Protein and Oil Content of Soybeans From Different Geographic Locations

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Data on soybean yield, protein content and oil content were provided by three crushing companies. There was a definite trend toward lower protein content in soybeans processed and most likely grown in northern versus southern locations (about 34 to 44 N latitude) in 1986-87 (r = 0.77). In 1983-86, protein content was generally lower in soybeans processed in Minnesota than in those processed in Indiana and Illinois. Effects of location on oil content and of year on protein and oil content were less clear. Uniform Soybean Tests data over 11 years and four locations (3 in Minnesota, 1 in Illinois) showed significant effects of year on oil content and of location on yield and oil content, but little effect of either on protein content.

Soybean [*Glycine max* (L.) Merr] has the highest protein content among all the edible legumes. A report on 500 samples of soybean showed a range in protein content of 30-46% and in oil, of 12-24% (1). The early growth of the soybean industry in the United States was influenced more by the demand for the oil than by the use of the meal for cattle feed. However, after the recognition of the value of soy protein for poultry, swine and other animal feeds, and the world shortage of food protein after World War II, the soybean industry has been influenced tremendously by the need for protein. It has been predicted that the world demand for soy meal will grow 4.6% annually in the next 20 years (2).

Furthermore, in recent years there has been increasing concern about the protein and oil content of soybeans in addition to their yield (3-7). The information from some soybean crushing companies has suggested that there has been a general decline in protein content of soybeans in the U.S. and in Minnesota relative to some other states since 1974. One company has noticed that protein content has been lower in soy meal produced in Minnesota than in that from Illinois. Another company has sometimes avoided buying Minnesota soybeans due to their allegedly lower protein content. This low soy protein problem, if it is a real one, will not only adversely affect soybean crushers' profits because they have to keep the protein content of their meals high enough to meet the specification, but will also consequently affect soybean growers' profits. Soybean growers are vulnerable because near infrared spectrophotometry makes on-line measurement of the oil and protein content of soybeans possible, enabling the pricing of soybeans at the producer level based on their oil and protein content (8).

Therefore, it is of importance to investigate differences, if any, in protein and oil content between soybeans grown in Minnesota and other states, such as Illinois or North Dakota.

TABLE 1

Comparison of Protein Content of Soybeans Processed in Various Locations[a]

Plant location	Latitude (degrees N)	% Protein difference in soy meal[b]
a	34 35′	3.50
b	33 28′	3.06
c	34 44′	2.91
d	38 12′	2.77
e	41 10′	2.50
f	39 33′	2.49
g	34 13′	2.48
h	38 43′	2.41
i	37 32′	2.26
j	40 7′	2.13
k	39 50′	2.10
l	40 57′	2.10
m	39 10′	1.84
n	39 6′	1.57
o	41 35′	0.74
p	40 48′	0.36
q	44 10′	0.00

[a]This information was provided by Company A and covered the processing period from March 1986 through February 1987.

[b]% protein in soy meal minus % protein in meal produced at location q.

MATERIALS AND METHODS

The data used for statistical analyses in this paper were either collected from the results of the Uniform Soybean Tests, Northern States, or provided by some soybean crushing companies. In order to protect the latters' interests, their names are designated as Company A, B or C. The statistical analysis was conducted on these data using the Minitab (Pennsylvania State University) computing program.

RESULTS AND DISCUSSION

Table 1 compares differences in protein content among soybeans processed in various locations (most likely also grown in the same locations) in the processing period from March 1986 through February 1987. Values in the table represent differences between soybean meal produced at the northernmost latitude location and each of the other locations. The cities in which the processing took place were designated as location a, b, etc., with their latitudes listed. This information was provided by Company A. The correlation coefficient (r) between the latitude of each location and its relative protein content of soybeans was -0.77. Although the sample size was not big enough to judge whether this coefficient was statistically significant and the data are from only one year, there was a trend toward lower protein content in soybeans as the latitude increased.

Table 2 shows the statistical data as the overall average values for protein and oil content of soybeans processed (and most likely grown) in Illinois, Indiana, Iowa and Minnesota from 1983 through 1986. Tables 3-6 show the statistical data of the protein and oil content of soybeans processed (and most likely grown) in these individual states, respectively. This information was provided by Company C. Although more data are needed to demonstrate whether there is an effect of year on the protein and oil content of soybeans, there is no indication of a decrease in protein content of soybeans processed by Company C (in these four states) in the period 1983 to 1986. However, comparison of the average values of protein content in each state (Tables 3-6) with those for all four states (Table 2) does indicate differences. Whether they are statistically significant is not known. For instance, the average values for protein content in Indiana (Table 4) were relatively higher and the average values in Iowa (Table 5) and particularly Minnesota (Table 6) were relatively lower than the overall average values for the four states. The average values in Illinois (Table 3) were rather close to them. Also, it is noticeable that the average values of oil content in Iowa and Minnesota, respectively, decreased from 20.23% and 20.20% in 1983 to 18.83% and 18.40% in 1986. It should be noted, however, that the average oil content in Indiana and Illinois remained basically constant from 1983 through 1986.

The above observations support the data shown in Table 1. Namely, the protein content of soybeans processed in the more northerly locations was slightly lower than those processed in the more southerly locations. In order to further investigate this problem, data from the results of the Uniform Soybean Tests, North-

TABLE 2

Statistical Data as the Overall Average Values for Protein and Oil Content of Soybeans Processed in Illinois, Indiana, Iowa and Minnesota (1983-1986)[a]

Year	No. of samples	Mean[b]	SD	Min value	Max value	SEM	Sum	Variance	CV (%)
					Protein				
1983	1489	36.14	1.48	27.42	42.92	0.038	53809.30	2.20	4.10
1984	1799	36.38	1.71	28.52	41.16	0.040	65450.51	2.93	4.70
1985	2046	37.94	1.31	25.25	41.42	0.029	77643.82	1.71	3.45
1986	1641	36.77	1.22	31.08	41.97	0.030	60339.16	1.49	3.31
					Oil				
1983	1489	19.88	0.78	17.55	24.31	0.02	29597.38	0.61	3.94
1984	1799	19.35	0.69	17.27	22.73	0.02	34817.92	0.48	3.57
1985	2046	19.49	0.86	16.38	23.65	0.02	39871.02	0.74	4.43
1986	1641	19.26	0.98	16.46	22.75	0.02	31611.78	0.96	5.09

[a]Information provided by Company C.

[b]Based on 10% moisture content.

TABLE 3

Statistical Data as the Average Values for Protein and Oil Content of Soybeans Processed in Illinois (1983-1986)[a]

Year	No. of samples	Mean[b]	SD	Min value	Max value	SEM	Sum	Variance	CV (%)
					Protein				
1983	355	36.31	1.31	31.35	40.05	0.07	12889.82	1.70	3.59
1984	277	36.70	1.44	31.55	41.16	0.09	10167.28	2.06	3.92
1985	522	38.57	0.99	34.04	41.42	0.04	20134.66	0.98	2.57
1986	486	36.86	1.14	32.86	40.19	0.05	17916.39	1.30	3.09
					Oil				
1983	355	19.95	0.67	17.78	21.79	0.04	7082.28	0.46	3.38
1984	277	19.67	0.66	17.91	21.39	0.04	5448.26	0.43	3.34
1985	522	19.72	0.55	17.53	21.43	0.02	10294.32	0.31	2.81
1986	486	19.95	0.76	18.16	22.32	0.03	9696.07	0.58	3.82

[a]Information provided by Company C.

[b]Based on 10% moisture content.

TABLE 4

Statistical Data as the Average Values for Protein and Oil Content of Soybeans Processed in Indiana (1983-1986)[a]

Year	No. of samples	Mean[b]	SD	Min value	Max value	SEM	Sum	Variance	CV (%)
					Protein				
1983	401	37.50	0.91	32.97	42.92	0.05	15035.52	0.82	2.42
1984	366	38.34	1.23	34.98	41.08	0.06	14032.48	1.51	3.20
1985	457	38.74	0.85	36.20	41.32	0.04	17702.41	0.71	2.18
1986	450	37.05	1.16	31.86	40.87	0.05	16670.60	1.35	3.14
					Oil				
1983	401	19.18	0.53	17.55	21.40	0.03	7689.48	0.28	2.77
1984	366	18.88	0.59	17.17	20.68	0.03	6909.35	0.34	3.10
1985	457	19.35	0.75	17.21	21.19	0.04	8843.23	0.57	3.90
1986	450	19.34	0.81	17.17	22.05	0.04	8704.46	0.65	4.17

[a]Information provided by Company C.

[b]Based on 10% moisture content.

TABLE 5

Statistical Data as the Average Values for Protein and Oil Content of Soybeans Processed in Iowa (1983-1986)[a]

Year	No. of samples	Mean[b]	SD	Min value	Max value	SEM	Sum	Variance	CV (%)
					Protein				
1983	625	35.46	1.20	27.42	39.13	0.05	22161.98	1.44	3.39
1984	1027	35.69	1.39	28.52	39.09	0.04	36658.41	1.92	3.88
1985	758	37.36	1.34	25.25	41.14	0.05	28317.47	1.70	3.59
1986	553	36.61	1.32	31.08	41.97	0.06	20248.01	1.74	3.61
					Oil				
1983	625	20.23	0.71	17.77	24.31	0.03	12644.45	0.51	3.53
1984	1027	19.42	0.67	17.51	22.73	0.02	19944.80	0.45	3.44
1985	758	19.79	0.79	17.35	23.65	0.03	15001.55	0.63	4.00
1986	553	18.83	0.95	16.46	22.75	0.04	10414.25	0.90	5.05

[a]Information provided by Company C.

[b]Based on 10% moisture content.

TABLE 6

Statistical Data as the Average Values for Protein and Oil Content of Soybeans Processed in Minnesota (1983-1986)[a]

Year	No. of samples	Mean[b]	SD	Min value	Max value	SEM	Sum	Variance	CV (%)
					Protein				
1983	108	34.46	0.97	31.79	31.17	0.09	3721.98	0.94	2.82
1984	129	35.60	1.17	32.91	39.78	1.10	4592.33	1.37	3.29
1985	309	37.18	1.10	32.92	39.86	0.06	11489.28	1.21	2.96
1986	152	36.21	0.97	32.84	38.26	0.08	5504.17	0.94	2.68
					Oil				
1983	108	20.20	0.52	19.08	21.42	0.05	2181.16	0.27	2.59
1984	129	19.50	0.54	17.74	20.79	0.05	2515.52	0.29	2.76
1985	309	18.55	0.90	16.38	20.69	0.05	5731.93	0.81	4.84
1986	152	18.40	0.60	17.00	20.74	0.05	2797.00	0.36	3.24

[a]Information provided by Company C.

[b]Based on 10% moisture content.

TABLE 7

Yield, Protein and Oil Content of Soybeans Grown at Three Locations in Minnesota and One in Illinois for Various Years from 1971 Through 1985[a]

	Yield (bu/a)				Protein (%)[b]				Oil (%)[b]			
	CR	MO	WA	UR	CR	MO	WA	UR	CR	MO	WA	UR
1971	23.0	38.3	36.6	51.1	40.4	38.7	39.1	40.8	20.3	22.4	21.9	21.9
1972	21.9	39.0	34.6	53.7	36.7	39.9	41.1	41.0	22.1	21.5	21.4	22.4
1973	24.3	43.0	51.4	56.8	42.4	40.4	40.5	40.9	20.6	22.5	22.7	22.3
1974	30.7	32.1	35.0	45.9	40.5	39.5	39.7	39.3	17.9	20.5	20.1	20.7
1975	25.0	31.5	49.5	56.4	40.4	37.5	38.9	41.8	19.6	22.3	22.5	21.1
1978	25.7	40.8	51.9	54.8	40.6	39.9	40.7	42.7	20.4	22.5	21.1	20.4
1979	31.0	45.0	49.3	53.2	40.6	40.8	39.5	40.5	19.1	18.4	19.2	20.5
1982	18.9	35.9	29.7	59.4	39.9	38.7	37.7	41.6	17.2	18.8	18.6	17.4
1983	25.2	40.4	37.6	42.0	39.6	40.3	38.2	39.1	22.0	22.9	23.3	23.1
1984	36.3	48.3	39.6	57.1	37.7	40.2	38.4	38.9	22.5	20.6	22.2	22.6
1985	29.0	42.8	28.8	70.7	39.7	40.5	38.7	40.6	18.3	19.2	21.0	21.7

[a]Wilcox and Knapp, 1970-1986.

[b]Data reported here on dry basis.

CR, Crookston, MN; MO, Morris, MN; WA, Waseca, MN; UR, Urbana, IL.

TABLE 8

Two-way ANOVA of Effects of Year and Growing Location on Soybean Yield and Oil and Protein Content[a]

		Calculated F			Tabular F		
Source	DF	Yield	Oil	Protein	p<0.10	p<0.05	p<0.005
Year	10	1.41	11.47	1.35	1.82	2.16	3.34
Location	3	35.66	5.53	2.59	2.28	2.92	5.24
Error	30						
Total	43						

[a]Data from Table 7.

ern States (9), were collected. These included yield (bu/a), oil and protein content (%) covering six maturity groups and four locations (i.e., Crookston, Morris and Waseca, Minnesota, and Urbana, Illinois), and a period of 11 years, i.e., 1971-75, 1978-79, 1982-85, (Table 7). Based on these data, a two-way test was conducted using the Minitab computing program. The results of the two-way analysis of variance are shown in Table 8 for yield, oil content and protein content.

It can be seen from Table 8 that the effect of year on the yield was not significant, whereas the differences in yields among the locations were highly significant. The differences in oil content through the years and among the different locations were both highly significant. However, the effect of year on the protein content was not significant. It should be noted that the differences in protein content among the locations were significant at $p \leq 0.10$ but not at $p \leq 0.05$. At this point, it is difficult, if not impossible, to judge which level is more practical to use. Consequently, no conclusion can be made to confirm whether the differences in protein content among the locations were statistically significant.

In view of this unsolved problem and the controversy regarding the effect of year on the protein content, it is necessary to collect more data to run more sophisticated statistical analyses. More accurate information can be obtained by analyzing the protein and oil content of soybeans grown in specific locations. By so doing, the confusion in the methods used for chemical analysis can be avoided.

If results confirm the hypothesis that the protein content of soybeans grown in Minnesota is indeed lower than that of those grown in southern states, efforts should be made to identify the causes related to this phenomenon. For example, the protein content of soybeans can be affected by variety as well as by weather, farming practices, seed coat color, oil content and other factors (4, 5, 7, 8, 10). Evaluating these causes can help soybean growers in Minnesota to improve the varieties of soybeans grown as well as their farming practices.

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