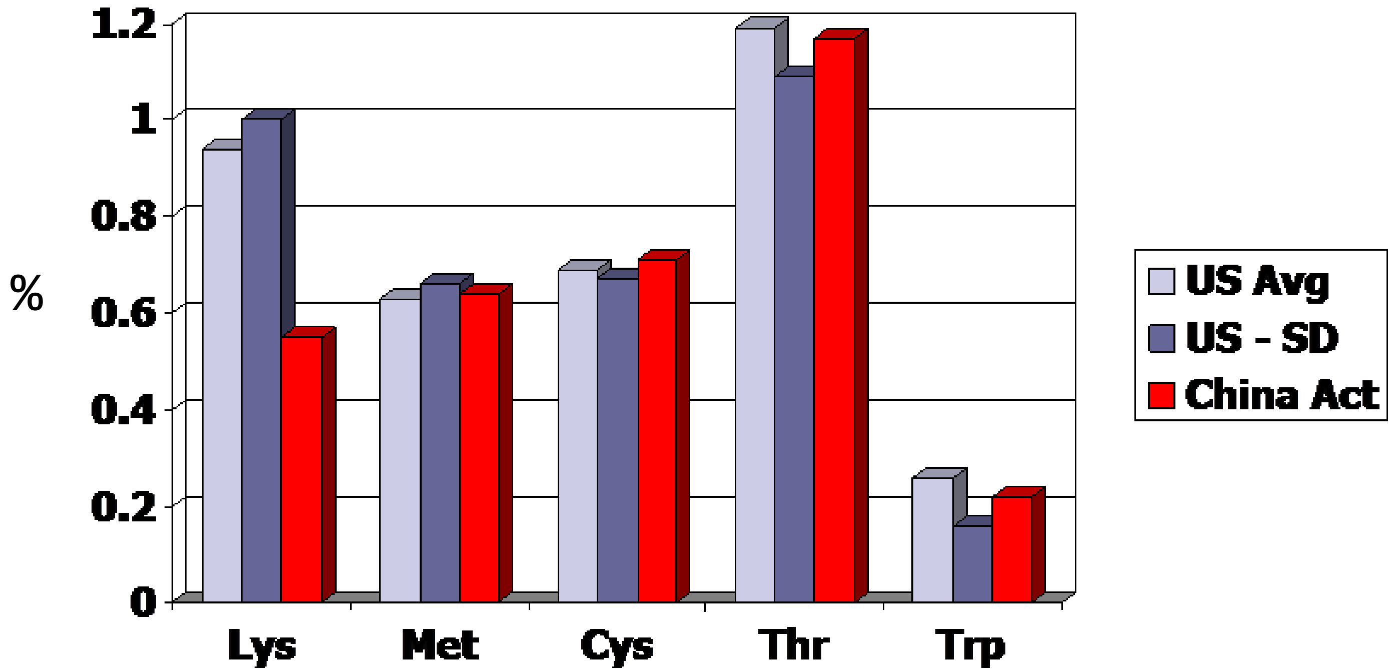
China Act = actual analyzed values of a sample of Chinese DDGS obtained from Taiwan

Comparison of Calculated DE, ME Values for Swine Between U.S. "New Generation" 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, 10^{th} Rev. Ed.

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



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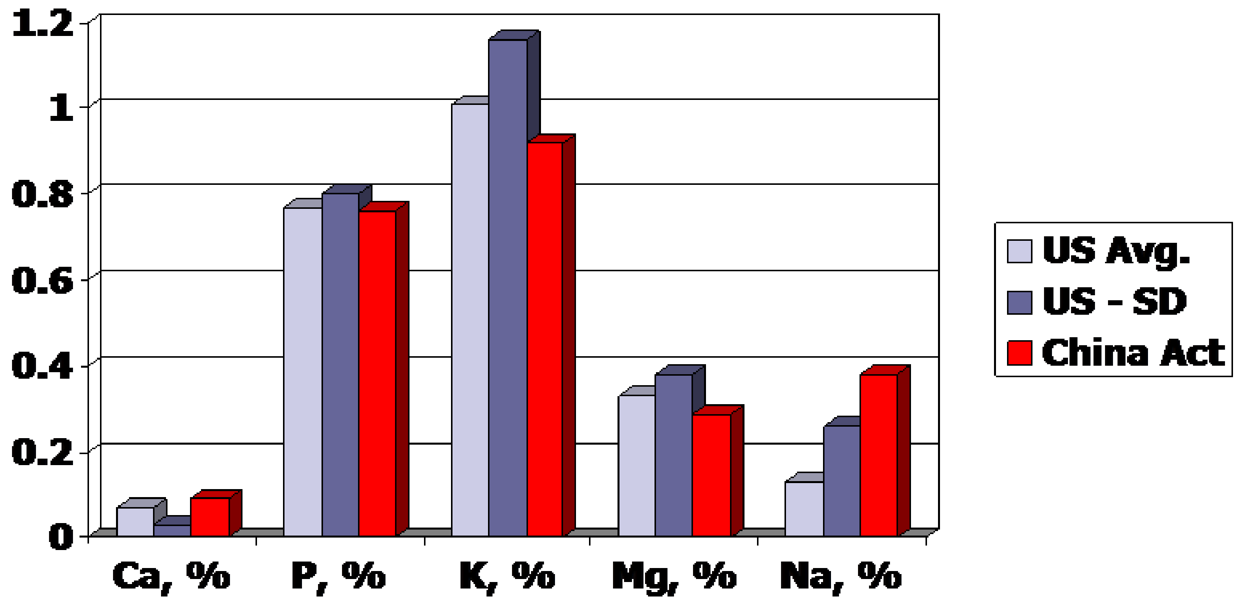
Comparison of Macro-mineral Analysis of U.S. "New Generation" DDGS to Chinese DDGS (100% Dry Matter Basis)



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

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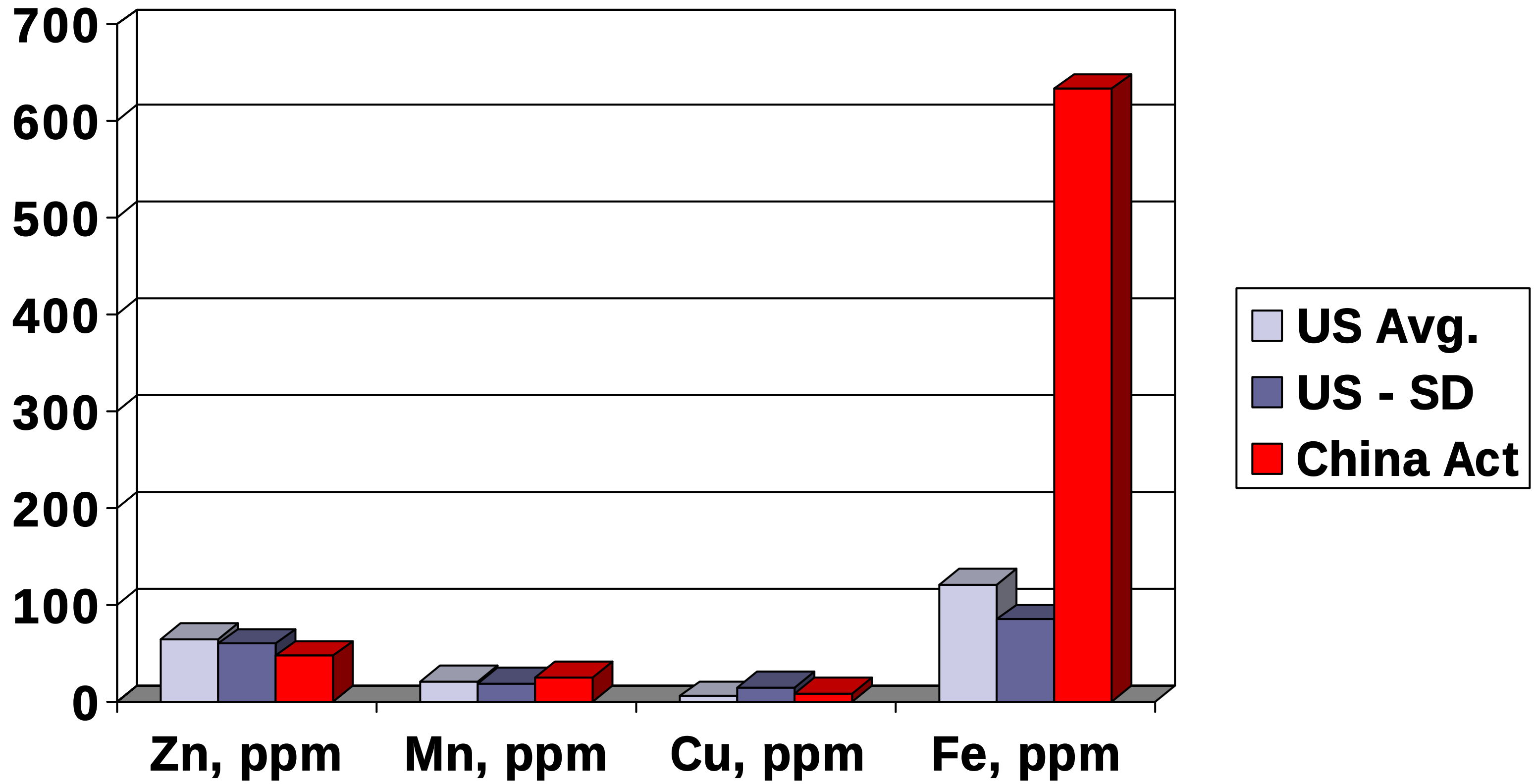
Comparison of Trace Mineral Analysis of U.S. "New Generation" DDGS to Chinese DDGS (100% Dry Matter Basis)



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

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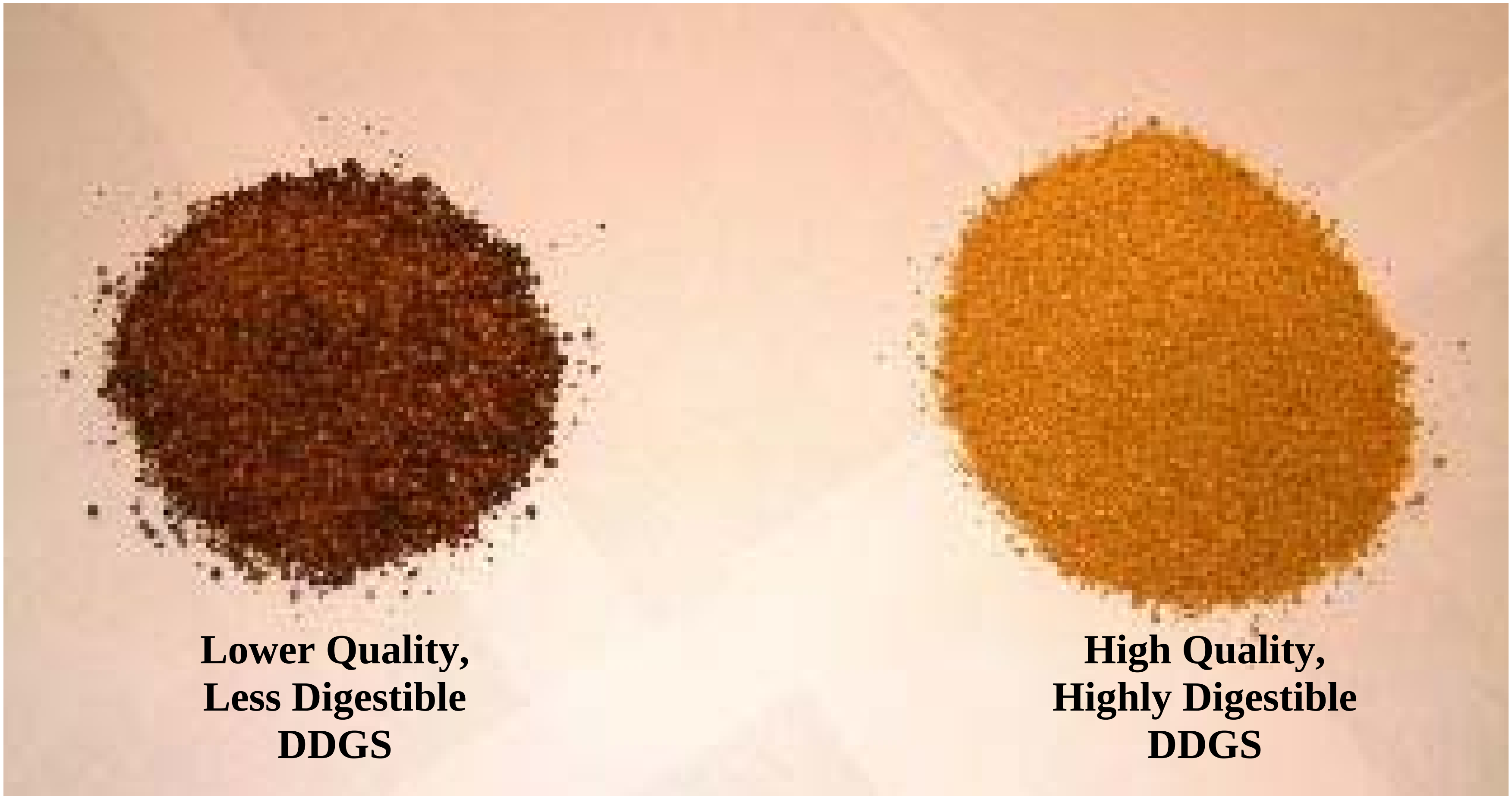
Comparison of Nutrient Composition (Dry Matter Basis) of "New Generation" DDGS to Corn Gluten Feed, Corn Gluten Meal, Corn Germ Meal, and Brewer's Dried Grains

	"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

"Old Generation" vs. "New Generation" DDGS



Proximate Analysis of "New Generation"DDGS (100% Dry Matter Basis)

Nutrient	"New Generation" DDGS
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)

	"New" DDGS Calculated	"New" DDGS Trial avg.	"Old" 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)

	"New" DDGS	"Old" 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)

	"New" DDGS	"Old" 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)

	"New" DDGS	"Old" 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 Energy Values of DDGS for Poultry (88% DM Basis)

	"New Generation" 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.

True Digestible Amino Acid Levels of 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.

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

	"New Generation" 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.


CORNHUSKER 800
CORNHUSKER 800

Physical Characteristics of "New Generation" DDGS

- Bulk density (16 "new generation" plants)
  - 35.7 ± 2.79 lbs/ft^3
  - Range 30.8 to 39.3 lbs/ft^3

- Particle size (16 "new generation" plants)
  - 1282 ± 305 microns
  - Range 612 to 2125 microns

Quality Assessment of “New Generation” 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 **(Cromwell et al., 1993)**
  - "new generation" DDGS is more golden and color is less variable
  - 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)**
  - "new generation" DDGS has a sweet, fermented smell
  - smell may affect palatability

Samples of "New Generation" 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

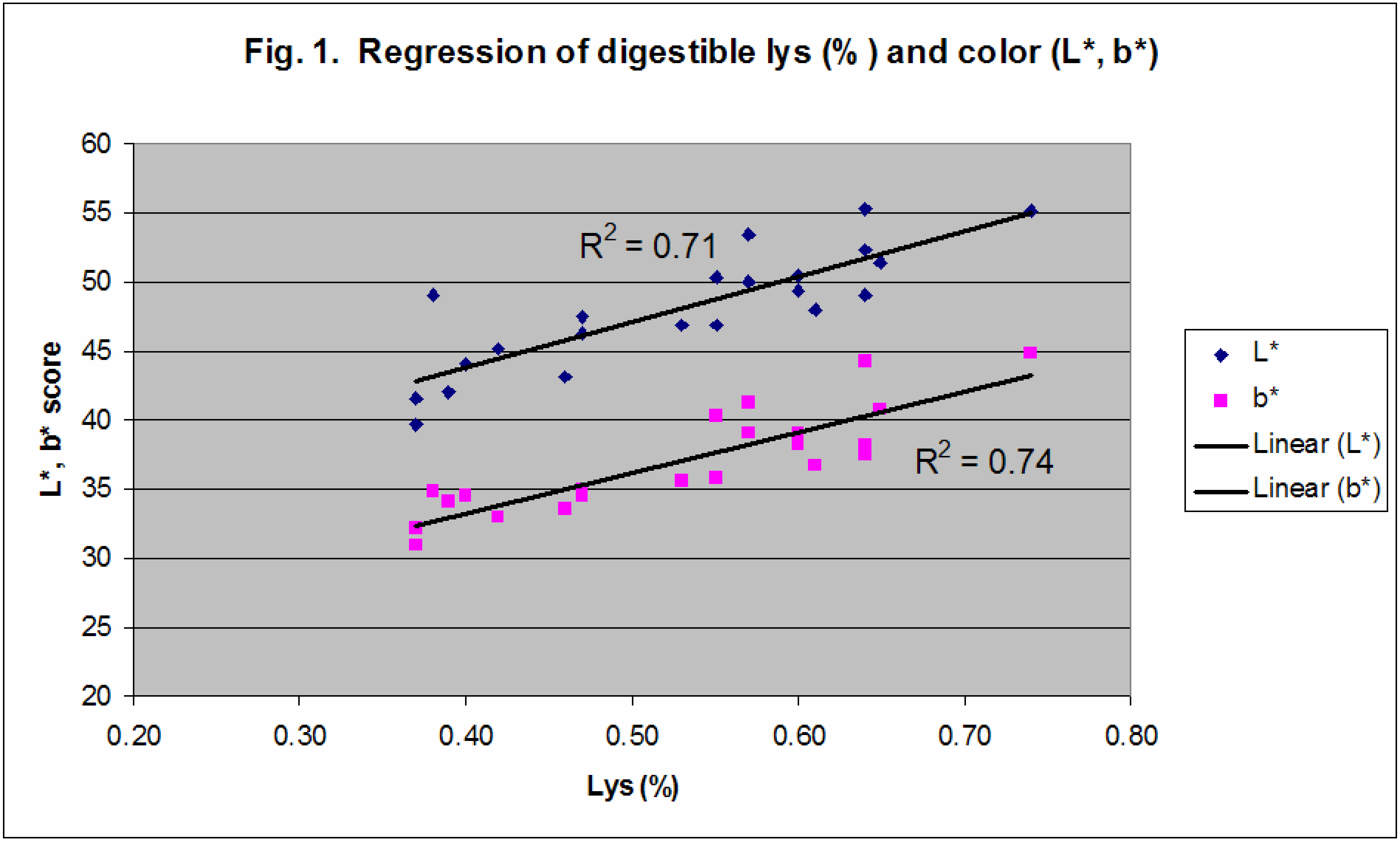


Fig. 1. Regression of digestible lys (%) and color (L*, b*)
60
55
50
45
40
35
30
25
20
L*, b* score
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Lys (%)
R2 = 0.71
R2 = 0.74
L*
b*
Linear (L*)
Linear (b*)

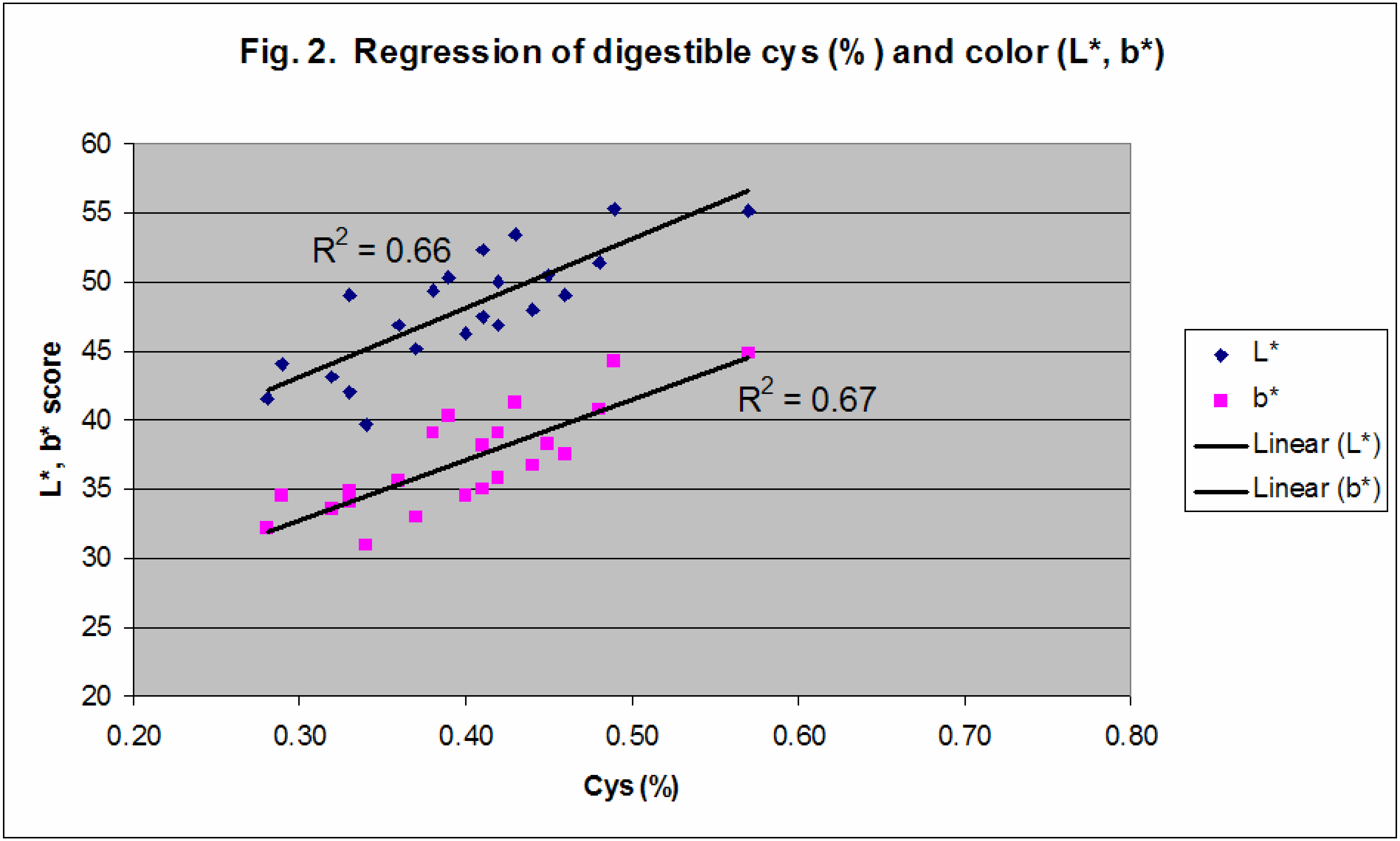
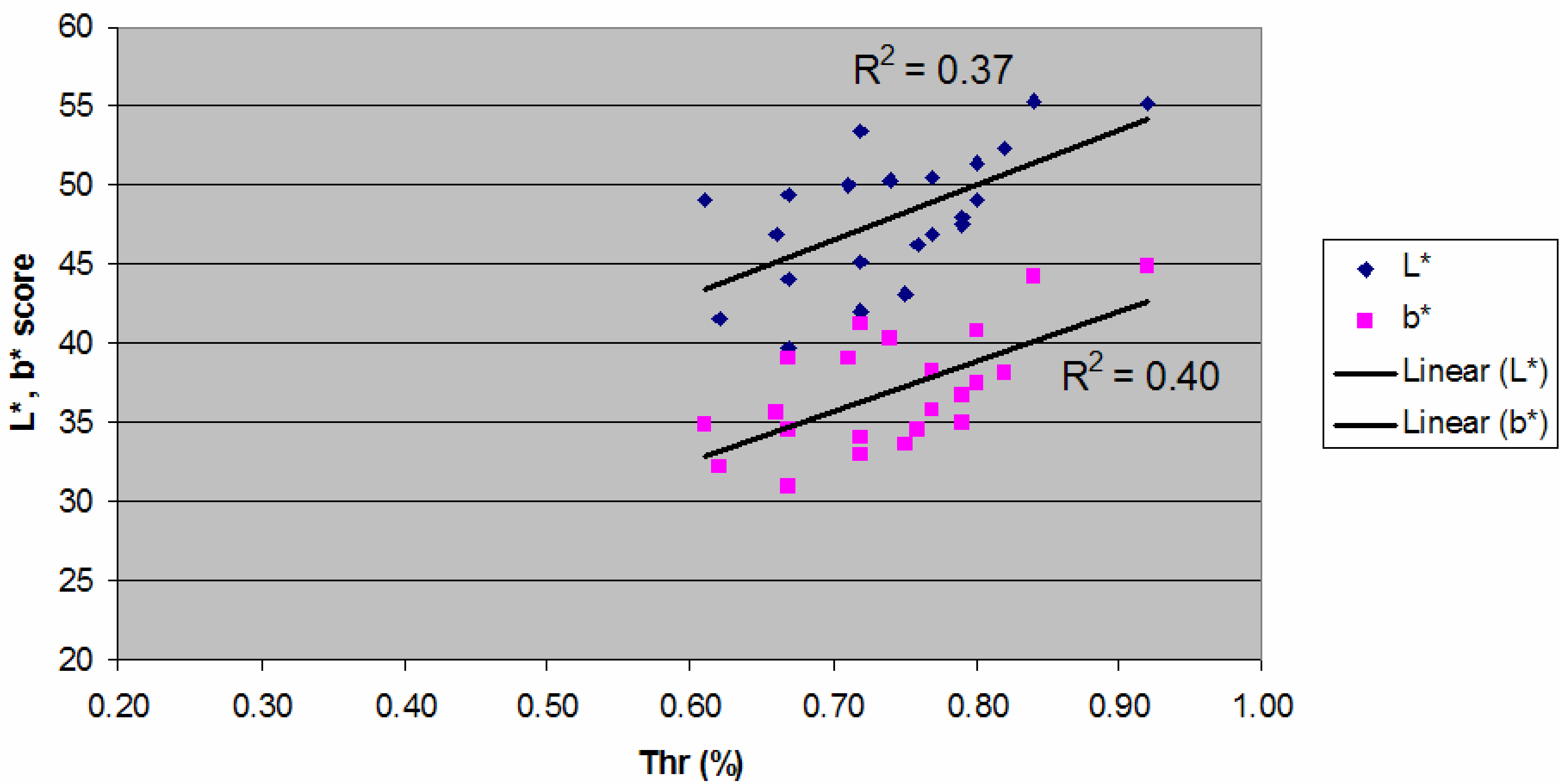


Fig. 2. Regression of digestible cys (%) and color (L*, b*)
60
55
50
45
40
35
30
25
20
L*, b* score
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Cys (%)
R2 = 0.66
R2 = 0.67
L*
b*
Linear (L*)
Linear (b*)

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

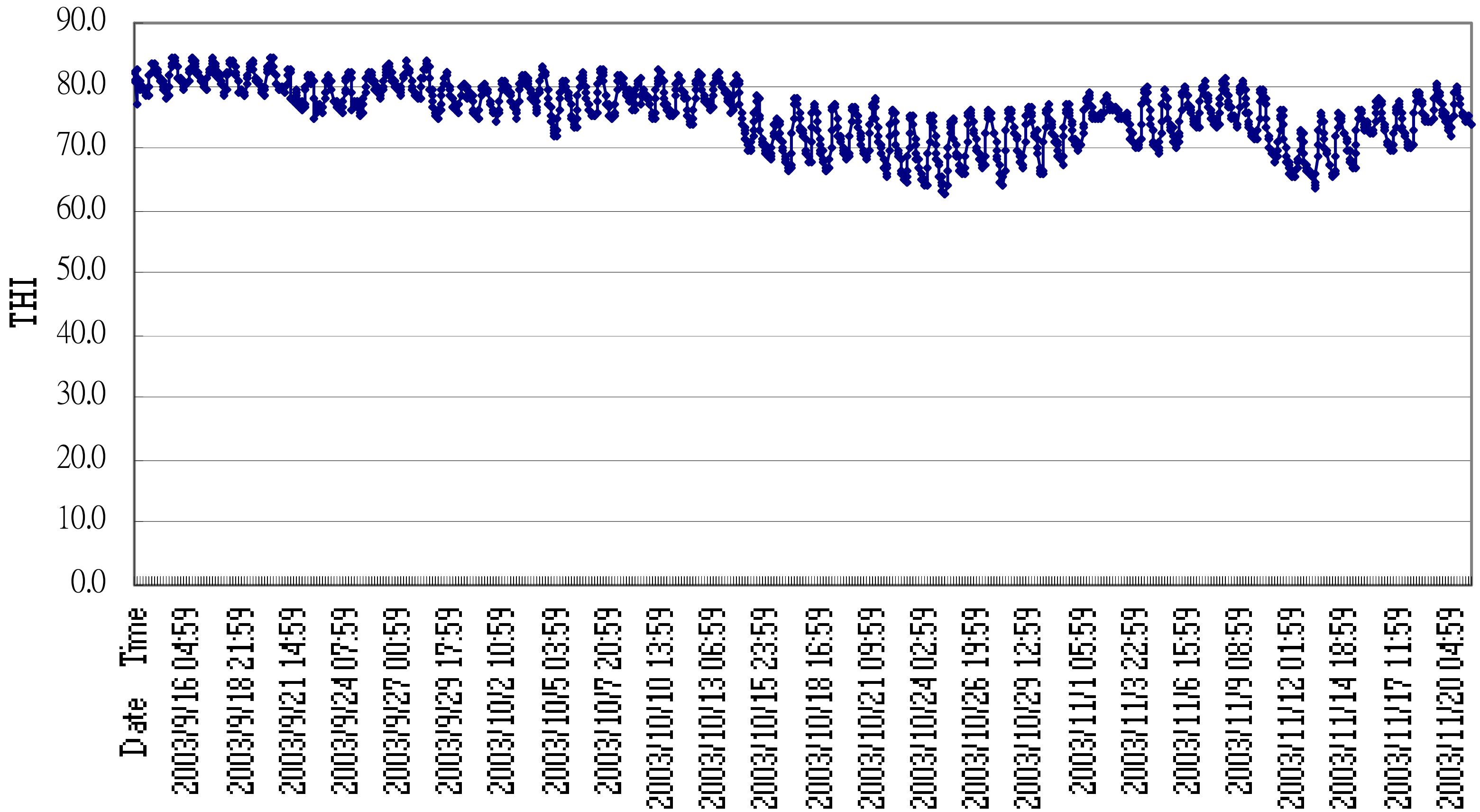
Fat Stability of DDGS in Taiwan

- 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.