Differences in Quality Characteristics Among U.S. DDGS Sources

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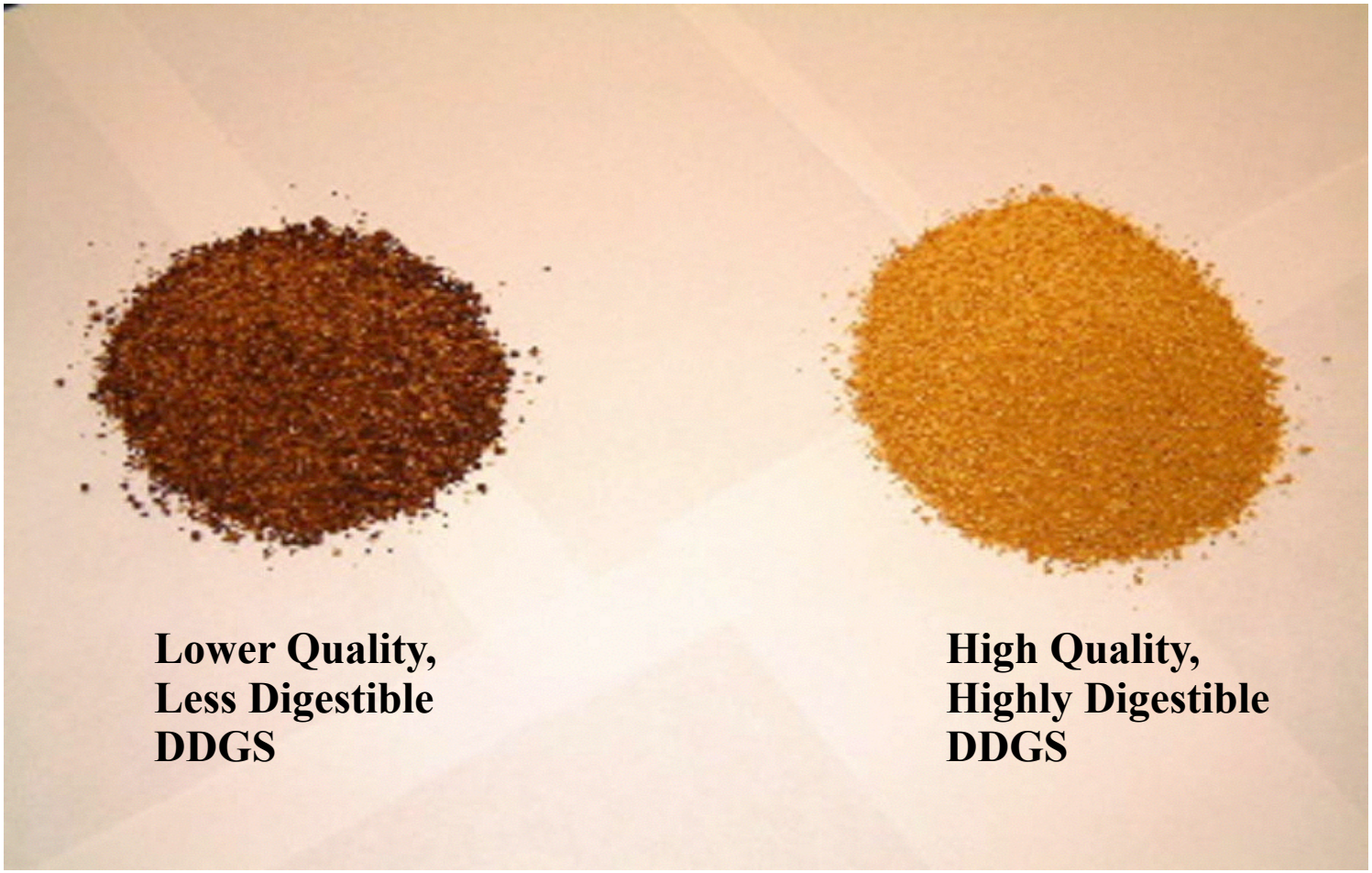
Color Extremes of DDGS



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

Proximate Analysis and Energy Value Averages and Ranges 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

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

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

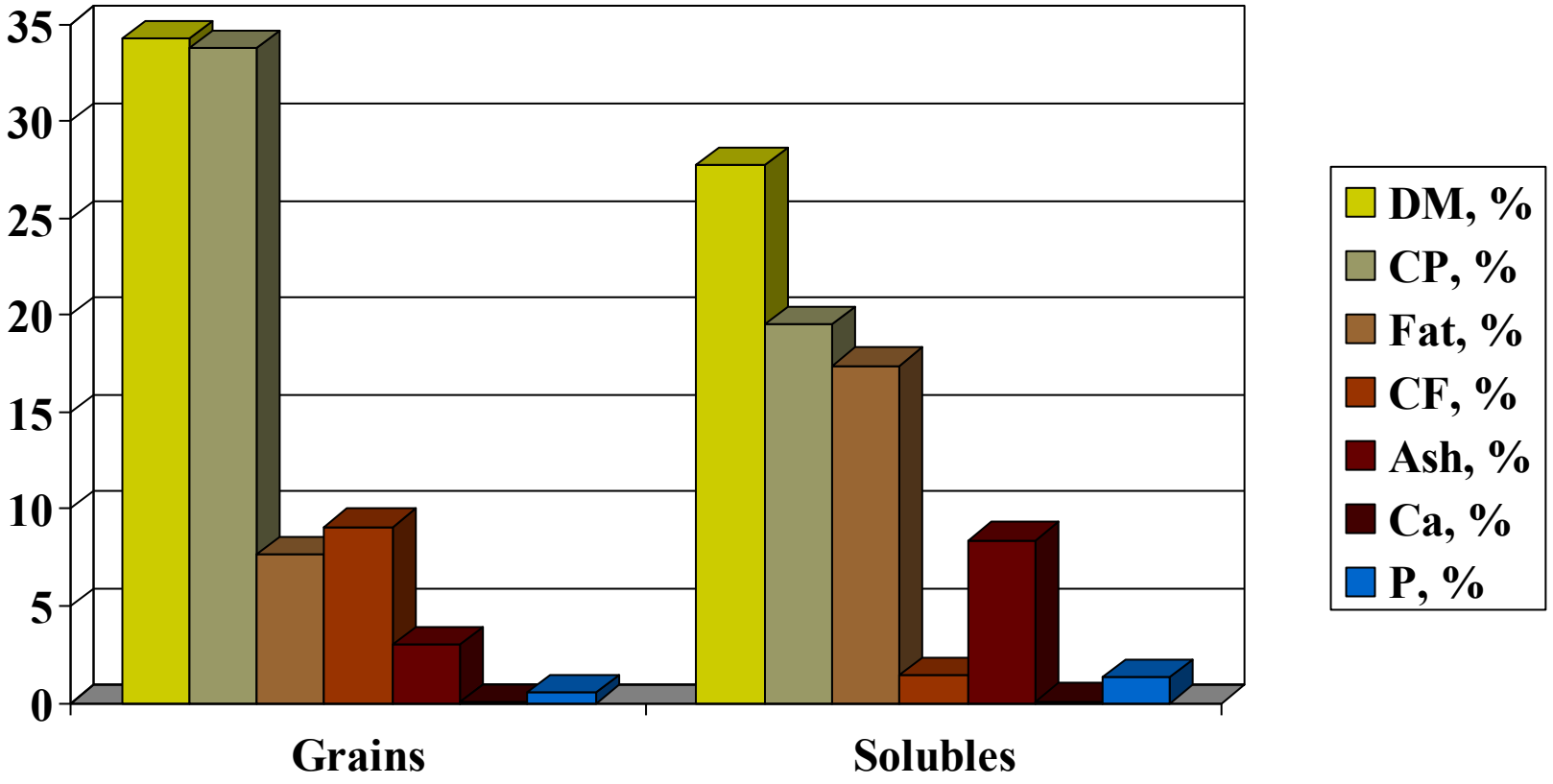
Nutrient	Average	Range
Arg, %	1.31	1.01 – 1.48
His, %	0.84	0.71 – 0.98
Ile, %	1.17	1.01 – 1.31
Leu, %	3.58	2.91 – 3.96
Lys, %	**0.89**	**0.61 – 1.06**
Met, %	**0.65**	**0.54 – 0.76**
Cys, %	0.68	0.61 – 0.76
Phe, %	1.51	1.36 – 1.72
Thr, %	**1.15**	**1.01 – 1.28**
Trp, %	**0.25**	**0.18 – 0.28**
Val, %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

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

	Golden Corn DDGS	Solulac	Badger State Ethanol	ADM - Peoria	Extruded DDGS/Soy (XDS Plus)	AGP Pelleted
Protein, %	31.82	29.32	31.62	30.12	34.44	27.0
Fat, %	11.32	3.52	15.25	8.96	13.33	9.00
Crude fiber, %	6.25	7.90	No data	7.77	7.78	15.10
ADF, %	12.37	11.80	17.91	20.95	14.44	No data
Ash, %	6.93	5.29	4.58	7.30	5.56	4.28
DE, kcal/kg*	4053	3808	No data	3796	No data	No data
ME, kcal/kg*	3781	3577	No data	3560	3749	No data
Lys, %	0.92	0.61	0.90	0.83	1.67	No data
Met, %	0.62	0.54	0.54	0.66	0.61	No data
Thr, %	1.17	1.01	1.04	1.13	2.50	No data
Trp, %	0.25	0.18	0.23	0.25	0.39	No data
Ca, %	0.07	0.12	0.06	0.51	0.22	0.17
P, %	0.77	0.78	0.89	0.68	0.72	0.62

*Calculated energy values for

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



Samples of Golden Corn DDGS from Various Midwestern U.S. Ethanol Plants

VeraSun - Aurora, SD

CVEC - Benson, MN

Al-Corn - Claremont, MN

MGP – Lakota, IA

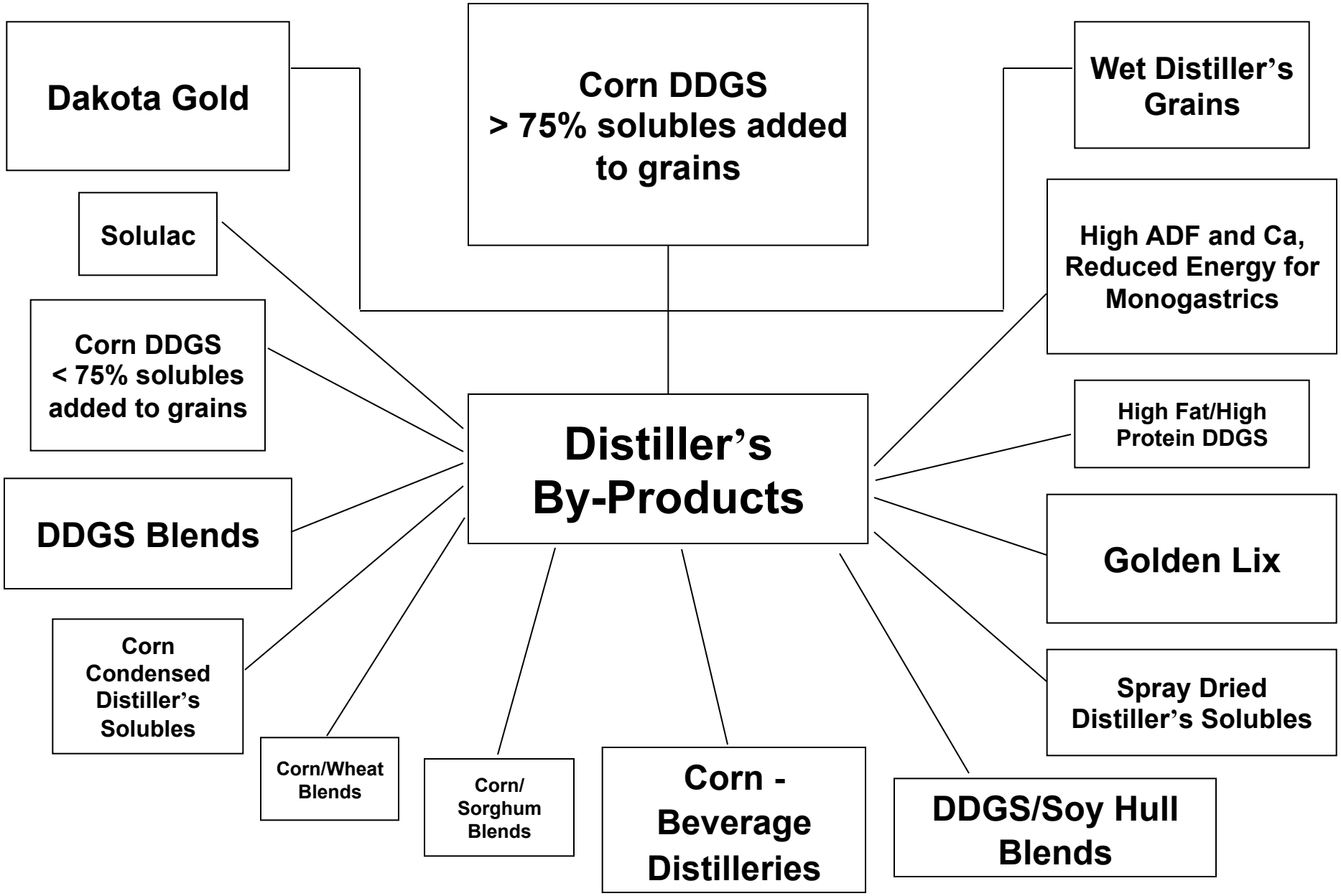
CMEC - Little Falls, MN

Agri-Energy - Luverne, MN

LSCP - Marcus, IA

DENCO – Morris, MN

Potential Categories of Distiller's By-Products



Quality Assessment of "New Generation" DDGS

- NIR
- Smell
- Color
- Bulk density
- Particle size
- Mycotoxins
- Fat stability

NIR Calibrations for DDGS

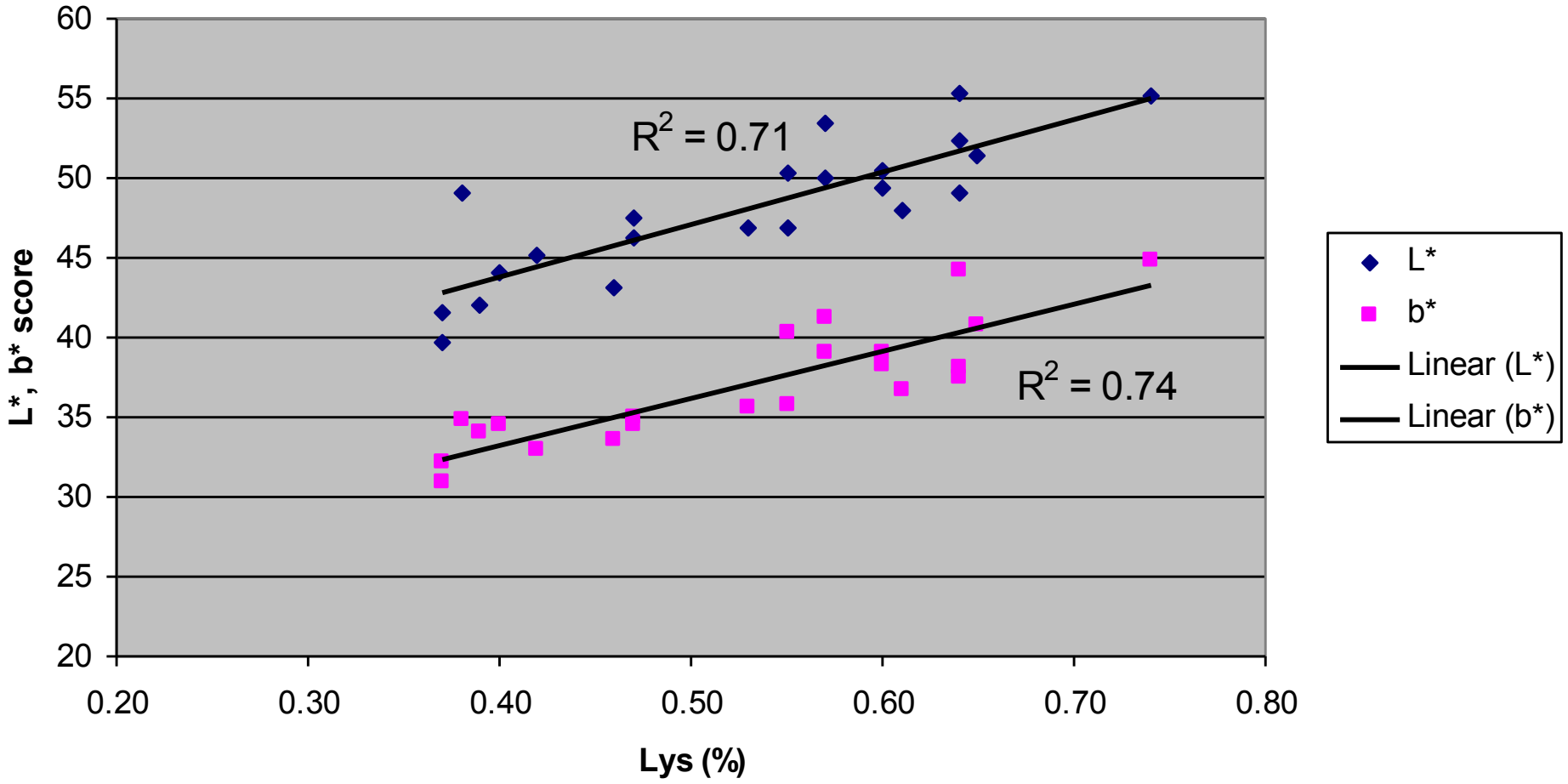
Nutrient	R	Rmsep,%	R^2	CV,%
Lysine	0.89	0.064	.79	16.2
Methionine	0.81	0.044	.66	14.2
Threonine	0.73	0.046	.53	6.2
Energy	0.87	37	.76	1.9

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

Corn DDGS Color and Smell are Indicators of Digestibility for Monogastrics

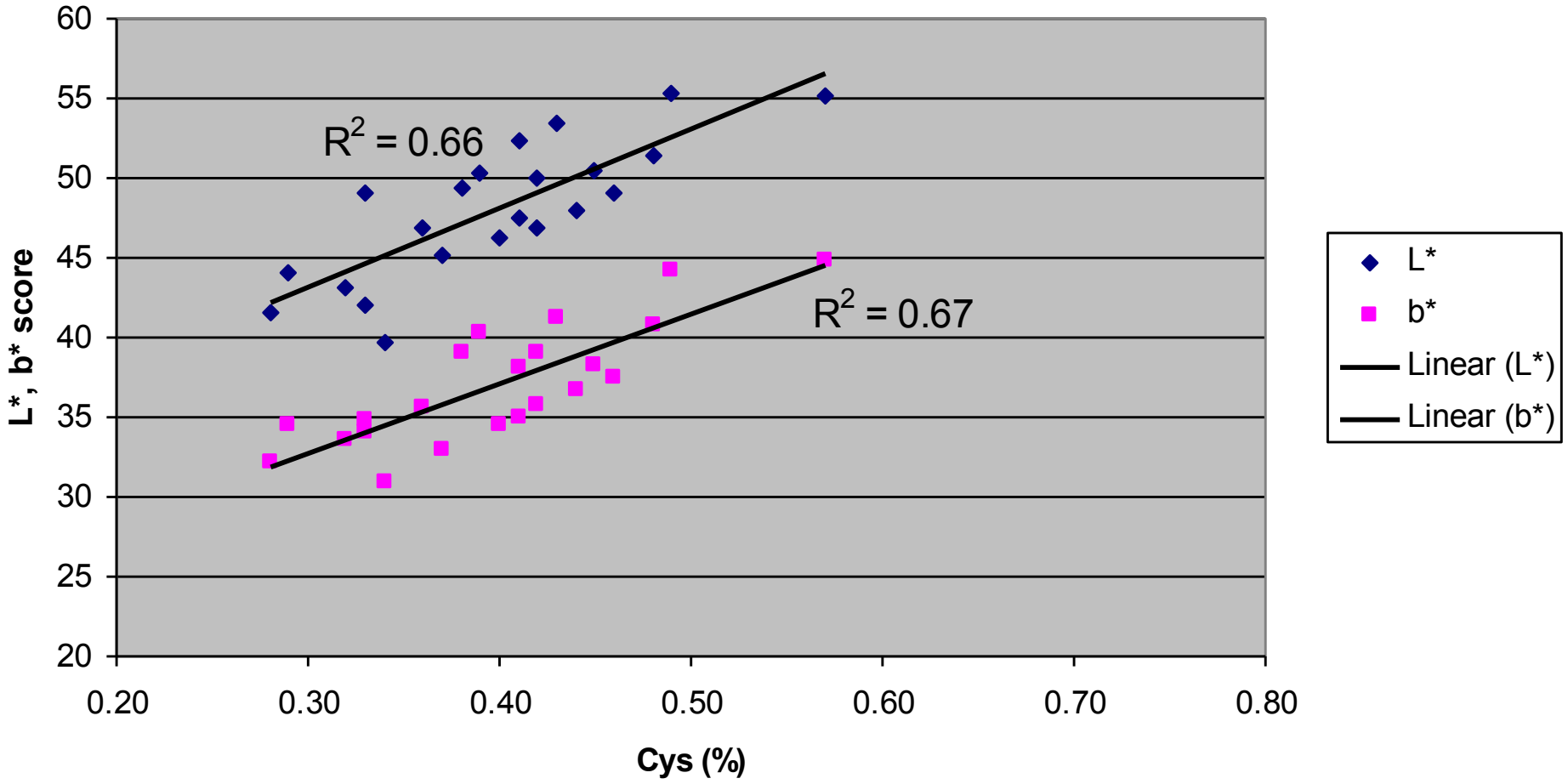
- **Color varies among sources**
  - ranges from dark to golden **(Cromwell et al., 1993)**
  - golden color of corn DDGS is correlated with higher amino acid digestibility in swine and poultry
- **Smell varies among sources**
  - ranges from burnt or smoky to sweet and fermented **(Cromwell et al.,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

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



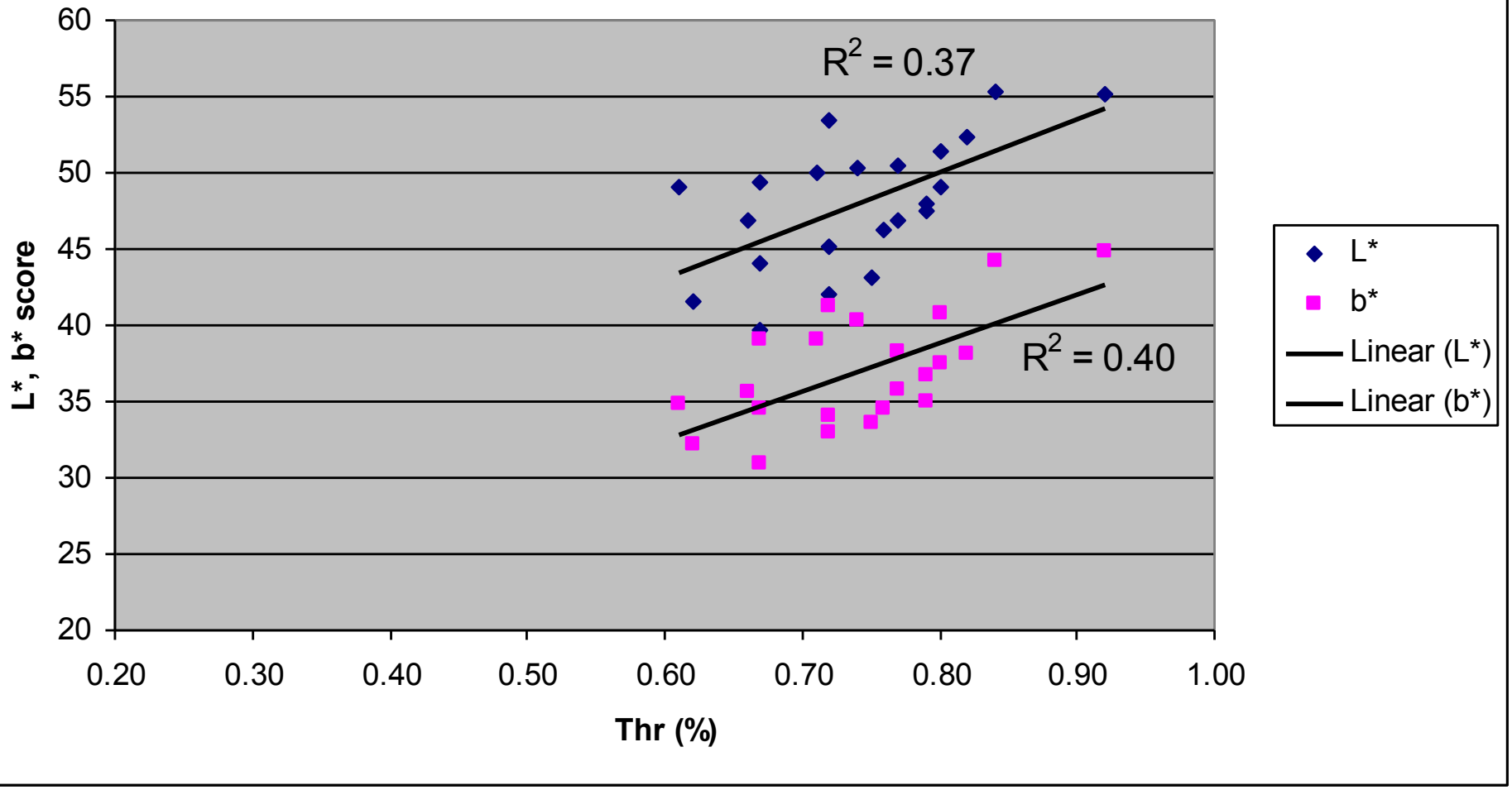
Source: Dr. Sally Noll (2003)

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



Source: Dr. Sally Noll (2003)

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

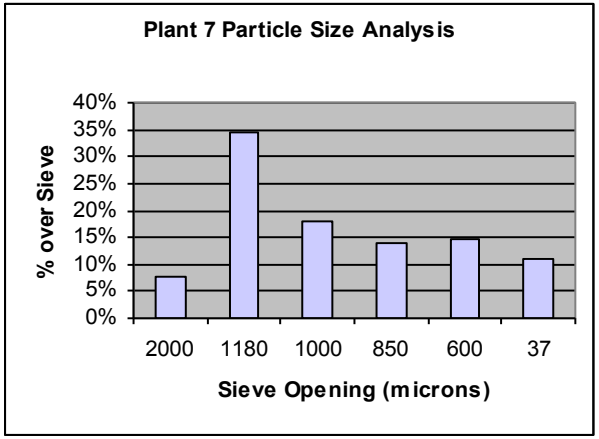


Source: Dr. Sally Noll (2003)

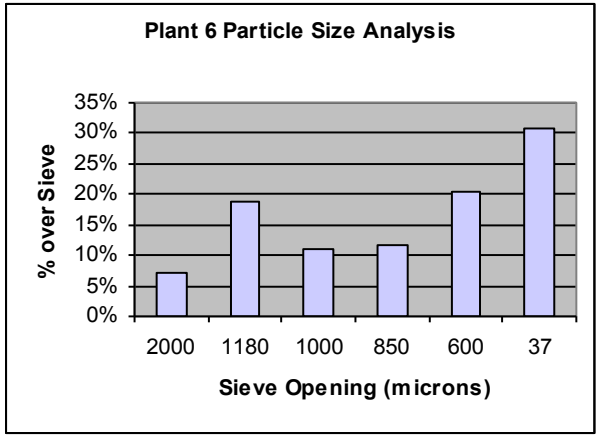
Physical Characteristics of "New Generation" DDGS

- Bulk density (16 new plants)
  - 35.7± 2.79 lbs/ft^3
  - Range 30.8 to 39.3 lbs/ft^3
- Particle size (16 new plants)
  - 1282± 305 microns
  - Range 612 to 2125 microns

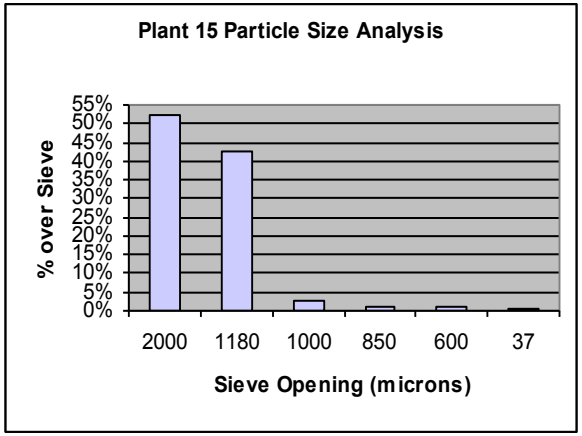
Examples of Particle Size Distribution of "New Generation" DDGS



Typical



Lowest Avg. Particle Size



Highest Avg. Particle Size

Mycotoxins

- Incidence of mycotoxin contamination of DDGS from upper Midwest ethanol plants is low
  - Poor quality corn = poor ethanol yields
  - Corn supplied from a relatively small geographic region
  - Corn produced in upper Midwest is generally lower risk for mycotoxins
- Must use thin layer chromatography (TLC) or HPLC for analyzing 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

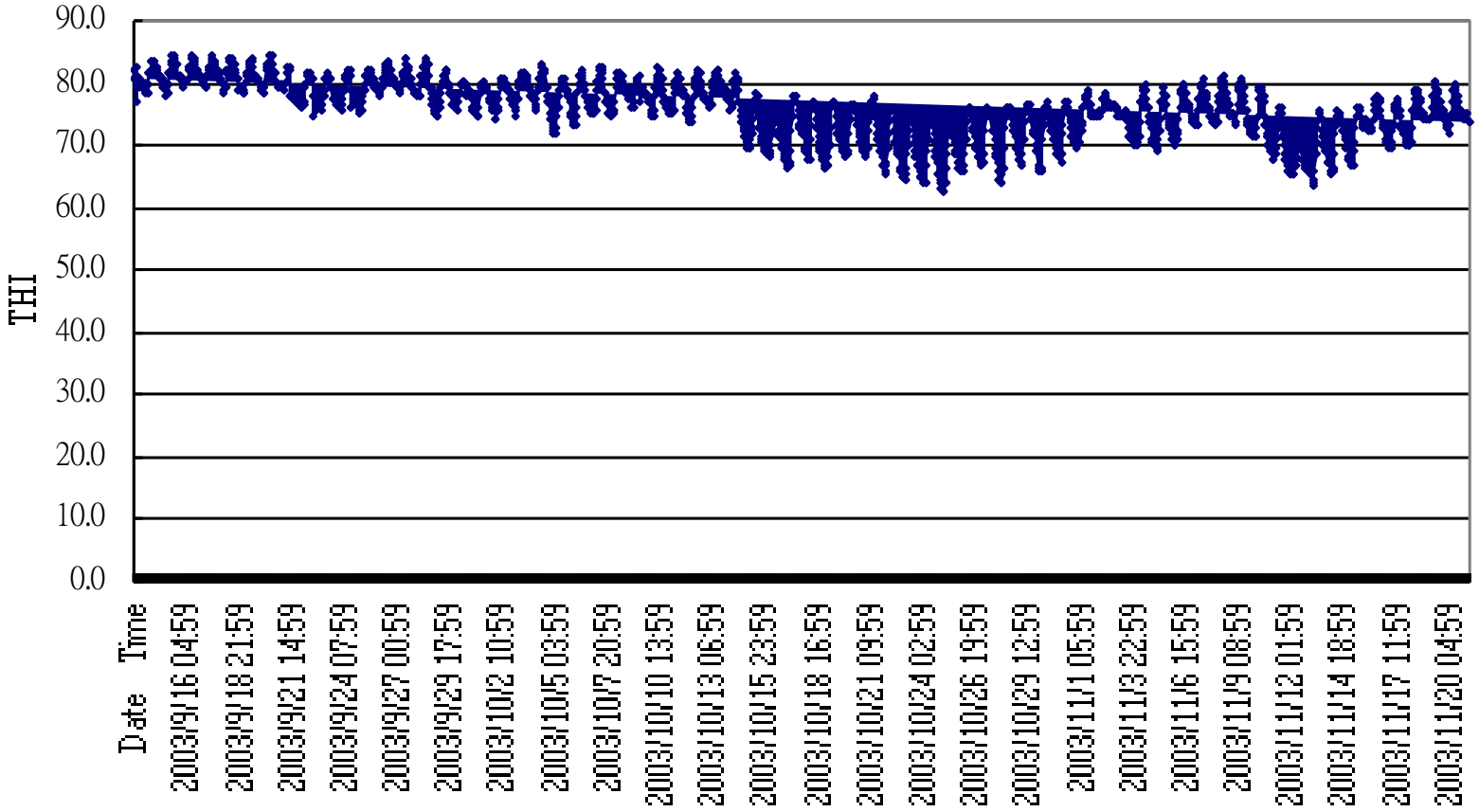
Fat Stability of DDGS in Taiwan

- 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.