degussa.
creating essentials

Variability of Amino Acid Content in DDGS

Jonathan Goodson, Ph.D. ACAN
Degussa Feed Additives
Kennesaw, GA
jonathan.goodson@degussa.com

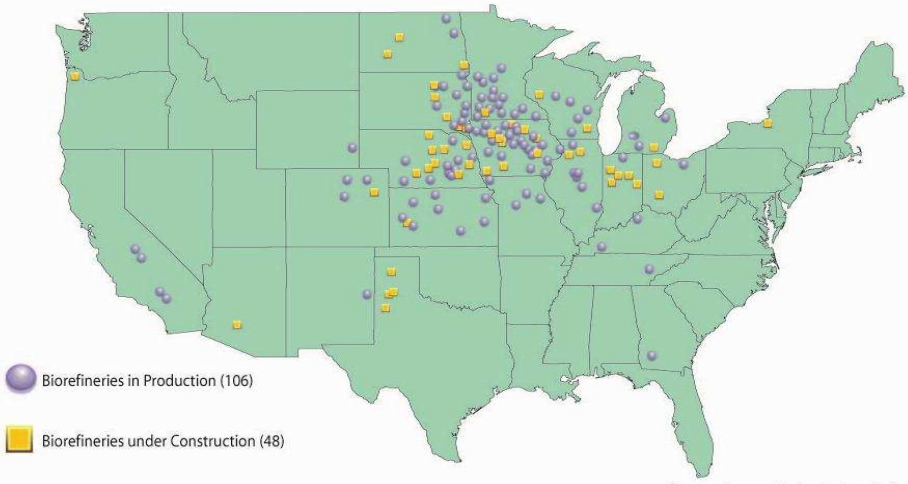
amino acids and more.

degussa.
creating essentials

Ethanol Production

amino acids and more.

U.S. Ethanol Biorefinery Locations



Source: Renewable Fuels Association

amino acids and more.

Ethanol Subsidies

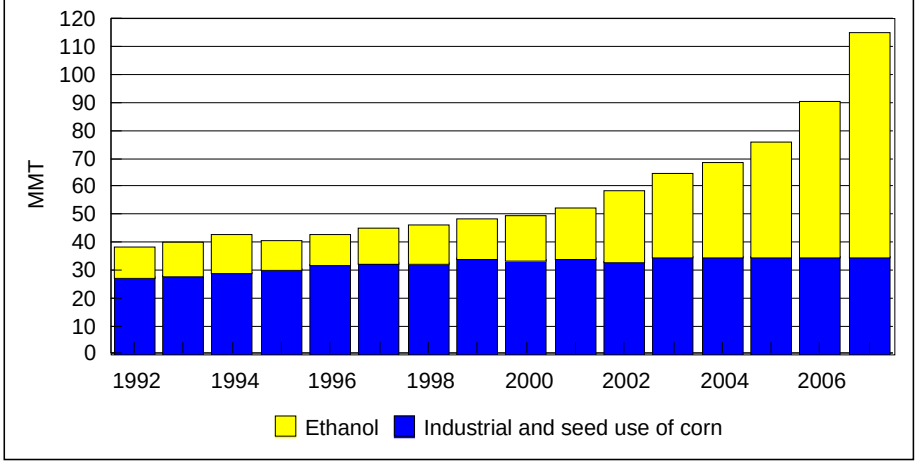
degussa.
creating essentials

- **51 cent / gallon subsidy to blender up to 7.5 billion gallons / year**
- **54 cent / gallon duty on imported ethanol to limit competition**
- **President proposed an ethanol goal of 35 billion gallons of ethanol and alternative fuels by 2017**
- **Congress likely to out propose that goal – will specify funds for bio mass, bio diesel, ethanol from crops and ethanol from coal**
- **EVERYONE is for this!**
- **3.785 liters / 1 gallon**

amino acids and more.

degussa

USA INDUSTRIAL CORN CONSUMPTION

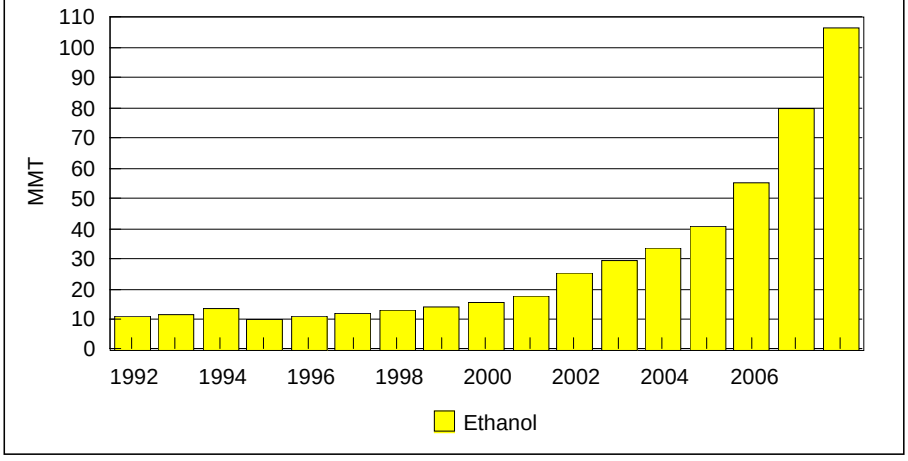


2007_06/JR Slide 5

amino acids and more.

degussa

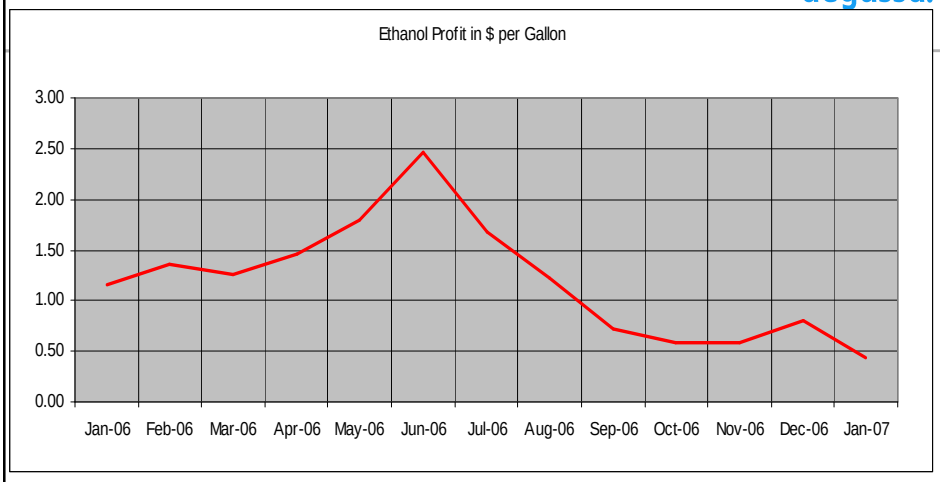
Corn Use for Ethanol Production



2007_06/JR Slide 6

amino acids and more.

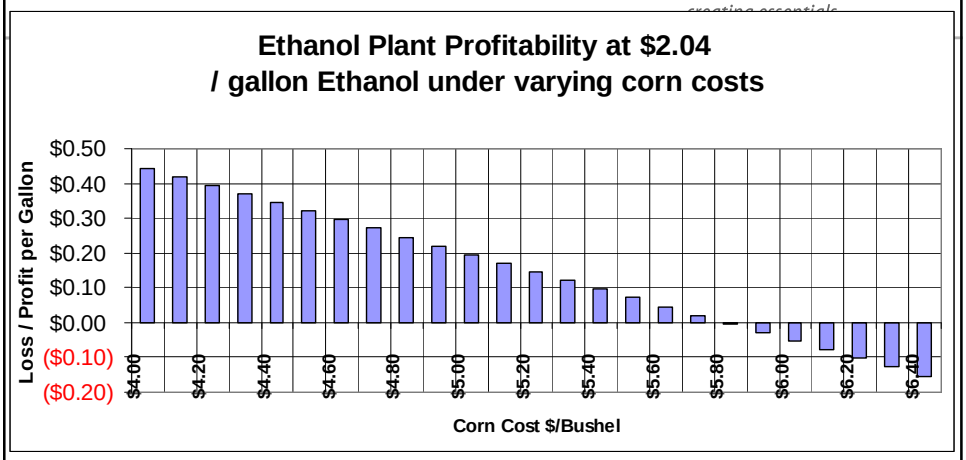
degussa.



amino acids and more.

degussa.

creating essentials



amino acids and more.

degussa.
creating essentials

Source Renewable Fuels Association

			Million Corn Bushels
Operating Capacity (113 plants)	5,583	Million Gallons	1994
Capacity Under Construction	6,140	Million Gallons	2193
(76 plants plus 8 expansions)	11,723	Million Gallons	4187

	Acres	Additional Corn Acres Needed	Seeded Corn Acres	
Corn for ethanol use in 2006/07	**14.4**		**78.3**	**million acres**
Corn for ethanol use in 2007/08	**21.9**	**7.5**	**85.8**	**million acres**
Corn for ethanol use in 2008/09	**28.4**	**6.4**	**92.2**	**million acres**

amino acids and more.

Ethanol

degussa.
creating essentials

Current Operating Capacity or capacity under construction = 11.6 billion gallons

Another 15 billion gallons of capacity on planned but not yet broken ground –

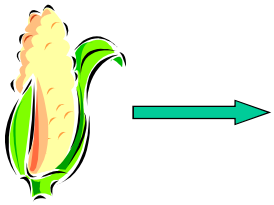
- Assume waiting financing or increase / extension in existing subsidy rules

amino acids and more.

degussa.
creating essentials

DDGS Production

1 Bushel



2.7 gallons Ethanol
18 lbs DDGS
18 lbs CO2

amino acids and more.

degussa.
creating essentials

What does that work out to?

amino acids and more.

degussa.
creating essentials

What does that work out to?

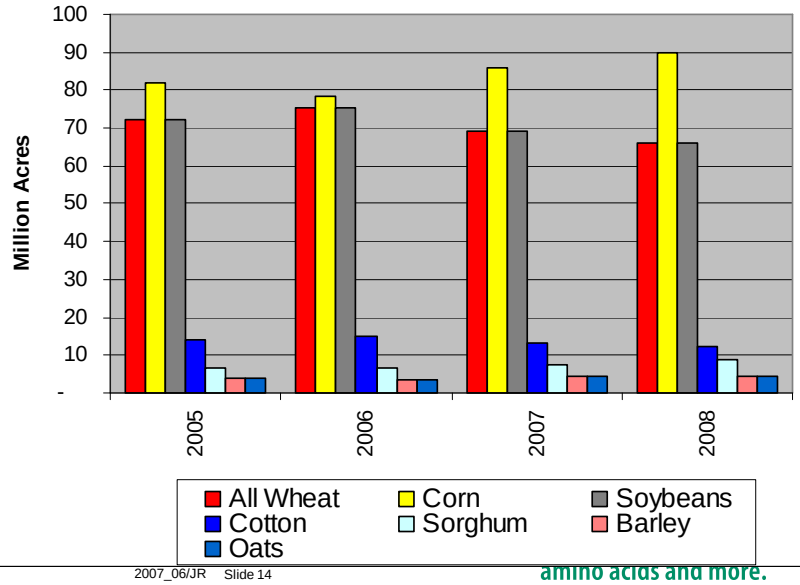
80 X 10^6 MT = 3,149,407,857 bushels

3,149,407,857 bushels * 18 lbs=

28,344,670 tons

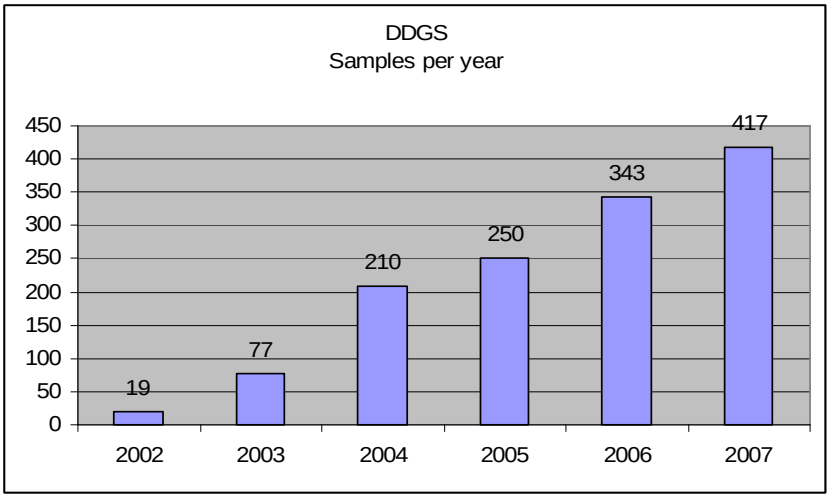
amino acids and more.

US Seeded Acres



amino acids and more.

degussa.
creating essentials



2007_06/JR Slide 15

amino acids and more.

degussa.
creating essentials

Data Set

- **1314 samples**
  - 2002 through August 2007

2007_06/JR Slide 16

amino acids and more.

degussa.
creating essentials

Dry matter (as received)

Mean	90.56
Min	86.09
Max	98.75
SD	1.57
CV	1.7%

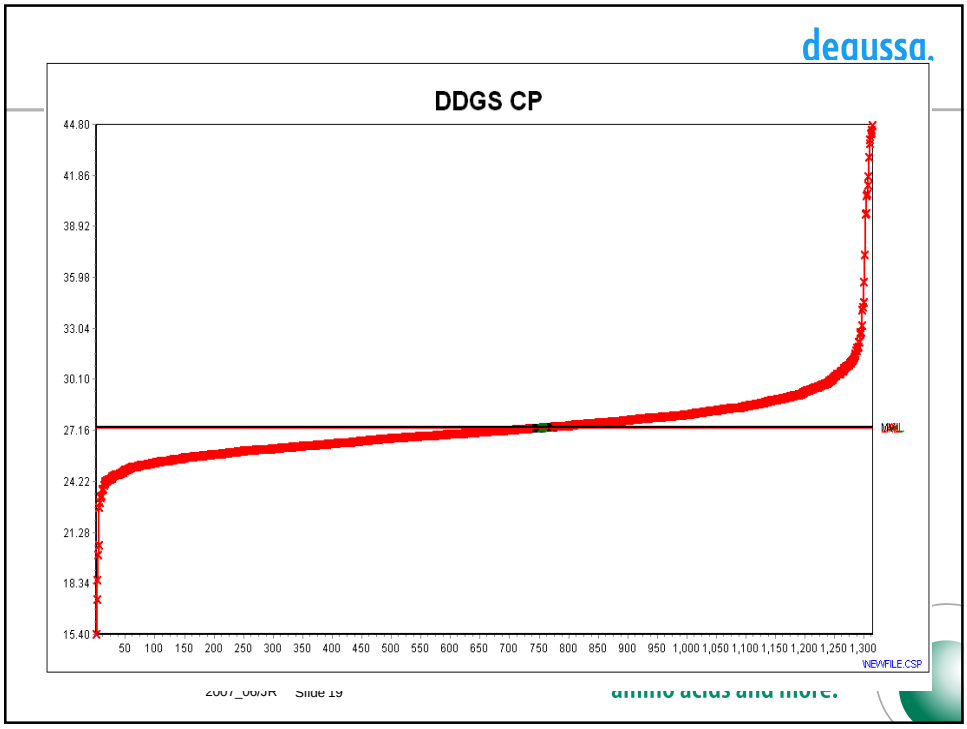
amino acids and more.

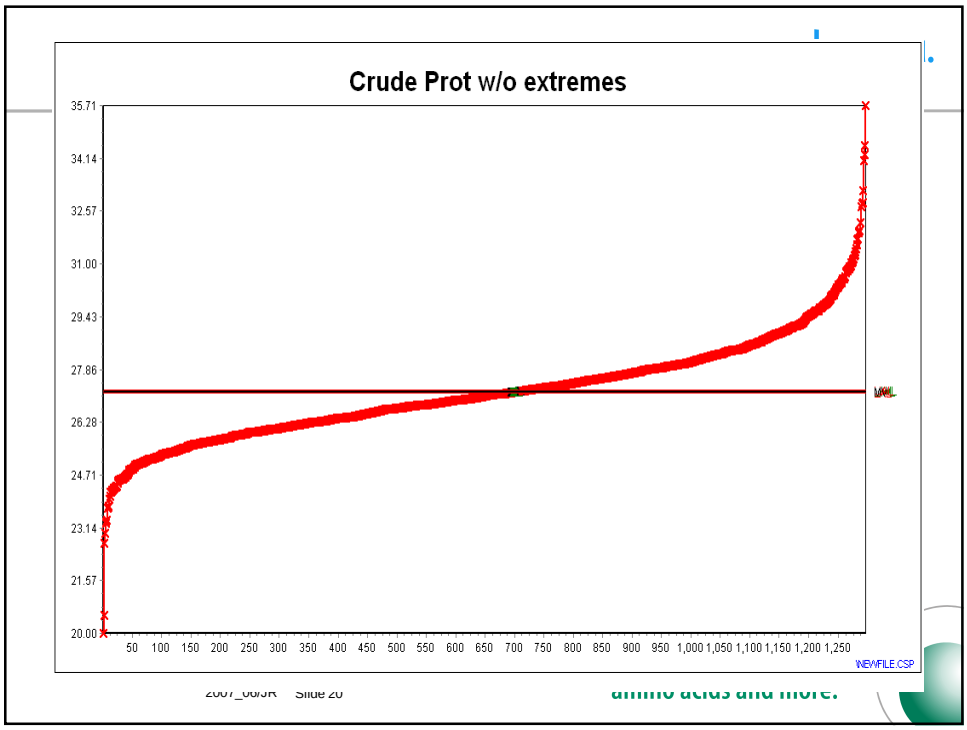
degussa.
creating essentials

Crude Protein

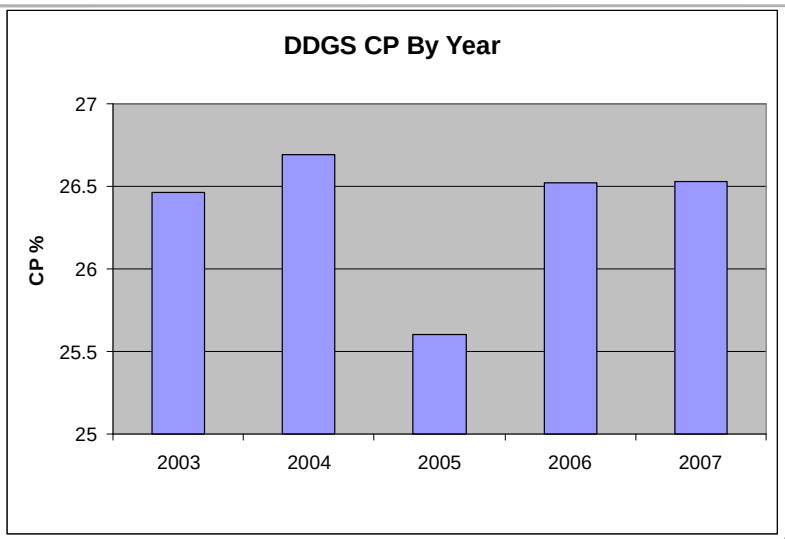
Mean	27.33
Min	15.41
Max	44.77
SD	2.23
CV	8.2%

amino acids and more.


deaussa.
DDGS CP
44.80
41.86
38.92
35.98
33.04
30.10
27.16
24.22
21.28
18.34
15.40
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1,000 1,050 1,100 1,150 1,200 1,250 1,300
\NEW\FILE.CSP
amino acids and more.


Crude Prot w/o extremes
35.71
34.14
32.57
31.00
29.43
27.86
26.28
24.71
23.14
21.57
20.00
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1,000 1,050 1,100 1,150 1,200 1,250
\NEW\FILE.CSP
amino acids and more.

degussa.
creating essentials



2007_06/JR Slide 21

amino acids and more.

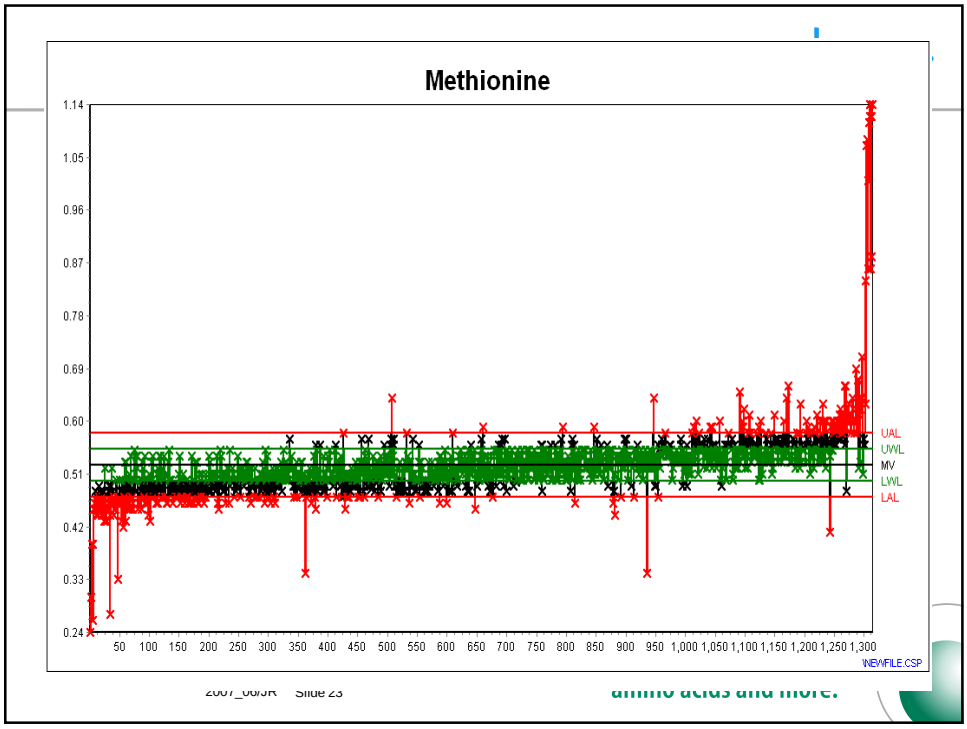
degussa.
creating essentials

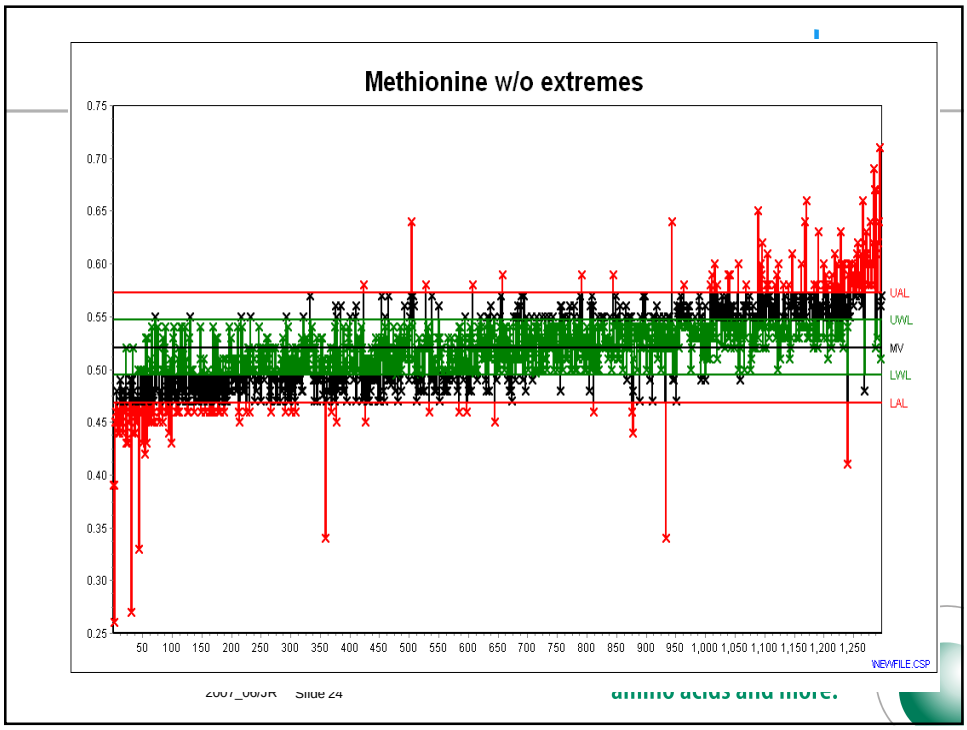
Methionine

Mean	**0.52**
Min	**0.24**
Max	**1.14**
SD	**0.06**
CV	**12.3%**

2007_06/JR Slide 22

amino acids and more.


Methionine
1.14
1.05
0.96
0.87
0.78
0.69
0.60
0.51
0.42
0.33
0.24
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1,000 1,050 1,100 1,150 1,200 1,250 1,300
UAL
UWL
MV
LWL
LAL
\NEW\FILE.CSP

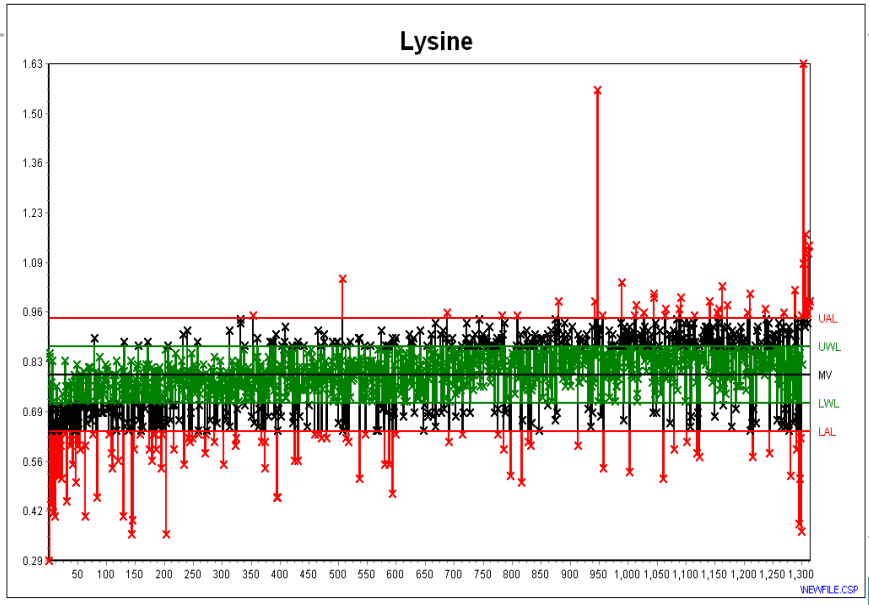

Methionine w/o extremes
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1,000 1,050 1,100 1,150 1,200 1,250
UAL
UWL
MV
LWL
LAL
\NEW\FILE.CSP

degussa.
creating essentials

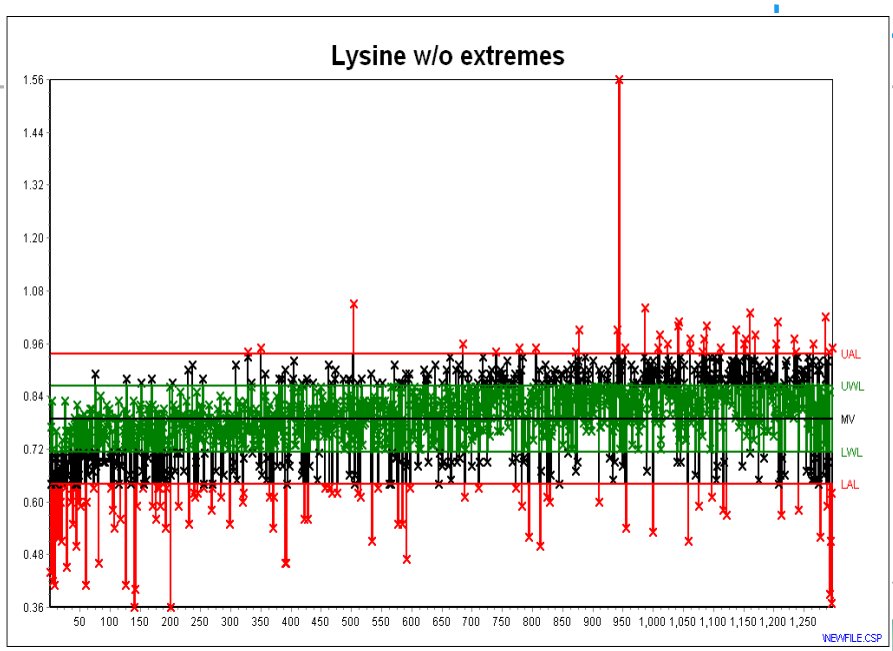
Lysine

Mean	**0.79**
Min	**0.29**
Max	**1.63**
SD	**0.11**
CV	**13.3%**

degussa.



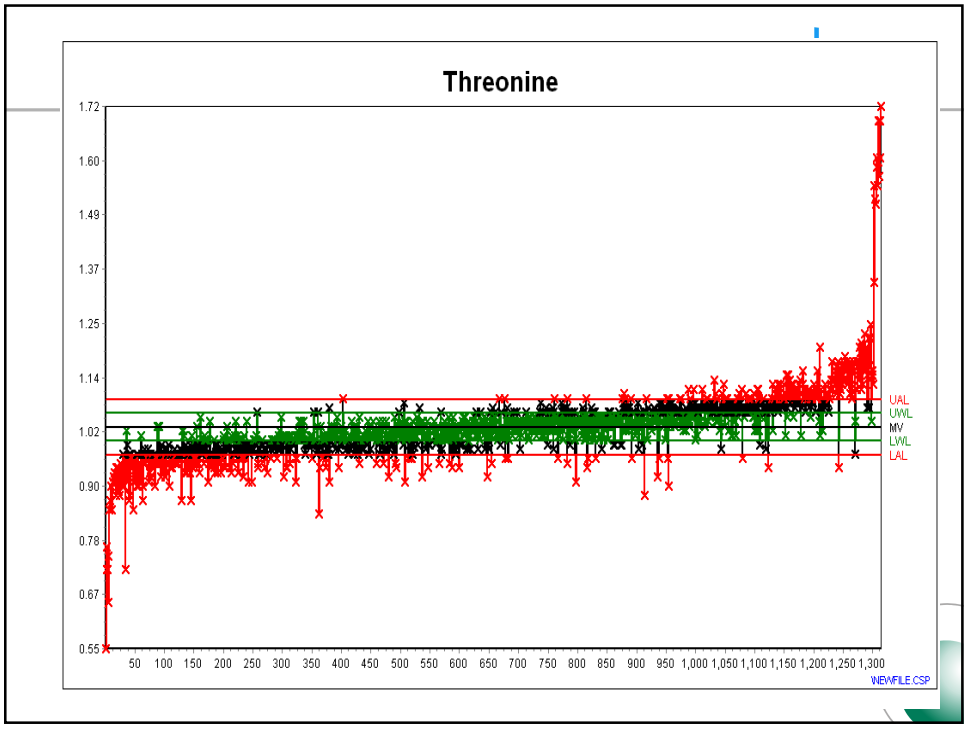
amino acids and more.

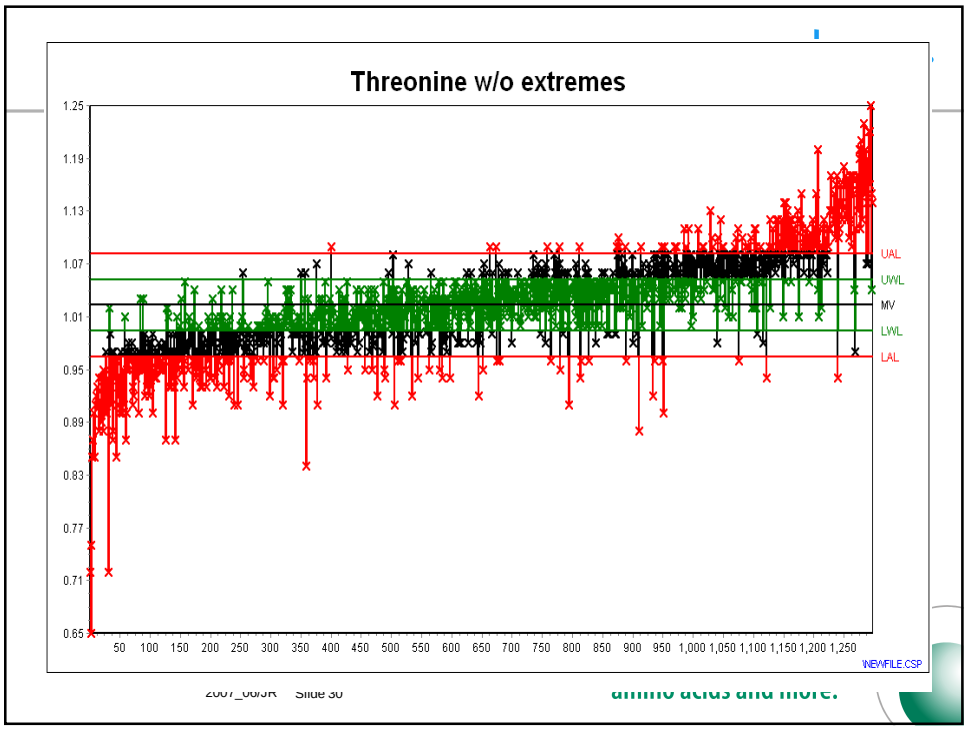


degussa.
creating essentials

Threonine

Mean	**1.03**
Min	**0.55**
Max	**1.72**
SD	**0.08**
CV	**8.2%**

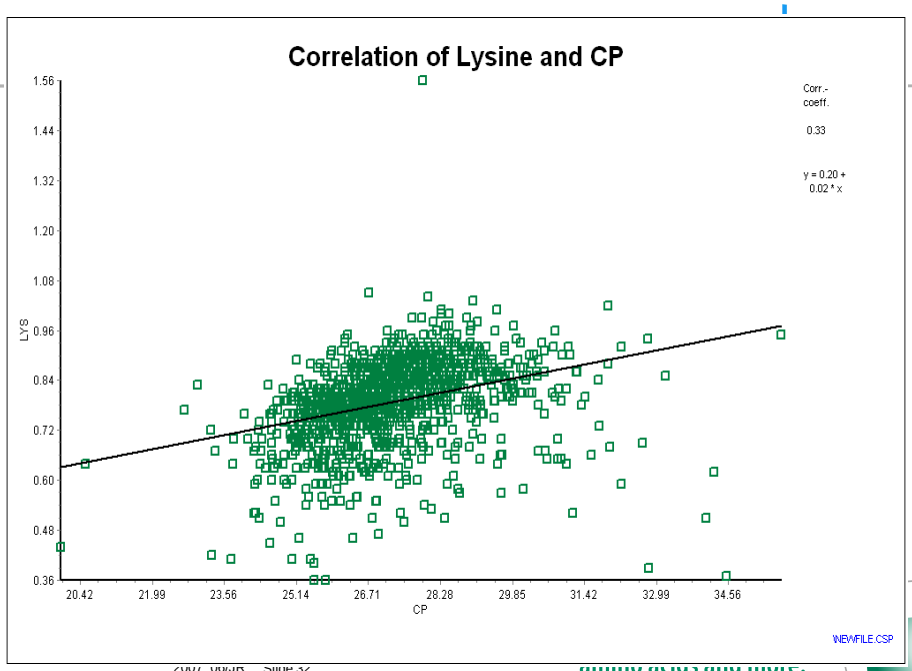

Threonine
1.72
1.60
1.49
1.37
1.25
1.14
1.02
0.90
0.78
0.67
0.55
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1,000 1,050 1,100 1,150 1,200 1,250 1,300
UAL
UWL
MV
LWL
LAL
\NEW\FILE.CSP


Threonine w/o extremes
1.25
1.19
1.13
1.07
1.01
0.95
0.89
0.83
0.77
0.71
0.65
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1,000 1,050 1,100 1,150 1,200 1,250
UAL
UWL
MV
LWL
LAL
\NEW\FILE.CSP

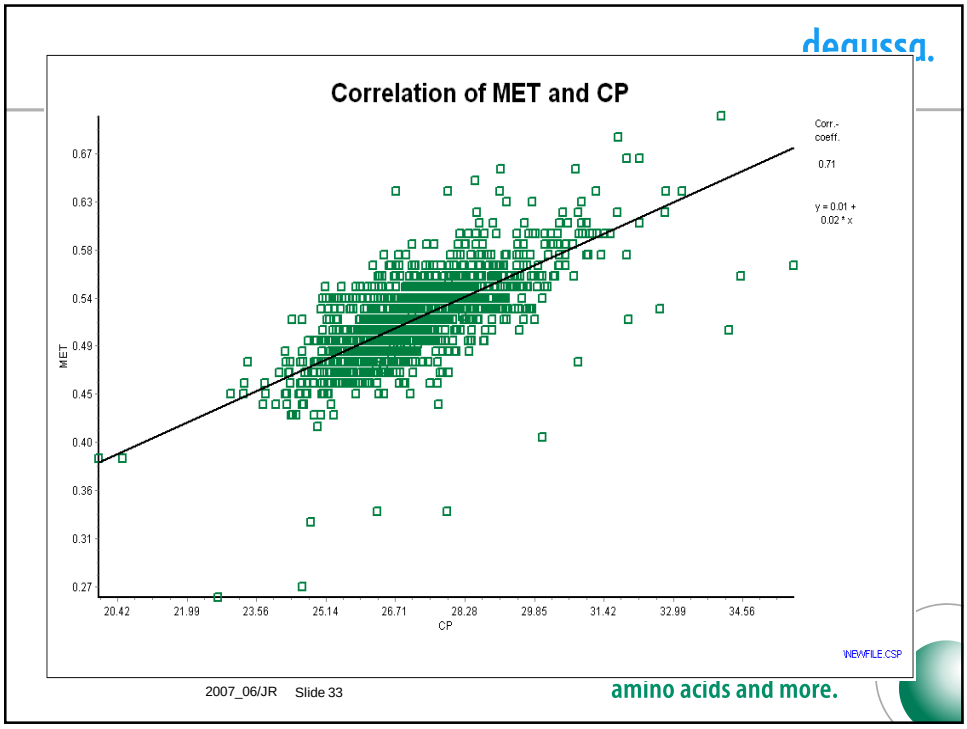
degussa.
creating essentials

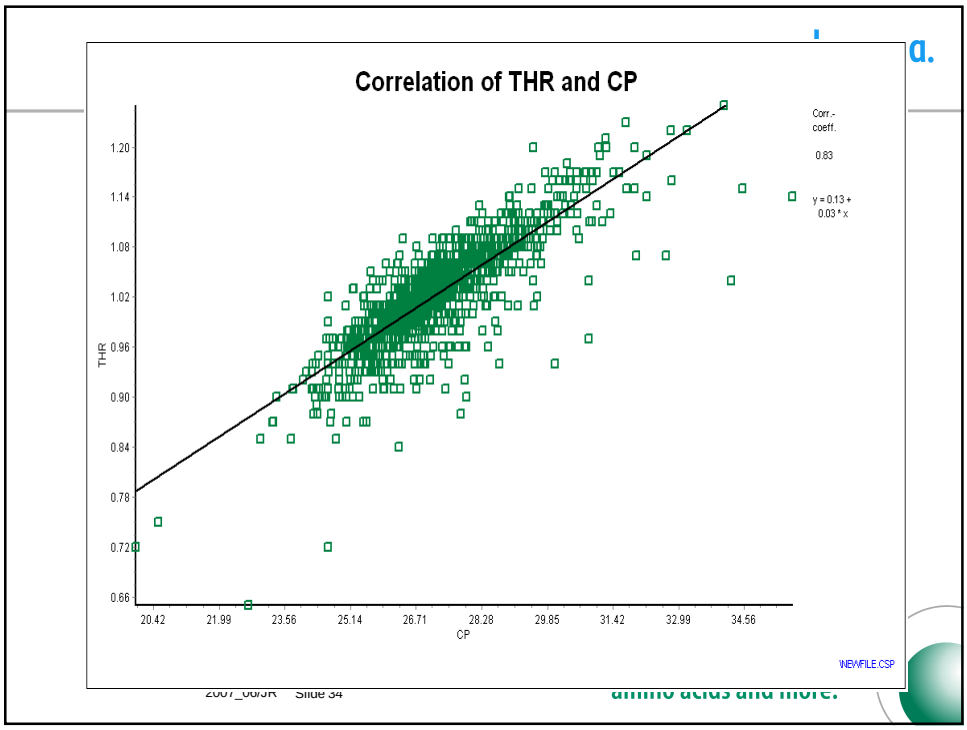
Another view….

amino acids and more.



amino acids and more.


Correlation of MET and CP
Corr.-coeff.
0.71
y = 0.01 + 0.02 * x
MET
CP
0.67
0.63
0.58
0.54
0.49
0.45
0.40
0.36
0.31
0.27
20.42
21.99
23.56
25.14
26.71
28.28
29.85
31.42
32.99
34.56
\NEW\FILE.CSP
2007_06/JR Slide 33
amino acids and more.


Correlation of THR and CP
Corr.-coeff.
0.83
y = 0.13 + 0.03 * x
THR
CP
1.20
1.14
1.08
1.02
0.96
0.90
0.84
0.78
0.72
0.66
20.42
21.99
23.56
25.14
26.71
28.28
29.85
31.42
32.99
34.56
\NEW\FILE.CSP

Variation in AA digestibility

degussa. creating essentials

DDGS total lysine content variation:

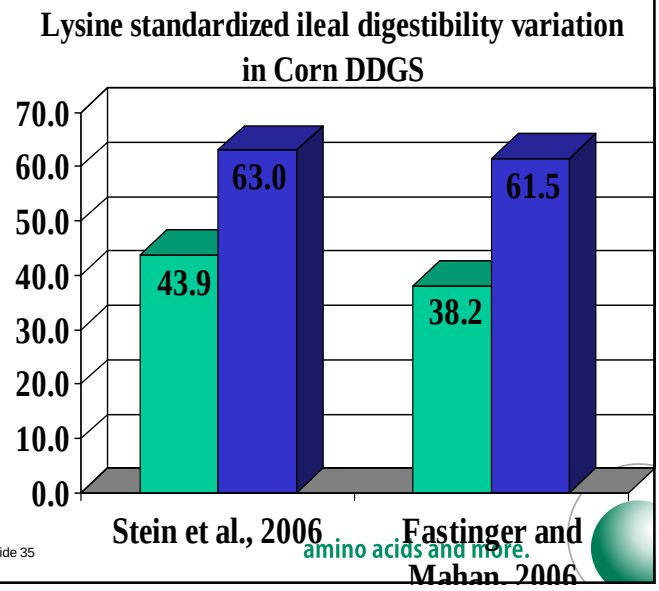
CV = 17%

Corn,

CV = 5.6%

SBM,

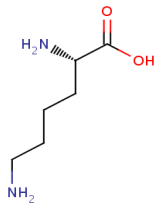
CV = 2.5%



2007_06/JR Slide 35

amino acids and more.

Causes of poor AA digestibility



Fiber

- NDF
- ADF

Maillard reaction

- Cromwell et al., 1993; Fastinger and Mahan, 2006; Stein et al., 2006
- Unreactive Lys 0.32 to 3.25 g/kg (Pahm et al., 2005).
- Between 3 to 40% of total Lys.

2007_06/JR Slide 36

amino acids and more.

degussa.
creating essentials

Maillard reaction stages, color, fluorescence and digestibility

Heat & Time	Reaction stage[1]	Digestibility[2]	Coloration[3]
Low	Schiff's bases	100%	No color
Moderate	Amadori compounds	60%	Fluorescence
Severe	Melanoidins	10%	Browning

[1]Davies and Labuza, 2000

[2]Finot, 2005

[3]Matiacevich *et al.*, 2005

degussa.
creating essentials

Optical Density and Maillard Products

Light absorbance at visual wavelength range (400 to 700 nm)

Basis to calculate L,a,b color parameters

OD at 420:

- Used to evaluate non-enzymatic browning in foods (e.g. milk, confectionery)

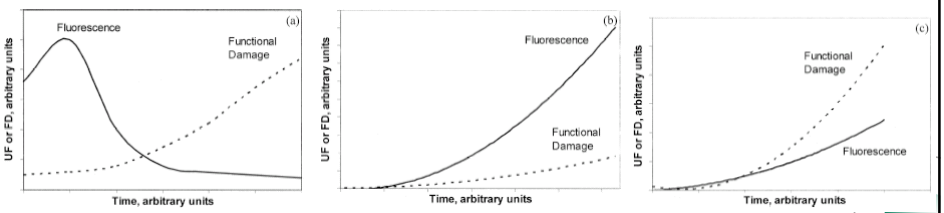
Others wavelengths could be related 490 nm in solutions with multiple AA (Labuza and Basier, 1992)

degussa.
creating essentials

Fluorescence and Maillard Products

Studied since 1942

- Deterioration in eggs extractions during storage
- Milk, Milk products, infant formulas (Birlouez-Aragon et al., 2005; Liu and Metzger, 2007; Schamberger and Labuza, 2006)



Matiacevich S, et al (2006)

amino acids and more.

degussa.
creating essentials

Materials and Methods

37 Distillers Grains

- 34 Corn DDGS (C)
- 1 Corn DDG (DDG)
- 1 Sorghum DDGS (S)
- 1 Blend of Corn Sorghum DDGS (CS)
- Maximize variation in Plants by selecting colors, locations,

Crude Protein

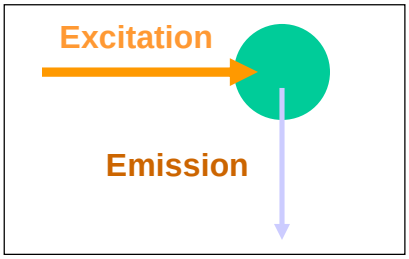
Optical Density (Hunter Spectrophotometer 65/10)

Fluorescence and Front Face Fluorescence

amino acids and more.

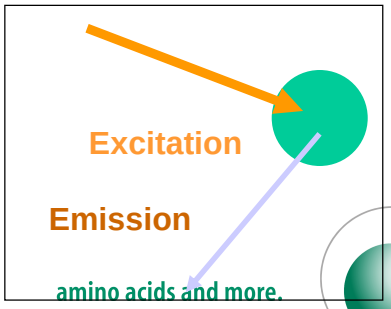
Fluorescence determination

degussa. creating essentials



Common Fluorescence

Front-Face Fluorescence (FFF)



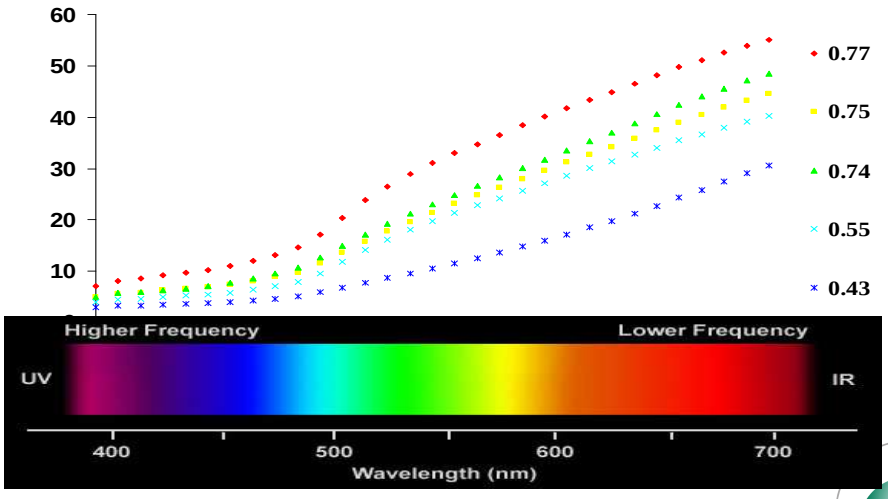
2007_06/JR Slide 41

amino acids and more.

Results:

Relationship between Dig-Lys and Optical Density (400-700nm)

degussa. creating essentials

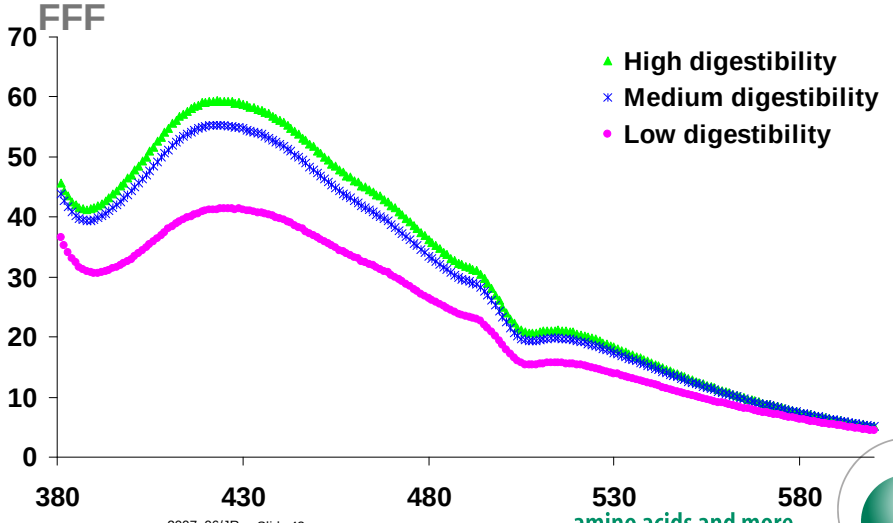


2007_06/JR Slide 42

amino acids and more.

degussa.
creating essentials

Relationship between Dig-Lys and FFF



amino acids and more.

degussa.
creating essentials

Conclusions

DDGS amino acid digestibility is affected by Maillard reaction

Optical density is a better predictor of Maillard reaction in DDGS, than color parameters L,a,b

Fluorescence in DDGS appears during early stages of the reaction

amino acids and more.

degussa.
creating essentials

Other attempts

Cecectomized rooster assay

Batal and Dale (2006) Amino Acid Digestion Coeficient

- **Lysine 70%**
- **Met 87%**
- **Cys 74%**
- **Thr 75%**

amino acids and more.

degussa.
creating essentials

Other attempts

Cecectomized rooster assay

Available lysine

- **Assay takes 3 days**
- **Degussa NIRS method**

amino acids and more.

degussa.
creating essentials

Bottomline

If you use DDGS……..

Get it analyzed

amino acids and more.

degussa.
creating essentials

Bottomline

If you use DDGS……..

Get it analyzed

Build a database that you have confidence in

amino acids and more.

degussa.
creating essentials

Bottomline

The stuff in inherently variable

amino acids and more.

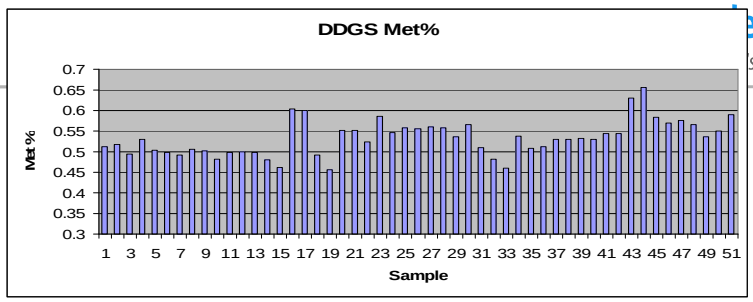
degussa.
creating essentials

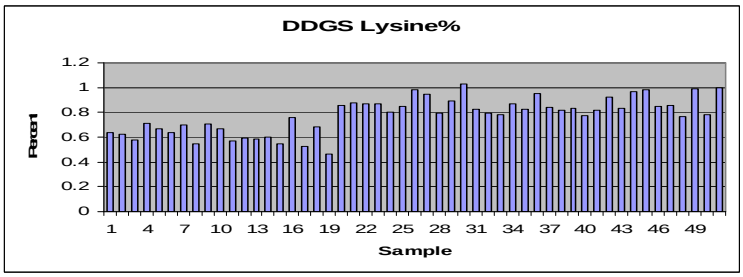
Bottomline

The stuff in inherently variable

Feed formulator/ration balancer has to decide how much variation is acceptable

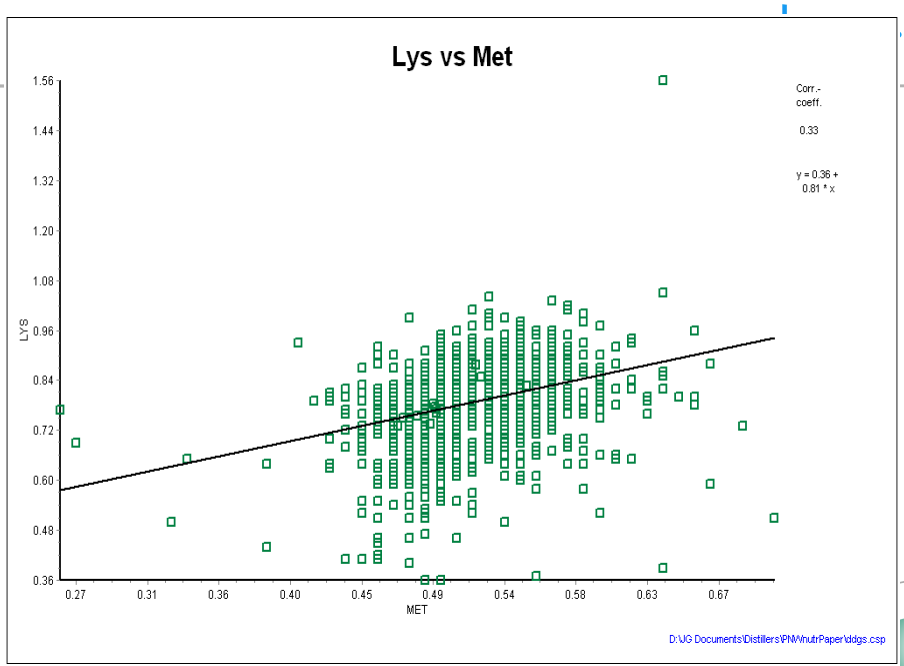
amino acids and more.





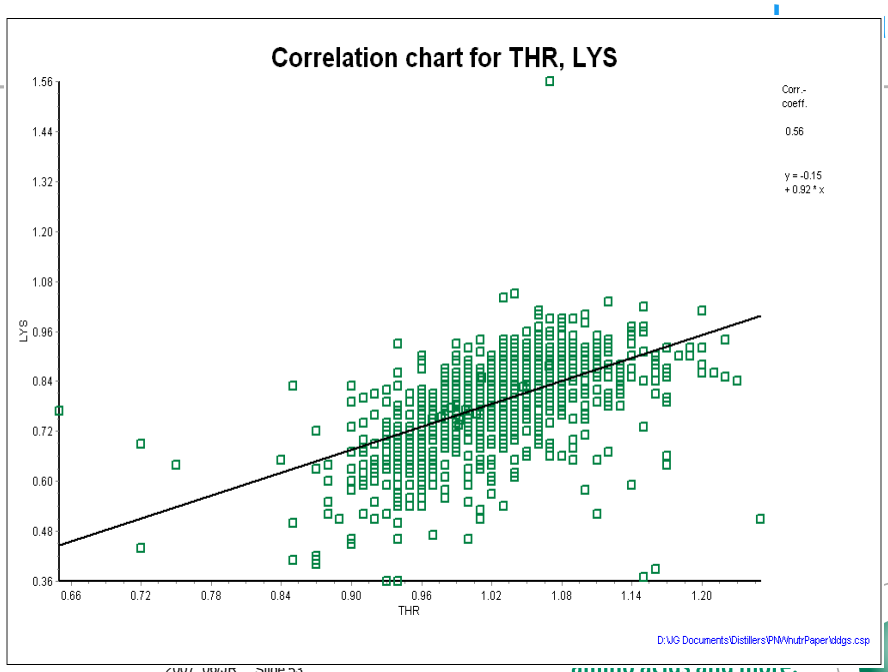
2007_06/JR Slide 51

amino acids and more.



2007_06/JR Slide 52

amino acids and more.



amino acids and more.

CFC/Concept5 Date: 10/
Time: 10:
Plant: 11 GUNTERSVILLE User: PRC
Product: 000016 Broiler Grower Day 22-42 DDGS Calculatio Page: 1

Batch: 2000.00 Nutr Class: 0 Ingr Costs: Owning Status: FEASIB
Stored: 10/17/

Production Formula Cost:	210.31/Ton	10.52/Clb	0.1052/Lb	Version:
Rounded Trial Formula Cost:	212.69/Ton	10.63/Clb	0.1063/Lb	Version:

INGREDIENT SOLUTION: (Rounded Wt: 2000.00)

IngrCode	Ingredient Name	Amount Pct	Prod'n Pct	Change	Cost $/Ton
116-D	CORN GROUND-D	65.8650	66.0366	-0.1715	159.25
249-D	SOYBEAN MEAL 8	18.1500	18.2000	-0.0500	300.00
212DLO	CORN DD GRAINS	7.0000		7.0000	165.00
245	PLTRY BY PROD	5.0000	5.0000		235.00
216	ANIMAL & VEG FAT	1.2500	1.2500		380.00
417	CALCIUM CARBONAT	0.7000	0.7000		30.70
639	Biolys	0.6949	0.5384	0.1565	943.40
422	DICAL PHOSPHATE	0.3500	0.3500		238.50
428	SALT PLAIN	0.3500	0.3500		125.40
648	METHIONINE DL	0.3250	0.2900	0.0350	1750.80
647	Threonine	0.1650	0.1350	0.0300	2358.70
570	BRLR STARTER VIT	0.1000	0.1000		7240.00
430	TM MIX 430	0.0500	0.0500		859.00

NUTRIENT SOLUTION:

No	Nutrient Name	Units	Analysis
3	CRUDE PROTEIN	PCT	18.681
5	LYSINE	PCT	1.229
6	METHIONINE	PCT	0.613
7	METH & CYSTINE	PCT	0.923
8	TRYPTOPHANE	PCT	0.197
16	THREONINE	PCT	0.837
35	MET ENG	C/LB	1477.404
44	CRUDE FAT	PCT	4.994
98	CYSTINE	%	0.291
132	Dig Ileal Dig Lys%		1.140

CFC/Concept5 Date: 10/17/07
Time: 10:58:33
Plant: 11 GUNTERSVILLE User: PROSUSER
Product: 000016 Broiler Grower Day 22-42 DDGS Calculatio Page: 1

Batch: 2000.00 Nutr Class: 0 Ingr Costs: Owning Status: FEASIBLE
Stored: 10/17/2007

Production Formula Cost: 210.31/Ton 10.52/Clb 0.1052/Lb Version: 21
Rounded Trial Formula Cost: 210.31/Ton 10.52/Clb 0.1052/Lb Version: 1

INGREDIENT SOLUTION: (Rounded Wt: 2000.00)

IngrCode	Ingredient Name	Amount Pct	Prod'n Pct	Change	Cost $/Ton
116-D	CORN GROUND-D	66.0366	66.0366		139.25
249-D	SOYBEAN MEAL 8	18.2000	18.2000		300.00
212DHI	CORN DD GRAINS	7.0000	7.0000		165.00
245	PLTRY BY PROD	5.0000	5.0000		235.00
216	ANIMAL & VEG FAT	1.2500	1.2500		380.00
417	CALCIUM CARBONAT	0.7000	0.7000		30.70
639	Biolys	0.5384	0.5384		943.40
422	DICAL PHOSPHATE	0.3500	0.3500		238.50
428	SALT PLAIN	0.3500	0.3500		125.40
648	METHIONINE DL	0.2900	0.2900		1750.80
647	Threonine	0.1350	0.1350		2358.70
570	BRLR STARTER VIT	0.1000	0.1000		7240.00
430	TM MIX 430	0.0500	0.0500		859.00

NUTRIENT SOLUTION:

No	Nutrient Name	Units	Analysis
3	CRUDE PROTEIN	PCT	19.118
5	LYSINE	PCT	1.230
6	METHIONINE	PCT	0.607
7	METH & CYSTINE	PCT	0.924
8	TRYPTOPHANE	PCT	0.197
16	THREONINE	PCT	0.836
35	MET ENG	C/LB	1477.385
44	CRUDE FAT	PCT	5.001
98	CYSTINE	%	0.292
132	Deg Ileal Dig Lys%		1.130

degussa.

DDGS - Nutrient Details

	Feeds					Feed Ingredient Profile										
Mix	Feed Name	Type	AsFed	DM	DM%	dgAA	TEAA	MP	Met	Lys	Leu	Ile	Val	Thr	Arg
		--	------	-------	------		-------	------	%DM	%DM	%DM	%DM	%DM	%DM	%DM
0	Bermuda hay coastal early	F	5.0000	4.5500	91.00	80	0	0	0.247	0.658	1.084	0.595	0.858	0.623	0.670
0	Corn sil 40% grain	F	55.0000	19.2500	35.00	80	0	0	0.129	0.207	0.704	0.273	0.384	0.231	0.191
0	Cottonseed hulls	BP	0.0000	0.0000	91.00	80	0	0	0.068	0.197	0.231	0.131	0.200	0.150	0.316
0	Hominy feed	BP	3.0000	2.7000	90.00	80	0	0	0.218	0.420	1.022	0.352	0.531	0.417	0.625
0	Soybean hulls	BP	4.0000	3.6400	91.00	80	0	0	0.138	0.746	0.742	0.437	0.599	0.430	0.565
0	Wheat midds	BP	4.0000	3.5600	89.00	80	0	0	0.201	0.704	1.065	0.553	0.831	0.530	1.104
0	Corn grain ground	G	8.0000	7.0400	88.00	80	0	0	0.201	0.274	1.069	0.306	0.430	0.333	0.430
0	Cottonseed whole	G	3.0000	2.7600	92.00	80	0	0	0.365	0.957	1.273	0.688	1.012	0.751	2.396
0	Molasses black strap	G	1.0000	0.7500	75.00	80	0	0	0.016	0.047	0.183	0.219	0.172	0.078	0.256
0	Soybean meal 48%	G	5.0000	4.4500	89.00	80	0	0	0.755	3.285	4.111	2.458	2.592	2.126	3.999
0	Urea 45%	G	0.0000	0.0000	99.00	80	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Ca 17%;P 21%	VM	0.0000	0.0000	97.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Limestone	VM	1.0000	0.9900	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Mag oxide	VM	0.0000	0.0000	98.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Pot-mag sulfate	VM	0.0000	0.0000	98.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Salt-white	VM	0.2500	0.2475	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Selenium 0.06%	VM	0.0000	0.0000	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Sodium sesquicarbonate	VM	0.2500	0.2475	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Trace mineral mix exampl	VM	0.0000	0.0000	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Vit ADE Example	VM	0.0000	0.0000	98.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Distillers ethanolHi	BP	5.0000	4.7000	94.00	80	0	0	0.700	1.600	2.726	0.898	1.288	0.975	0.989
0	Distillers ethanolLo	BP	0.0000	0.0000	94.00	80	0	0	0.260	0.350	2.726	0.898	1.288	0.975	0.989
		--	------	-------	------	------	-------	------	--%MP--	--%MP--	--%MP--	--%MP--	--%MP--	--%MP--	--%MP--
	Concentrations								2.130	7.200	9.210	5.510	6.160	5.370	5.480
		--	--lbs--	lb DM	-%DM-		------g----	------g----	------g----	------g----	------g----	------g----	------g----	------g----	------g----
	Totals		94.5000	54.8850	58.08		1285	2511	54.000	183.000	234.000	140.000	156.000	136.000	139.000
	Requirements			53.1900				2111	57.000	174.000	207.000	114.000	133.000	100.000	81.000
	Difference			1.7000				430	-3.000	9.000	27.000	26.000	23.000	36.000	58.000

amino acids and more.

degussa.

DDGS - Nutrient Details

Feeds						Feed ingredient Profile										
Mix	Feed Name	Type	AsFed	DM	DM%	dgAA	TEAA	MP	Met	Lys	Leu	Ile	Val	Thr	Arg
		---	-------	-------	-------		-------	-------	%DM	%DM	%DM	%DM	%DM	%DM	%DM
0	Bermuda hay coastal early	F	5.0000	4.5500	91.00	80	0	0	0.247	0.658	1.084	0.595	0.858	0.623	0.670
0	Corn sil 40% grain	F	55.0000	19.2500	35.00	80	0	0	0.129	0.207	0.704	0.273	0.384	0.281	0.191
0	Cottonseed hulls	BP	0.0000	0.0000	91.00	80	0	0	0.068	0.197	0.231	0.131	0.200	0.160	0.316
0	Hominy feed	BP	3.0000	2.7000	90.00	80	0	0	0.218	0.420	1.022	0.352	0.531	0.417	0.625
0	Soybean hulls	BP	4.0000	3.6400	91.00	80	0	0	0.190	0.746	0.742	0.437	0.559	0.490	0.565
0	Wheat midds	BP	4.0000	3.5600	89.00	80	0	0	0.281	0.704	1.086	0.553	0.831	0.588	1.184
0	Corn grain ground	G	8.0000	7.0400	88.00	80	0	0	0.201	0.274	1.069	0.306	0.430	0.333	0.430
0	Cottonseed whole	G	3.0000	2.7600	92.00	80	0	0	0.365	0.957	1.278	0.688	1.012	0.751	2.306
0	Molasses black strap	G	1.0000	0.7500	75.00	80	0	0	0.016	0.047	0.188	0.219	0.172	0.078	0.256
0	Soybean meal 48 %	G	5.0000	4.4500	89.00	80	0	0	0.755	3.285	4.111	2.458	2.592	2.126	3.999
0	Urea 45%	G	0.0000	0.0000	99.00	80	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Ca 17%:P 21%	VM	0.0000	0.0000	97.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Limestone	VM	1.0000	0.9900	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Mag oxide	VM	0.0000	0.0000	98.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Pot-mag sulfate	VM	0.0000	0.0000	98.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Salt-white	VM	0.2500	0.2475	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Selenium 0.06%	VM	0.0000	0.0000	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Sodium sesquicarbonate	VM	0.2500	0.2475	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Trace mineral mix exampl	VM	0.0000	0.0000	99.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Vit ADE Example	VM	0.0000	0.0000	98.00	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	Distillers ethanolHi	BP	0.0000	0.0000	94.00	80	0	0	0.700	1.600	2.726	0.898	1.288	0.975	0.989
0	Distillers ethanolLo	BP	5.0000	4.7000	94.00	80	0	0	0.260	0.350	2.726	0.898	1.288	0.975	0.989
		---	-------	-------	-------		-------	-------	--%MP--	--%MP--	--%MP--	--%MP--	--%MP--	--%MP--	--%MP--
	Concentrations								2.020	6.900	9.450	5.640	5.320	5.510	5.630
		---	--lbs--	lb DM	-%DM-		------g----	------g----	------g----	------g----	------g----	------g----	------g----	------g----	------g----
	Totals		94.5000	54.8350	58.08		1247	2434	49.000	166.000	230.000	137.000	154.000	134.000	137.000
	Requirements			53.1900				2111	57.000	174.000	207.000	114.000	133.000	100.000	81.000
	Difference			1.7000				323	-8.000	-6.000	23.000	23.000	21.000	34.000	56.000

amino acids and more.

degussa.

creating essentials

Thanks..

amino acids and more.