

CHEMICAL COMPOSITION OF SOYBEAN PRODUCED IN THE WESTERN HEMISPHERE

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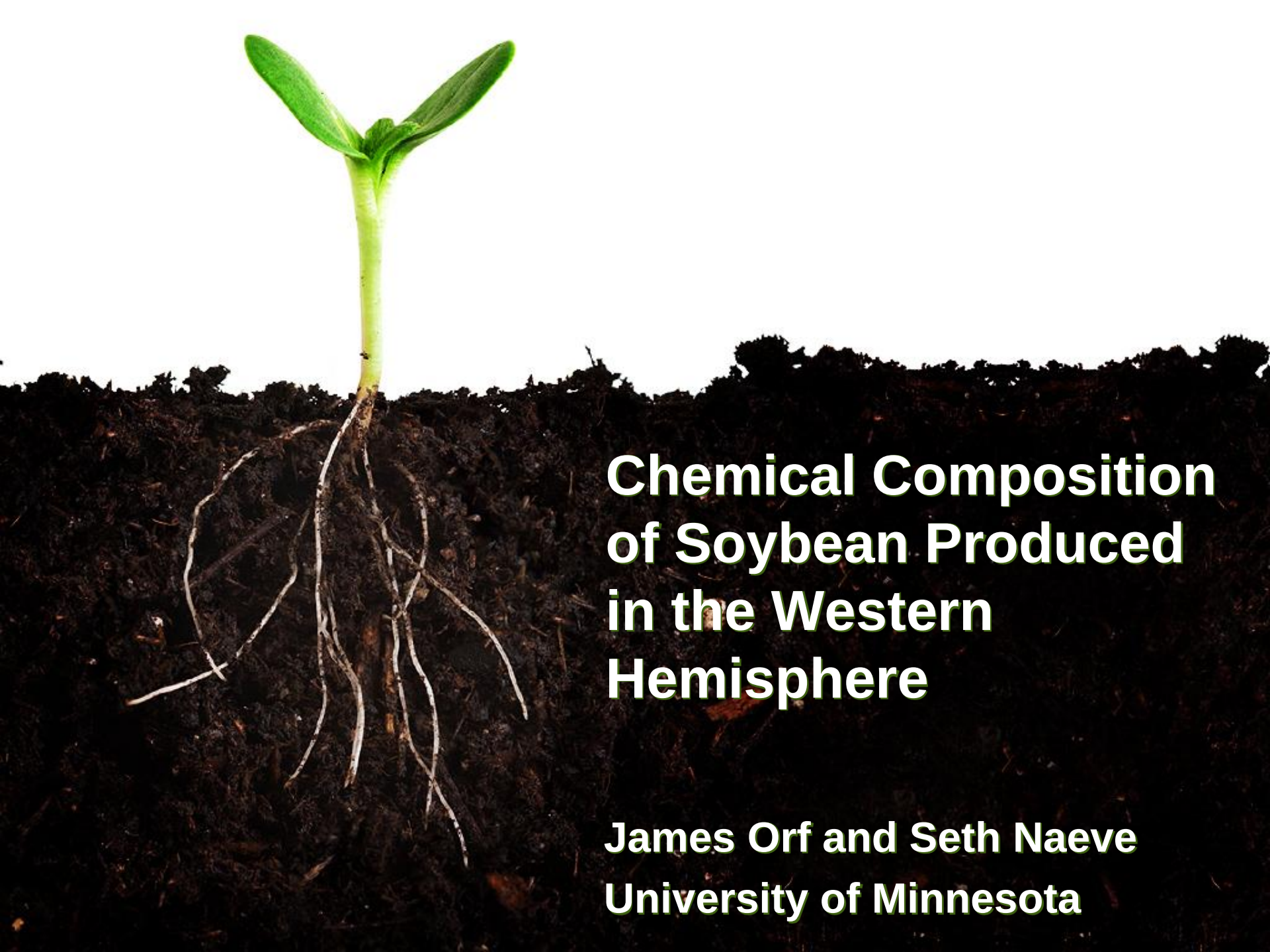
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Despite a centre of origin in north-eastern China, the centre of production for the world's soybeans has moved to the western hemisphere. Today about 90% of the world's production occurs in the western hemisphere and nearly all of the world's traded soybeans originate from there. Soybean producers in the US have supported an annual survey of the quality of the US soybean crop since 1986. The results of this survey have clearly demonstrated the range in protein and oil concentrations found within the US. Recent surveys have begun evaluating the variation in secondary and tertiary soybean seed constituents in the US. Meanwhile, it has been largely accepted that soybeans produced in South America have considerable variation in protein and oil concentrations by region, but little is known about variation in secondary and tertiary constituents in South American soybeans, and between US and South American soybeans.

Therefore, a study was initiated in 2011 to thoroughly characterize the quality of soybeans produced in both North and South America. In 2011, 100 samples that best represented the US crop as a whole were identified and analyzed for their full range of chemical characteristics that might affect value to the end user. Samples were analyzed for proximates, ADF and NDF, starch, soluble sugar profile, amino acid profile + available lysine, and fatty acid profile by standard (AOCS or other) chemical techniques. In 2012, 365 samples representing soybeans harvested during the 2011-2012 growing season in Brazil, Argentina, Paraguay and Uruguay, were analyzed by the same techniques. In addition, 200 samples were selected from the 2012 US soybean crop. Additional samples from both South and North America were analyzed with near infrared spectroscopy (NIRS) to confirm the results obtained from the smaller subset of samples analyzed by chemical techniques.

A summary of these results will be provided that will clearly describe the variation within and between North and South American soybeans for both primary constituents (protein and oil) and secondary constituents (including amino acids, energy levels); data from two US and one South American harvest will be included.



Chemical Composition of Soybean Produced in the Western Hemisphere

**James Orf and Seth Naeve
University of Minnesota**

BACKGROUND

- ❖ Soybeans and soybean products are valued primarily based on proximate analysis that include measures of Crude Protein (N) and Oil concentration
- ❖ Today, purchasers all along the value chain can utilize modern testing methods (NIRS) to rapidly evaluate the value of their products
- ❖ When soybeans and soy products are tested and priced based on value to the end user, sellers are rewarded for high value products



BACKGROUND

- ✿ A better understanding of inherent variation in constituents of soybeans will ultimately allow for better testing of soybeans and soy products
- ✿ Component pricing based on the relative value of the product as a whole rather than just protein and oil presents opportunities



BACKGROUND

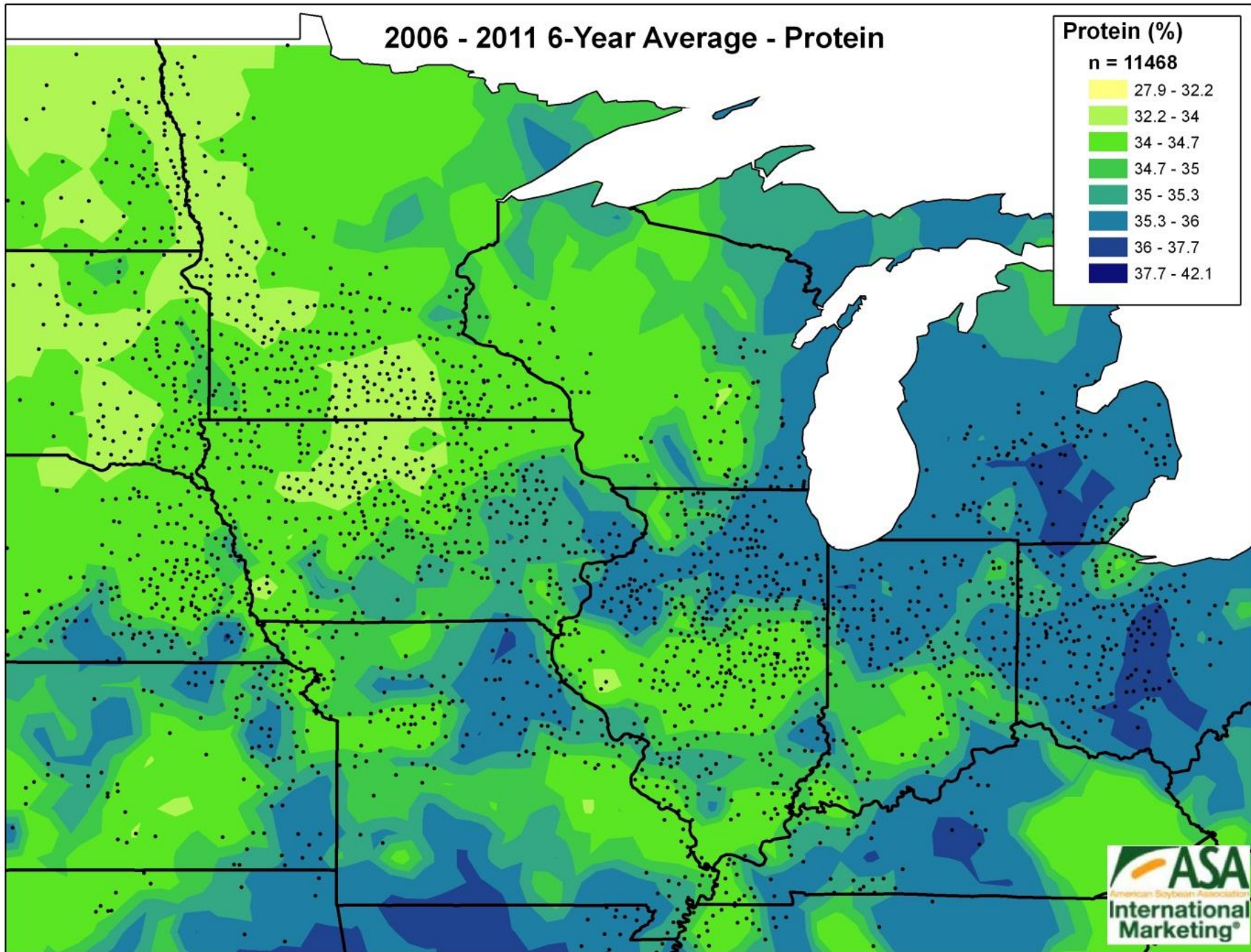
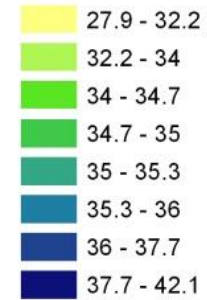
- ✿ Since 1986, U.S. soybean quality has been evaluated by an annual survey: multi-year data show consistent patterns in **protein** and **oil** variation. **Secondary** and **tertiary** seed constituents will also be evaluated



2006 - 2011 6-Year Average - Protein

Protein (%)

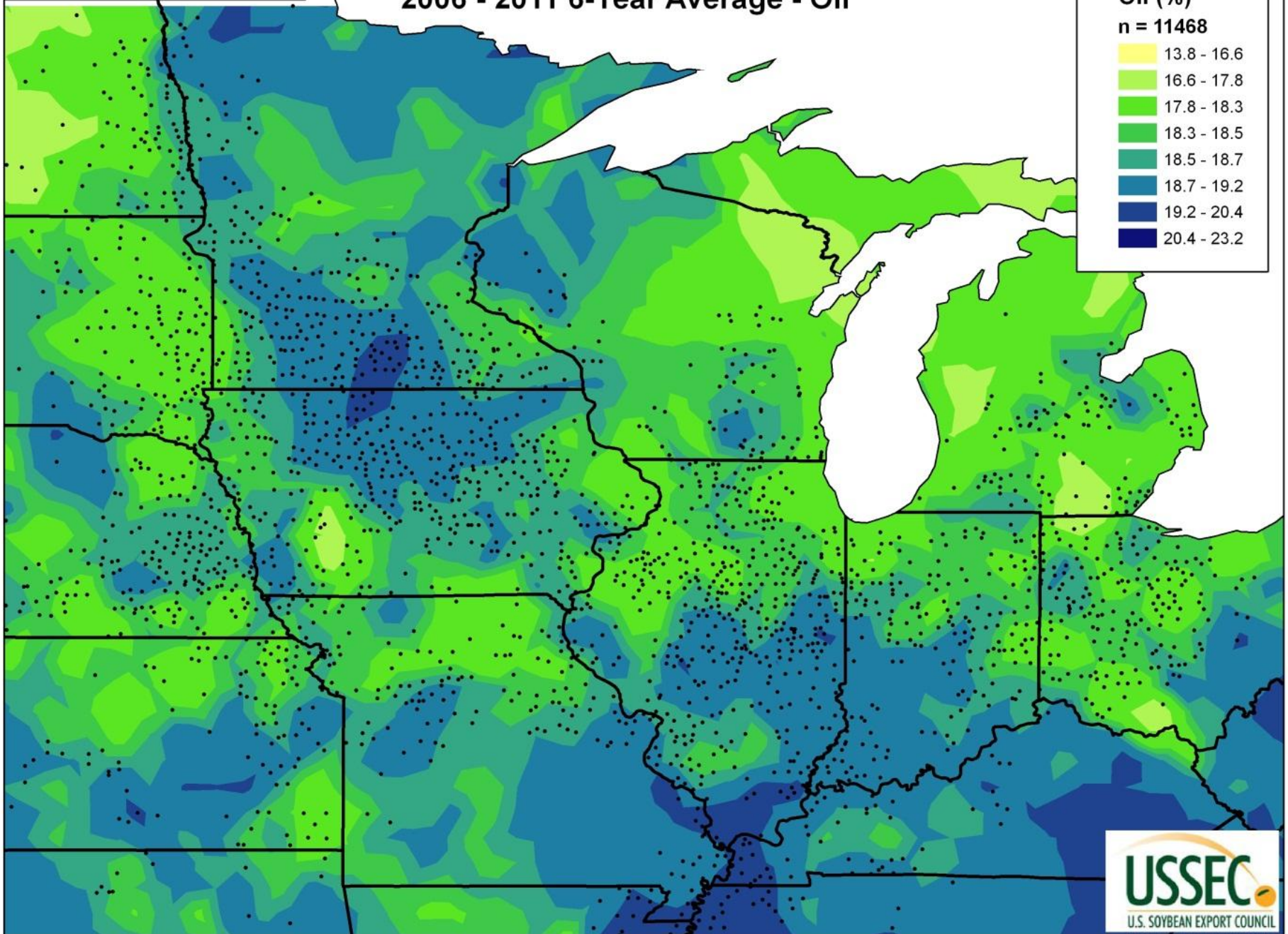
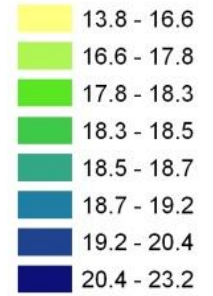
n = 11468



2006 - 2011 6-Year Average - Oil

Oil (%)

n = 11468



BACKGROUND

- ✿ There is considerable variation in South American soybeans for **protein** and **oil**; **secondary** and **tertiary** seed constituents in South American soybeans have not been well-characterized

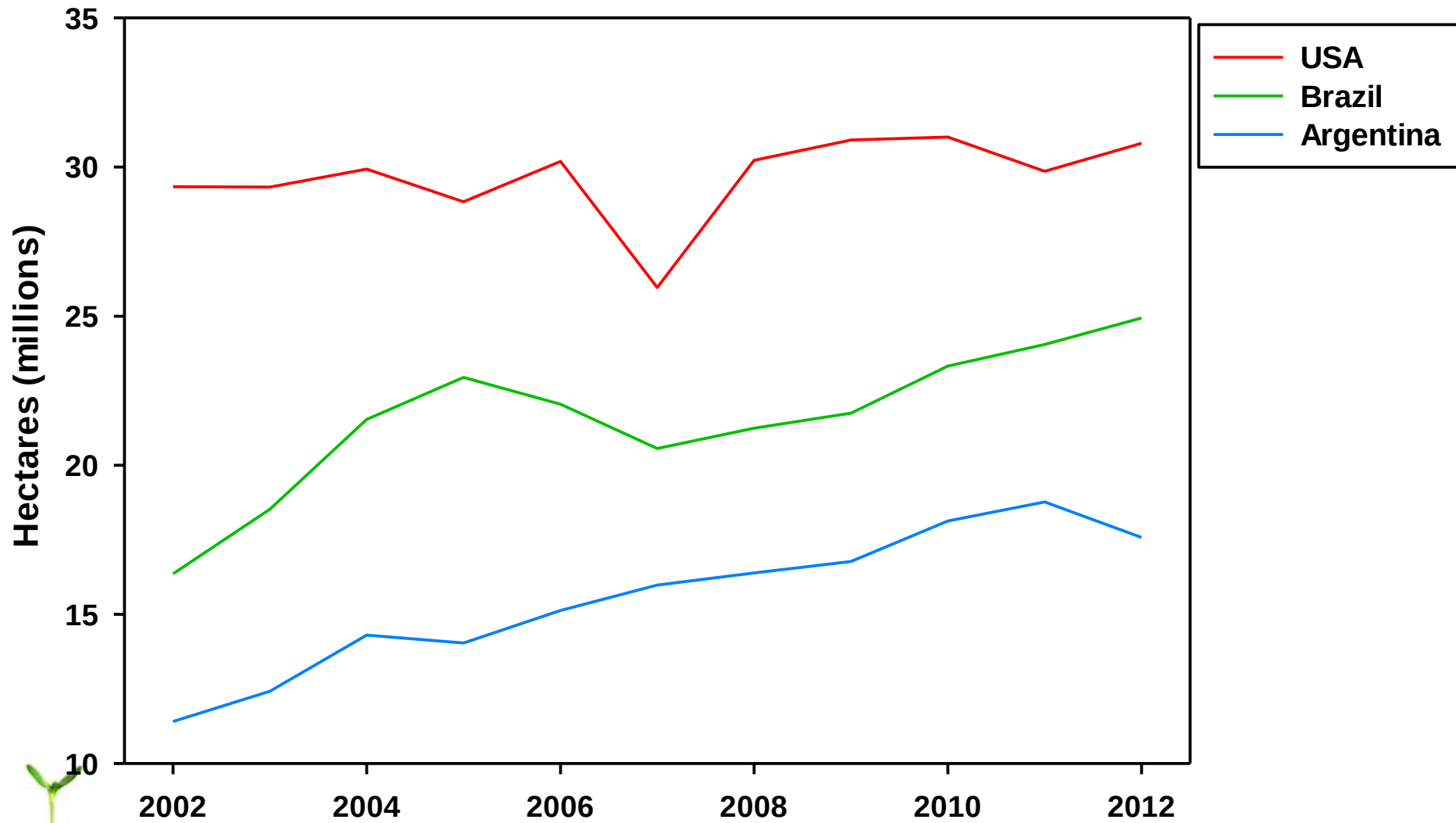


BACKGROUND

- ✿ Our current and future research will attempt to answer the question: how do U.S. and South American soybeans compare in chemical characteristics that may impact value to the end-user?

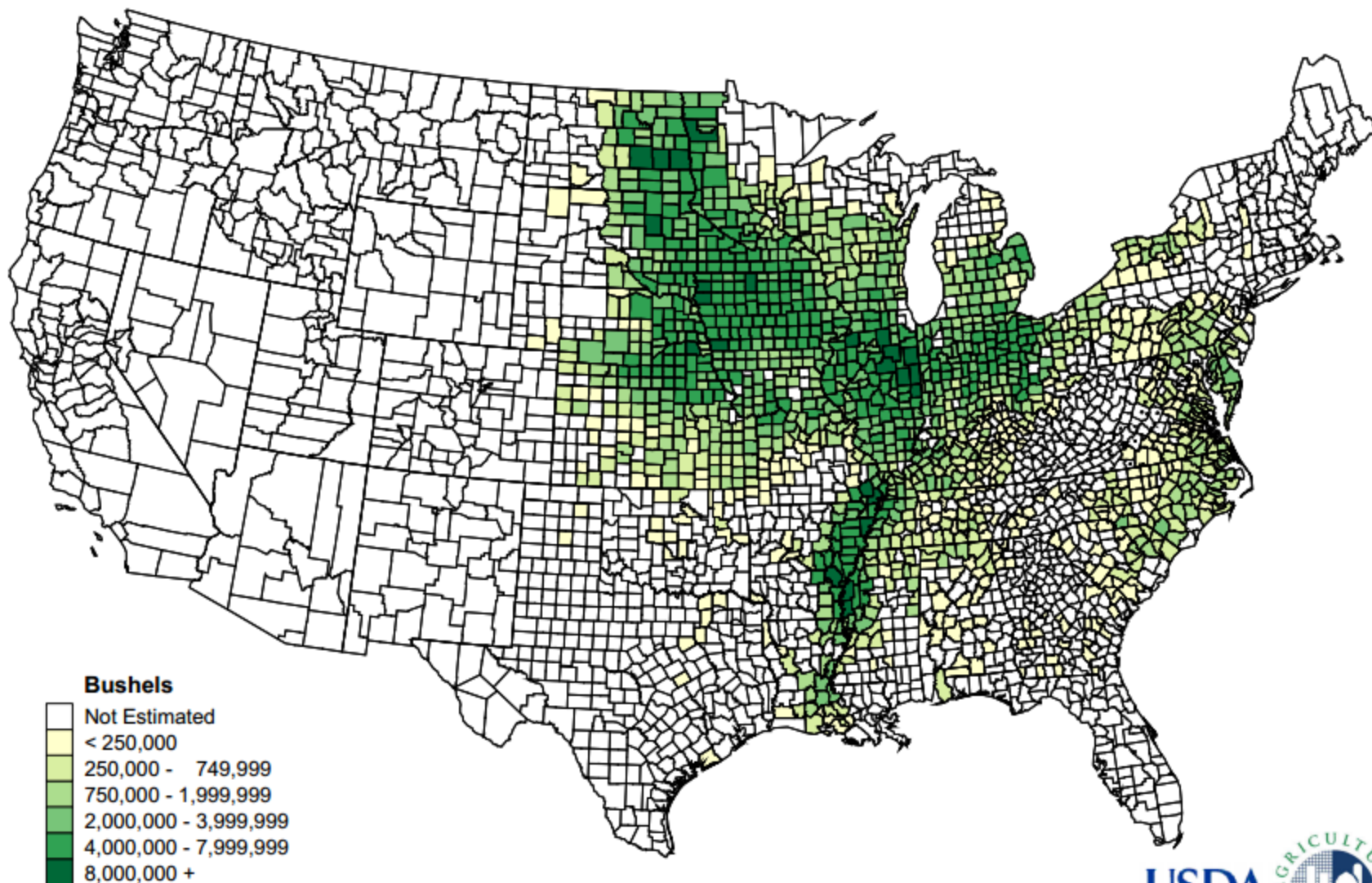


Area Harvested



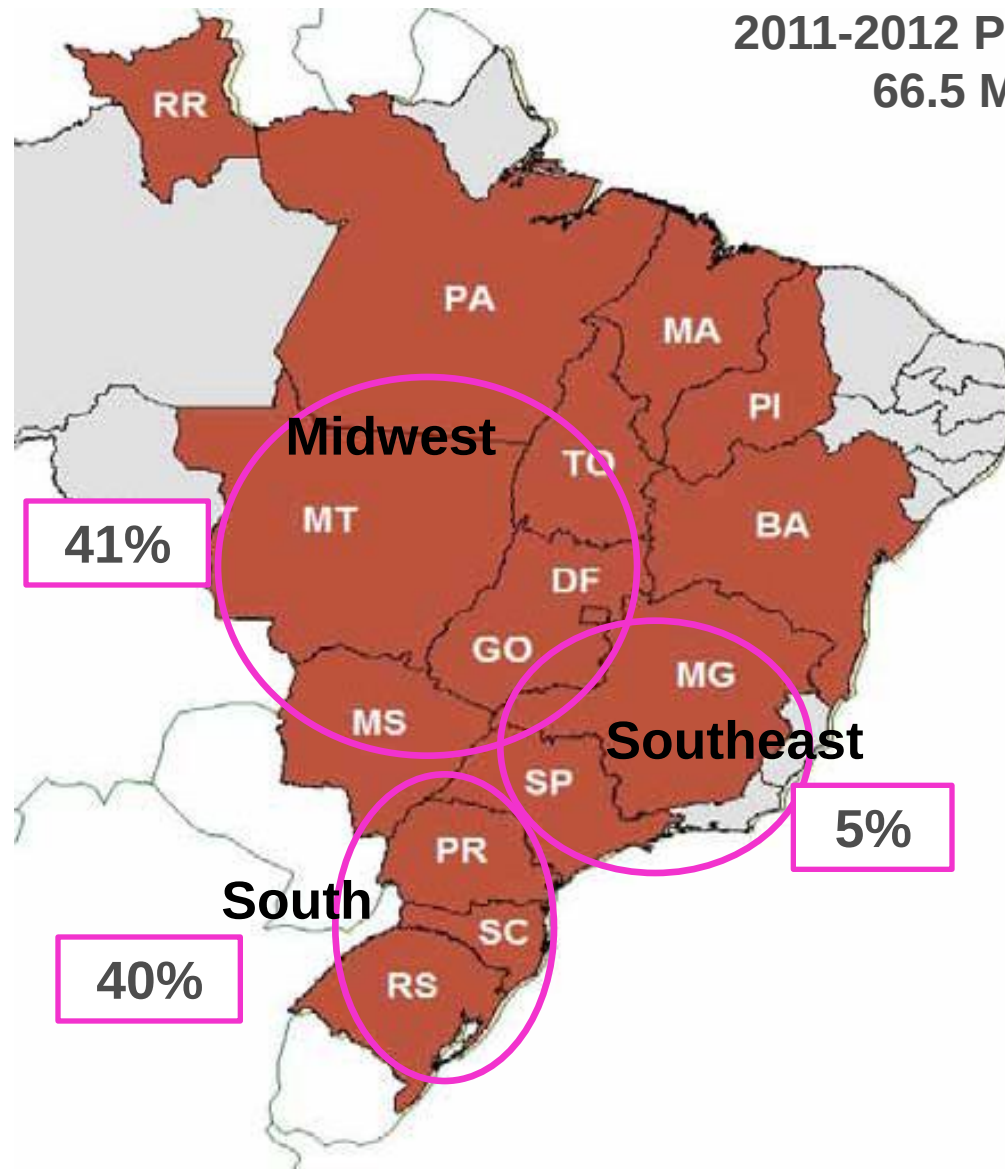
**Soybeans 2011
Production by County
for Selected States**

**2011 Production
84.2 MMT**



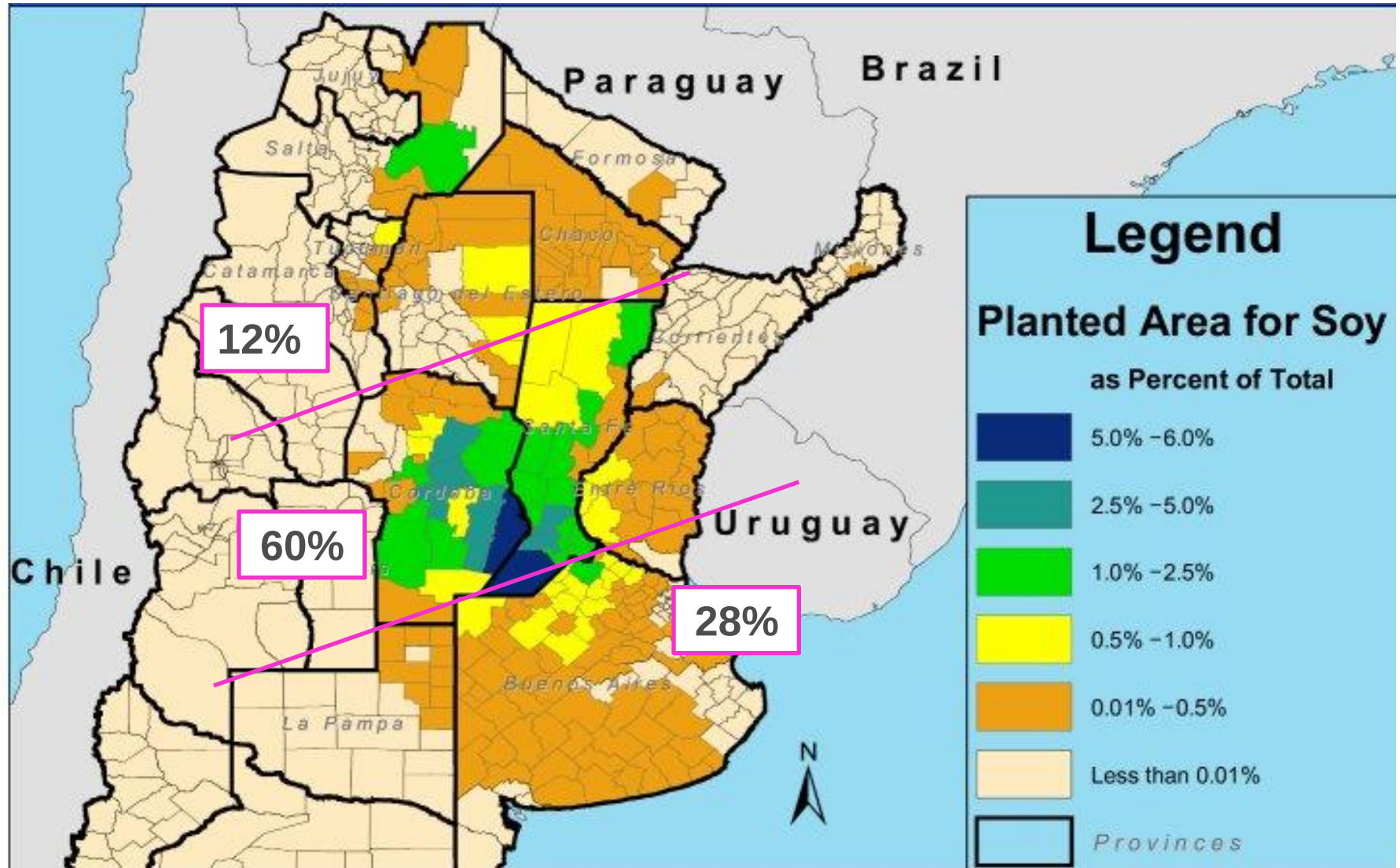
Soybean Production in BRAZIL

2011-2012 Production
66.5 MMT



Soybean Production in ARGENTINA

2011-2012 Production
40.1 MMT



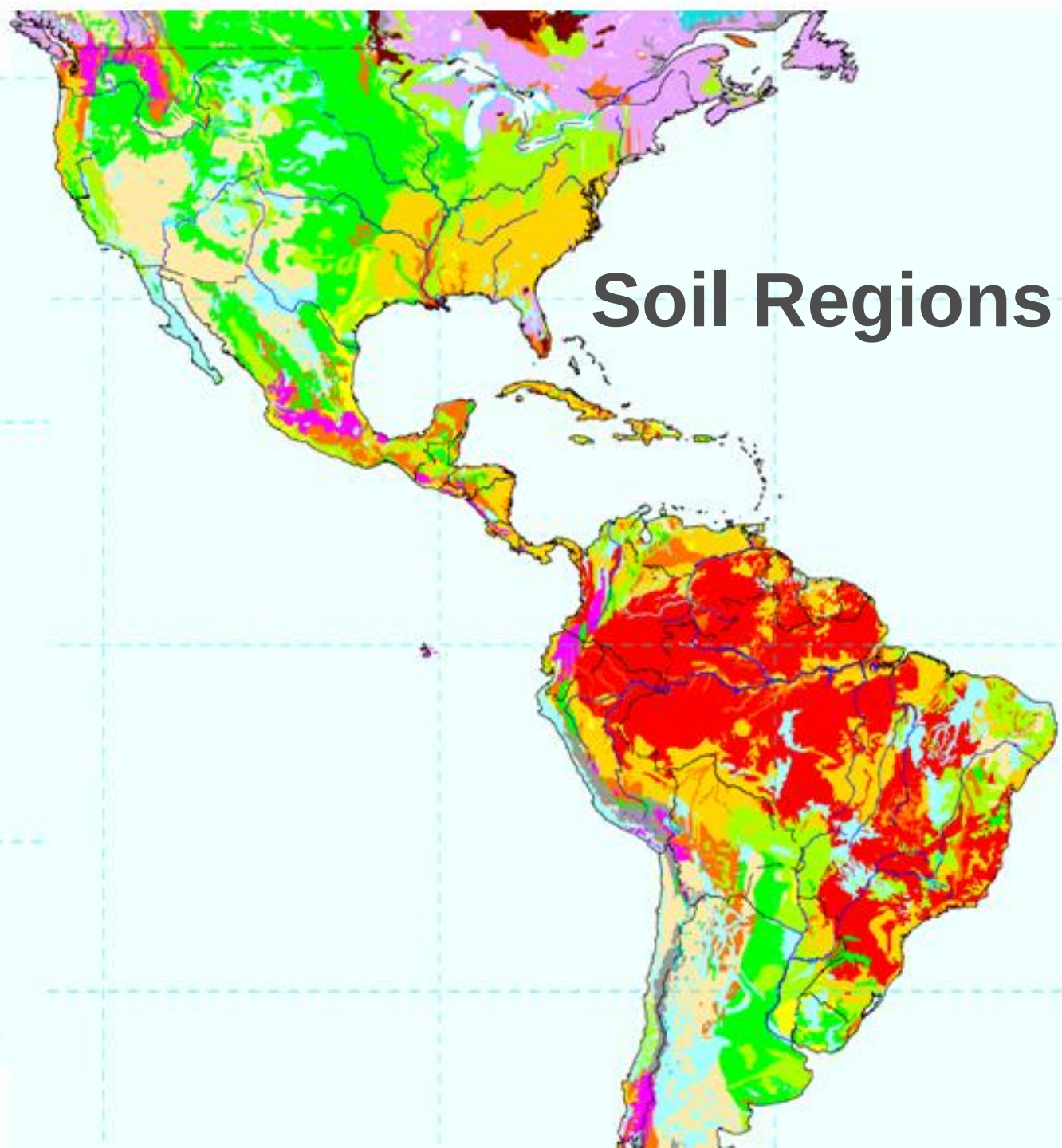
BACKGROUND

- ✿ Soybean seed quality is affected by
 - ✿ Variety
 - ✿ Environment
 - ✿ Static factors
 - ✿ Soil
 - ✿ Latitude
 - ✿ Variable factors
 - ✿ Weather – temperature, rainfall
 - ✿ Production hazards



Soil Regions

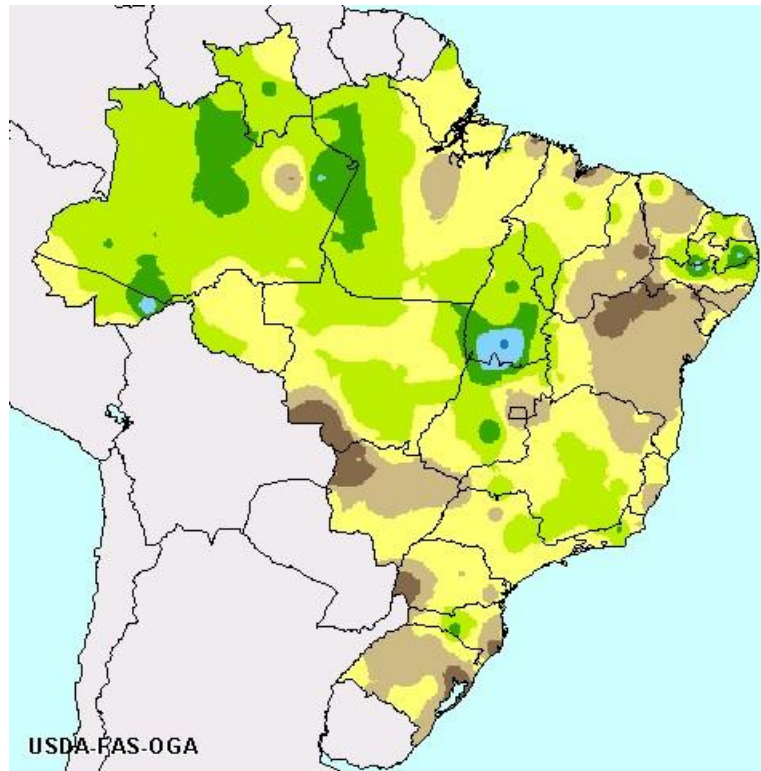
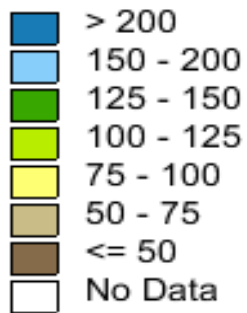
- Alfisols
- Andisols
- Aridisols
- Entisols
- Gelisols
- Histosols
- Inceptisols
- Mollisols
- Oxisols
- Spodosols
- Ultisols
- Vertisols
- Rocky Land
- Shifting Sands
- Ice/glacier



Seasonal Percent of Normal Precipitation

09/01/11 - 02/29/12

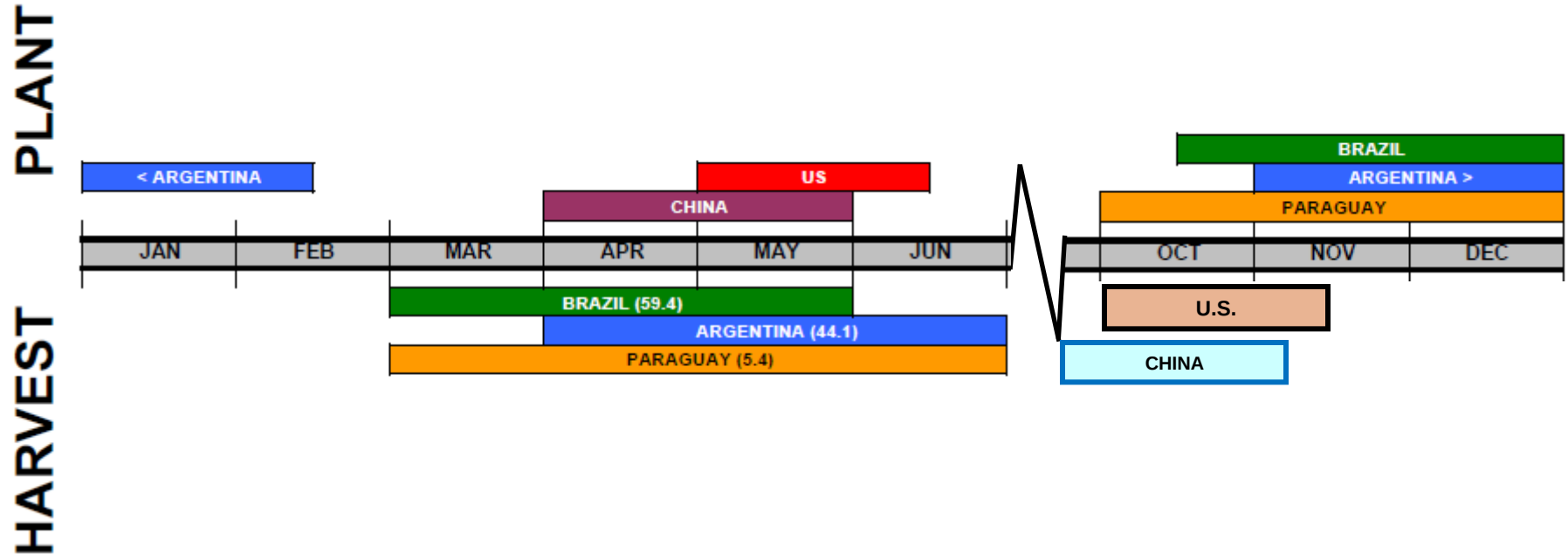
Seasonal Percent of Normal (%)



	Midwest		Southeast		South	
Month	°C	mm	°C	mm	°C	mm
Oct	24.55	161	22.2	158.6	18.6	161.7
Nov	24.5	212.25	22	204.9	21.8	136.5
Dec	24.5	253.4	21.7	297.2	22.4	195.9
Jan	23.9	269.2	22.1	273	22.9	175.2
Feb	25.4	224.4	22.2	194.1	22.7	164.8
Mar	24.1	206.5	22.9	166	21.3	119.9
Apr	25.65	129.2	21.2	73.9	19.1	97.3
May	23.25	45.95	19.7	24.8	16.4	123.9
Jun	23.1	9.5	18.5	6.2	15.4	123.5
Jul	22.65	6.55	18.2	13.1	16.2	82.6
Aug	23.8	20	20.3	13.3	16.9	84.4
Sep	24.95	59.9	22.1	49.3	18.2	138.1



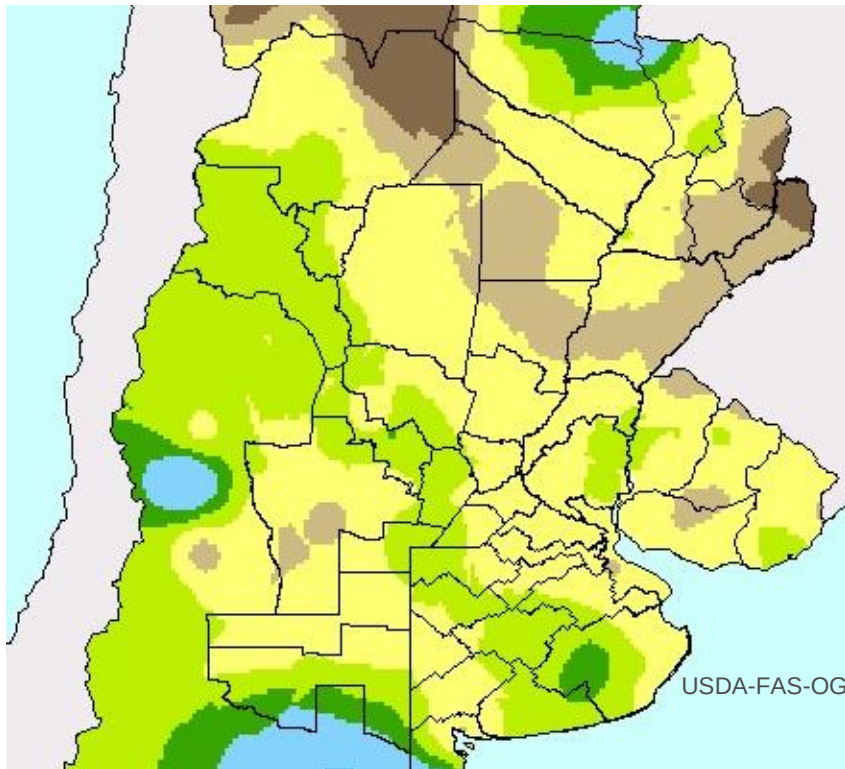
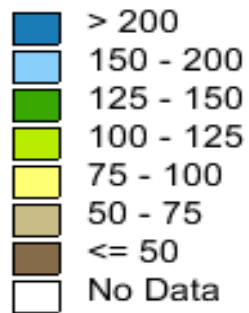
Average Range of Global Soybean Planting and Harvest by Country



Seasonal Percent of Normal Precipitation

09/01/11 - 03/31/12

Seasonal Percent of Normal (%)



	North		Central		South	
Month	°C	mm	°C	mm	°C	mm
Oct	18.7	26.1	19.8	64	16	110
Nov	20.3	65.3	22.6	83.4	19.5	103.9
Dec	21.2	138	24.75	113.25	22.4	110.3
Jan	21.2	182	25.45	127.2	23.6	128
Feb	20.1	162.9	24.3	111.4	22.3	121
Mar	18.9	118.3	22	102	19.7	138.3
Apr	16.2	36.6	18.5	49.2	16.1	101.5
May	13.3	8.6	15.2	26.4	12.5	47.3
Jun	10.1	2.6	11.35	16.3	9.3	39.6
Jul	10.1	3.5	11.25	14.8	9.3	43.9
Aug	12.3	4.2	13.1	12.25	10.6	44.6
Sep	15	6.6	16.05	34.4	13.3	65.3



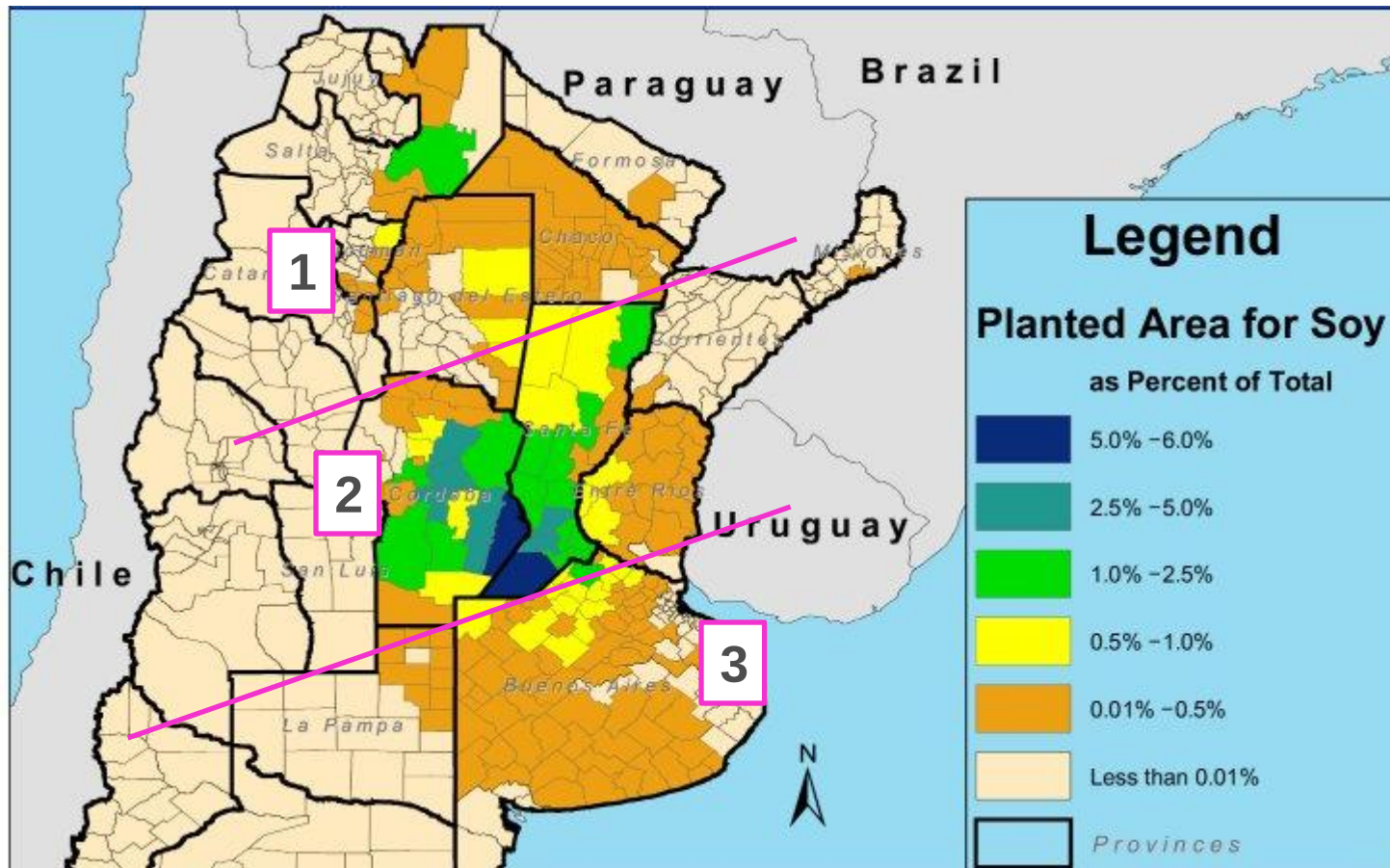
METHODS

- ✦ Collected 375 representative samples from South America (Argentina, Brazil, Paraguay, Uruguay)
- ✦ Measured amino acids, fatty acids, soluble proteins, fiber, and sugars through standard chemical analyses



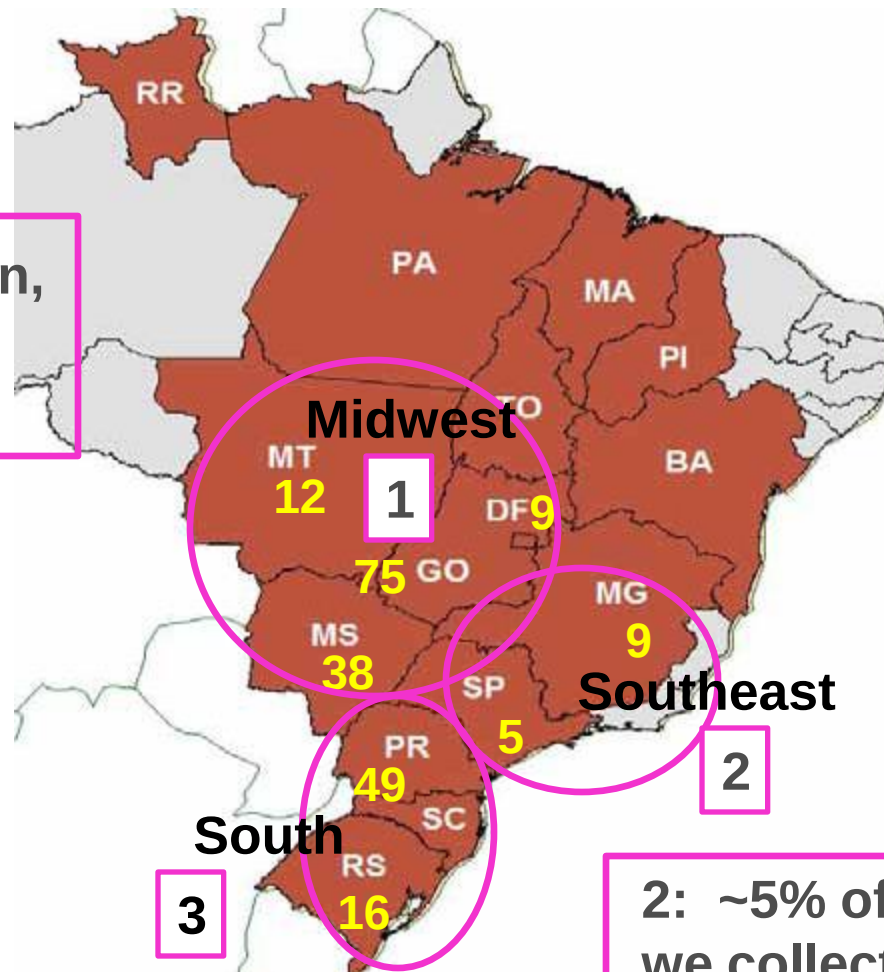
120 SAMPLES FROM ARGENTINA

- 1: ~12% of production, we collected 12 samples
- 2: ~60% of production, we collected 55 samples
- 3: ~28% of production, we collected 53 samples



213 SAMPLES FROM BRAZIL

1: ~41% of production,
we collected 134
samples (63%)



2: ~5% of production,
we collected 14
samples (7%)

3: ~40% of production,
we collected 65 samples (31%)



28 SAMPLES FROM PARAGUAY

- 1: north, we collected 8 samples
- 2: central, we collected 12 samples
- 3: south, we collected 8 samples



14 SAMPLES FROM URUGUAY

1: north, we collected 7 samples

2: south/west, we collected 7 samples



RESULTS

- ✿ Among the South American countries sampled, Paraguay tended to have the highest protein concentrations, while Brazil produced soybeans with the highest oil
- ✿ However, the essential amino acid fraction of the seed protein tended to be lowest in soybeans from Brazil and Paraguay



Protein, Oil, and Essential Amino Acids

SAMPLE LOCATION	Protein db	Oil db	Total of 10 Essential Amino Acids % P	Total of 5 Essential Amino Acids % P
375 SOUTH AMERICA	40.20	22.37	39.13	14.08
120 ARGENTINA	39.20	21.83	39.15	14.10 ns
213 BRAZIL	40.64**	22.70**	39.18 ns	14.07
120 ARGENTINA	39.20	21.83	39.15**	14.10*
28 PARAGUAY	41.31**	22.43**	38.55	13.94
120 ARGENTINA	39.20	21.83 ns	39.15	14.10
14 URUGUAY	39.81 ns	21.82	39.30 ns	14.43*
213 BRAZIL	40.64	22.70 ns	39.18**	14.07 ns
28 PARAGUAY	41.31**	22.43	38.55	13.94
213 BRAZIL	40.64 ns	22.70**	39.18	14.07
14 URUGUAY	39.81	21.82	39.30 ns	14.43**
28 PARAGUAY	41.31**	22.43 ns	38.55	13.94
14 URUGUAY	39.81	21.82	39.30**	14.43**

RESULTS

- ✿ The relative abundance of Lysine in the protein (Lys % P) was highest in Brazil and Paraguay
- ✿ Lysine availability differed very little between South American countries

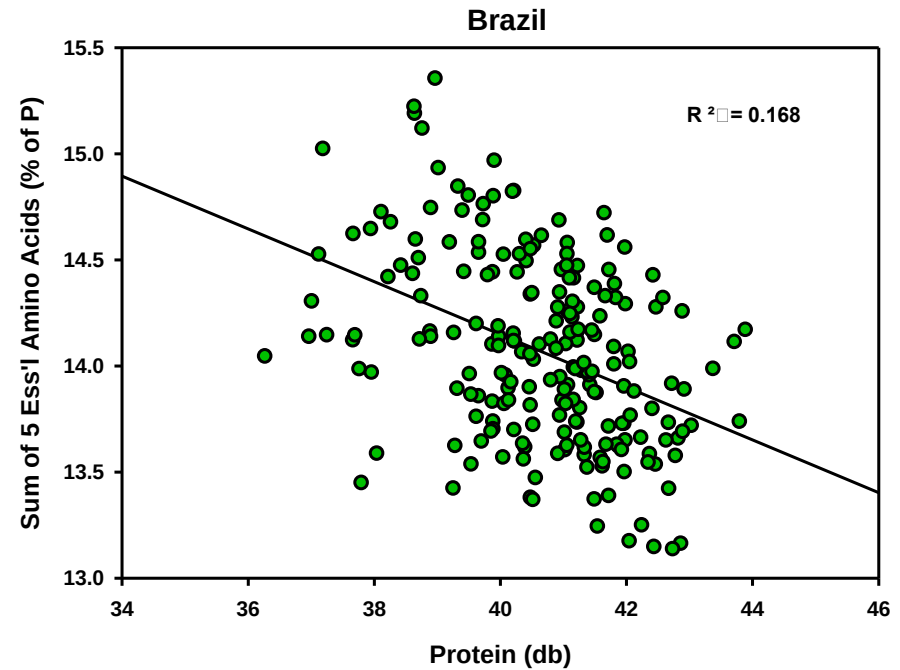
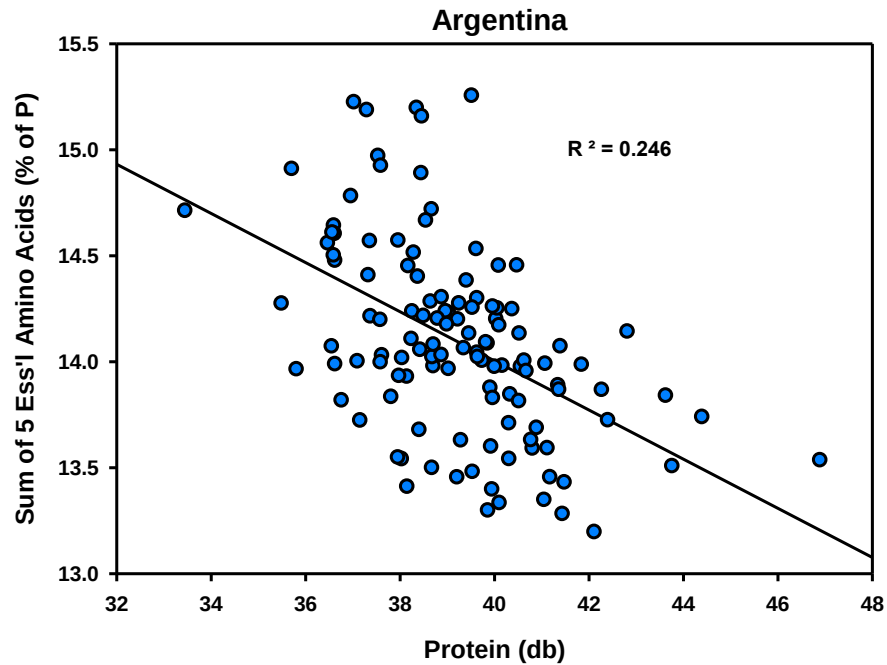


Individual Essential Amino Acids

SAMPLE LOCATION	Lysine % P	Cysteine % P	Methionine % P	Threonine % P	Tryptophan % P	Avail. Lysine ÷ Total Lysine db
375 SOUTH AMERICA	6.52	1.34	1.33	3.74	1.15	0.98
120 ARGENTINA	6.48	1.33	1.36**	3.73	1.20**	0.99**
213 BRAZIL	6.55**	1.33	1.31	3.75 ns	1.14	0.98
120 ARGENTINA	6.48*	1.33	1.36	3.73**	1.20	0.99**
28 PARAGUAY	6.39	1.45**	1.37 ns	3.66	1.06**	0.97
120 ARGENTINA	6.48	1.33	1.36	3.73	1.20**	0.99**
14 URUGUAY	6.65**	1.42*	1.38 ns	3.90**	1.08	0.98
213 BRAZIL	6.55**	1.33	1.31	3.75**	1.14**	0.98**
28 PARAGUAY	6.39	1.45**	1.37**	3.66	1.06	0.97
213 BRAZIL	6.55	1.33	1.31	3.75	1.14 ns	0.98
14 URUGUAY	6.65*	1.42*	1.38**	3.90**	1.08	0.98
28 PARAGUAY	6.39	1.45 ns	1.37	3.66	1.06	0.97
14 URUGUAY	6.65**	1.42	1.38 ns	3.90**	1.08 ns	0.98**



5 Essential Amino Acids by Seed Protein



RESULTS

- ✿ Uruguay showed lower fiber levels and higher sucrose, raffinose, and total sugars
- ✿ In most other cases, there was an inverse relationship between sucrose and raffinose



Fiber and Sugars

SAMPLE LOCATION	Fiber db	ADF db	NDF db	Sucrose db	Raffinose db	Total sugars db
375 SOUTH AMERICA	5.51	11.34	14.38	5.47	0.83	10.11
120 ARGENTINA	5.58 ns	11.22	14.30	5.59 ns	0.71	9.92
213 BRAZIL	5.50	11.35 ns	14.35 ns	5.55	0.86**	10.24 ns
120 ARGENTINA	5.58 ns	11.22	14.30	5.59**	0.71	9.92*
28 PARAGUAY	5.49	12.07**	15.24**	3.99	1.10 ns	9.17
120 ARGENTINA	5.58**	11.22**	14.30 ns	5.59	0.71	9.92
14 URUGUAY	5.18	10.71	13.70	6.20 ns	0.83**	11.55**
213 BRAZIL	5.50 ns	11.35	14.35	5.55**	0.86	10.24**
28 PARAGUAY	5.49	12.07**	15.24**	3.99	1.10**	9.17
213 BRAZIL	5.50**	11.35**	14.35 ns	5.55	0.86 ns	10.24
14 URUGUAY	5.18	10.71	13.70	6.20*	0.83	11.55*
28 PARAGUAY	5.49**	12.07**	15.24**	3.99	1.10**	9.17
14 URUGUAY	5.18	10.71	13.70	6.20**	0.83	11.55**



RESULTS

- ✿ Net energy of the simulated meal fraction from each soybean sample was estimated with 'EVAFIG' [<evapig.com>](http://evapig.com) by subtracting the energy from the oil fraction to give the whole soybean energy value
- ✿ Argentina and Uruguay had slightly higher net energy values than Brazil, despite lower overall protein levels



Net Energy - Example

SAMPLE LOCATION	(Net Energy, Adult Pig) - (Net Energy from Oil) (MJ/kg)
375 SOUTH AMERICA	5.89
120 ARGENTINA	5.92**
213 BRAZIL	5.87
120 ARGENTINA	5.92**
28 PARAGUAY	5.83
120 ARGENTINA	5.92
14 URUGUAY	5.97 ns
213 BRAZIL	5.87*
28 PARAGUAY	5.83
213 BRAZIL	5.87
14 URUGUAY	5.97**
28 PARAGUAY	5.83
14 URUGUAY	5.97**



RESULTS

- ❖ Brazilian and Uruguayan samples tended to contain higher fractions of saturated fatty acids, while Argentinian and Paraguayan samples tended to have higher fractions of unsaturated fatty acids



Fatty Acids

SAMPLE LOCATION	Main Saturated Fats	Palmitic (16:0)	Stearic (18:0)	Arachidic (20:0)	Behenoic (22:0)	Main Unsaturated Fats	Oleic (9c-18:1)	Linoleic (18:2n6)	Linolenic (18:3n3)
375 SOUTH AMERICA	16.82	11.48	4.46	0.40	0.49	82.88	23.35	52.34	7.19
120 ARGENTINA	16.97**	11.61*	4.56**	0.37	0.43	82.77	20.91	53.82**	8.04**
213 BRAZIL	16.64	11.45	4.29	0.39**	0.51**	83.08**	23.83**	52.32	6.93
120 ARGENTINA	16.97	11.61**	4.56	0.37	0.43	82.77**	20.91	53.82**	8.04**
28 PARAGUAY	17.58**	11.32	5.13**	0.52**	0.60**	81.75	31.71**	45.12	4.92
120 ARGENTINA	16.97 ns	11.61**	4.56	0.37	0.43	82.77	20.91 ns	53.82	8.04
14 URUGUAY	16.79	11.14	4.74 ns	0.41*	0.50**	82.88 ns	20.07	54.30 ns	8.51 ns
213 BRAZIL	16.64	11.45 ns	4.29	0.39	0.51	83.08**	23.83	52.32**	6.93**
28 PARAGUAY	17.58**	11.32	5.13**	0.52**	0.60**	81.75	31.71**	45.12	4.92
213 BRAZIL	16.64	11.45*	4.29	0.39	0.51 ns	83.08 ns	23.83**	52.32	6.93
14 URUGUAY	16.79 ns	11.14	4.74**	0.41 ns	0.50	82.88	20.07	54.30**	8.51**
28 PARAGUAY	17.58**	11.32 ns	5.13*	0.52**	0.60**	81.75	31.71**	45.12	4.92
14 URUGUAY	16.79	11.14	4.74	0.41	0.50	82.88**	20.07	54.30**	8.51**



Summary

- ⦿ The information represents one year of quality data – we will collect another year of data (2012/2013) from South America
- ⦿ We also will collect U.S. samples and determine the same quality constituents



Summary

- ✿ There is considerable variability for protein, oil, amino acids, sugars, and other constituents *between* and *within* South American countries
- ✿ There are **varietal** differences in all of the characteristics measured, hence, we can find a wide range of values in any country or region





Thank you!

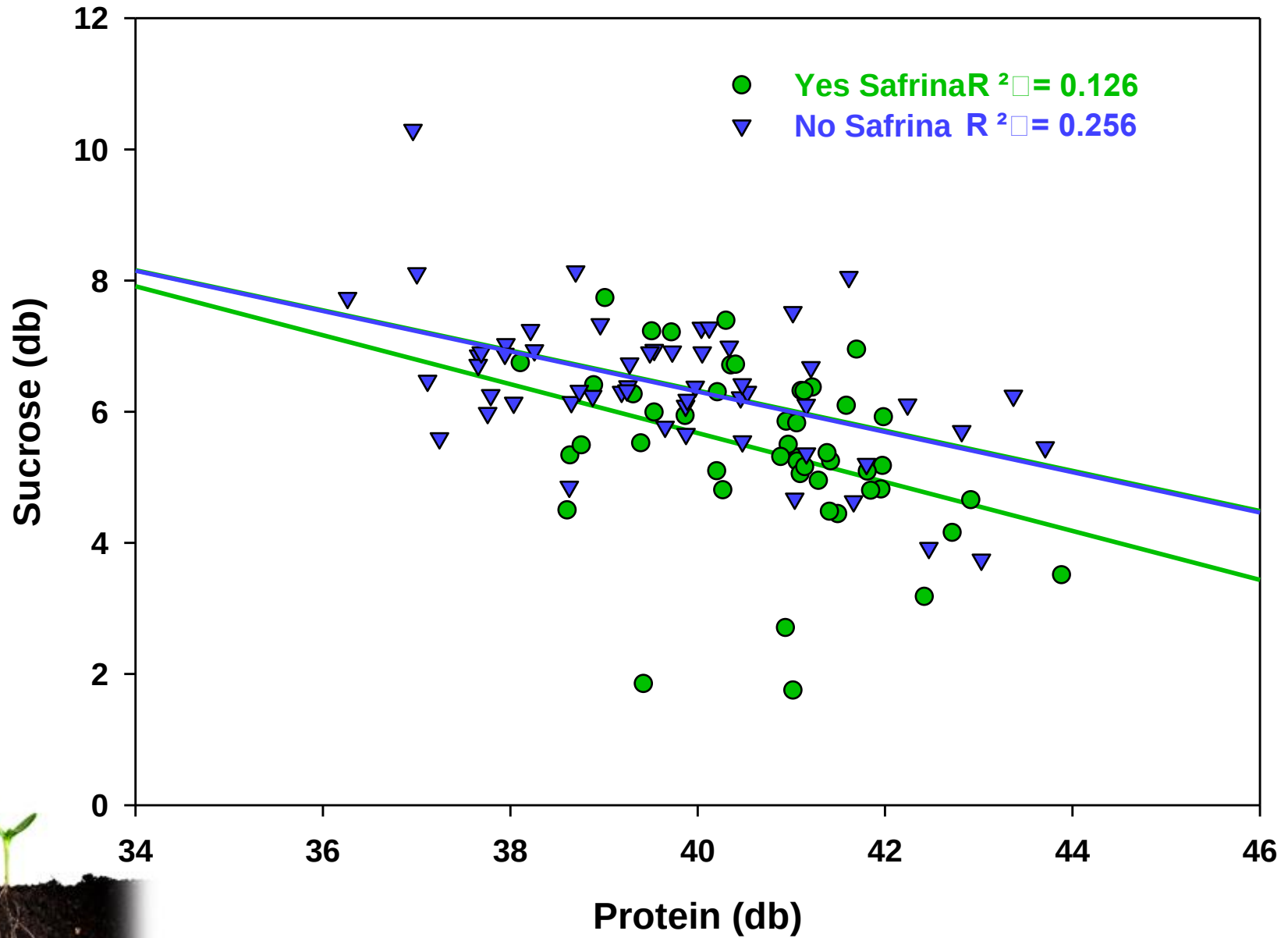
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Country	State	Region Within Production Area	Region Code Number	# Samples from that Region	Total # Samples by Region
Argentina	Chaco	north	1	1	
	Formosa	north	1	2	
	Salta	north	1	4	
	Santiago del Estero	north	1	2	
	Tucuman	north	1	3	12
	Cordoba	central	2	23	
	Corrientes	central	2	2	
	Entre Rios	central	2	8	
	Santa Fe	central	2	22	55
	Buenos Aires	south	3	52	
	La Pampa	south	3	1	53
					120
Country	State	Region Within Production Area	Region Code Number	# Samples from that Region	Total # Samples by Region
Brazil	Distrito Federal	midwest	1	9	
	Goiias	midwest	1	75	
	Mato Grosso	midwest	1	12	
	Mato Grosso do Sul	midwest	1	38	134
	Minas Gerais	southeast	2	9	
	Sao Paulo	southeast	2	5	14
	Parana	south	3	49	
	Rio Grande do Sul	south	3	16	65
					213
Country	State	Region Within Production Area	Region Code Number	# Samples from that Region	Total # Samples by Region
Paraguay	Amambay	north	1	1	
	Canindeyu	north	1	5	
	San Pedro	north	1	2	8
	Alto Parana	central	2	9	
	Caaguazu	central	2	3	12
	Itapua	south	3	8	8
					28
Country	State	Region Within Production Area	Region Code Number	# Samples from that Region	Total # Samples by Region
Uruguay	Rivera	north	1	5	
	Tacuarembó	north	1	2	7
	Colonia	south/west	2	2	
	Soriano	south/west	2	5	7
					14
TOTAL SAMPLES FOR ANALYSIS					375

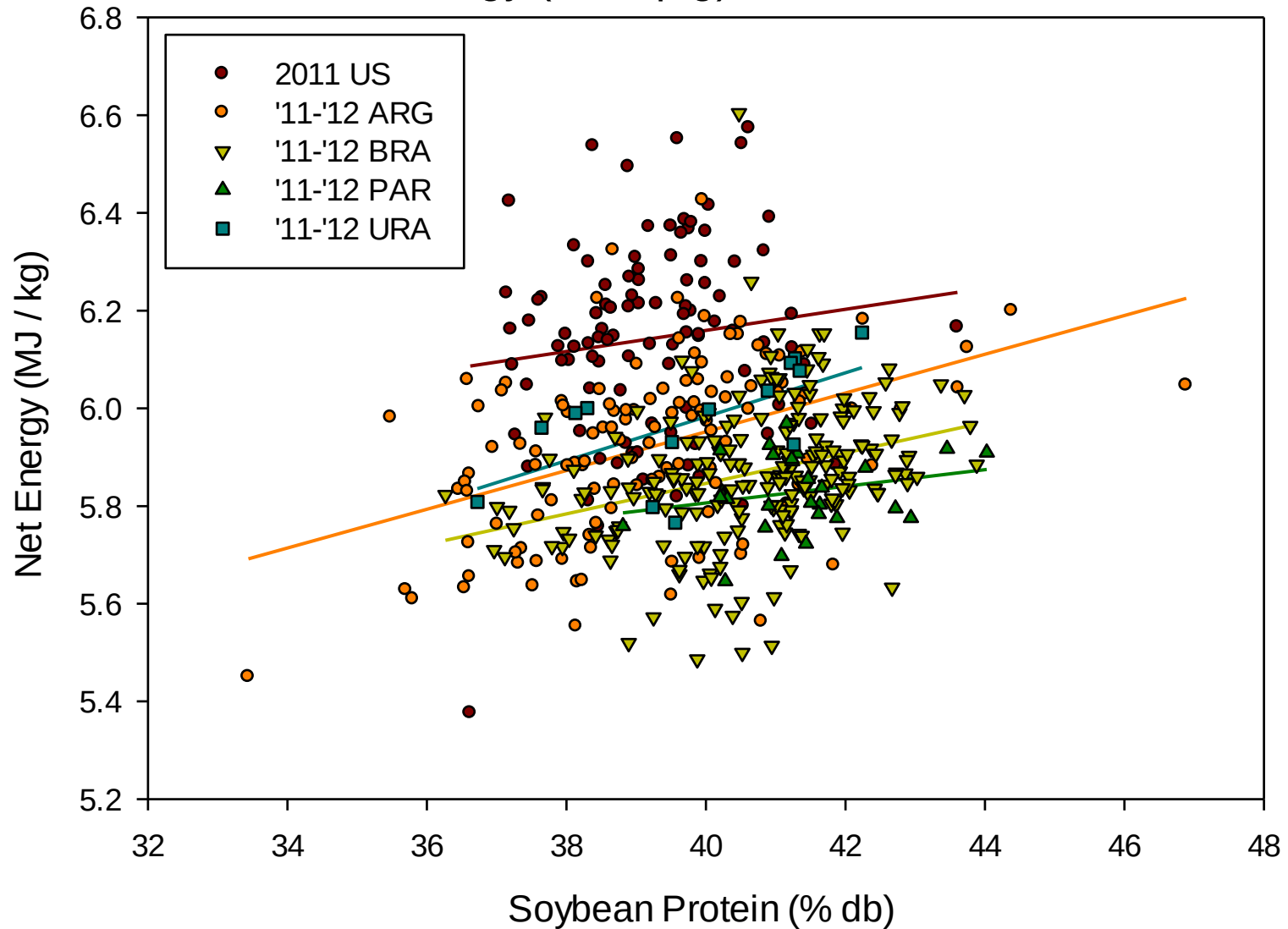
Brazil (midwest)



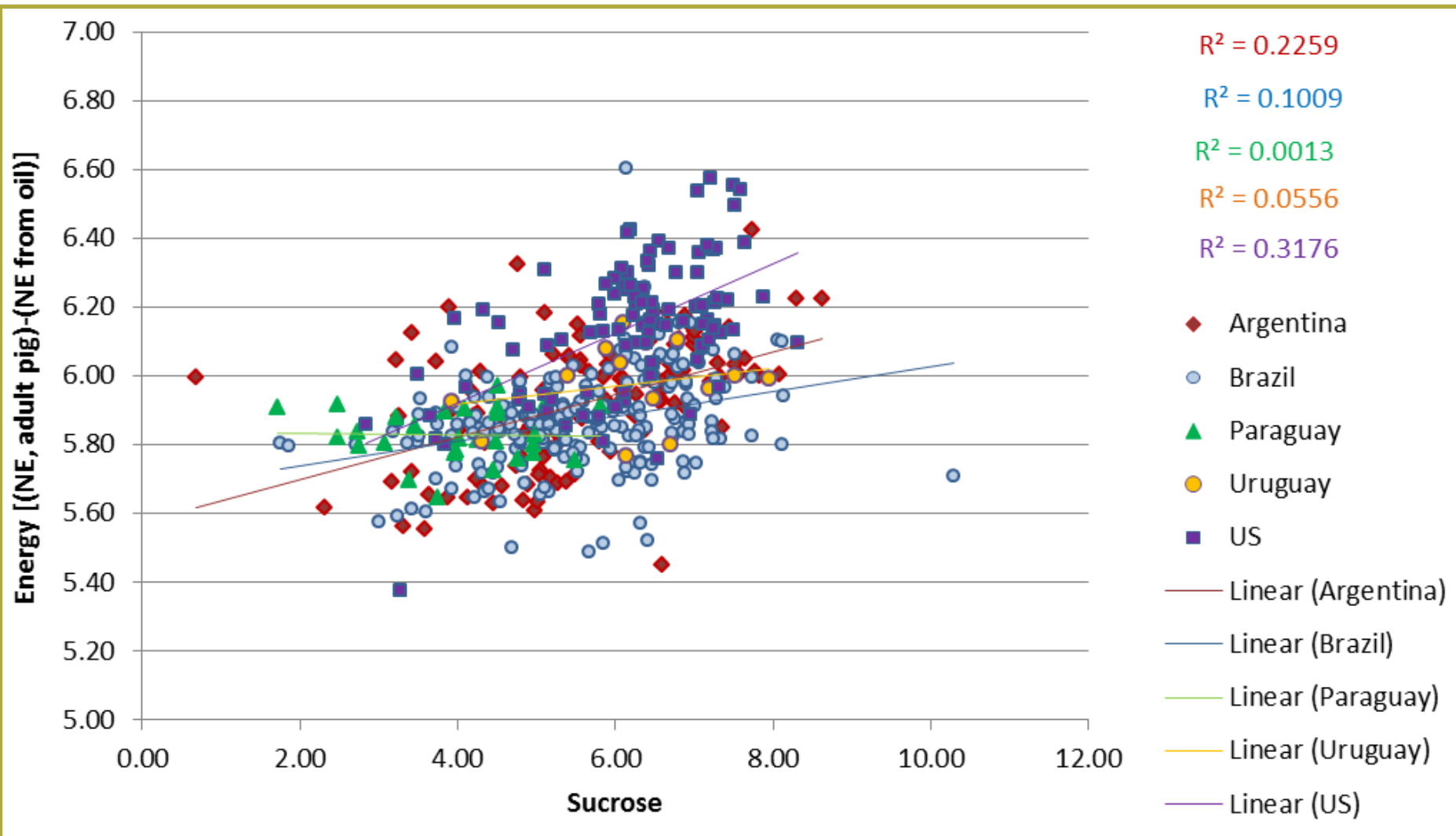
	yes safrinha	no safrinha
n =	48	55
protein	**40.75	39.67
oil	ns 22.75	22.51
P + O	**63.5	62.18
energy	5.84	ns 5.85
sucrose	5.39	**6.42
raffinose	0.82	**1.03
stachyose	3.41	**4.89
verbascose	*0.31	0.28
5 ess'l. aas	ns 14.27	14.15
10 ess'l. aas	**39.57	39.18



Net Energy (adult pig) of simulated meal

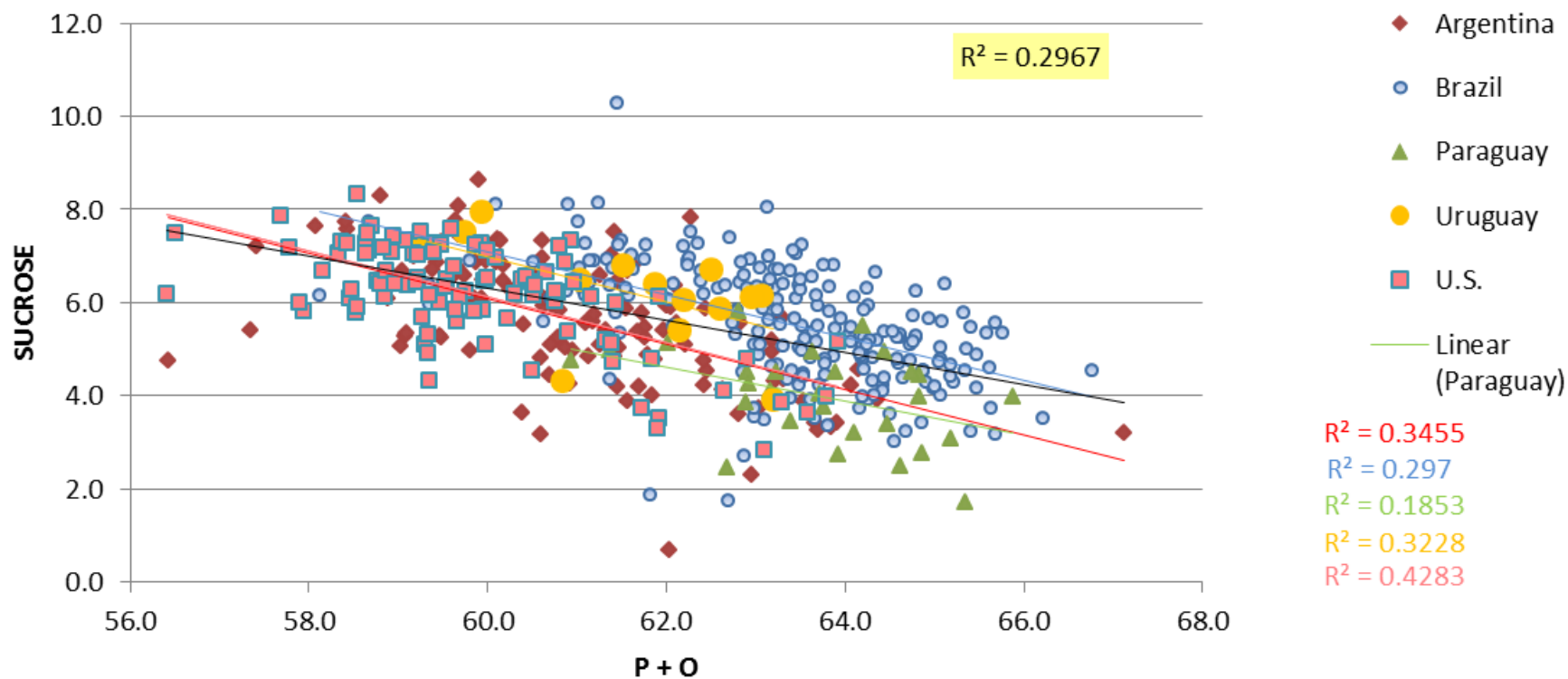


Net Energy by Sucrose



Sucrose by P+O

2011-12 South American and 2011 U.S. Samples Lab Data





Quality Constituent	100 United States	375 South America
Protein (db)		40.20
Oil (db)		22.37
Sum of 10 Essential Amino Acids (%P)	39.42	
Sum of 5 Most Critical Essential Amino Acids (%P)	14.32	
Lysine (%P)		6.52
Cysteine (%P)	1.46	
Methionine (%P)	1.40	
Threonine (%P)	3.74 ns	3.74 ns
Tryptophan (%P)	1.23	
Fiber (db)	5.98	
ADF (db)	11.86	
NDF (db)	15.88	
Sucrose (db)	6.18	
Raffinose (db)		0.83
Total Sugars (db)	11.32	
Main Saturated Fatty Acids (% of total fat)		16.82
Main Unsaturated Fatty Acids (% of total fat)	83.17	
Net Energy (MJ/kg)	6.14	

