

Quality of the United States Food Soybean Crop: 2011¹

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Summary

The American Soybean Association has supported a survey of the quality of the US commodity soybean crop since 1986. That survey is intended to provide new crop quality data to aid international customers with their purchasing decisions. The Food Soybean Survey was conducted for the first time in 2007, and is intended to assist international buyers, as well as to provide producers valuable information about the quality of these specialty soybeans. Due to both the wide range of food bean types (tofu, natto, edamame, etc.) and the range of varieties grown for each type in different geographic regions of the US, it is difficult to provide generalized conclusions regarding the 2011 United States food soybean crop as a whole. This report provides state by state food soybean quality information (protein and oil), regional quality averages by seed size, and quality trends for the entire US food soybean crop. The commodity soybean crop information is provided as a guide for better understanding the regional environmental influences affecting both commodity and food soybean crops.

2011 Acreage, Yields, and Total Production

According to the 12 October, 2011 United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) crop report, the total US soybean production area decreased slightly from last year to 29.8 million hectares harvested (Table 1). Average yields decreased as well, to 2.79 MT per ha. With a smaller production area than in 2010 and smaller yields, total US soybean production is estimated to be 83.4 million MT. This makes the 2011 crop 9% smaller than that of 2010.

Quality of the 2011 US Food Soybean Crop

Participating companies provided a total of 199 samples by October 27, 2011. Due to colder and wetter spring conditions in much of the US (see Climate Summary for details), soybean planting and eventual maturity were delayed. The late harvest caused sample numbers to be smaller than in 2010 (294). Samples were analyzed for protein and oil concentration by near infrared spectroscopy (NIRS) using a Pertem DA7200 diode array instrument (Huddinge, Sweden) equipped with calibration equations developed at the University of Minnesota. The 199 samples were scanned whole, then ground and rescanned to provide us with soluble sugar and amino acid data. Additionally, we determined average seed size (grams per 100 seeds) for each sample.

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Average protein values for the food bean samples by region (Table 2) indicate that samples received from the Northern growing region (Michigan, Minnesota, North Dakota, and Wisconsin) had slightly higher protein concentrations than the samples received from the Central growing region (Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio). When we examined the protein concentration data using seed size categories to group the data (Table 3), the north-south protein differences were very minor. The ranges in protein values for 2011 are larger than the ranges found in 2010, due to the variable environmental growing conditions throughout the US. As was found in previous food soybean surveys, the small-seeded samples (protein of 36.1) were lower in protein than the average or large-seeded samples (37.2 and 40.6 protein, respectively). Lower protein concentrations are desirable for making natto. As was also found in previous food soybean surveys, the larger seed size samples were higher in protein than the average seed size samples within both the Northern and Central regions.

Oil concentrations in the Northern region were lower than in the Central region, for all three seed size categories (Tables 2 and 3). When the oil data were grouped by seed size and region, average seed size samples showed higher oil concentrations than did large seed size samples within a region (Table 3). Oil concentration also was more variable in 2011.

Soluble Sugars

Historically, northern soybeans have tended to have a larger proportion of their soluble sugars in sucrose relative to stachyose and raffinose. Results from the 2011 survey support this trend. Samples in all three seed size categories from the Northern region had higher sucrose concentrations than the same size samples from the Central region (Table 4). Within each region, small seed size samples had higher concentrations of sucrose than the average and large seed size samples. Concentrations of raffinose were very similar across regions. Concentrations of stachyose were lower in Northern samples for both the small and average seed size samples.

Amino Acids

Amino acids are the “building block” organic compounds linked in various combinations to form unique proteins. In humans, dietary proteins are critical for a number of vital functions; these needs are fulfilled by the essential and non-essential amino acids in dietary proteins. Soy in human nutrition is often part of a diet comprised of other protein sources. When soy was studied along with other foods (rice, corn flour, milk solids), its nutritive value was high, close to that of milk and similar to that for high quality animal protein (Young and Scrimshaw, 1979). Additionally, Young and Scrimshaw concluded in their review of studies evaluating the use of soybean in human diets, “When well processed soy products serve as the major or sole source of the protein intake, their protein value approaches or equals that of foods of animal origin, and they are fully capable of meeting the long term essential amino acid and protein needs of children and adults”.

Although soybeans from the US are generally lower in crude protein, both US soybeans and soybean meal contained higher concentrations of critical amino acids (Thakur and Hurburgh, 2007), thus making the protein a better quality protein. We have recently investigated the relative abundance of amino acids found in soybean protein within the US by evaluating Soybean Quality Survey samples from 2006-2009. We identified approximately 100 samples

each year which collectively represented the US crop. These samples were evaluated with HPLC (High Performance Liquid Chromatography) for total amino acids. In 2009 and 2010, more than 1,500 samples were evaluated for total amino acids using NIRS. Lysine, expressed as percent of the protein, is evaluated since lysine is often a limiting amino acid diet in vegetarian diets. . If the first limiting amino acid is not supplied in adequate amounts in feed diets, the remaining essential amino acids are not efficiently used. For these analyses we considered the ten essential amino acids to include: leucine, histidine, isoleucine, lysine, methionine and cysteine, phenylalanine, threonine, tryptophan, and valine. The eight non-essential amino acids included: alanine, arginine, aspartic acid, glutamic acid, glycine, proline, serine, and tyrosine. While the relative abundance of each of the amino acids varied from sample to sample and average values varied across years, the same general trends noted in previous work that compared US and Brazilian soybean samples was noted within US soybeans.

- Soybean samples with lower crude protein levels tend to have a protein fraction that is enriched in essential amino acids relative to higher protein samples
- The largest and most consistent increase in relative abundance of the essential amino acids appears to be lysine. In other words, lysine appears to be an important factor driving this increase in the sum of the essential amino acids in lower protein samples

Table 5 contains amino acid data from the food soybean samples, grouped by seed size and growing region. Within each growing region, the trend for the three sample size categories is the same and reflects our findings discussed in the first bulleted item above: the lower protein samples showed higher lysine, essential amino acids, and non-essential amino acids. For example, in the Northern region, the small seed size samples had an average protein of 36.1 compared to 40.6 for the large seed size category; however, along with the lower protein of 36.1 we found that the lysine, essential amino acids, and non-essential amino acids were higher (lower protein of 36.1: 6.0 lysine, 39.0 essential amino acids, and 56.7 non-essential amino acids versus higher protein of 40.6: 5.2 lysine, 36.5 essential amino acids, and 54.4 non-essential amino acids). The same trend is seen when we look at the Central region by protein level: lower protein samples had higher lysine, essential amino acids, and non-essential amino acids than higher protein samples. Thus, although we examined fewer samples for the food soybean survey, the sample quality trends for amino acids were consistent with our previous amino acid findings.

US Commodity Soybean Survey

The quality of the overall US soybean crop is estimated yearly by a separate project supported by the United Soybean Board and the international marketing committee of the American Soybean Association (ASA-IM). By August 30, 2011 sample kits were mailed to approximately 10,637 producers. Producers were selected based on total land devoted to soybean production in each state, so that response distribution would closely match soybean production. By October 25, 2011, 1669 samples were received. These were analyzed for protein, oil, and amino acid concentration by near-infrared spectroscopy (NIRS) using a Perten DA7200 diode array instrument (Huddinge, Sweden) equipped with calibration equations developed by Perten in cooperation with the University of Minnesota. Regional and national average quality values

were determined by computing weighted averages using state and regional soybean production values, so that average values better represent the crop as a whole.

Average protein and oil concentrations for the 2011 US soybean crop dropped slightly from that of the 2010 US crop and were both lower than the long-term US averages. Average US soybean protein concentration was 0.2 percentage points lower in 2011, at 34.8%, and average oil concentration was 0.4 percentage points lower at 18.2% when compared with 2010. As is noted in most years, Western Corn Belt states (in the North and West ranges of US soybean production) showed lower protein concentrations than the US crop as a whole. Soybeans grown in the Midsouth and East Coast states tended to have higher protein concentrations. Midsouth, Southeastern, and East Coast states produced a soybean crop with higher oil concentration than the main soybean production regions of the Eastern and Western Corn Belt.

Compared with the 2010 crop, protein concentrations from the Eastern Corn Belt and Midsouth regions, decreased slightly. Protein levels increased slightly in the East Coast region. Oil concentrations were lower throughout the Corn Belt states, but higher in the Midsouth, Southeast, and East Coast states.

As was the case in 2010, seed from the 2011 crop tended to be dryer than normal at harvest time. The average moisture of samples received in 2011 was 10.6%. The driest soybeans were found in the Western states (Kansas, Nebraska, and South Dakota). The Western Corn Belt region as a whole had average moisture levels of 10.1%. When protein levels are adjusted to an 'as-is' basis rather than a 13% moisture basis, the protein level of the average US soybean increased from 34.7 to 35.6%. Similarly, oil would appear to increase from 18.2 to 18.7% when the average US soybean is evaluated on an 'as-is' basis.

Climate Summary

Planting: precipitation for the period covering March, April, and May was 200% of normal from southwestern Missouri through the Ohio Valley. Temperatures were generally below normal in Iowa, Minnesota, and Wisconsin, and above normal farther south. In *May*, the temperature trend was generally cooler in the west and warmer in the east. Persistent wet weather and flooding impacted spring planting progress; at the end of May in Ohio only 7% of soybeans were planted compared to the average 76%. As of May 29, 51% of the intended US soybean acreage was planted, 20% behind normal pace. Iowa and some other Midwestern areas, however, were ahead of the normal pace of planting and the soybean crop there benefited from frequent rains.

Mid-season: *June* precipitation was either 2 to 3x normal rainfall in parts of Iowa, Illinois, and Michigan or <50% of normal in Missouri and along the Michigan-Ohio border. Temperatures were slightly below normal in the northwest and above normal in the south. *July* was much warmer and more humid than normal across the Midwest. Missouri experienced its hottest month in more than 30 years. Flooding continued along the Missouri River in Iowa and Missouri in July. *August* rainfall was very variable across the Midwest, from <25% of normal to almost 200% of normal. Temperatures were mostly normal to above normal. A record drought continued throughout the summer in Texas, Oklahoma, Southern Kansas, and Western

Louisiana. Drought conditions continued to intensify through the state of Georgia throughout the late summer. A moderate drought stressed the soybean crop from August through harvest time in Indiana, Illinois, Iowa, and Minnesota. This widespread drought had the largest effect on the US soybean crop of any weather event in 2011.

Harvest: *September* started out hot but ended cooler than average. In regions from Wisconsin and Illinois eastward through Ohio and Kentucky there was excessive rainfall, but in areas west of the Mississippi River rainfall was well below normal (Figure 1). In addition to the dry conditions, the upper Midwest had a freeze on September 15. At the time of the freeze, only a small proportion of the soybeans were fully mature and yield losses were realized. Growers were harvesting across much of the major soybean growing region by September 25. By *October 30*, 87% of the soybean crop had been harvested, 8% behind last year's pace but 8% ahead of the 5-year average (Figure 2); 56% of the crop was rated in good or excellent condition as of October 9.

Overall the 2011 season was marked by a slower planting pace than normal because of excess moisture and cool temperatures; this led to slower crop development. Later in the season, drought and mid-September freezing temperatures impacted the crop in some major production areas.

References

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Total Precipitation: Percent of Mean
September 1, 2011 to September 30, 2011

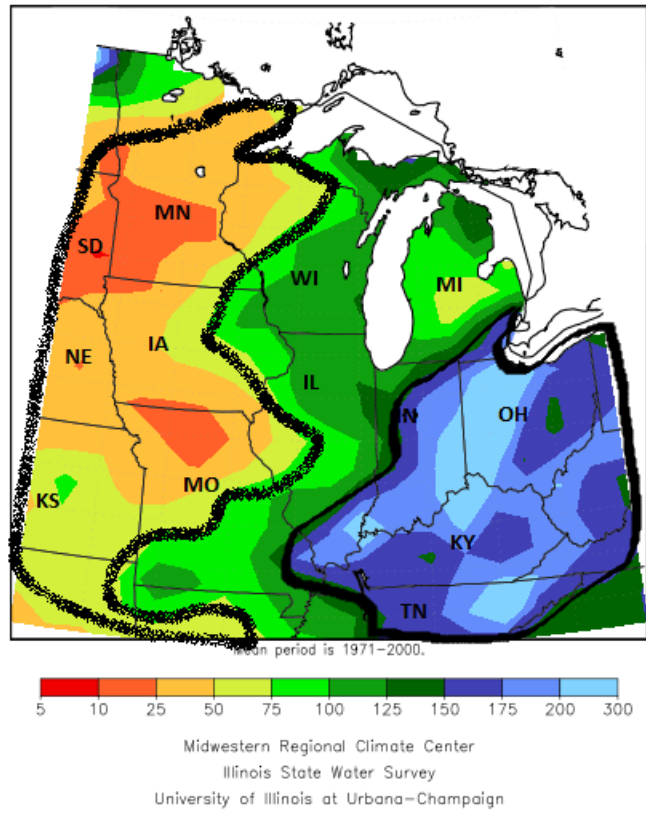


Figure 1. Areas outlined in black on the left received well below average precipitation in September and areas outlined in black on the right were well above average.

Table 2. ASA-IM 2011 Food Soybean Quality Survey by State and Region

State (# of samples)	Region	Protein* (%)	Protein Range	Regional Protein Average	Oil* (%)	Oil Range	Regional Oil Average
Michigan (49)	Northern	38.1	33.0 – 43.5		16.3	13.1 – 21.0	
Minnesota (48)	Northern	37.8	29.2 – 47.7		16.3	11.1 – 21.1	
North Dakota (15)	Northern	36.6	32.5 – 41.6		16.6	13.5 – 19.3	
Wisconsin (15)	Northern	35.6	32.8 – 38.4	37.5	17.6	16.0 – 18.4	16.5
Illinois (6)	Central	34.4	30.3 – 43.0		19.9	14.2 – 22.8	
Indiana (2)	Central	36.9	36.0 – 37.8		18.9	17.9 – 19.9	
Iowa (38)	Central	37.3	31.2 – 44.0		17.0	14.4 – 19.8	
Missouri (18)	Central	37.6	35.0 – 41.4		17.6	15.9 – 20.5	
Nebraska (2)	Central	35.5	35.0 – 36.0		17.1	15.5 – 18.6	
Ohio (6)	Central	40.3	36.5 – 43.4	37.3	16.2	13.7 – 19.6	17.4

Data as of October 27, 2011

* 13% moisture basis

Table 3. ASA-IM 2011 Food Soybean Quality Survey by Seed Size[§] & Region[‡]

Region	Seed Size	Number Samples	Seed Size (g/100 seeds)	Protein* (%)	Protein Range	Oil* (%)	Oil Range
Northern	Small	12	10.1	36.1	33.3 – 42.4	16.2	11.1 – 18.4
	Average	100	16.8	37.2	29.2 – 47.7	16.7	12.5 – 21.1
	Large	15	23.0	40.6	34.6 – 42.5	15.1	13.1 – 17.7
Central	Small	6	12.4	35.8	33.1 – 37.9	17.7	15.5 – 19.0
	Average	63	15.4	37.3	30.3 – 44.0	17.4	13.7 – 22.8
	Large	3	23.2	40.8	39.1 – 43.4	16.2	15.7 – 16.7

Data as of October 27, 2011

[§] **Small seed: ≤13.0 g/100 seeds; Average: 13.1-21.0 g/100 seeds; Large: >21 g/100 seeds (unofficial categories)**

[‡] **Northern region = Michigan, Minnesota, North Dakota, and Wisconsin; Central region = Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio**

^{*} **13% moisture basis**

Table 4. ASA-IM 2011 Food Soybean Quality Survey NIR-predicted Carbohydrate Data by Seed Size[§] & Region[‡]

Region	Seed Size	Number Samples	Seed Size Average (g/100 seeds)	Sucrose (% DM basis)	Raffinose (% DM basis)	Stachyose (% DM basis)
Northern	Small	12	10.1	5.48	0.56	3.64
	Average	100	16.8	5.09	0.53	3.64
	Large	15	23.0	4.89	0.52	3.76
Central	Small	6	12.4	5.20	0.54	3.98
	Average	63	15.4	4.58	0.53	3.77
	Large	3	23.2	4.46	0.50	3.67

Data as of October 27, 2011

[§] **Small seed: ≤13.0 g/100 seeds; Average: 13.1-21.0 g/100 seeds; Large: >21 g/100 seeds (unofficial categories)**

[‡] **Northern region = Michigan, Minnesota, North Dakota, and Wisconsin; Central region = Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio**

Table 5. ASA-IM 2011 Food Soybean Quality Survey NIR-predicted Amino Acid Data by Seed Size[§] & Region[‡]

Region	Seed Size	Number Samples	Seed Size Average (g/100 seeds)	Protein[*] (%)	Lysine (as % of P)	Essential[¶] Amino Acids (as % of P)	Non-Essential[†] Amino Acids (as % of P)
	Small	12	10.1	36.1	6.0	39.0	56.7
Northern	Average	100	16.8	37.2	5.7	38.4	56.1
	Large	15	23.0	40.6	5.2	36.5	54.4
	Small	6	12.4	35.8	5.7	39.2	57.5
Central	Average	63	15.4	37.3	5.6	38.4	56.5
	Large	3	23.2	40.8	5.1	36.1	54.1

Data as of October 27, 2011

[§] Small seed: ≤13.0 g/100 seeds; Average: 13.1-21.0 g/100 seeds; Large: >21 g/100 seeds (unofficial categories)

[‡] Northern region = Michigan, Minnesota, North Dakota, and Wisconsin; Central region = Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio

^{*} 13% moisture basis

[¶]Essential amino acids: leucine, histidine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, and cysteine

[†]Non-essential amino acids: alanine, arginine, aspartic acid, glutamic acid, glycine, proline, serine, and tyrosine

Table 1. Soybean production data for the United States, 2011 crop

Region	State	Yield (MT ha ⁻¹)	Area Harvested (1000 ha)	Production (MMT)
Western Corn Belt (WCB)	Iowa	3.39	3,750	12.7
	Kansas	1.81	1,539	2.8
	Minnesota	2.75	2,839	7.8
	Missouri	2.49	2,126	5.3
	Nebraska	3.63	1,964	7.1
	North Dakota	1.95	1,600	3.1
	South Dakota	2.62	1,640	4.3
	Western Corn Belt	2.7	15,459	43 51.8%
Eastern Corn Belt (ECB)	Illinois	3.09	3,584	11.1
	Indiana	2.82	2,142	6.1
	Michigan	2.96	786	2.3
	Ohio	3.09	1,839	5.7
	Wisconsin	3.02	648	2.0
	Eastern Corn Belt	3.0	8,999	27 32.5%
Midsouth (MDS)	Arkansas	2.49	1,316	3.3
	Kentucky	2.62	595	1.6
	Louisiana	2.42	397	1.0
	Mississippi	2.69	721	1.9
	Oklahoma	1.14	101	0.1
	Tennessee	2.35	506	1.2
	Texas	1.01	45	0.0
	Midsouth	2.1	3,681	9 10.9%
Southeast (SE)	Alabama	2.02	117	0.2
	Georgia	1.41	59	0.1
	North Carolina	2.08	547	1.1
	South Carolina	1.75	146	0.3
	Southeast	1.8	869	2 2.1%
East Coast (EC)	Delaware	2.55	68	0.2
	Maryland	2.62	186	0.5
	New Jersey	2.28	35	0.1
	New York	2.82	112	0.3
	Pennsylvania	2.82	196	0.6
	Virginia	2.62	219	0.6
	East Coast	2.6	816	2 2.6%
USA 2011		2.79	29,839	83.4
USA 2010		2.95	31,113	91.9

Source: United States Department of Agriculture, NASS 2011 Crop Production Report (October 12, 2011)