United States Food Soybean Quality

Annual Report 2016

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FOOD QUALITY REPORT: 2016

SUMMARY

The US Soy Family, which includes the American Soybean Association, United Soybean Board, and US Soybean Export Council, 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 first conducted in 2007, and is intended to assist international buyers, as well as to provide food manufacturers 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 across different geographic regions of the US, it is difficult to provide generalized conclusions regarding the 2016 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.

2016 ACREAGE, YIELDS, AND TOTAL PRODUCTION

According to the October 2016 United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) Crop Production report, area harvested and yields will both increase from 2015. The total US soybean harvested area increased by 1.6% to 33.6 million hectares compared to 2015 (Table 1). Average yield increased 9% to 3.5 MT per hectare. Together, increased yields and area harvested will result in a US crop that is almost 8% higher than the record 2014 crop. The USDA expects the US crop to be 116.3 million MT. At the time of writing this report (November 1), we expect the November 9 Crop Production report to forecast even higher yields.

QUALITY OF THE 2016 US FOOD SOYBEAN CROP

Participating companies provided a total of 164 samples by November 2, 2016. Samples were analyzed for protein and oil concentration by near infrared spectroscopy (NIRS) using a Perten DA7250 diode array instrument (Huddinge, Sweden) equipped with calibration equations

developed at the University of Minnesota. The 164 whole soybean samples were ground before scanning on the NIR machine. Additionally, we determined average seed size (grams per 100 seeds) for each sample. The food soybean samples are grouped using the same geographical categories as in the commodity soybean quality report. In 2016, we received food soybean samples from regions categorized as ECB (Eastern Corn Belt) and WCB (Western Corn Belt).

Average protein values for the food bean samples by region (Table 2) indicate that samples received from the WCB region (Iowa, Minnesota, Nebraska, North Dakota, and South Dakota) had lower protein concentrations when compared with the samples received from the ECB growing region (Illinois, Michigan, Ohio, and Wisconsin); WCB regional protein average was 35.7, and ECB's was 36.3. When we examined the protein concentration data using both regional and seed size categories to group the data (Table 3), the WCB-ECB protein differences were mixed. Protein was lower in the average-seeded WCB samples (35.4) and small-seeded WCB samples (35.9) compared to the average- and small-seeded ECB samples (36.0, and 36.3, respectively). This lower WCB protein vs. ECB protein trend within the same seed size category was reversed for the large-seeded samples, such that large-seeded WCB protein of 37.4 was higher than the large-seeded ECB protein of 36.8. The ranges in protein values in WCB and ECB samples were fairly similar. Surprisingly in 2016 we found that the small-seeded samples were higher in protein at 35.9 in the WCB and 36.3 in the ECB than the average-seeded samples in those regions, 35.4 in the WCB and 36.0 in the ECB.

Overall, oil concentrations in the WCB region (18.5) were very slightly lower than in the ECB region (18.7) (Table 2). When the data were grouped by seed size category and region (Table 3), again the average-seeded WCB samples were nearly identical in oil to the average-seeded ECB samples, but the same was not true for the large-seeded samples (WCB 17.6 < ECB 18.6); however, the sample numbers within the groups were not balanced. Within the WCB and ECB regions, oil concentrations were higher in the average-seeded samples (WCB 18.8, ECB

18.7) than in the large-seeded samples (WCB 17.6, ECB 18.6), though the values were similar in the ECB. Ranges in oil values in WCB samples were again similar to those than in ECB samples.

SOLUBLE SUGARS

Typically small-seeded samples are higher in sucrose than large- or average-seeded samples. Similar to what we reported in 2015, the 2016 sucrose concentrations did not follow the pattern we have noted in earlier surveys. In 2016, we found that the small-seeded WCB samples were higher in sucrose than the average-sized samples but not the large; however, the small-seeded samples in the ECB had the lowest sucrose values of any seed size sample in that region. Typically we find that more northerly WCB region samples have higher sucrose concentrations than samples from the more southerly ECB region; this holds true in 2016 when we compared sucrose values in similarly-sized samples between those regions, eg, small WCB vs. small ECB. Sucrose concentrations overall were higher in 2016 than in 2015, likely because oil concentrations were slightly reduced.

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”.

In soybeans, those with lower crude protein have a higher proportion of the five most critical essential amino acids (lysine, cysteine, methionine, threonine, and tryptophan), (Thakur and Hurburgh, 2007; Medic et al., 2014; Naeve unpublished data). Table 5 contains amino acid data from the 2016 food soybean samples, grouped by seed size and growing region. Within the WCB and ECB, the trend for the sample size categories was the same: lower protein samples have higher concentrations of the five limiting essential amino acids. For example, in the WCB, the average-seeded samples had an average protein of 35.4 compared to 37.4 for the large-seeded samples; the samples with the lower protein of 35.4 had a higher sum of the five limiting essential amino acids (14.4), and the samples with the higher protein of 37.4 had a lower sum of the five limiting amino acids (14.2). The protein in lower protein samples is more concentrated in those five amino acids than is the protein in higher protein samples. We have found this to be the case in the US commodity soybean survey results as well.

US COMMODITY SOYBEAN SURVEY

Overall, when compared with the extraordinarily high quality 2015 crop, protein and oil concentrations noted in the 2016 crop were quite good. Average protein concentration increased very slightly while oil concentrations were off by one half percentage point when compared with 2015. Although oil receded, the 2016 crop appears to produce on average oil concentration at the second highest level in the previous 10 years, and was one half percentage point higher than the average of the previous 10 years. Protein was 0.3 percentage points lower than the previous 10-year average. Compared with the long-term average (1986-2015), 2016 US soybeans were 0.7 of a point lower in protein, but 0.6 percentage points higher in oil. The high oil levels noted again in 2016 should allow soybean processors to simultaneously achieve both good soybean oil yields and reasonable protein concentrations in the resulting soybean meal.

Protein and oil concentrations were unusually consistent across the US in 2015. The current year returns to a more normal variability in both protein and oil. Western Corn Belt states are

expected to produce more than half of the total US soybean volume, and are therefore primary drivers of average US protein and oil values. Western Corn Belt states had average protein and oil concentrations that were 0.4 and 0.2 points lower, respectively, than the US average. Protein in Iowa and Missouri decreased by 0.3 points from 2015 to 2016, and oil concentrations in Minnesota and North Dakota decreased by 1.0 and 0.8 points respectively.

Protein and oil concentrations in the Eastern Corn Belt were both higher than the national average. Together, the Eastern Corn Belt states also fared a bit better with an increased protein concentration but an equal decrease (0.3 points) in oil compared to 2015. Protein increased in all states in the Eastern Corn Belt. Oil was reduced by 0.4 points in Michigan, Ohio, and Wisconsin compared to 2015.

As is often noted, Midsouth states had protein and oil concentrations that were higher than the national average; this year protein and oil were 0.8 and 0.4 points greater. Compared with 2015, the region saw protein increase by 0.6 and oil decrease by 0.5 points. These changes were fairly uniformly distributed across the region with Arkansas and Mississippi increasing protein by 0.5 points each and decreasing oil by 0.6 and 0.4 each, respectively.

Likely due to frequent rainfall through the early harvest period in the majority of soybean-producing states, the incoming moisture of 2016 samples (12.4%) was higher than the 2015 value at 11.6%. Although average incoming moisture was higher in 2016 than in the previous year, there was less variability in the data. Samples with moisture above 13% could be found in all major soybean-producing states.

In 2016, amino acid results varied a bit by state and region. Lysine (expressed as a percent of the 18 primary amino acids) tended to be highest in the Western Corn Belt (6.8) and lowest in the Midsouth (6.6). There were similar regional differences in the sum of the five most limiting amino acids (also known as CAAV), cysteine, lysine, methionine, threonine, and

tryptophan, with the WCB at 14.6; ECB, MDS, and EC at 14.4; and SE at 14.5. Regional differences alone do not fully explain amino acid concentration differences in the samples; when we evaluated the samples based on protein level rather than region, we found that the protein in lower protein samples is more concentrated in the five critical amino acids than is the protein in higher protein samples. Thus, protein concentration differences may account for much of the amino acid concentration differences across regions, rather than region *per se*. It appears to us that meal produced from lower protein soybeans is likely to be slightly enriched in the most limiting essential amino acids, and will provide additional value to the end user. However, low protein meal will not necessarily be enriched in these important amino acids due in part to processing; high fiber meals are not likely to be enriched in essential amino acids. Therefore, we support complete and independent analysis of soybeans, soybean meal, and feeds throughout the value chain to ensure that the end user has access to the highest quality feed, not based on protein alone, but the full quality package that includes amino acid balance, energy, and more.

WEATHER AND CROP SUMMARY

Planting: Average temperatures in the Midwest were above normal and precipitation varied, even within states. Areas in parts of MI, MO, the Ohio Valley (OH, IN, IL, WV, PA, and KY), and western IA experienced above normal precipitation, while parts of MN, eastern IA, MO, and IL were drier than normal early in the season. Higher than average rainfall erased the early-season drought in the central and southern Plains. In the Midwest overall, weather was generally favorable for planting; planting was mostly complete by early June and was ahead of the 5-year average in most soybean-producing states.

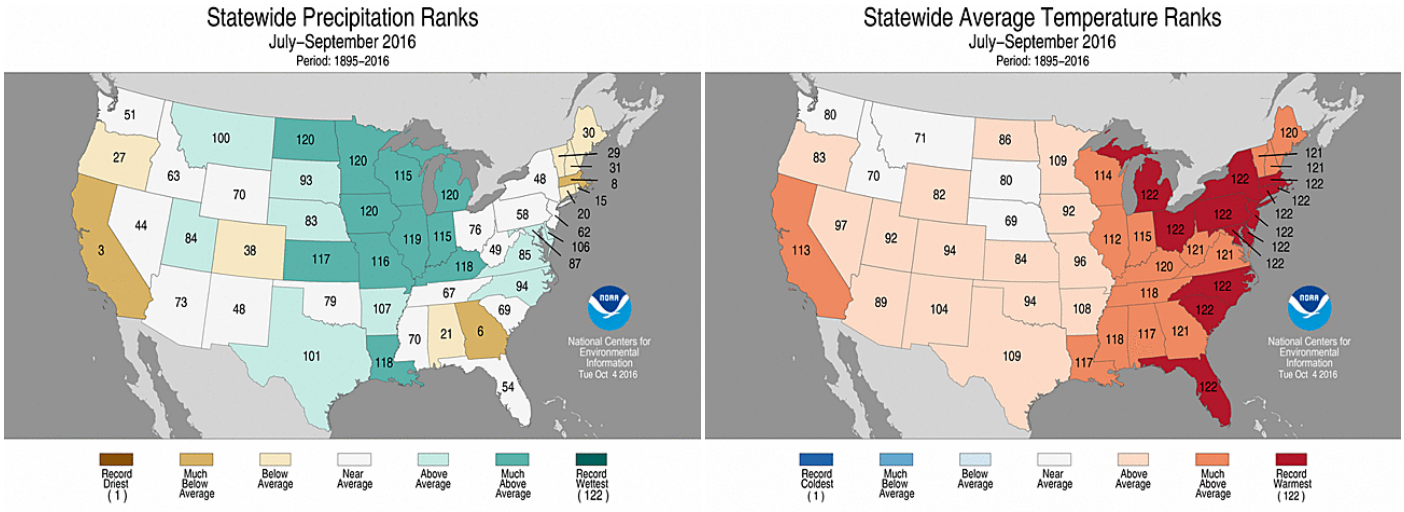
Mid-Season: The entire US experienced its warmest June on record. Average minimum temperatures were in the top 10 warmest for all Midwestern states except MN. Rainfall in early July broke records in MO, IL, IN, and KY. July rainfall in the Midwestern states of MN, WI, KY, IN, IL, and MI ranked in the top 10 wettest. Ohio rainfall was well below normal for

July and August, and the Southeast experienced significant drought conditions all season. By the end of August, 94% of the US soybeans were at or beyond pod setting stage, well ahead of average.

Harvest: The Midwest experienced its 7th warmest September since 1895 and above average temperatures continued through October. Widespread flooding occurred in the first part of September in IA, MN, and WI, but some states in the region were below normal for rainfall. By the end of October, more than three-quarters of the nation's soybean crop was harvested, slower than last year but on par with the 5-year average.

Overall, weather during the 2016 growing season was generally wetter and warmer than normal in most primary soybean-producing states.

Weather Figure 1.



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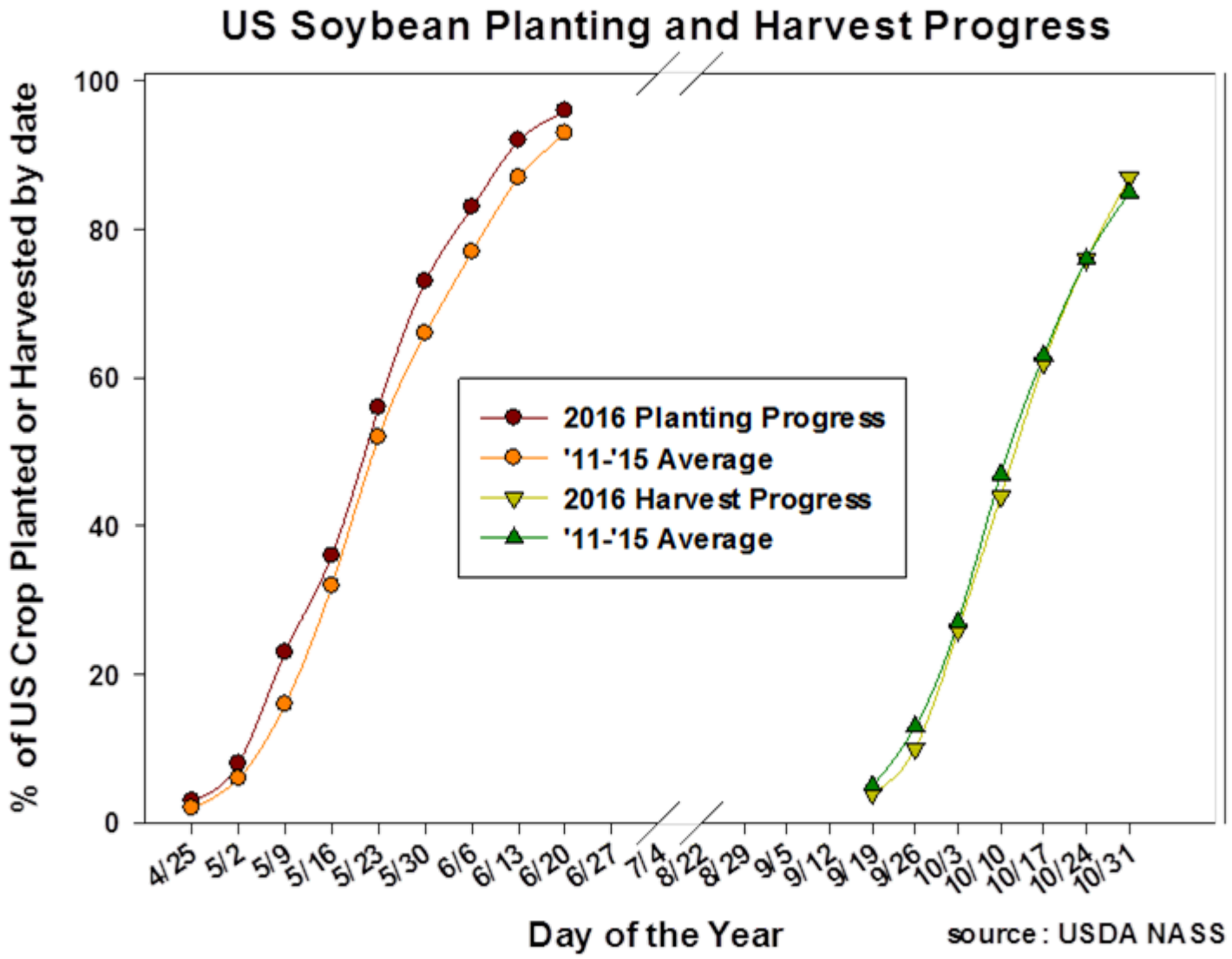
US Soybean Planting and Harvest Progress
% of US Crop Planted or Harvested by date
100
80
60
40
20
0
2016 Planting Progress
'11-'15 Average
2016 Harvest Progress
'11-'15 Average
4/25
5/2
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
8/22
8/29
9/5
9/12
9/19
9/26
10/3
10/10
10/17
10/24
10/31
Day of the Year
source: USDA NASS

Figure 1

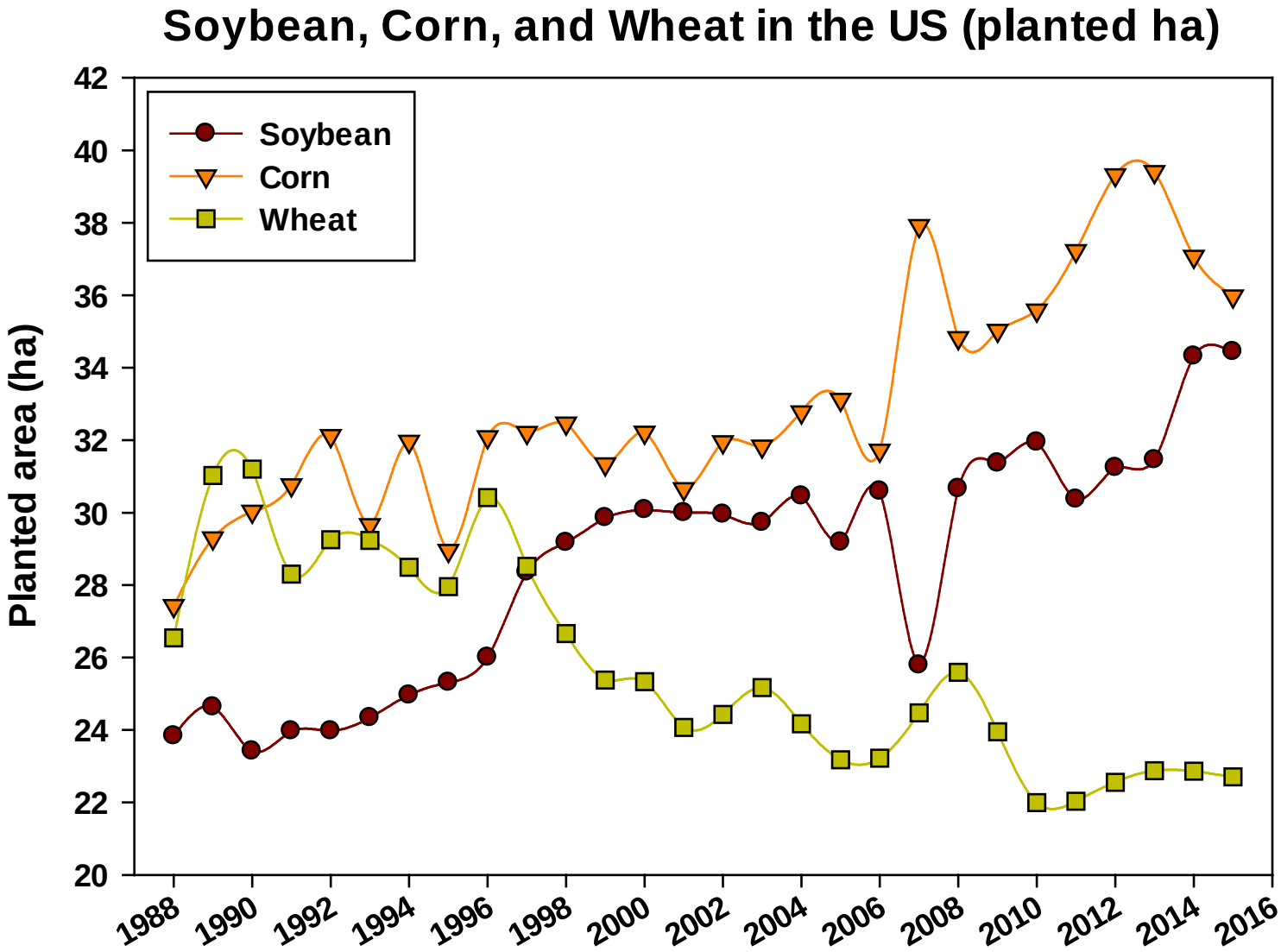
Soybean, Corn, and Wheat in the US (planted ha)
Planted area (ha)
Soybean
Corn
Wheat
42
40
38
36
34
32
30
28
26
24
22
20
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

Figure 2

Table 1. Soybean production data for the United States, 2016 crop

Region	State	Yield (MT ha^{-1})	Area Harvested (1000 ha)	Production (M MT)
Western Corn Belt (WCB)	Iowa	3.9	3,848	15.0
	Kansas	3.0	1,624	4.9
	Minnesota	3.3	3,058	10.1
	Missouri	3.4	2,248	7.6
	Nebraska	4.1	2,086	8.6
	North Dakota	2.6	2,434	6.4
	South Dakota	3.1	2,094	6.5
	Western Corn Belt	3.3	17,391	59.0
				50.7%
Eastern Corn Belt (ECB)	Illinois	4.2	4,070	17.0
	Indiana	4.0	2,300	9.1
	Michigan	3.2	846	2.7
	Ohio	3.6	1,960	7.0
	Wisconsin	3.5	790	2.8
	Eastern Corn Belt	3.7	9,967	38.5
				33.1%
Midsouth (MDS)	Arkansas	3.2	1,264	4.1
	Kentucky	3.4	725	2.4
	Louisiana	3.3	490	1.6
	Mississippi	3.2	822	2.7
	Oklahoma	1.8	190	0.3
	Tennessee	3.1	664	2.1
	Texas	1.8	59	0.1
	Midsouth	2.8	4,214	13.3
				11.4%
Southeast (SE)	Alabama	2.3	166	0.4
	Georgia	2.7	103	0.3
	North Carolina	2.6	676	1.7
	South Carolina	2.3	166	0.4
	Southeast	2.5	1,112	2.8
				2.4%
East Coast (EC)	Delaware	2.8	68	0.2
	Maryland	3.0	209	0.6
	New Jersey	2.7	40	0.1
	New York	2.8	132	0.4
	Pennsylvania	3.0	237	0.7
	Virginia	2.6	243	0.6
	East Coast	2.8	928	2.6
				2.3%
US 2016		3.5	33,634	116.3
US 2015		3.2	33,101	107.0

Source: United States Department of Agriculture, NASS 2016 Crop Production Report (October 2016)

Table 2. USSEC 2016 Food Soybean Quality Survey Protein and Oil Data by State and Region[§]

State (# of samples)	Region	Protein [*] (%)	Protein Range	Regional Protein Average	Oil [*] (%)	Oil Range	Regional Oil Average
Iowa (7)	WCB	36.5	33.5 – 38.5		18.2	16.7 – 19.9	
Minnesota (30)	WCB	36.4	32.7 – 40.1		18.1	16.4 – 20.6	
Nebraska (1)	WCB	35.0			18.2		
North Dakota (25)	WCB	34.9	31.7 – 37.4		18.8	17.0 – 20.7	
South Dakota (3)	WCB	34.2	33.0 – 36.1	35.7	19.5	17.7 – 20.6	18.5
Illinois (6)	ECB	36.9	36.2 – 38.3		18.7	18.1 – 19.2	
Michigan (33)	ECB	35.8	34.0 – 40.5		18.6	16.5 – 19.6	
Ohio (17)	ECB	37.8	36.0 – 39.7		18.5	16.8 – 19.7	
Wisconsin (42)	ECB	35.9	32.4 – 39.5	36.3	18.7	17.2 – 20.0	18.7

Data as of November 2, 2016

[§] WCB: Western Corn Belt; ECB: Eastern Corn Belt (see Table 1 for complete list of states included in these regions)

[*] 13% moisture basis

Table 3. USSEC 2016 Food Soybean Quality Survey Protein and Oil by Seed Size[‡] & Region[§]

Region	Seed Size	Number Samples	Seed Size (g/100 seeds)	Protein[*] (%)	Protein Range	Oil[*] (%)	Oil Range
WCB	Small	9	9.5	35.9	34.6 – 37.1	17.5	16.4 – 18.7
	Average	49	17.2	35.4	31.7 – 40.1	18.8	16.7 – 20.7
	Large	8	23.7	37.4	35.2 – 39.6	17.6	16.8 – 18.6
ECB	Small	2	11.0	36.3	34.5 – 38.2	17.8	16.8 – 18.7
	Average	65	18.4	36.0	32.4 – 40.5	18.7	16.5 – 20.0
	Large	31	22.9	36.8	35.0 – 39.7	18.6	17.1 – 19.5

Data as of November 2, 2016

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

[§] WCB: Western Corn Belt (Iowa, Minnesota, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Michigan, Ohio, and Wisconsin)

[*] 13% moisture basis

Table 4. USSEC 2016 Food Soybean Quality Survey 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)
WCB	Small	9	9.5	6.55	0.62	4.82
	Average	49	17.2	6.23	0.68	4.21
	Large	8	23.7	6.64	0.62	4.50
ECB	Small	2	11.0	5.77	0.69	4.41
	Average	65	18.4	6.13	0.63	4.30
	Large	31	22.9	6.26	0.64	4.35

Data as of November 2, 2016

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

[§] WCB: Western Corn Belt (Iowa, Minnesota, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Michigan, Ohio, and Wisconsin)

Table 5. USSEC 2016 Food Soybean Quality Survey Amino Acid (AA) Data by Seed Size[‡] & Region[§]

Region	Seed Size	Number Samples	Seed Size Average (g/100 seeds)	Protein[*] (%)	Lysine (% of 18AAs)	Five Limiting Essential[¶] Amino Acids (% of 18AAs)
WCB	Small	9	9.5	35.9	6.73	14.5
	Average	49	17.2	35.4	6.66	14.4
	Large	8	23.7	37.4	6.60	14.2
ECB	Small	2	11.0	36.3	6.76	14.4
	Average	65	18.4	36.0	6.71	14.4
	Large	31	22.9	36.8	6.62	14.3

Data as of November 2, 2016

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

[§] WCB: Western Corn Belt (Iowa, Minnesota, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Michigan, Ohio, and Wisconsin)

[*] 13% moisture basis

[¶] Five limiting essential amino acids: cysteine, lysine, methionine, threonine, and tryptophan

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