QUALITY OF THE 2002 SOYBEAN CROP FROM THE UNITED STATES [1/]

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Quality continues to be an important soybean marketing issue. This report summarizes current knowledge on the following soybean quality topics:

- Protein and oil composition of the 2002 U.S. soybean crop
- The 2002 crop in historical perspective
- Factors affecting soybean quality
- Genetic modifications
- Amino acid composition of the 2002 U.S. soybean crop

The data and analyses in this report are intended to assist customers in the sourcing and use of U.S. soybeans.

The Quality Survey

Since 1986, Iowa State University (ISU) and the American Soybean Association (ASA) have been surveying the quality of new crop soybean harvests. U.S. soybean producers representing 30 soybean production states, in response to a mailed request, provided samples of 2002 crop soybeans for analysis. Samples received by November 15, 2002 were analyzed for protein, oil, and amino acid contents using an Infratec near-infrared instrument (Foss North America, Eden Prairie, Minn.). Amino acid analyses were verified through wet chemistry analyses on a subset of the total sample set. From other sources, data on the yield and physical quality (U.S. Grade factors) of U.S. soybeans have been collected. Data were organized by state and region (groups of states). This procedure has been utilized for the 17 years of the survey.

The 2002 U.S. Soybean Crop

The United States produced 2.69 billion bushels (73.3 million metric tons) of soybeans according to the November 1 USDA production estimates (USDA, 2002a). This is a decrease of 7 percent from 2001, and the lowest since 1999. The average soybean yield was 37.5 bushels per acre. An estimated 71.8 million acres (29.1 million hectares) of soybeans were harvested, a 2% decrease from 2001. Table 1 summarizes production statistics for the 2002 crop, by state and growing region.

In June, 2002, USDA surveyed producers as to their plantings of GM varieties, almost exclusively Roundup Ready™ soybeans (USDA, 2002b). Approximately 75% of U.S. soybeans were GM in 2002, an increase from the 2001 estimate of 68%.

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Most of the production decreases occurred in the far western Corn Belt states (Nebraska, Kansas), the upper Ohio River Valley, and the Atlantic Coast. Hot and dry weather conditions in those areas contributed to poor yields. Over 230,000 acres (93,000 hectares) were abandoned in Kansas and Nebraska due to severe drought conditions. The Mississippi Valley growing regions, and in particular, the upper Mississippi Valley, experienced ideal growing conditions throughout most of the season.

Composition data are given in Table 2. Average U.S. protein and oil contents for 2002 were 35.46% and 19.34% respectively. These are above the long-term U.S. averages of 35% protein and 19% oil. These soybeans will produce, on average, 43.2 lbs of 48% protein meal and 11.3 lbs of oil per bushel.

The variability (standard deviation) within states, regions, and the U.S. was significantly lower than 2001. More consistent protein and oil contents in export cargoes can be expected relative to last year. The north to south protein pattern (lower north, higher south) was again evident in 2002. Harvest temperatures were at or above average throughout harvest, so there should be little frost damaged soybeans which cause oil refining problems. Expect moistures around 11% to 12% this year, about the historical average.

Reports of purple and brown staining of seed coats are less frequent in 2002, although this phenomenon hasn't completely disappeared. These discolorations are caused by viruses but do not affect crushing value. The discoloration is an acceptance problem for food uses. Commodity beans are probably becoming more tolerant to leaf beetles and other mechanisms that spread the virus.

Producers were also asked to indicate whether the samples they sent represented soybeans destined for identity-preserved (IP) or for bulk sales. Out of a total of 1327 samples received, 190 indicated IP soybeans and 932 indicated bulk soybeans, and 205 did not make an indication. The IP soybeans had an average content of 35.81% protein and 19.26% oil. The bulk soybeans had an average content of 35.46% protein and 19.31% oil, almost identical to the overall U.S. average. It would be expected that the IP soybeans would be higher in protein – many IP shipments are destined for food purposes where higher protein levels are often more desirable.

Historical Performance

Soybean yields and acreage have been increasing steadily until this year. Table 3 shows a combination of USDA production (USDA, 2002c) and survey composition data. The same data is shown graphically in Figure 1. Over the long term, yields have been increasing at approximately 0.5 bushels/acre/year, with little change in average protein and oil content. This year's increase in protein and oil content can be attributed mainly to weather related conditions. Breeding programs continue to succeed in producing yield gains without quality loss.

The processing chart in Figure 2 shows the combinations of protein and oil content that will produce 47.5% to 48.5% protein soybean meal. Only once (1997) did U.S. soybeans fall to the left of the optimal area, shown by the shading. Soybeans from individual states and regions often fall to the far right, above 48.5% meal, and the U.S.

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averages are regularly in the middle of this area. In 2002, the U.S. average is above and to the right of the long-term U.S. average, reflecting the greater value inherent in this year's crop.

The USDA Grain Inspection Packers and Stockyards Administration (GIPSA) collects results from Official soybean export inspections (GIPSA, 2002). Official inspections establish Grade based on a set of physical factors and, on request, will report protein and oil contents. Historical data is given in Table 4. The majority of inspections (>93%) were for U.S. No. 2 soybeans in 2001. There has been little change in physical quality over time, and the GIPSA composition measurements line up well with the ASA-ISU survey data.

Factors Affecting Soybean Quality

There have been many studies relating soybean protein and oil content to environmental conditions. Table 5 is a qualitative summary of soybean composition in response to weather and non-agronomic variables. While some general trends are evident, the cause of quality variations in specific situations remains difficult to predict.

Variety selection is also an important factor influencing composition. Many public institutions report composition in variety comparisons. Generally, the difference among varieties (at a location) is approximately 50% of the total composition variation in an area. Previous studies show that about 20% of varieties were above average in both yield and composition (Hurburgh, 2000).

Since 1999, one U.S. soybean processing firm, Ag Processing Inc., has been offering premiums for enhanced composition. The current premium scale is given in Table 6, based on protein and oil contents on an as-is moisture basis. Soybean producers are planting varieties that are high-yielding and able to earn a premium. Seed companies are beginning to market varieties with higher protein and oil contents in this processor's trading territory.

Genetic Modifications

Roundup Ready? soybeans, genetically modified to resist the herbicide Roundup? , continue to be the only "GMO" soybean approved for production in the United States. Numerous public yield trials, in particular, the Iowa Soybean Yield Tests (Iowa Crop Improvement Association, 2002), have provided separate comparisons for Roundup Ready? and conventional soybeans. There continues to be no consistent difference in composition between the RR and non-RR soybeans, over thousands of tests each year.

The high percentage of planting of GM soybeans (75% in 2002) virtually ensures that soybeans purchased by U.S. grade factors (#1 or #2) will contain some level of GM. However, widespread adoption of GM by U.S. producers has sharply reduced the levels of weed seeds and plant parts in soybean foreign material. Non-GM markets are emerging within the U.S. Premiums are approximately 40-60 cents/bushel ($15-$22/mt), with about 40% going to the producer. The remainder is divided across the rest of the market chain (Hurburgh, 2001).

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Several U.S. grain elevator firms are developing documented ISO 9000 quality management systems in order to serve these specialized markets. One example is the Farmers Cooperative Elevator Co. of Farnhamville, Iowa, the largest producer-owned grain handling firm in Iowa. They have recently been certified under the Quality Systems Evaluation format from the American Institute of Baking and will be ISO 9000 certified within the year (GEAPS, 2002). These systems will allow tracking of individual trucklots of grain back to the producer, and will provide documented traceability of soybean shipments, increasingly important as soybean buyers wish to verify the quality and origin of their purchases.

Amino Acid Composition

Modern high-performance nutrition focuses more on subunits (amino acids, fatty acids, etc.) than on crude composition. Specifically for soybean meal and corn, the concentrations of the limiting amino acids (AA) are important: lysine (swine), methionine + cysteine (poultry), and tryptophan (both). If there is no connection between individual amino acid levels and protein, then including amino acid data in assessment of soybean value will simply magnify the variability among lots at all protein levels. If an amino acid rises (or falls) with increasing (or decreasing) protein, then the amino acid change could add or subtract from the value gain of protein, depending on whether the ratio of amino acid to protein increased or decreased.

The Iowa State University Grain Quality Laboratory has amassed an amino acid database of over 600 samples over eight crop years (Hurburgh, 2002). For a uniform protein content, there are wide ranges of amino acid levels. As a percentage of protein, the amino acids in whole soybeans should be approximately equal to those in meal. Thus, published values of amino acids in soybeans or soybean meal will not accurately represent specific situations.

Analysis of this database shows that threonine and lysine are correlated with protein, but TSAA (total sulfur-containing amino acids, methionine + cysteine), methionine, tryptophan and cysteine are not. Using protein as a proxy for amino acids is not appropriate, although for changes in lysine and threonine, a mathematical relationship could account for 70% of the change in protein.

It is known that soybean meal can vary widely in amino acid content. The explanation for these wide ranges of meal quality now becomes clearer. Figure 2 shows the combinations of protein and oil that will make a specified meal protein content. Soybeans from 34% to 38% protein can all produce 48% protein meal, but with a range of amino acid contents, reflecting variability in amino acid to protein ratios. Lower protein would not produce 48% meal but could yield meal with higher relative amounts of essential amino acids.

Table 7 further illustrates this situation for two amino acids, lysine and TSAA (cysteine + methionine), based on samples from the amino acid database. The example protein levels of 32% to 38% are within the regional variations consistently reported in the ASA Survey. For swine nutrition (lysine dependent), 32% protein soybeans and 36% soybeans are equivalent. For poultry nutrition (sulfur amino acid dependent), the 32%

soybeans were actually superior to all others. Therefore, regions that typically produce low protein may not be at the disadvantage now assessed by the market.

It is interesting to note that the United Soybean Board has identified improvements in lysine, methionine, cysteine, tryptophan, and threonine (essential to one or more monogastric species) as targets of the "Better Bean Initiative" (USB, 1999).

A subset of the 2002 Survey samples (n=178) were analyzed for amino acid content by wet chemistry methods. The number of samples that were randomly selected from within each state roughly corresponded to each state's percentage of U.S. soybean production. The results are presented in Table 8. While the averages by region did not vary significantly, the range in particular amino acid results was 20 to 40% of the mean for that amino acid. The AA results of the 2002 Survey, expressed as a percentage of protein, is given in Table 9.

Amino Acid Analyses by Near Infrared Spectroscopy (NIR)

If the amino acid content of soybeans is a more accurate reflection of value, rapid and inexpensive measurements will be needed. Near infrared spectroscopy is already used extensively to accurately determine soybean protein and oil content. This technology is so far unproven for determining amino acids in soybeans.

Hurburgh (2002) used the same amino acid database to develop near infrared calibrations for selected amino acids in the Foss/Infratec NIR analyzer, the device used by GIPSA to determine soybean protein and oil. The calibration statistics are given in Table 10. Although significant improvements over protein regression relationships were made, the calibrations were not accurate enough for quantification of amino acid levels. More accurate measurements are necessary if NIR amino acid analyses are used to mix animal rations or to pay premiums. NIR data from the 2002 Survey (not reported) confirm this result.

The results, however, do indicate the potential for improvement and further application, especially for rapid screening in soybean breeding development programs. It is clear that more sensitive NIR units with more complex mathematical capabilities will be needed for major improvements in determining amino acids with this technology.

Summary

The 2002 U.S. soybean crop has above average protein (35.5%) and oil (19.3%) contents. Yields and total production were down sharply from 2002. Approximately 75% of the U.S. crop was genetically modified (Roundup Ready?). Soybean meal from lower protein soybeans is likely to have equal or higher essential amino acid levels than meal from higher protein soybeans. Rapid near-infrared testing for amino acids, while an improvement over correlations to crude protein, need additional work before they can be used for mixing animal rations or paying premiums.

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Table 1. Soybean production data for the United States, 2002 crop.

Region	State	Yield (bu/a)	Acreage (1000 acres)	Production (1000 bushels)	Percentage of acres in GM*
Western Corn Belt (WCB)	Iowa	46	10,650	489,900	75
	Kansas	24	2,600	62,400	83
	Minnesota	45	6,900	310,500	71
	Missouri	33	4,650	153,450	72
	Nebraska	38	4,700	178,600	85
	North Dakota	34	2,400	81,600	61
	South Dakota	30	4,150	124,500	89
	Western Corn Belt	38.9	36,050	1,400,950	76
	% of US Total		50.2%	52.1%	
Eastern Corn Belt (ECB)	Illinois	41	10,350	424,350	71
	Indiana	41	5,680	232,880	83
	Michigan	38	1,940	73,720	72
	Ohio	32	4,620	147,840	73
	Wisconsin	42	1,420	59,640	78
	Eastern Corn Belt	39.1	24,010	938,430	75
	% of US Total		33.4%	34.9%	
Midsouth (MDS)	Arkansas	35	2,900	101,500	68
	Kentucky	33	1,210	39,930	---
	Louisiana	33	760	25,080	---
	Mississippi	34	1,420	48,280	80
	Oklahoma	28	280	7,840	---
	Tennessee	32	1,120	35,840	---
	Texas	28	240	6,720	---
	Midsouth	33.4	7,930	265,190	
	% of US Total		11.0%	9.9%	
Southeast (SE)	Alabama	26	140	3,640	---
	Florida	38	30	1,150	---
	Georgia	23	145	3,335	---
	North Carolina	22	1,290	28,380	---
	South Carolina	17	430	7,310	---
	Southeast	21.5	2,035	43,815	
	% of US Total		2.8%	1.6%	
East Coast (EC)	Delaware	22	192	4,224	---
	Maryland	21	505	10,605	---
	New Jersey	25	88	2,200	---
	New York	30	153	4,590	---
	Pennsylvania	27	380	10,260	---
	Virginia	21	460	9,660	---
	East Coast	23.4	1,778	41,539	
	% of US Total		2.5%	1.5%	
	U.S. Total	37.5	71,799	2,689,691	75

* GM = genetically modified soybean varieties (Roundup-Ready? ?

Source: U.S. Department of Agriculture (2000a, 2000b). Data for all states not given.

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Table 2. American Soybean Association 2002 soybean quality survey data.

			Protein		Oil	
Region	State	Number of Samples	Percent Average	Standard Deviation	Percent Average	Standard Deviation
Western	Iowa	275	35.41	1.33	19.18	0.76
Corn Belt	Kansas	27	35.54	1.56	19.31	0.84
	Minnesota	106	34.55	1.59	19.27	0.73
	Missouri	70	35.53	1.39	19.42	0.95
	Nebraska	116	34.96	1.30	19.34	0.78
	North Dakota	30	34.55	1.32	19.17	0.76
	South Dakota	57	35.03	1.90	19.27	0.98
	Averages	681	35.15	1.48	19.26	0.81
	Ranges		30.2-40.2		16.5-22.6	
Eastern	Illinois	250	35.45	1.41	19.47	0.91
Corn Belt	Indiana	117	36.36	1.53	19.17	1.11
	Michigan	35	36.53	1.20	18.77	0.97
	Ohio	94	35.44	1.72	19.60	1.18
	Wisconsin	28	34.60	1.96	19.57	0.94
	Averages	524	35.68	1.59	19.38	1.03
	Ranges		28.6-39.8		16.3-22.6	
Midsouth	Arkansas	33	36.29	1.73	19.56	1.15
	Kentucky	11	35.74	1.42	19.85	0.64
	Louisiana	4	37.33	0.49	19.53	0.68
	Mississippi	25	36.45	1.44	19.38	0.97
	Oklahoma	4	37.13	1.60	19.24	0.53
	Tennessee	13	36.37	1.26	19.53	0.73
	Texas	5	34.52	3.13	20.76	1.41
	Averages	95	36.27	1.66	19.59	1.00
	Ranges		29.6-39.9		17.2-23.0	
Southeast	Alabama	1	37.10	---	19.60	---
	Florida	1	34.60	---	20.00	---
	Georgia	1	36.60	---	21.30	---
	North Carolina	4	34.55	1.15	19.93	1.04
	South Carolina	1	37.80	---	20.35	---
	Averages	8	35.54	1.58	20.12	0.86
	Ranges		33.1-37.8		18.5-21.3	
East Coast	Delaware	2	36.55	0.49	19.65	0.49
	Maryland	7	37.03	0.97	19.17	1.13
	New Jersey	2	37.00	0.71	19.40	1.13
	New York	3	35.90	0.53	18.53	0.67
	Pennsylvania	3	36.50	1.25	19.50	1.04
	Virginia	2	35.90	2.97	20.40	1.98
	Averages	19	36.59	1.13	19.33	1.08
	Ranges		33.8-38.2		17.2-21.8	
USA	Averages	1327	35.46	1.58	19.34	0.93
	Ranges		28.6-40.2		16.3-23.0	
	1986-2002 average		35.40		18.60	

Basis: 13% Moisture

Table 3. Summary of Yield and Quality Data for U.S. Soybeans.

Year	Yield (bu/a)	Protein (%)	Oil (%)	Sum (%)	Harvested (000 acres)	Production (000 bu)
1986	33.3	35.76	18.54	54.30	58,312	1,941,790
1987	33.9	35.46	19.11	54.57	57,172	1,938,131
1988	27.0	35.13	19.27	54.40	57,373	1,549,071
1989	32.3	35.18	18.73	53.91	59,538	1,923,077
1990	34.1	35.40	19.18	54.58	56,512	1,927,059
1991	34.2	35.48	18.66	54.14	58,011	1,983,976
1992	37.6	35.56	17.27	52.83	58,233	2,189,561
1993	32.6	35.73	18.03	53.76	57,307	1,868,208
1994	41.4	35.39	18.20	53.59	60,809	2,517,493
1995	35.3	35.45	18.19	53.64	61,544	2,172,503
1996	37.6	35.57	17.90	53.47	63,349	2,381,922
1997	38.9	34.55	18.47	53.02	69,110	2,688,379
1998	38.9	36.13	19.14	55.27	70,441	2,740,155
1999	36.5	34.55	18.61	53.16	72,476	2,645,374
2000	38.0	36.22	18.65	54.87	73,024	2,774,912
2001	39.4	34.98	18.97	53.95	74,100	2,922,914
2002	37.5	35.46	19.34	54.80	71,799	2,689,691
Averages	35.8	35.40	18.60	54.02	63,477	2,285,542
Std. Dev.	3.5	0.45	0.56	0.69	6,654	410,307

Sources: United States Department of Agriculture and Iowa State University
Protein and oil contents basis 13% moisture

Table 4. Summary of GIPSA Grain Inspection Data for Soybeans.

Calendar Year	Crop Years	Percent No. 2YSB	Moisture (%)	Foreign Material (%)	Damaged Kernels (%)	Protein (%)	Oil (%)	ASA Survey Results* Protein (%)	ASA Survey Results* Oil (%)
1990	89,90	86.1	11.7	1.8	1.1	35.5	18.6	35.3	19.0
1991	90,91	86.4	12.1	1.7	1.1	35.5	19.0	35.4	18.9
1992	91,92	75.3	12.0	1.7	1.2	35.2	18.9	35.5	18.0
1993	92,93	86.2	12.5	1.7	1.1	35.4	18.3	35.6	17.5
1994	93,94	90.3	12.6	1.7	1.1	35.5	18.4	35.5	18.1
1995	94,95	92.3	12.2	1.7	1.0	35.2	18.5	35.4	18.2
1996	95,96	92.2	12.1	1.7	1.1	35.1	18.5	35.5	18.0
1997	96,97	90.9	12.6	1.6	0.8	35.3	18.4	35.0	18.2
1998	97,98	90.0	12.2	1.6	1.0	35.5	18.8	35.3	18.8
1999	98,99	89.4	12.0	1.6	0.9	35.3	18.8	35.3	18.9
2000	99,00	90.0	11.4	1.7	1.0	35.0	18.5	35.4	18.6
2001	00,01	93.1	11.5	1.7	1.3	35.8	18.5	35.6	18.8

Sources: USDA Grain Inspection Packers and Stockyards Administration and Iowa State University
Protein and oil basis 13% moisture

* Average of listed crop years

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Table 5. Soybean composition response to weather and non-agronomic variables.

Variable	Impact on	
	Protein	Oil
High temperatures	Inconclusive	Inconclusive
Early season drought	–	+
Late season drought[a]	+	–
Early frost/cold temperatures	–	–[b]
Additional soil nitrogen	+	–
Increased fertility (P, S)	+	+
Late planting	+	–
Insect defoliation	–	–
Insect depodding	+	Inconclusive
Inoculation with Rhizobia (N-fixing bacteria)	+	–

[a] After Westgate et al. (1999)
[b] Oil reduced because of additional refining needs
+ = increase; – = decrease

Table 6. Soybean Component Premium Schedule, 2002 crop

Percent Oil @ As-Is Moisture	Premium	Protein Premium 37% or Higher @ As-Is Moisture
19.4 or less	None	None
19.5 to 19.8	2.0 cents/bu	3.0 cents/bu
19.9 to 20.1	3.0 cents/bu	3.0 cents/bu
20.2 to 20.4	4.0 cents/bu	3.0 cents/bu
20.5 to 20.7	5.0 cents/bu	3.0 cents/bu
20.8 to 21.0	6.0 cents/bu	3.0 cents/bu
21.1 and higher	7.0 cents/bu	3.0 cents/bu

* Minimum oil required is 19.5% to receive protein premium
Source: Ag Processing, Inc., AGP (2002).

Table 7. Examples of soybean and soybean meal quality.

Soybean Protein (%)[a]	**Soybean Meal[b]**				
	Protein (%)	**Lysine**		**TSAA**	
		% of Protein	**% by Weight**	**% of Protein**	**% by Weight**
34	48	6.39	3.07	3.34	1.60
36	48	6.29	3.02	3.15	1.51
38	48	6.09	2.92	2.98	1.43
32	46.5	6.49	3.02	3.54	1.65

[a] Basis 13% moisture
[b] Basis 12% moisture

Table 8. Amino acid content (wt %) of a subset of samples from the 2002 Survey.

			LYS*		MET*		CYS*		TSAA*		
Region	State	Number of Samples	% Avg	Std Dev	% Avg	Std Dev	% Avg	Std Dev	% Avg	Std Dev	
Western	Iowa	38	2.21	0.10	0.50	0.02	0.63	0.05	1.12	0.06	
Corn Belt	Minnesota	18	2.20	0.09	0.48	0.02	0.59	0.03	1.06	0.05	
	Missouri	12	2.25	0.11	0.52	0.03	0.65	0.05	1.17	0.09	
	Nebraska	14	2.23	0.09	0.53	0.03	0.67	0.04	1.19	0.07	
	North Dakota	6	2.21	0.10	0.49	0.03	0.62	0.04	1.11	0.07	
	South Dakota	9	2.23	0.15	0.51	0.04	0.64	0.06	1.15	0.10	
	Averages	97	2.22	0.10	0.50	0.03	0.63	0.05	1.13	0.08	
	Ranges		2.00-2.48		0.43-0.59		0.52-0.79		0.95-1.37		0
Eastern	Illinois	29	2.25	0.09	0.51	0.02	0.65	0.04	1.16	0.05	
Corn Belt	Indiana	19	2.30	0.10	0.51	0.02	0.64	0.04	1.15	0.06	
	Michigan	5	2.27	0.07	0.50	0.01	0.62	0.02	1.11	0.03	
	Ohio	12	2.25	0.13	0.51	0.04	0.62	0.05	1.12	0.08	
	Wisconsin	5	2.21	0.09	0.50	0.02	0.63	0.04	1.13	0.06	
	Averages	70	2.26	0.10	0.51	0.02	0.64	0.04	1.15	0.06	
	Ranges		2.01-2.49		0.45-0.57		0.56-0.72		1.02-1.27		0
Midsouth	Arkansas	8	2.20	0.10	0.49	0.02	0.66	0.04	1.15	0.06	
	Ranges		2.03-2.39		0.47-0.53		0.61-0.72		1.08-1.26		0
Southeast	North Carolina	3	2.15	0.04	0.49	0.03	0.63	0.06	1.13	0.09	
	Ranges		2.11-2.19		0.47-0.52		0.56-0.68		1.04-1.21		0
USA	Averages	178	2.23	0.10	0.50	0.03	0.63	0.05	1.14	0.07	
	Ranges		2.00-2.49		0.43-0.59		0.52-0.79		0.95-1.37		0

Basis: 13% Moisture

*LYS = Lysine, MET = Methionine, CYS = Cysteine, TSAA = total sulfur-containing amino acids (MET+CYS), TRP = Tryptophan, THR = Thre

Table 9. Amino acid content (wt % of total protein) of a subset of samples from the 2002 Surve

Region	State	Number of Samples	LYS* % Avg	LYS* Std Dev	MET* % Avg	MET* Std Dev	CYS* % Avg	CYS* Std Dev	TSAA* % Avg	TSAA* Std Dev	
Western	Iowa	38	6.52	0.09	1.46	0.05	1.85	0.14	3.31	0.18	
Corn Belt	Minnesota	18	6.53	0.07	1.42	0.04	1.74	0.11	3.16	0.14	
	Missouri	12	6.54	0.07	1.50	0.07	1.89	0.12	3.40	0.18	
	Nebraska	14	6.51	0.09	1.53	0.07	1.94	0.12	3.47	0.18	
	North Dakota	6	6.59	0.08	1.46	0.07	1.85	0.07	3.32	0.14	
	South Dakota	9	6.56	0.08	1.51	0.08	1.88	0.15	3.39	0.23	
	Averages	97	6.53	0.10	1.47	0.03	1.85	0.05	3.32	0.08	
	Ranges		6.36-6.84		1.34-1.63		1.47-21.5		2.82-3.76		1
Eastern	Illinois	29	6.55	0.07	1.48	0.04	1.91	0.13	3.39	0.15	
Corn Belt	Indiana	19	6.51	0.08	1.44	0.06	1.81	0.13	3.26	0.17	
	Michigan	5	6.51	0.09	1.42	0.03	1.77	0.08	3.19	0.10	
	Ohio	12	6.53	0.10	1.47	0.06	1.79	0.12	3.26	0.17	
	Wisconsin	5	6.60	0.09	1.49	0.06	1.88	0.16	3.37	0.21	
	Averages	70	6.54	0.10	1.47	0.02	1.86	0.04	3.32	0.06	
	Ranges		6.31-6.73		1.28-1.56		1.53-2.14		2.88-3.67		1
Midsouth	Arkansas	8	6.44	0.15	1.44	0.05	1.94	0.12	3.38	0.17	
	Ranges		6.27-6.64		1.37-1.53		1.80-2.11		3.17-3.58		1
Southeast	North Carolina	3	6.60	0.07	1.51	0.09	1.95	0.21	3.46	0.29	
	Ranges		6.55-6.68		1.42-1.60		1.71-2.09		3.13-3.69		1
USA	Averages	178	6.53	0.09	1.47	0.06	1.86	0.14	3.33	0.19	
	Ranges		6.27-6.84		1.28-1.63		1.47-2.15		2.82-3.76		1

Basis: 13% Moisture

*LYS = Lysine, MET = Methionine, CYS = Cysteine, TSAA = total sulfur-containing amino acids (MET+CYS), TRP = Tryptophan, THR = Thre

Table 10. Calibration statistics for selected soybean amino acids, Foss/Infratec 1229 analyzer.

Amino acid	Algorithm	SECV [a] (% pts)	RPD [b]	
			NIR	Protein [c]
Lysine	PLS	0.057	3.7	2.9
Methionine	PLS	0.026	1.9	1.5
	LWR-GA	0.023	2.1	1.5
Tryptophan	PLS	0.037	1.7	1.2
Threonine	PLS	0.047	2.6	2.0

3 units, 1088 spectra, as-is moisture basis
[a] Standard error of cross validation
[b] Relative performance determinant = StDev of data/SECV
[c] Regression against protein
PLS = Partial Least Squares
LWR-GA = Locally weighted regression with genetic algorithm wavelength search.

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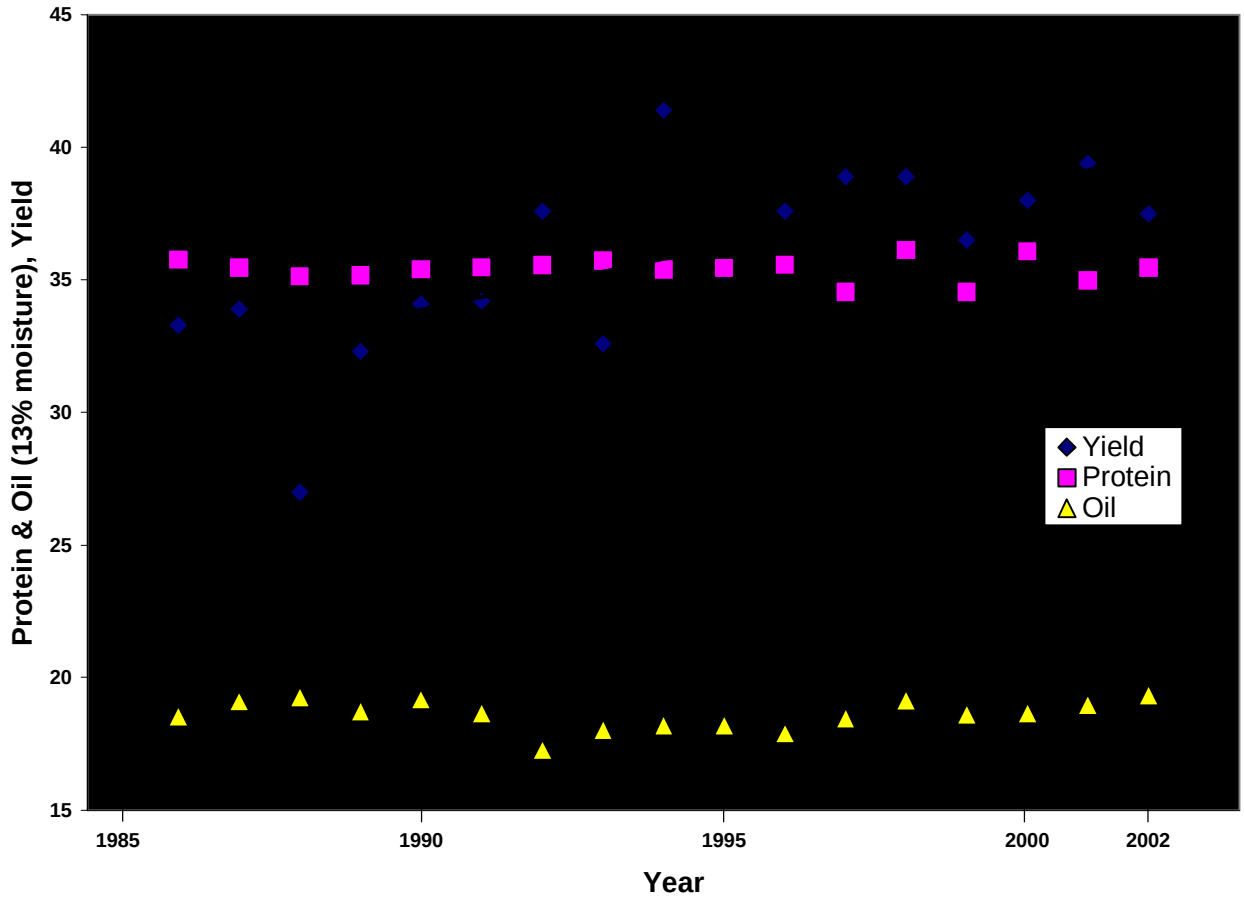
Figure 1. Trends in U.S. soybean yield, protein and oil.



Source: U.S. Department of Agriculture (2002a) and Iowa State University.

Figure 2. Protein and oil combinations that will produce 47.5% to 48.5% protein meal.