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DDGS Color, Energy Prediction Equations, and Mycotoxin Concerns for Swine and Poultry
豬隻與家禽產業對玉米乾酒粕顏色、熱能值預測公式、和黴菌毒素的關切

Dr. Jerry Shurson

Department of Animal Science

University of Minnesota

How Should We Define DDGS Quality?
玉米乾酒粕的品質應該如何定義?

- Definition of Quality品質的定義
  - an essential character or inherent feature that represents a degree of excellence, superiority, or a distinguishing attribute

    一種基本形質或先天特性可以展現優良卓越的程度或可以差異化的屬性
- Quality品質
  - general term概括性描述
  - can mean different things to different people

    意義可能因人而異

DDGS Quality玉米乾酒粕的品質

- Feed manufacturers and animal producers use a variety of qualitative and quantitative methods to assess the quality of feed ingredients and feeds.飼料和畜牧業者採用各種質性和量化的方法來評估飼料和飼料原料的品質
  - Physical物理性
  - Chemical化學性
  - Biological生物性

Physical quality characteristics 物理性品質性狀

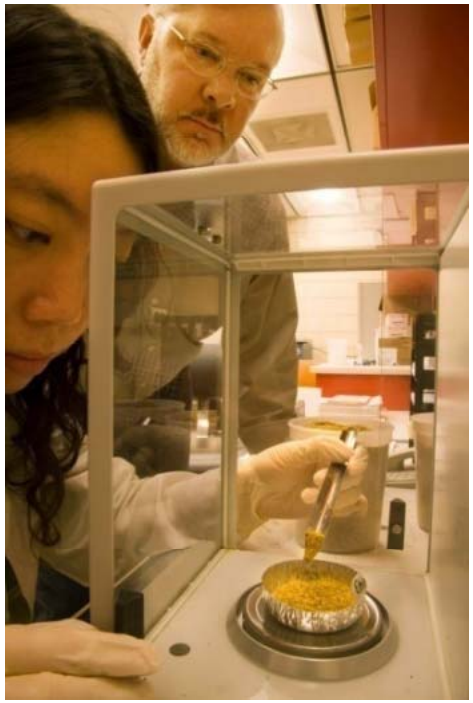
- Qualitative measure物理性測定
  - Color顏色
  - Particle size粒度大小
  - Bulk density比重
  - Homogeneity均勻度
  - Smell風味
  - Taste味道
  - Touch觸感
  - Sound聲音
  - Presence of physically identifiable contaminants可辨識的夾雜物

Feed microscopy飼料鏡檢

- Microscope procedures to determine if feeds have been adulterated or contain contaminants.飼料鏡檢可用來檢視飼料或原料是否被摻假或含有外來污染物
  - Evaluate Particle評估飼料顆粒的:
    - Shape形狀
    - Color顏色
    - Particle size粒度大小
    - Softness軟
    - Hardness硬
    - Texture組織結構

Chemical determination of quality 化學性測定

- Quantitative and estimates nutrient content and possible contaminants可量化的，並且可以估計營養成分和可能的外來雜質
  - Moisture水分
  - Crude protein粗蛋白質
  - Crude fiber粗纖維
  - Crude fat粗脂肪
  - Ash灰分
  - Amino acids胺基酸
  - Mycotoxins黴菌毒素
  - Others其它



Chemical determination of quality is used for:化學測定可用於:

- Quality assurance in feed manufacturing飼料生產的品質保證
- Specifications for ingredient purchasing agreements原料採購的合約規格
- More quantitative assessment of ingredient and feed quality原料和飼料的量化評估
- May have some application when formulating diets應用於核算日糧配方
- Presence of specific contaminants找出特定的外來汙染物

Biological determination of quality 生物性測定

- Quantitative可量化的
- Most precise of all quality assessments

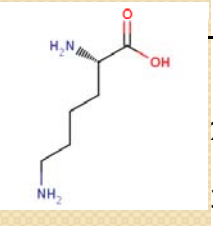
  最精準的品質評估
- Measure animal responses to specific feeds 測定動物對特定原料的反應
  - Expensive成本高
  - Time consuming耗時
  - Requires specialized knowledge, equipment, and procedures需要專業的知識、設備、和程序
  - Not practical for routine quality assurance programs at feed mills不適用於飼料製造品管的例行步驟

Is Color an Indication of DDGS Quality?
顏色是玉米乾酒粕的品質指標嗎?

- Negative effects of dark color
  顏色暗黑的負面效應:
  - May indicate excessive heat used during drying
    可能代表乾燥過程加熱過度
    - Maillard reaction – reduces amino acid digestibility
      梅納反應-降低胺基酸消化率
  - May indicate increased lipid oxidation
    可能代表脂肪的過度氧化
  - May indicate reduced xanthophyll content
    可能意味著葉黃素的含量較少

Maillard Reaction Stages, Color, Fluorescence and Lysine Digestibility
梅納反應的程度、顏色、螢光反應、和離酸消化率

Heat & Time 加熱程度和時間	Reaction stage[1] 反應階段	Digestibility[2] 消化率	Coloration[3] 顏色
Low 低度	Schiff's bases	100%	No color 無色
Moderate 中度	Amadori compounds	60%	Fluorescence 螢光
Severe 重度	Melanoidins	10%	Browning 棕色



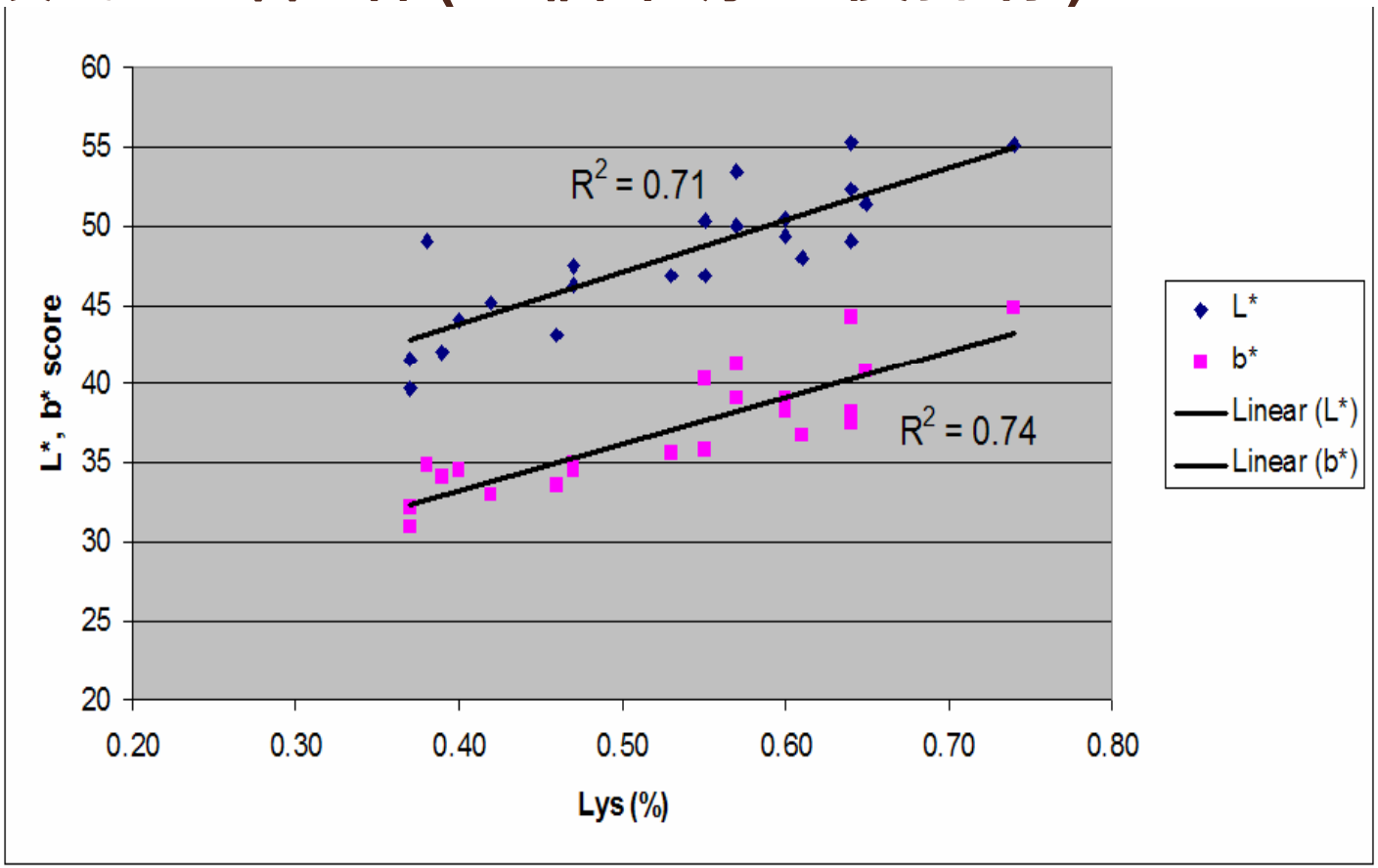
[1]Davies and Labuza, 2000

[2]Finot, 2005

[3]Matiacevich *et al.*, 2005

Regression of Digestible Lysine (%) and Color (L*, b*) of Multiple Samplings from 5 Sources of DDGS for Poultry

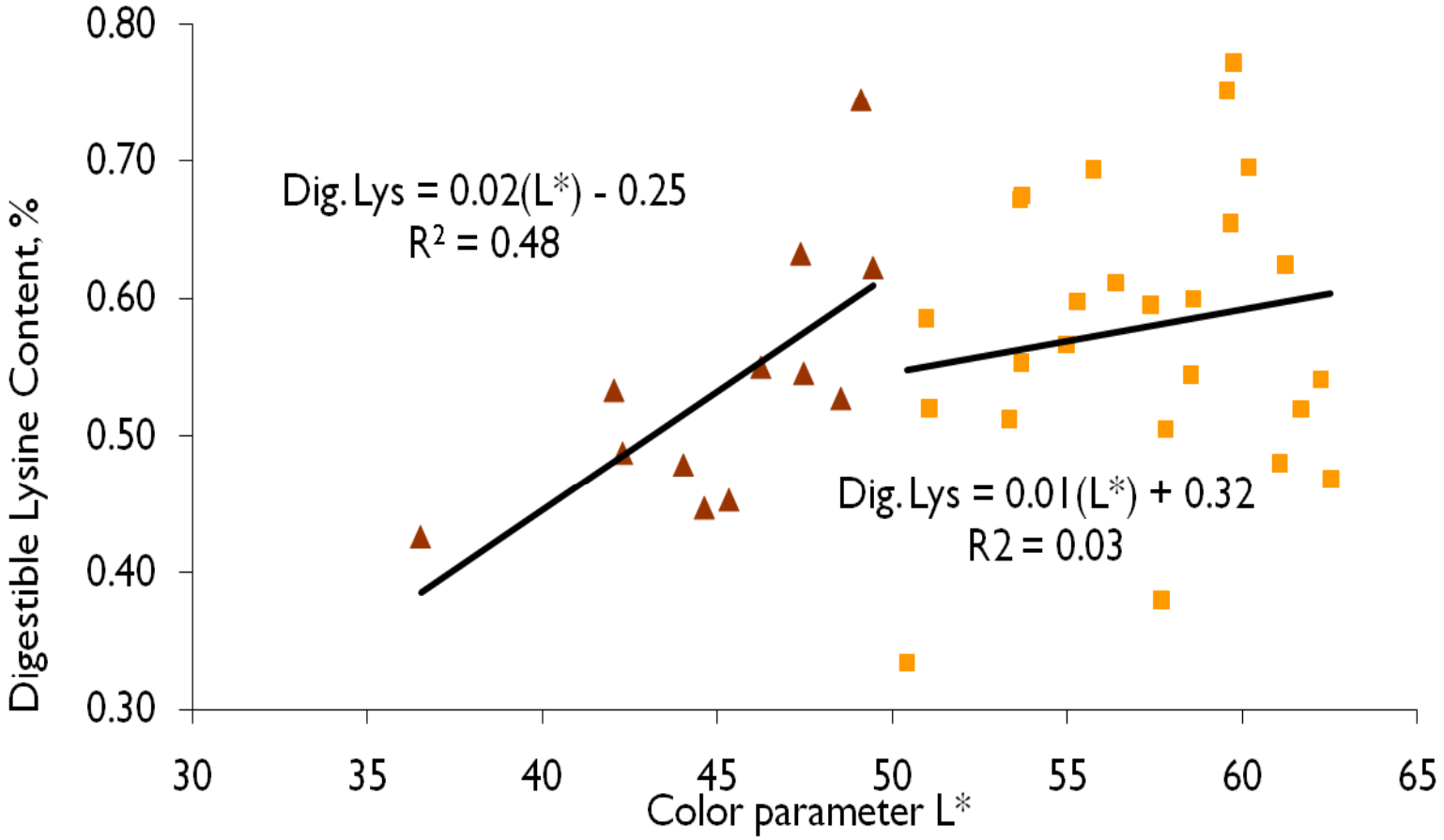
玉米乾酒粕顏色亮度和黃色度與家禽可消化離胺酸的迴歸關係(五個來源重複採樣)



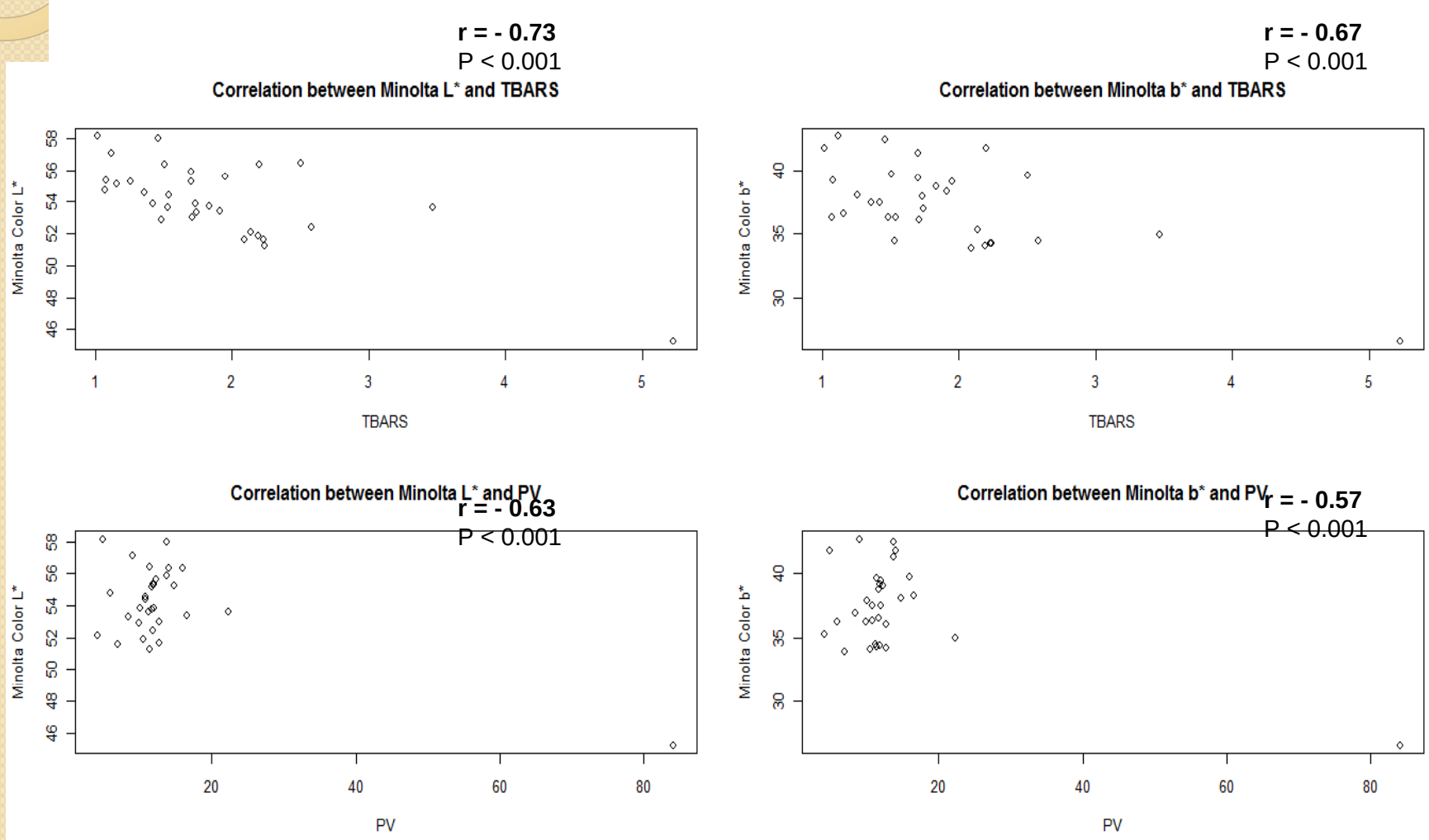
Ergul et al. (2003)

Relationship Between Color (L*) and Digestible Lysine Content in 36 Sources of DDGS for Swine

玉米乾酒粕顏色亮度(L*值)和豬隻可消化離胺酸含量的關係(樣品來自36個不同來源)



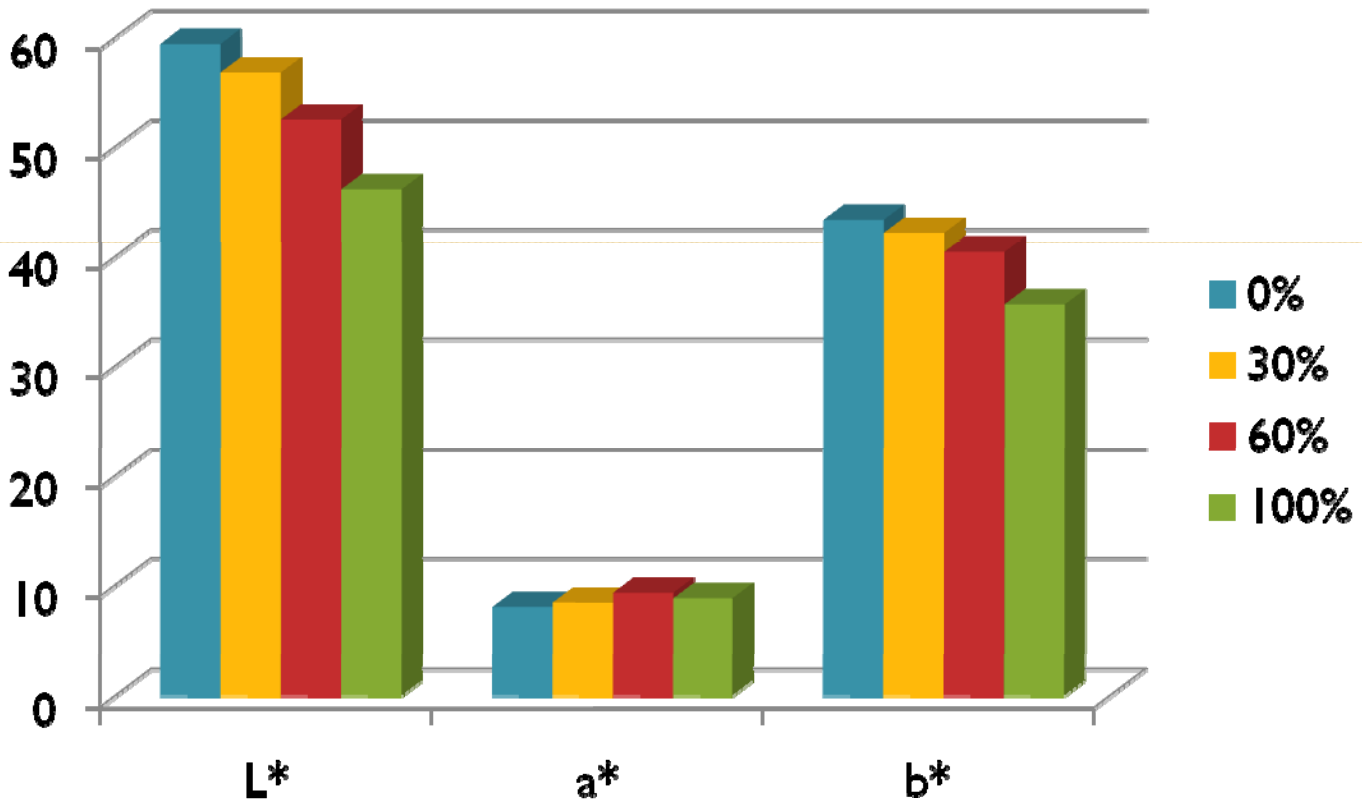
Correlation Between Measures of Lipid Oxidation (TBARS, Peroxide Value) and Color in DDGS
玉米乾酒粕顏色和脂肪氧化(硫代巴比妥酸值、過氧化價)的相關係數



Is Color an Indication of DDGS Quality?
顏色是玉米乾酒粕的品質指標嗎?

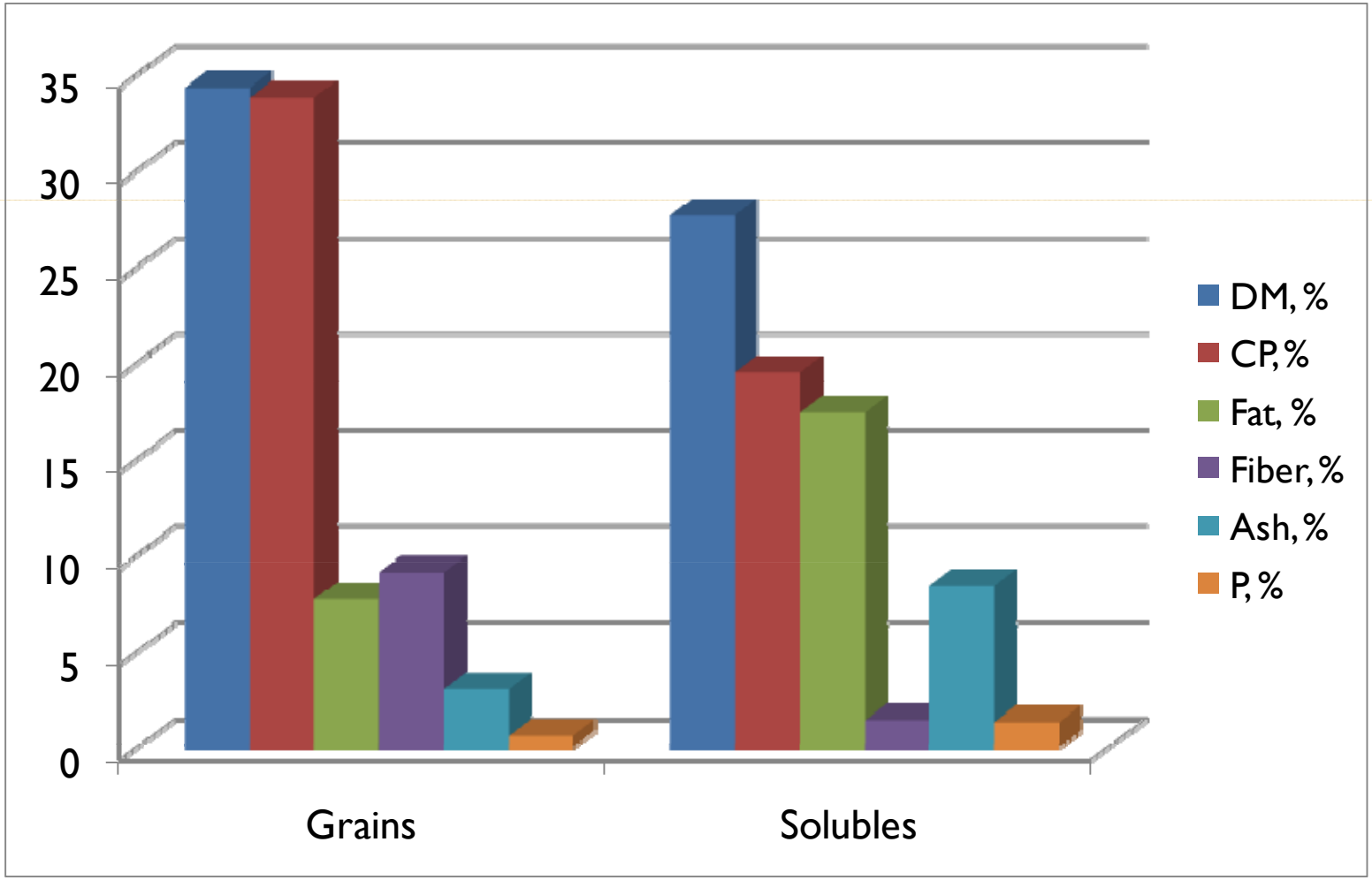
- Positive effects of dark color
  顏色暗黑的正面效應:
  - May indicate more solubles added to grains to produce DDGS生產玉米乾酒粕時可能添加較多的可溶物
    - Increased fat, energy, ash, phosphorus提高脂肪、熱能、灰分、和磷的含量
    - Reduced crude protein and crude fiber降低粗蛋白質和粗纖維
  - May indicate increased P availability磷的有效率可能較高

Effect of Amount of Solubles Addition to Grains Fraction on DDGS Color
可溶物添加量對玉米乾酒粕顏色的影響

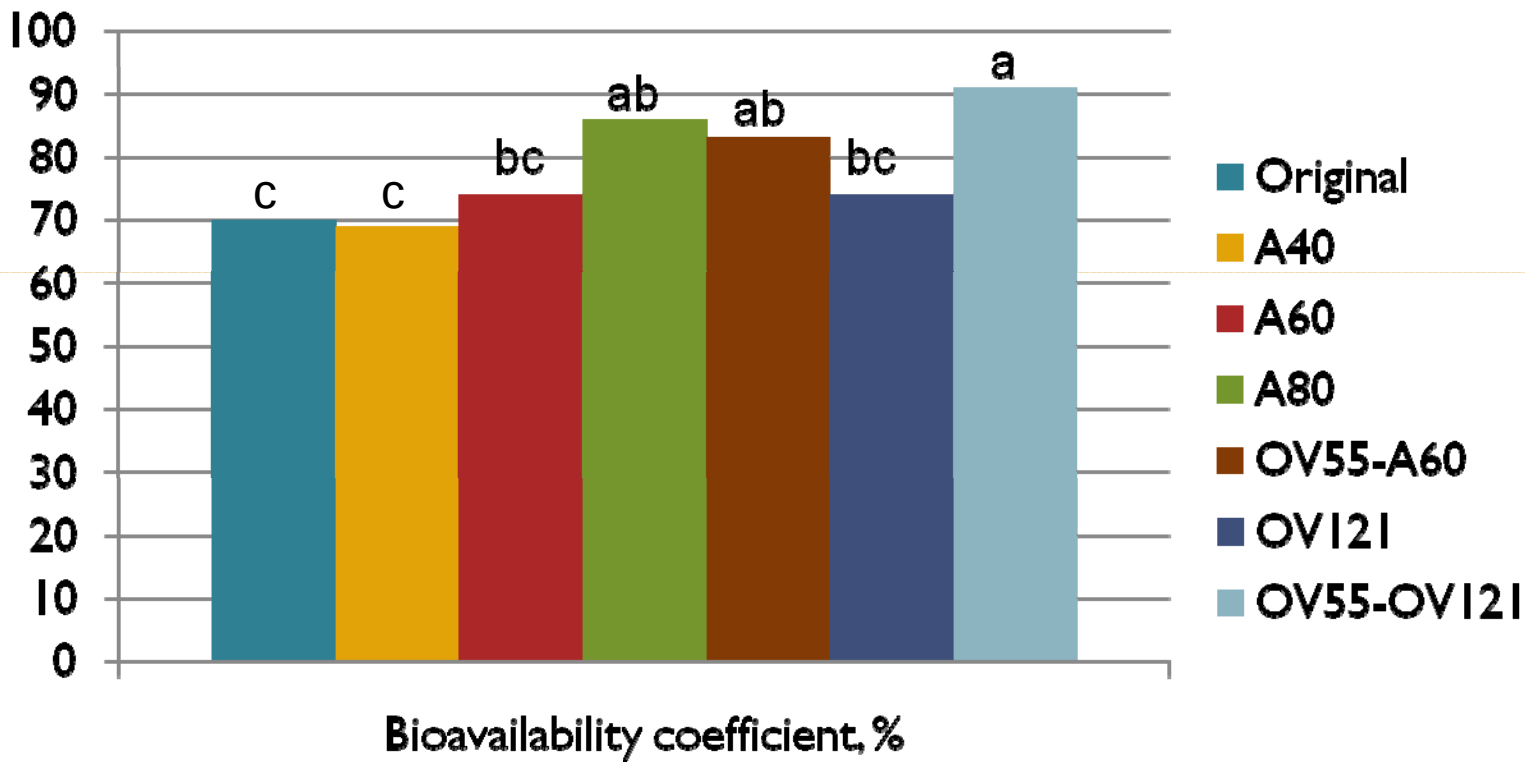


Adapted from Noll et al. (2006)
Pearson correlation (L* = -0.98, a* = 0.62, b* = -0.92)

Comparison of the Nutrient Content of Corn Distiller's Grains and Corn Condensed Distiller's Solubles
不含可溶物酒粕和可溶物的成分比較



Phosphorus Bioavailability Coefficients in DDGS Heat Processed Under Different Conditions for Poultry
不同加熱處理方法對玉米乾酒粕用於家禽的磷生物有效性的影響



[a, b, c] Means with no common superscript differ significantly ($P < 0.05$).
A = autoclaved for 40, 60, or 80 minutes
OV55-A60 = oven dried at 55°C for 3 days then autoclaved for 60 minutes
OV121 = oven dried at 121°C
OV55-OV121 = oven dried at 55°C for 3 days then oven dried at 121°C for 60 minutes

Martinez Amezcua and Parsons (2007)

Nutrient Composition and Variability of DDGS
玉米乾酒粕的成分和變異性

Composition of Selected Nutrients Among 32 DDGS Sources (DM basis)
玉米乾酒粕的營養成分(32個樣品來源，乾物基)

Nutrient營養成分	Average (CV, %) 平均值(變異係數，%)	Range範圍
Dry matter乾物質, %	89.3	87.3 – 92.4
Crude protein粗蛋白質, %	30.9 (4.7)	28.7 – 32.9
Crude fat,粗脂肪 %	10.7 (16.4)	8.8 – 12.4
Crude fiber粗纖維, %	7.2 (18.0)	5.4 – 10.4
Ash, 灰分%	6.0 (26.6)	3.0 – 9.8
Swine ME, kcal/kg (predicted) 預估豬隻可代謝能，千卡/公斤	3810 (3.5)	3504 – 4048
Lysine離胺酸, %	0.90 (11.4)	0.61 – 1.06
Phosphorus磷, %	0.75 (19.4)	0.42 – 0.99

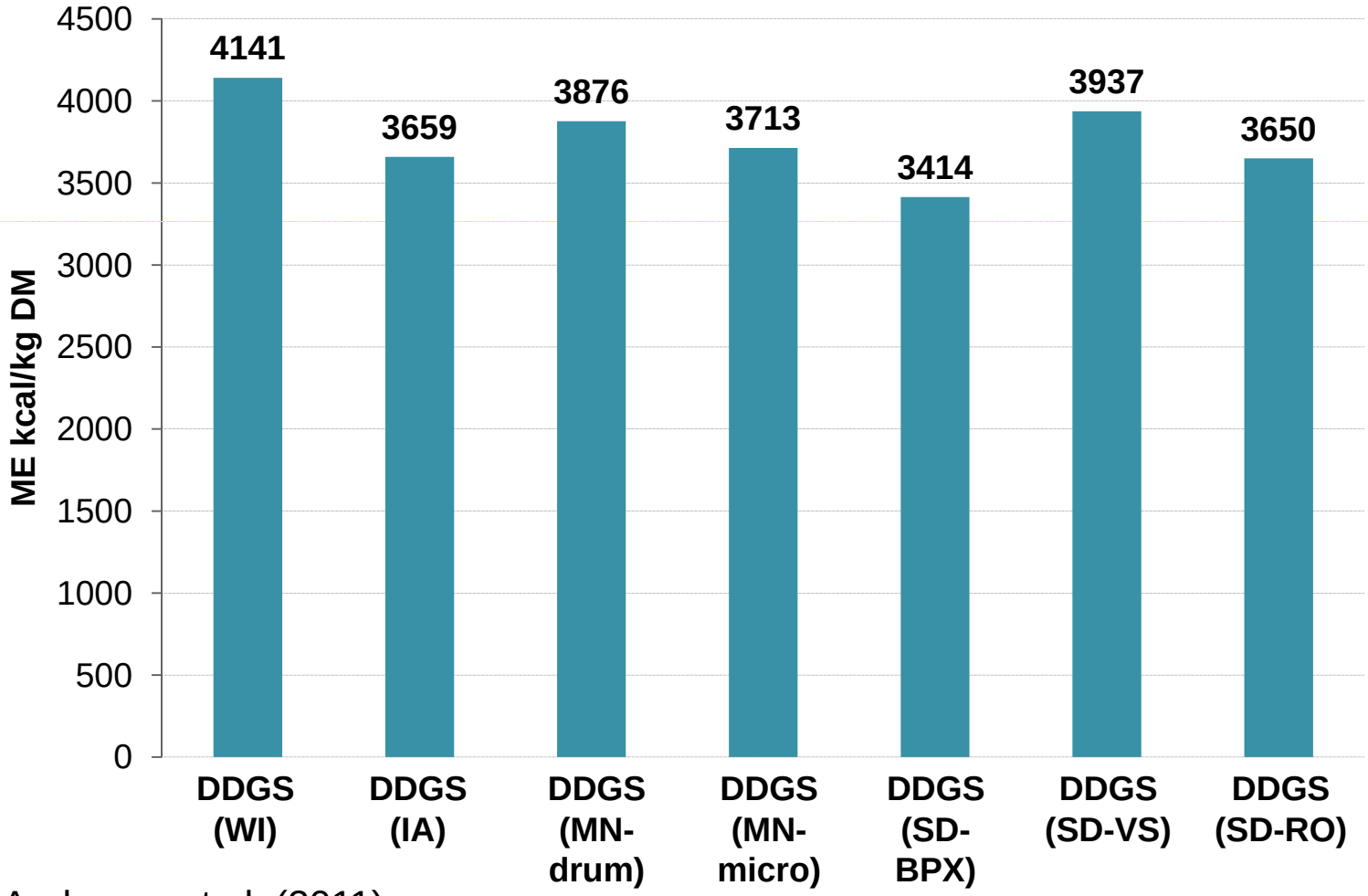
Source: University of Minnesota

Factors Influencing Nutrient Composition of DDGS
影響玉米乾酒粕營養成分的因素

Raw Materials原料	Processing Factors製程因素
•Types of grains股物種類 •Grain variety股物品系 •Grain quality穀物品質 •Soil conditions土壤狀況 •Fertilizer施肥 •Weather氣候 •Production and harvesting methods 生產與收穫 •Grain formula穀物配方 Olentine, 1986	•Grind Procedure粉碎方法 •Fineness粗細度 •Duration持續時間 •Cooking蒸煮方法 •Amount of water添加水量 •Amount of pre-malt發芽前的量 •Temperature and time溫度和時間 •Continuous or batch fermentation連續獲批次發酵 •Cooling time冷卻時間 •Conversion轉換率 •Type, quantity, and quality of malt發芽的形式、量、和品質 •Fungal amylase澱粉酶 •Time and temperature時間和溫度 •Dilution of converted grains轉換股務的稀釋 •Volume and gallon per bushel or grain bill每英斗的加侖量 •Quality and quantity of grain products穀物的質量 •Fermentation發酵 •Yeast quality and quantity酵母的質量 •Temperature溫度 •Time 時間 •Cooling 冷卻 •Agitation攪拌 •Acidity and production control酸度和生產控制 •Distillation蒸餾 •Type: vacuum or atmospheric, continuous or batch發酵槽型式:真空或常壓、連續或批次 •Direct or indirect heating直接或間接加熱 •Change in volume during distillation蒸餾時的容量改變 •Processing製程 •Type of screen: stationary, rotating, or vibratory篩網種類:固定式、轉動式、或震動式 •Use of centrifuges離心 •Type of presses壓榨 •Evaporators蒸發機 •Temperature溫度 •Number數量 •Dryers乾燥機 •Time時間 •Temperature溫度 •Type乾燥型式 •Amount of syrup mixed with grain糖漿(可溶物)的迴加量

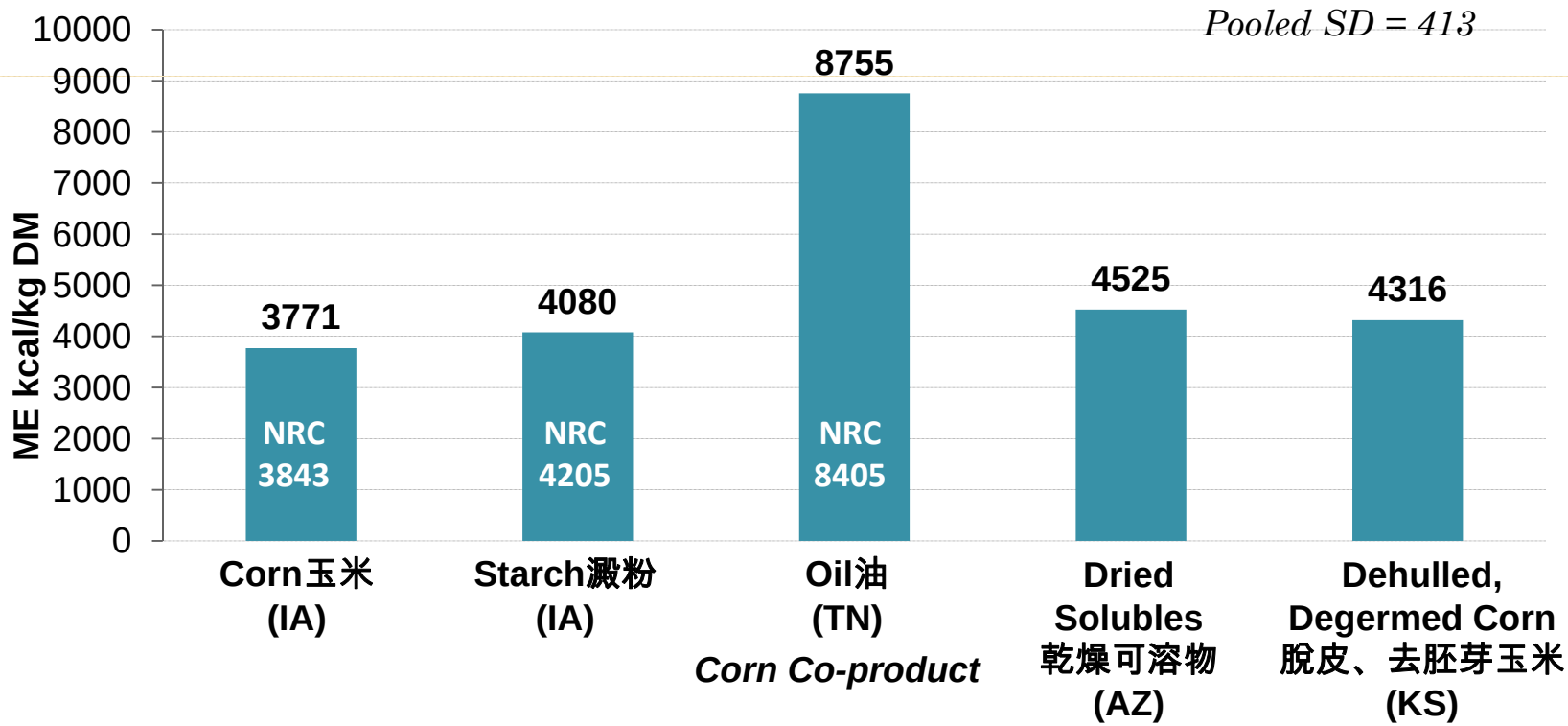
Metabolizable Energy Content and Prediction in DDGS Sources for Swine and Poultry
估算玉米乾酒粕的豬隻與家禽可代謝能

Metabolizable Energy (Swine) of Corn DDGS Co-products
玉米乾酒粕的可代謝能(豬隻)



Anderson et al. (2011)

Metabolizable Energy (Swine) of Low Fiber Corn Co-products
低纖維玉米副產品的可代謝能含量(豬隻)



Anderson et al. (2011)

There Are Many Ways of Measuring and Describing Carbohydrates
分析和描述碳水化合物的方法

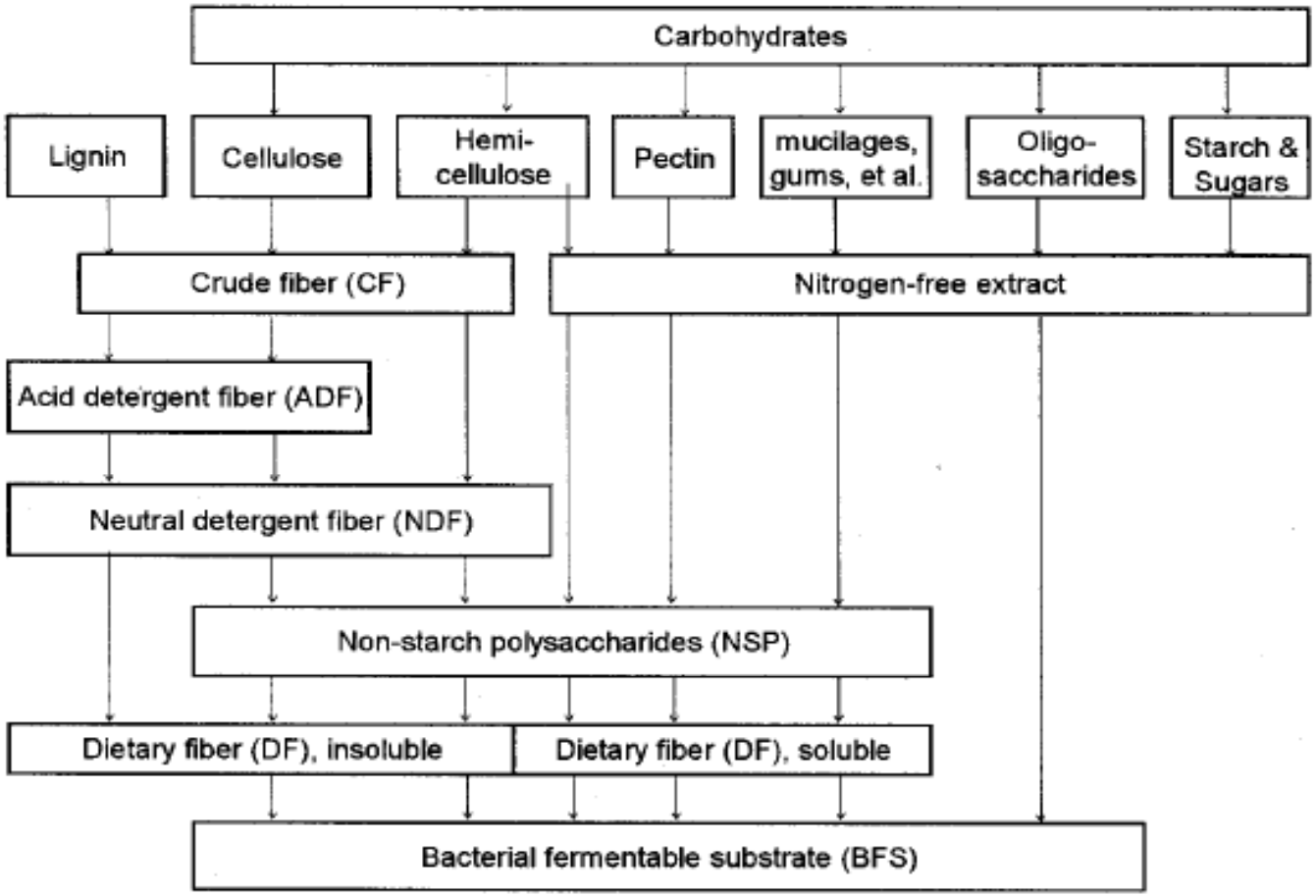
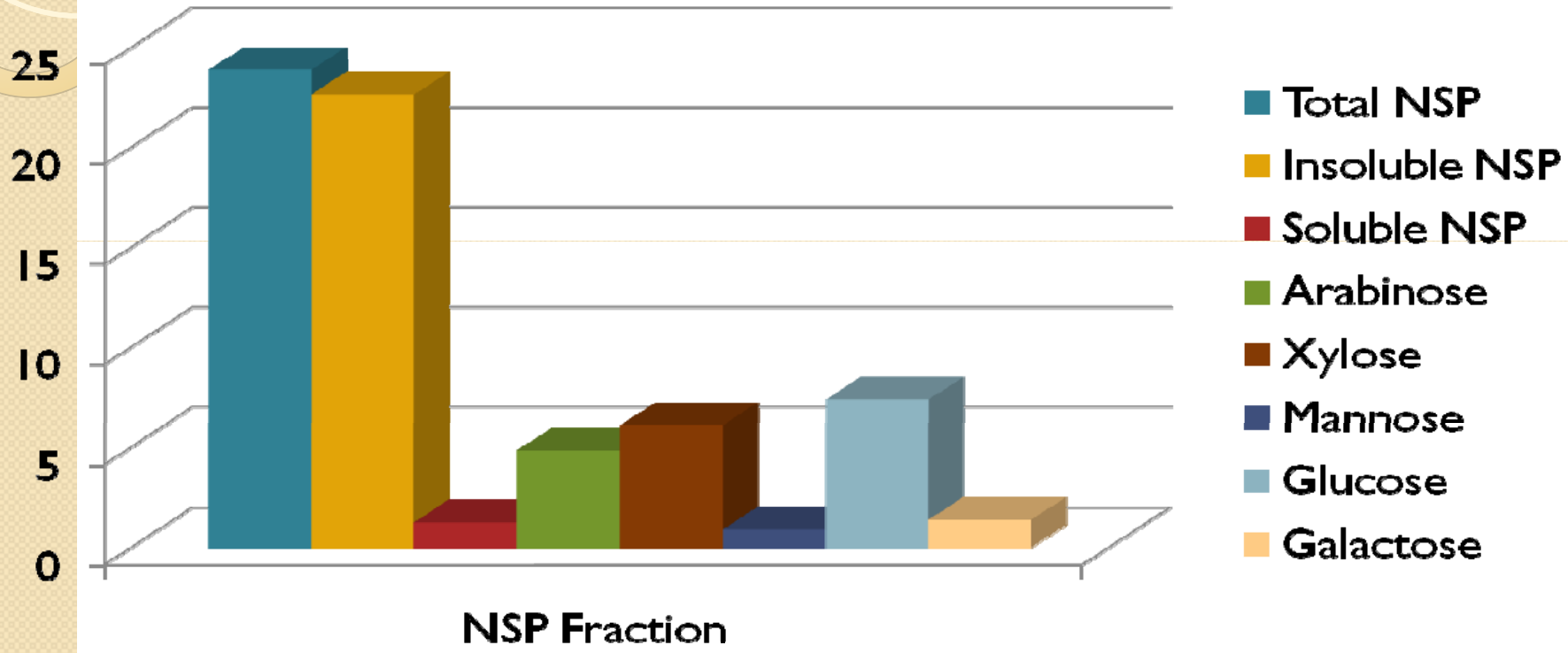


Figure 1.2. Classification of the carbohydrates (adapted from Bakker et al. (1998))

NSP Composition of DDGS (As-is Basis, %)
玉米乾酒粕的非澱粉多醣體組成(實物基，%)



Rhamnose, ribose, and fucose analysis resulted in high lab error and data are not presented.

Patience and Kerr, 2011 (unpublished)

Concentration of Carbohydrates and Apparent Total Tract Digestibility (ATTD) of Dietary Fiber in Corn DDGS
玉米乾酒粕的碳水化合物含量和纖維的腸道表面消化率

Carbohydrate fraction 碳水化合物成分	Average 平均值	Range 範圍	SD 標準偏差
Total starch總澱粉, %	7.3	3.8 – 11.4	1.4
Soluble starch可溶解澱粉, %	2.6	0.5 – 5.0	1.2
Insoluble starch不可溶解澱粉, %	4.7	2.0 – 7.6	1.5
ADF酸洗纖維, %	9.9	7.2 – 17.3	1.2
NDF中洗纖維, %	25.3	20.1 – 32.9	4.8
Insoluble total dietary fiber, % 不可溶總膳食纖維	35.3	26.4 – 38.8	4.0
Soluble dietary fiber, % 可溶總膳食纖維	6.0	2.4 – 8.5	2.1
Total dietary fiber, % 總膳食纖維	42.1	31.2 – 46.3	4.9
ATTD, total dietary fiber, % 總膳食纖維嘗到表面消化率	43.7	23.4 – 55.0	10.2

Stein and Shurson (2009)

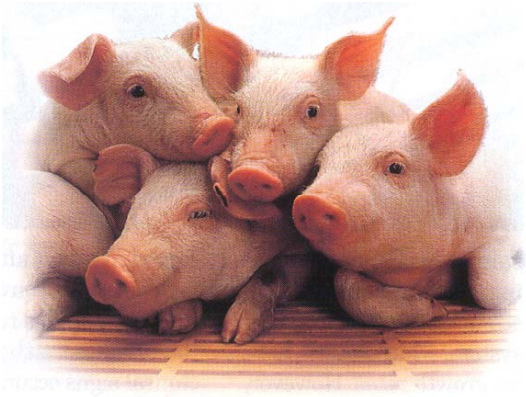
ME Prediction Equations for DDGS in Swine Diets
估算不同來源玉米乾酒粕在豬隻可代謝能值的預測公式

ME kcal/kg DM = (0.949 × kcal **GE**/kg DM) – (32.238 × % **TDF**) – (40.175 × % **ash**)

Anderson et al. (2011) $r^2 = 0.95$ SE = 306

ME kcal/kg DM = 2,815 + (94.5 × % **crude fat**) + (96.2 × % **crude fiber**) – (33.2 × % **NDF**) – (66.2 × % **ash**) + (25.9 × % **starch**)

Mendoza et al. (2010) $r^2 = 0.90$ SE = 49



ME Prediction Equations for DDGS in Swine Diets估算不同來源玉米乾酒粕在豬隻可代謝能值的預測公式(Pedersen et al., 2007)

ME kcal/kg DM = −10,866 − (108.12 × % **ash**) + (37.55 × % **CP**) − (8.04 × % **starch**) − (71.78 × % **EE**) − (164.99 × % **ADF**) + (15.91 × % **NDF**) + (3.007 × **GE**, kcal/kg) $r^2 = 0.99$

ME kcal/kg DM = −11,128 − (124.99 × % **ash**) + (35.76 × % **CP**) − (63.40 × % **EE**) − (150.92 × % **ADF**) + (14.85 × % **NDF**) + (3.023 × **GE**, kcal/kg)
$r^2 = 0.99$

ME kcal/kg DM = −10,267 − (175.78 × % **ash**) + (23.09 × % **CP**) − (71.22 × % **EE**) − (137.93 × % **ADF**) + (3.036 × **GE**, kcal/kg)
$r^2 = 0.99$

ME kcal/kg DM = −7,803 − (223.19 × % **ash**) − (61.30 × % **EE**) − (121.94 × % **ADF**) + (2.702 × **GE**, kcal/kg)
$r^2 = 0.97$

ME kcal/kg DM = −4,212 − (266.38 × % **ash**) − (108.35 × % **ADF**) + (1.911 × **GE**, kcal/kg)
$r^2 = 0.94$

AME Prediction Equations for Corn Co-products (Including DDGS) in Poultry Diets
預測玉米副產品(包括玉米乾酒粕)的家禽表面可代謝能公式

Based on 13 diverse corn co-products:

AME_n, kcal/kg DM = 3,517 + (46.02 × % **crude fat**) – (82.47 × % **ash**) – (33.27 × % **hemicellulose**)

Dozier et al. (2010) $r^2 = 0.89$, SE = 191

Based on DDGS only:

AME_n = 2138 - (263.5 x % **crude fiber**) + (566.3 x % **ash**) $r^2 = .99$
AME_n = 1278 - (19.7 x % **TDF**) + (470 x % **ash**) $r^2 = .99$

Dozier et al. (2011)

Prediction of Poultry TME of DDGS from Proximate Values of Crude Protein, Fat, Fiber and Ash Content以粗蛋白質、脂肪、纖維、和灰分含量預測玉米乾酒粕的家禽真可代謝能(TME)公式(Batal and Dale, 2006)

TME_n, **kcal/lb** = 2439.4 + (43.2 × % crude fat) $r^2 = 0.29$

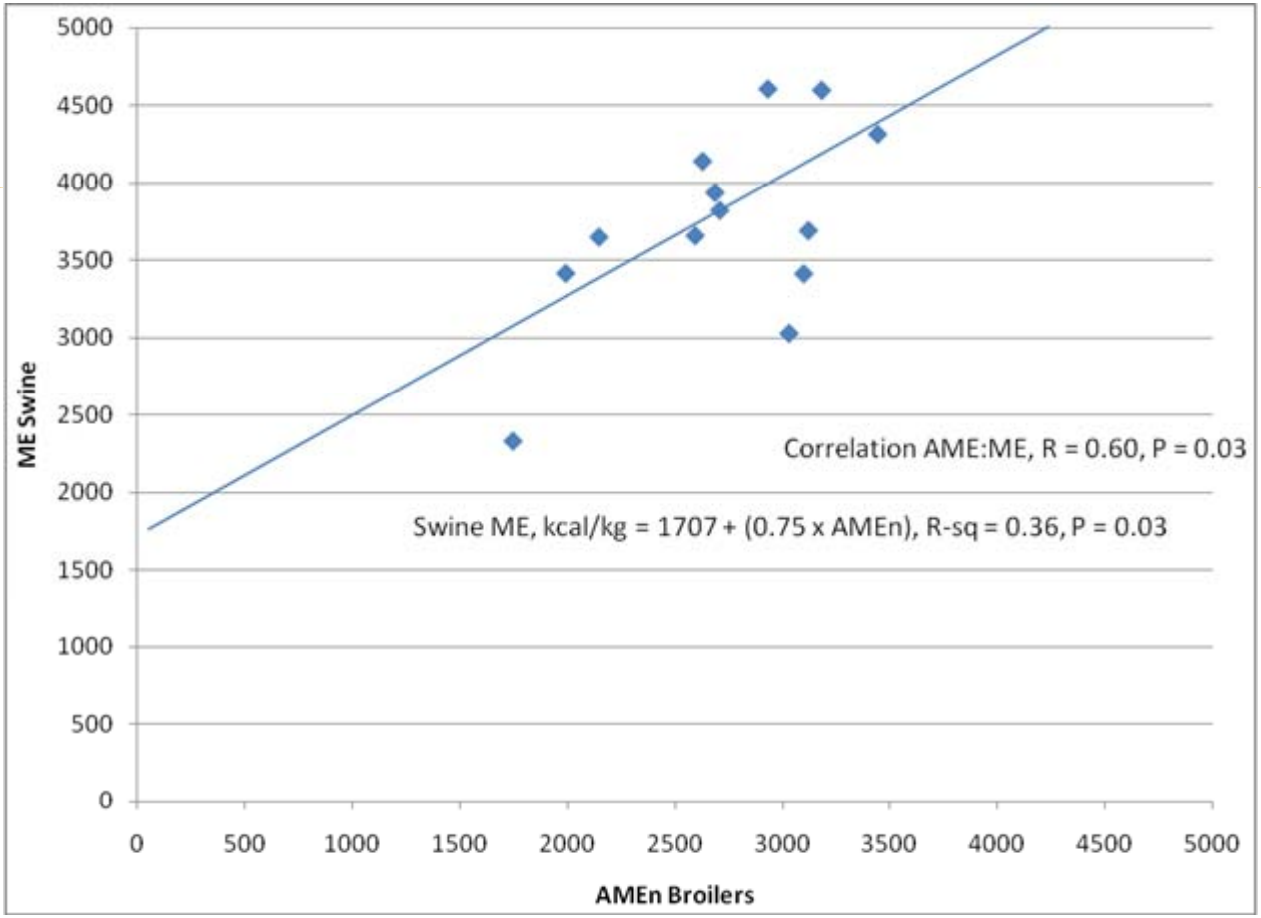
TME_n, **kcal/lb** = 2957.1 + (43.8 × % crude fat) – (79.1 × % crude fiber) $r^2 = 0.43$

TME_n, **kcal/lb** = 2582.3 + (36.7 × % crude fat) – (72.4 × % crude fiber) + (14.6 × % crude protein) $r^2 = 0.44$

TME_n, **kcal/lb** = 2732.7 + (36.4 × % crude fat) – (76.3 × % crude fiber) + (14.5 × % crude protein) – (26.2 × % ash) $r^2 = 0.45$

Average TME_n for 17 DDGS samples of 1282 ± 82 **kcal/lb**, with a range of 1132 to 1450 **kcal/lb**

Correlation Between Swine ME and Poultry AME for Corn Co-products
玉米副產品的豬隻可代謝能和家禽表面可代謝能的相關性



Dozier and Kerr, 2011 (unpublished)

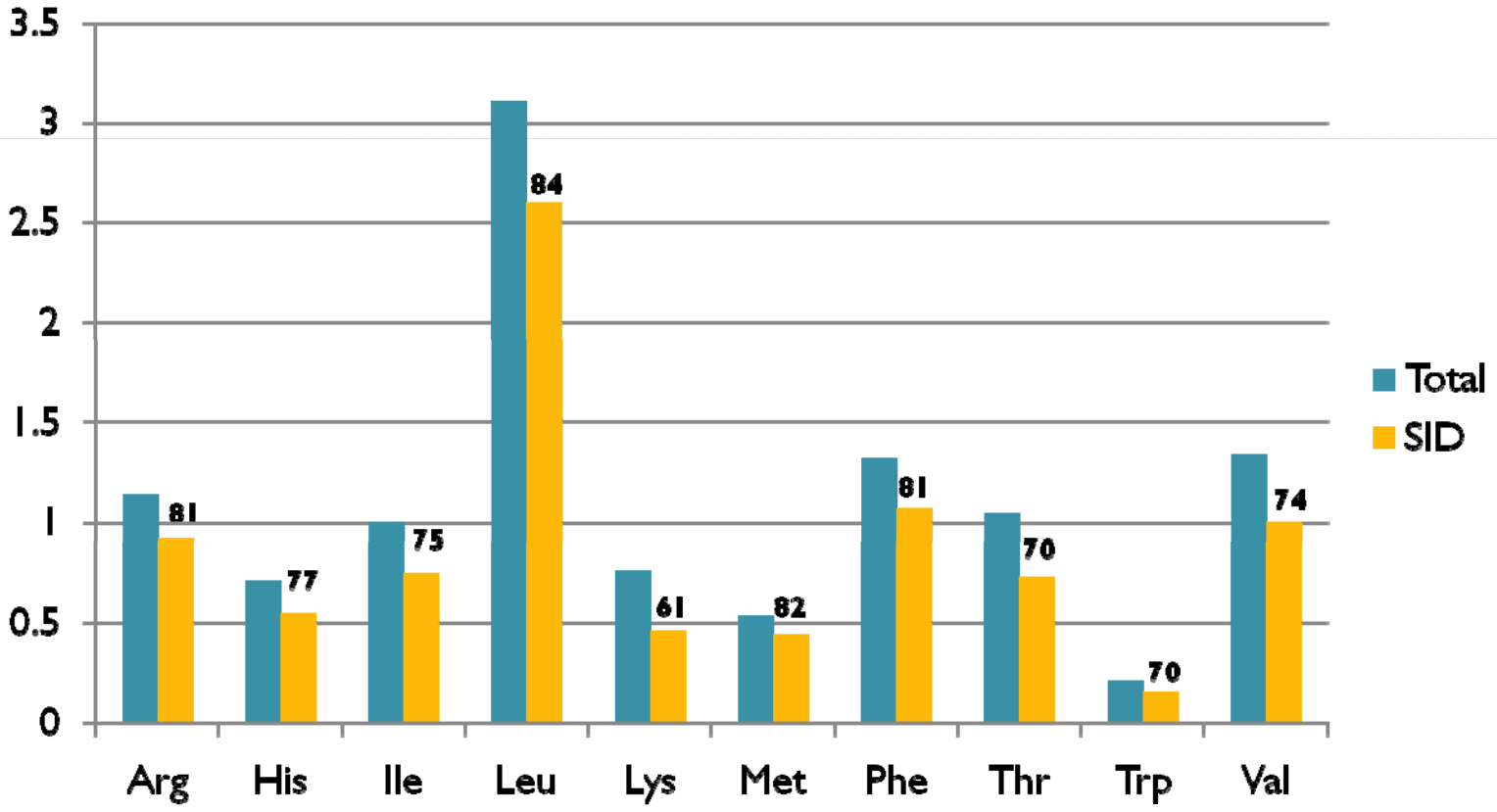
Challenges of Using ME Equations
使用可代謝能估算公式的挑戰

- Validate accuracy準確性的驗證
- Representative of nutrient variability among sources?

  是否代表不同來源樣品的變異性?
- Some analyses required by equations (e.g. GE, TDF) are not:某些公式中需要的養份分析項目
  - routinely measured不會例行檢驗
  - expensive成本很高
- Analytical variability among labs and procedures affects accuracy (e.g. NDF).不同的試驗室和分析方法而有潛在的分析變異
- Adjustments for fat and fiber in some equations seem counterintuitive.某些公式中脂肪和纖維的調整和既有的觀念相反

Prediction of Amino Acid Content and Digestibility of DDGS
預測玉米乾酒粕的胺基酸含量和消化率

Average Concentration (%) and Standardized Ileal Digestibility (SID) of Amino Acids in Corn DDGS for Swine
玉米乾酒粕的胺基酸平均濃度(%)和豬隻的胺基酸標準化迴腸消化率



Stein and Shurson, 2009

Variation in Digestible Crude Protein and Amino Acid Content in 34 Sources of Corn DDGS
玉米乾酒粕的可消化粗蛋白質和胺基酸含量(34個來源)

Nutrient 營養成份	Maximum 最高值	Minimum 最低值	CV, % 變異係數
Crude protein粗蛋白質, %	28.3	18.8	12.2
Lysine離胺酸, %	0.77	0.33	18.4
Methionine甲硫胺酸, %	0.66	0.40	12.6
Threonine息寧胺酸, %	0.96	0.68	10.2
Tryptophan色胺酸, %	0.21	0.10	15.8

Equations to Predict Amino Acid Content of DDGS from Crude Protein (CP), Fat, and Fiber
以粗蛋白質、脂肪、和纖維預測玉米乾酒粕胺基酸含量的公式

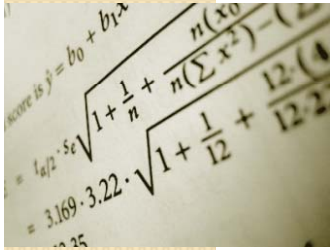
Amino acid	Equation	R^2
Arginine	Y = 0.07926 + 0.0398 x CP	0.48
Isoleucine	Y = -0.23961 + 0.04084 x CP + 0.01227 x fat	0.86
Leucine	Y = -1.15573 + 0.13082 x CP + 0.06983 x fat	0.86
Lysine	Y = -0.41534 + 0.04177 x CP + 0.00913 x fiber	0.45
Methionine	Y = -0.17997 + 0.02167 x CP + 0.01299 x fat	0.78
Cystine	Y = 0.11159 + 0.01610 x CP + 9.00244 x fat	0.52
TSAA	Y = -0.12987 + 0.03499 x CP + 0.05344 x fat – 0.00229 x fat^2	0.76
Threonine	Y = -0.05630 + 0.03343 x CP + 0.02989 x fat – 0.00141 x fat^2	0.87
Tryptophan	Y = 0.01676 + 0.0073 x CP	0.31
Valine	Y = 0.01237 + 0.04731 x CP + 0.00054185 x fat^2	0.81

Fiene et al. (2006)

Prediction of Amino Acid Digestibility in DDGS
預測玉米乾酒粕的胺基酸消化率

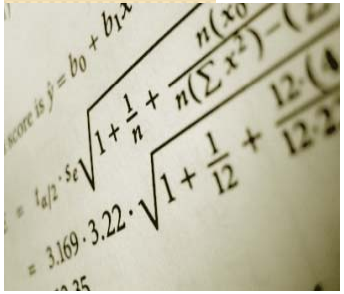
- Crude protein粗蛋白質
  - **Poor prediction** of SID Lys 預測離胺酸標準化迴腸消化率的準確度低(r^2 = 0.02)
    - Kim et al., 2010

- Total lysine總離胺酸
  - **Good predictor** of SID Lys預測離胺酸標準化迴腸消化率的好指標(r^2 = 0.85)
    - Kim et al., 2010
  - SID Lys% = - 0.482 + (1.148 × analyzed Lys, %)



Prediction of Amino Acid Digestibility in DDGS 預測玉米乾酒粕的胺基酸消化率

- Reactive lysine活性離胺酸含量
  - **Good predictor** of SID Lys預測離胺酸標準化迴腸消化率的好指標(r^2 = 0.90)
    - Kim et al., 2010
  - SID Lys% = - 0.016 + (0.716 × reactive Lys, %)
- Lysine:CP ratio預測離胺酸標準化迴腸消化率的好指標
  - **General indicator** of relative lysine digestibility相對離胺酸消化率的一般指標
    - > 2.8 lys:CP for use in swine and poultry diets比值大於2.8的玉米乾酒粕可以用於豬和家禽飼糧的原料



Prediction of Amino Acid Digestibility in DDGS預測玉米乾酒粕的胺基酸消化率

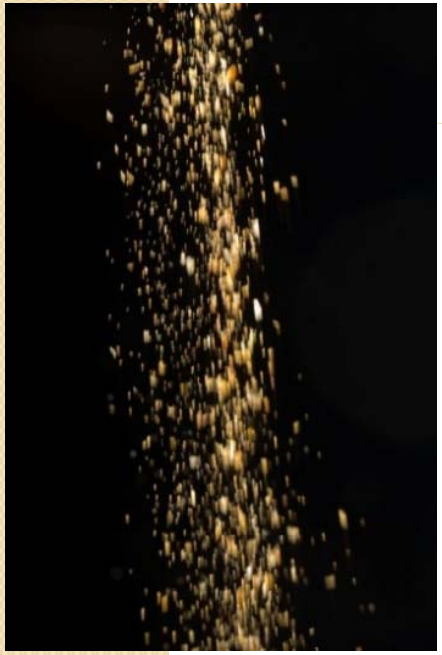
- IDEA™ - Novus固定式消化酵素測定法
  - **Good predictor** of Dig Lys for poultry (r^2 = 0.88) but not for swine or other amino acids預測家禽的可消化離胺酸準確度還不錯，但對豬隻和其它胺基酸則不適用
    - (Schasteen et al., 2005)
- Pepsin-pancreatin胃蛋白酶-胰酶
  - **Poor predictor** of CP digestibility不是預測粗蛋白質消化率的好指標 (r^2 = 0.55) Pedersen et al. (2005)
- ADIN酸洗不可溶纖維
  - **Moderate correlation** with DDGS color和玉米乾酒粕的顏色中度相關 (r^2 = 0.62)
    - Cromwell et al. (1991)
  - **Higher correlation** with broiler ADG (r^2 = 0.86) and F/G (r^2 = 0.72)和肉雞的日增重和飼料換肉率高度相關

Prediction of Amino Acid Digestibility in DDGS預測玉米乾酒粕的胺基酸消化率

- Color (L*, a*, b*)顏色(亮度、紅色度、黃色度)

- Optical density吸光值
- Front face fluorescence 表面螢光光電比色法

Commercial Nutritional "Tools" Are Available to Manage Nutrient Variability Among DDGS Sources
管理不同來源玉米乾酒粕成份變異的商業化工具



- Assess relative value among sources
  評估不同來源的相對價值
- Provide accurate nutrient loading values for diet formulation提供核算日糧配方所需的準確營養值
- Examples例子:
  - Illuminate® - VAST
  - Optimum Value Supplier® database - Cargill
  - Aminored ® - Evonik
  - IDEA® - NOVUS
  - Adisseo

Illuminate® 試驗室分析結果 Laboratory Results

	A	B	C	D	E
DM乾物質, %	87.9	90.1	86.5	91.7	90.0
Crude protein粗蛋白質, %	28.2	26.7	27.7	26.7	25.1
Fat脂肪, %	11.4	9.9	11.5	10.6	11.2
Starch澱粉, %	7.3	8.1	7.2	8.3	4.6
ADF酸洗纖維, %	11.4	10.8	12.5	10.6	8.6
Ash灰分, %	4.5	3.3	4.4	3.9	4.4
Phosphorus磷, %	0.90	0.66	0.82	0.75	0.76
Lysine,離胺酸 %	0.88	0.83	0.86	0.89	0.78

Illuminate® Nutrient Loadings and Relative Value Comparison of 5 DDGS Sources for Swine
五個不同玉米乾酒粕的營養分析值相對價值比較(豬隻)

	A	B	C	D	E
ME, kcal/kg 可代謝能，千卡/公斤	3070	3460	2970	3410	3540
Dig. Lys可消化離胺酸, %	0.54	0.52	0.54	0.61	0.54
Dig. Met可消化甲硫胺酸, %	0.50	0.47	0.49	0.48	0.46
Dig.Thr可消化息寧胺酸, %	0.70	0.68	0.70	0.72	0.68
Dig.Trp可消化色胺酸, %	0.16	0.15	0.16	0.16	0.14
Avail. Phos有效磷, %	0.67	0.50	0.62	0.56	0.64
Relative Value相對價值	$175	$204	$165	$208	$215

Are DDGS a source of mycotoxins? 玉米乾酒粕是黴菌毒素的來源?

- Yes, but…是的，可是……
  - no more than corn from which it is made不會比其原料玉米嚴重
    - Levels in corn concentrated by ~ 3x in DDGS玉米的黴菌毒素會在玉米乾酒粕中濃縮3倍
    - Ethanol plants have implemented mycotoxin screening of incoming corn loads酒精工廠對進貨的玉米會執行嚴格的篩檢
    - 2009 was a bad year for vomitoxin in corn across the Midwestern U.S. 2009年美國中西部的玉米嘔吐毒素的汙染情況嚴重
      - Ethanol plants rejected high vomitoxin corn to minimize levels in DDGS酒精工廠退運高嘔吐毒素的玉米以降低玉米乾酒粕的毒素濃度
    - 2010 corn crop was very low in mycotoxins = low mycotoxins in 2011 DDGS.

2010年的玉米黴菌毒素很低=2011年玉米乾酒粕的毒素也很低

Results from a Comprehensive DDGS Sampling Survey on Mycotoxin Contamination (Zhang et al., 2009)玉米乾酒粕黴菌毒素汙染的全面性採樣調查結果

- 235 samples (2006 to 2008)2006至2008年共採樣235個樣品
  - 20 ethanol plants.二十個酒精工廠
  - 23 export shipping containers二十三個出口貨櫃
- Determined the prevalence and levels of測定下列毒素的發生率和濃度:
  - Aflatoxins黃麴毒素
  - Deoxynivalenol嘔吐毒素
  - Fumonisins伏馬鐮孢毒素
  - T-2 toxin毒素
  - Zearalenone玉米赤黴醇

Results from a Comprehensive DDGS Sampling Survey on Mycotoxin Contamination (Zhang et al., 2009)玉米乾酒粕黴菌毒素汙染的全面性採樣調查結果

1. None of the samples contained aflatoxins or deoxynivalenol levels > U.S. FDA guidelines for use in animal feed

   沒有樣品的黃麴毒素和嘔吐毒素的濃度超過美國食品藥物管理局飼料規範

2. No more than 10 % of the samples contained fumonisin levels > the recommendation for feeding equids and rabbits, and remaining samples contained fumonisins < FDA guidelines for use in animal feed

   伏馬鐮孢毒素濃度高於馬和兔子餵飼標準的比例不超過10%，其餘樣品的伏馬鐮孢毒素含量都不超過食品藥物管理局的規範

Results from a Comprehensive DDGS Sampling Survey on Mycotoxin Contamination (Zhang et al., 2009)玉米乾酒粕黴菌毒素汙染的全面性採樣調查結果

3. None of the samples contained T-2 toxins > the detection limit

   沒有樣品含有可檢出的T-2毒素

4. Most samples contained zearalenone levels < the detection limit

   大部分樣品的玉米赤黴醇濃度都不高於可檢出下限

5. Containers used for export shipping of DDGS did not contribute to mycotoxin production

   用於出口運輸的貨櫃並不會造成黴菌毒素的產生

Presence of mycotoxins in DDGS samples from 14 ethanol plants in 7 states in the Midwest U.S.
美國中西部七州十四個酒精工廠玉米乾酒粕樣品的黴菌毒素發生狀況

黴菌毒素 Mycotoxin	樣品數 N	最低值 Minimum Level	最高值 Maximum Level	平均值 Average Level	超標百分比 % Samples Above Lowest FDA Level
Aflatoxin, ppb 黃麴毒素	20	< 1	3.7	0.7	0 %
DON, ppm 嘔吐毒素	20	< 0.1	1.2	0.3	0 %
Fumonisin, ppm 伏馬鐮孢毒素	20	< 0.1	8.6	1.9	10 %
T-2 toxin毒素, ppm	20	< 0.1	< 0.1	0.0	NA
Zearalenone, ppm 玉米赤黴醇	20	< 0.05	0.14	0.04	NA

NCERC (2008)

Presence of mycotoxins in DDGS samples from 4 Midwestern U.S. ethanol plants (2008)

美國中西部四個酒精工廠玉米乾酒粕樣品的黴菌毒素發生狀況(2008)

黴菌毒素 Mycotoxin	樣品數 N	最低值 Minimum Level	最高值 Maximum Level	平均值 Average Level	超標百分比 % Samples Above Lowest FDA Level
Aflatoxin, ppb 黃麴毒素	77	< 1	1.1	0.01	0 %
DON, ppm 嘔吐毒素	77	0.2	1.9	0.5	0 %
Fumonisin, ppm 伏馬鐮孢毒素	77	< 0.2	7.2	2.7	10 %
T-2 toxin毒素, ppm	77	Not available	Not available	Not available	NA
Zearalenone, ppm 玉米赤黴醇	77	< 0.2	< 0.2	0.0	NA

Primary Mechanisms Through Which Mycotoxins Affect Animals

- Reduction in feed intake

- Suboptimal nutrition
  - Reduce nutrient content of feed
  - Reduce nutrient absorption
  - Alter nutrient metabolism

- Suppress the immune system
- Hormonal effects (primarily estrogenic)
- Antibiotic effects
- Cellular death

Aflatoxins黃麴毒素

- Many types種類
  - B1, B2, G1, G2, M1, M2
- Produced by由 *Aspergillus flavus*菌屬在適當的情況下產生 under ideal production conditions:
  - 82° to 90° F 華氏
  - Grain moisture穀物水分 22% to 26%
- More of a problem in the SE U.S.
  大多發生在美國東南部
- Occur in the Midwest during drought conditions
  美國中西部乾旱情況下也會發生

Aflatoxins黃麴毒素

- Only mycotoxin regulated by FDA
  美國食品藥物管理局唯一明文規範的毒素
  - Carcinogenic具致癌性
- No more than 20 ppb allowed for interstate shipment
  跨州運輸的產品不得超過20ppb
- Grains with > 20 ppb can not be used for human food consumption and dairy feeds
  超過20ppb的穀物不可用於食品和乳牛飼料
  - Should not be used in feeds for young animals
    不可用於幼畜飼料

Aflatoxins黃麴毒素

- 濃度在At 20 to 200 ppb
  - Reduces appetite and growth rate
    食慾和生長速度下降
  - Suppresses the immune system
    抑制免疫系統
  - Decreases milk production
    降低產乳量
- 高於> 1000 ppb
  - Death致死

FDA Action Levels for Aflatoxins
食品藥物管理局的黃麴毒素管理行動標準

• finishing beef cattle肥育肉牛	< 300 ppb
• finishing swine (>100 lbs) 肥育豬	< 200 ppb
• breeding beef cattle 種用肉牛	< 100 ppb
• breeding swine 種豬	< 100 ppb
• mature poultry 成禽	< 100 ppb
• immature animals, dairy cattle, or intended use is not known 幼畜、乳牛或未知用途之禽畜	< 20 ppb

Deoxynivalenol (vomitoxin) 嘔吐毒素

- Produced by 由*Fusarium graminearum*菌屬產生
  - White or reddish fungus白色或紅色黴菌
- Ideal growing conditions理想的生長狀況
  - Cool, damp weather涼爽潮濕的氣候
- More common in upper Midwest and Canada 較常發生在美國上中西部和加拿大
- Reduces feed consumption and causes vomiting at high levels降低採食量，高濃度時會引起嘔吐

FDA Action Levels for DON
食品藥物管理局的嘔吐毒素管理行動標準

- Beef cattle > 4 mo. of age四月齡以上肉牛 <10 ppm
- Chickens 雞 < 10 ppm
  - these ingredients should be < 50% of the diet of cattle and chickens該原料使用量不超過牛和雞日糧的50%
- All other animals 其它動物 < 5 ppm
  - these ingredients not exceed 40% of the diet of cattle and chickens該原料使用量不超過日糧的40%
- Swine 豬 < 5 ppm
  - these ingredients not exceed 20% of the diet該原料使用量不超過日糧的20%

Zearalenone玉米赤黴醇

- Produced by 由*Fusarium graminearum* 菌屬產生and may be present with DON可能和嘔吐毒素並存
- More likely to be produced during grain storage
  較常在穀物儲存的過程發生
- Mimics the action of estrogen and should NOT be fed to breeding animals
  具有類似動情素的作用，不可用於種用動物
- Causes造成
  - Abortions流產
  - Prolapses生殖道脫垂
  - Shrunken ovaries卵巢萎縮
  - Decreased fertility繁殖力下降

FDA Action Levels for Zearalenone
食品藥物管理局的玉米赤黴醇毒素管理行動標準

- None未制定明確標準
- Swine豬隻
  - Finishing pigs 肥育豬 < 3 ppm
  - Breeding herd 種豬 < 2 ppm
  - Young growing pigs幼小成長豬 < 1 ppm

Fumonisins伏馬鐮孢毒素

- Types 類型B1 (75%), B2, and B3

- Produced by 由*Fusarium moniliforme*菌屬產生
- Found in corn in upper Midwest主要在上中西部所產的玉米中發現
- Carcinogenic有致癌性
- Causes:造成
  - Weakened immune system弱化免疫系統
  - Pulmonary edema肺水腫
  - Reduced brain, liver and lung function傷害腦、肝臟和肺臟的功能

FDA Action Levels for Fumonisins
食品藥物管理局的伏馬鎌孢毒素管理行動標準

- Poultry being raised for slaughter肉用家禽 < 100 ppm
  - < than 50% of the diet 用量不超過日糧的50%
- Ruminants raised for slaughter肉用反芻動物 < 60 ppm
  - < 50% of the diet用量不超過日糧的50%
- Breeding ruminants and poultry種用反芻動物和家禽< 30 ppm
  - < 50% of the diet用量不超過日糧的50%
- Swine 豬隻 < 20 ppm
  - < 50% of the diet用量不超過日糧的50%
- All other species or classes of livestock and pets 其它家禽和寵物 < 10 ppm
  - < 50% of the diet用量不超過日糧的50%
- Horses and rabbits 馬和兔子 < 5 ppm
  - < 20% of the diet用量不超過日糧的20%

Mycotoxin Adsorbents
黴菌毒素吸附劑

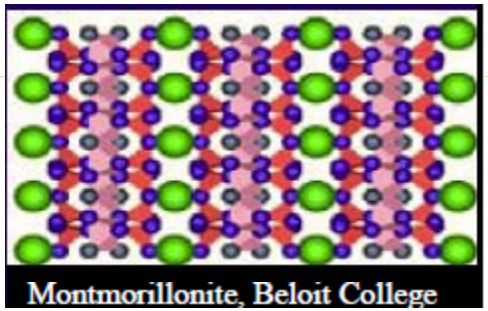
- An ideal mycotoxin adsorbent should effectively sequester mycotoxin(s) to prevent toxicity in the gastrointestinal tract and prevent absorption across the gut wall when added to the diet.
  理想的黴菌毒素吸附劑要能有效的吸附封存黴菌毒素以預防期在消化道所造成的毒性，並且避免毒素在腸道被吸收

A Mycotoxin Adsorbent Should:
黴菌毒素吸附劑需要能:

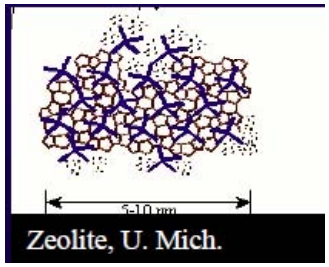
- Effectively adsorb mycotoxins of interest
  有效的吸附黴菌毒素標的
- Reduce mycotoxin availability/activity
  降低黴菌毒素的有效性和毒性
- Reduce animal toxicity and tissue residues
  減少動物的毒性和在組織的殘留
- Not be detrimental to the animal of food products
  不能對動物有害
- Have verifiable positive results
  證實有正面的效果
- effectiveness must be verified at the recommended diet inclusion rate
  在建議使用量下，證實有實際效果
- Resistant to physical effects of feed manufacturing
  能夠耐過飼料加工過程的物理作用
- Be cost effective 符合經濟效益

Mycotoxin Adsorbents
黴菌毒素吸附劑

- Silicate products矽酸鹽類
  - Phyllosilicates (silicate sheets)層狀矽酸鹽
    - Clays黏土
      - Montmorillonite蒙莫里榮高嶺土
      - Bentonite膠質粘土、澎潤土
      - Smectite (HSCAS)蒙脫石
      - Sepiolite海泡石


Montmorillonite, Beloit College

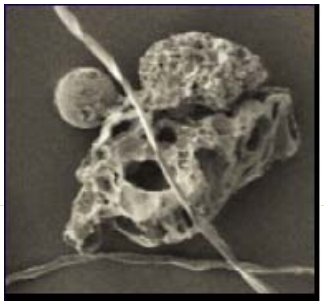
  - Tectosilicate架狀矽酸鹽類(silicate frameworks)
    - Zeolites沸石
    - Clinoptiliolite水合鈉鉀鈣鋁硅酸鹽

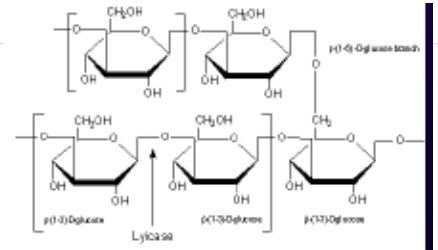

Zeolite, U. Mich.

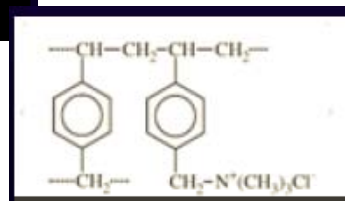
- Chemically treated silicates化學處理矽酸鹽

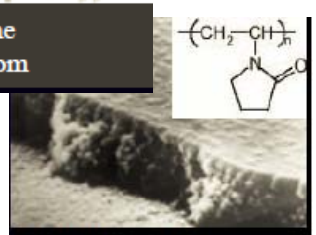
Mycotoxin Adsorbents
黴菌毒素吸附劑

- Carbon products 碳化合物
  - Activated or superactivated charcoal 活性或超活性碳
- Glucan products 葡聚醣產品
- Inorganic polymers無機聚合物
  - Cholestyramine膽苯烯胺
  - Polyvinylpyrrolidone 聚乙烯吡咯啶
  - (聚維酮， PVP)


Activated charcoal, OHSU


Yeast 1,3 *B* Glucan - Sigma


Cholestyramine
IBSMedical.com


PVP -Kansai U.-Japan

Effectiveness of Mycotoxin Adsorbents (Positive Responses/Trials)
黴菌吸附劑的有效性 (有正面效果次數/總試驗數)

Mycotoxin 黴菌毒素	Carbon	Glucan	Clay	Zeolite	PVP	Bacteria	Clay/Enzyme
Aflatoxin 黃麴毒素	6/8	7/9	35/35	11/16	1/2	-	-
DON 嘔吐毒素	-	-	0/1	-	-	-	-
Zearalenone 玉米赤黴醇	1/1	0/1	1/2	2/3	-	-	-
T-2毒素	3/3	1/1	0/5	0/1	-	-	-
"Fusarium"菌屬所產生的毒素	-	5/9	1/2	0/1	-	-	0/2
Aflatoxin黃麴毒素 + "Fusarium" 菌屬所產生的毒素	-	2/2	1/1	-	-	1/1	-

> 50% positive responses正面效果反應>50%

Are there any effective commercial products for vomitoxin?商業產品對嘔吐毒素有效嗎?

- Very little published information研究文獻的資訊有限
  - Field experience is about the only source現場經驗是唯一來源
- Several products are being used that can't be legally called mycotoxin binders in the U.S.在美國有一些不屬於黴菌吸附劑的產品用於此用途
- Hydrolyzed yeast (glucan) products provide some effectiveness depending on level of DON水解酵母(葡聚醣)的效果是嘔吐毒素的濃度而定
  - No benefits in feeds with 飼料濃度> 5 ppm DON無效
  - Some benefits in feeds with 飼料濃度< 5 ppm DON稍有效果
  - Greater benefits in feeds with飼料濃度 < 3 ppm DON效果較佳

Summary of Mycotoxin Adsorbents
黴菌吸附劑-結論

- Responses to adsorbents similar across species
  不同動物對吸附劑添加的反應很類似
- Some adsorbents are mycotoxin specific
  有些吸附劑只對特定的黴菌毒素有效
- No adsorbent has been shown to be effective across all mycotoxins
  沒有一種吸附劑對所有的黴菌毒素都有效
- Adsorption varies with adsorbent types
  吸附效果因吸附劑種類而有所不同
- Most studies have been done on silicates and aflatoxin
  大部分已完成的研究文獻著重在矽酸鹽類和黃麴毒素
- Limited data for inorganic polymers (PVP & cholysteramine)
  無機聚合物的研究資料有限
- Research on bacterial adsorption is beginning and promising
  微生物吸附劑的研究剛剛起步且可能有效果

Aflatoxin Testing Kits for DDGS (Approved by GIPSA)
美國穀物倉儲裝運檢查管理局核准適用於檢測玉米乾酒粕黃麴毒素的檢驗套組

Brand Name商品名	Manufacturer製造商	Test Range檢測範圍
Veratox Aflatoxin	Neogen Corporation	5 – 50 ppb
Ridascreen FAST SC	R-Biopharm	5 – 100 ppb
Aflatest	Vicam	5 – 100 ppb
FluroQuant® Afla IAC	Romer	5 – 100 ppb

Fumonisins Testing Kits for DDGS (Approved by GIPSA)
美國穀物倉儲裝運檢查管理局核准適用於檢測玉米乾酒粕伏馬鐮孢毒素的檢驗套組

Brand Name商品名	Manufacturer製造商	Test Range檢測範圍
AgraQuant Total Fumonisin 0.25/5.0	Romer	0.5 – 5 ppm

Zearalenone Testing Kits for DDGS (Approved by GIPSA)
美國穀物倉儲裝運檢查管理局核准適用於檢測玉米乾酒粕玉米赤黴醇的檢驗套組

Brand Name商品名	Manufacturer製造商	Test Range檢測範圍
ROSA® Zearalenone	Charm Sciences, Inc.	50 – 1000 ppb