1990

Protein and Oil Content of Soybeans Received at Country Elevators

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Abstract
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Keywords
Grain quality, Near-infrared reflectance, Nutrient content

Disciplines
Agriculture | Bioresource and Agricultural Engineering

Comments
This article is from Applied Engineering in Agriculture, 6, no. 1 (1990): 65–68.

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PROTEIN AND OIL CONTENT OF SOYBEANS RECEIVED AT COUNTRY ELEVATORS

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ABSTRACT

Soybeans received at 12 central Iowa elevators in 1985-1987 were analyzed for protein and oil content. The standard deviation among deliveries to an individual elevator was 1.0 and 0.5 percentage points for protein and oil, respectively. About 15% of samples were above average in both nutrients. About 15% were below average in both nutrients. The rest were above average in one and below average in the other. Although the elevators were located within a 120-km (72-mile) diameter circle, some differences among locations in average protein and oil content were consistent over the three years of this study. Because 70% of the variability in protein and oil occurred at an individual elevator, it will be most important to identify protein and oil at the first point of sale. A near-infrared reflectance analyzer was capable of operating within the constraints of a large country elevator involved in corn and soybean trade.

INTRODUCTION

The Federal Grain Inspection Service plans to offer protein and oil analysis as optional criteria in Official USDA inspections of soybeans by September 1989. This will create an opportunity to include protein and oil content in the pricing structure for soybeans.

A range in protein and oil content will be necessary for protein and oil pricing to be successful. The variation in nutrient percentages is only useful to the extent that it represents differences in processing value to the soybean crusher. A model to predict soybean meal and oil (crush) value from whole-bean protein and oil percentages was developed by Brumm and Hurburgh (1987). This model was based on mass balances and operational efficiencies for solvent-extraction soybean processing. The model predicts the maximum possible differentiation among soybean samples and assumes that the crusher is able to take advantage of compositional differences.

Any computation of crush value must be related to specific soy oil and soy meal prices. Concurrent increases in the prices of both products will magnify the spread between grain lots; whereas, relative changes may cause shifts in the ranking of lots. The Brumm and Hurburgh analysis used market prices in November 1987 to show a spread in crush value of $0.84/bu among typical samples. In June 1988, the same samples had a spread of $1.15/bu.

Because there are clear differences in crush value, certain growers could receive higher average prices than others. If local geographic differences are consistent, certain country elevators could also receive higher average prices than others. The range in value of soybeans delivered to an individual location indicates the potential for segregation for sale to nutrient sensitive markets and the possibilities for improved average nutrient quality of soybeans.

Hurburgh et al. (1988a) reported significant regional differences in soybean nutrient composition. Regions in this case were states and groups of states. Generally, southern soybeans were 1 to 2 percentage points higher in protein and about equal in oil to corn belt soybeans. About 3000 samples from three crop years were involved in this study. The standard deviations of protein and oil within a state were 1.2 and 0.6 percentage points, respectively.

A soybean processing plant will buy soybeans from an area smaller than a whole state. Buying practices depend on local transportation costs, but generally plants receive beans from a 50-80 km (30-50 mile) radius around the plant. Although processors have traditionally believed that localized patterns of protein and oil content do exist, there is little such data in the public domain. The relative magnitude of differences in local averages compared with the differences among lots at a given location is a crucial point in determining whether protein and oil pricing will extend to the grower level or will simply be contained in the average price offered to specific country elevators.

In 1983 and 1984, soybean deliveries to 13 midwestern elevators were analyzed for protein and oil content (Hurburgh et al., 1987). All sample groups were obtained by sampling producer deliveries on one day during harvest, and protein and oil values were obtained from a near-infrared reflectance (NIR) analyzer. From these data, the standard deviation of protein and oil content in inbound soybeans at a single elevator was estimated to be 1.0 and 0.5 percentage points, respectively, with both protein and oil expressed on a 13% moisture basis. The extent to which single-instance sampling represents harvest-season variation is not known. More complete data are needed for elevators to develop handling and merchandizing strategies in response to composition pricing.

The success of NIR in measuring soybean composition has been reported extensively (Hymowitz et al., 1974; Hurburgh et al., 1987; Panford et al., 1988). However, most data were collected under laboratory conditions. Assuming...
that protein and oil pricing will extend to grower-country elevator trades, NIR units will have to function in elevators and will have to produce test results in 1 to 2 min per sample. As reported in Hurburgh et al. (1987), this seems to be within the capability of the NIR technology.

OBJECTIVES
1. Determine the distribution of soybean protein and oil content in soybeans delivered to an individual country elevator and to elevators within the normal local trading area of a soybean processing plant over several harvest seasons.

2. Field test a near-infrared reflectance analyzer under country elevator conditions, given the workflow constraints of a high-volume Corn Belt elevator.

PROCEDURES
The study was conducted in the 1985, 1986, and 1987 crop seasons. In October 1985, a Dickey-john GAC III NIR analyzer was taken to a large central Iowa elevator (location 9, Fig. 1). The NIR analyzer had been calibrated to measure soybean moisture (of the ground material), protein, and oil content. Samples were ground before analysis with a Magic Mill III+ home flour mill. Details of the calibration were reported in Hurburgh et al. (1987).

The NIR analyzer was placed in the elevator’s sampling station. From each load sampled, a 30 to 50-g subportion of the elevator’s sample was removed, cleaned with a 3.2-mm (8/6-in.) round-hole screen, ground, and packed into the NIR sample cup. The entire NIR procedure took 60-90 s/sample. At this rate, the NIR operator was able to keep up with the rate of grain receiving. The elevator was receiving corn and soybeans simultaneously; corn samples were analyzed for moisture, protein, oil, and starch content by the same procedure. Few sample grinding difficulties were encountered, even though whole soybean moisture ranged from 8% to 18%, wet basis, by the elevators’ moisture meter.

Testing was done on seven different days during the 1985 harvest. In addition to the samples tested on-site, personnel at eight branch elevators owned by the same company collected about 40 samples from each elevator during the harvest season. The relative location of the elevators is shown as locations 1 through 8 in Fig. 1. These samples were analyzed with the same NIR unit at Iowa State after the on-site study was completed.

In 1986 and 1987, all samples were analyzed at Iowa State University. Sample groups were collected by the same nine elevators plus other facilities numbered 10, 11, and 12. All 12 elevators were located within a 120-km (75-mile) diameter circle. Samples, weighing 400-800 g, were the probe samples used to establish quality for trade. The samples were refrigerated in plastic storage bags until analysis.

Protein and oil percentages were converted to a 13% moisture basis. The NIR determined moisture on the ground sample. This moisture percentage was used to adjust protein and oil to 13% moisture. The 13% moisture basis was used because that is the normal pricing basis for soybeans.

RESULTS AND DISCUSSION
1985 RESULTS
The data for the 1985 on-site study are given in Table 1. There were differences in average composition as the harvest season progressed. Although the number of loads varied by day, pairwise t-tests showed that differences of 0.2% points (protein) and 0.1% points (oil) generally were significant (P = 0.05). The most likely explanation is that, on any given day, a limited group of farmers was delivering soybeans. As some growers finished and others began harvesting, the mix of varieties and maturities changed. Varietal differences in soybean protein and oil are well-documented by publicly sponsored comparison tests (Iowa State University, 1988). Particularly on the days with fewer sample numbers, the deliveries from two or three growers predominated. This not only caused average differences among days but also probably caused the standard deviations to be lower within a day than across all days in the season. The practical significance is that an elevator operator or a processor wanting the average and variability of soybean composition should not base estimates on

<table>
<thead>
<tr>
<th>Date of Testing</th>
<th>Number of Loads</th>
<th>Protein* (%)</th>
<th>Oil* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-03-85</td>
<td>144</td>
<td>33.9</td>
<td>19.8</td>
</tr>
<tr>
<td>10-09-85</td>
<td>45</td>
<td>34.4</td>
<td>19.4</td>
</tr>
<tr>
<td>10-10-85</td>
<td>36</td>
<td>34.4</td>
<td>19.6</td>
</tr>
<tr>
<td>10-11-85</td>
<td>17</td>
<td>34.0</td>
<td>19.7</td>
</tr>
<tr>
<td>10-16-85</td>
<td>13</td>
<td>34.7</td>
<td>19.2</td>
</tr>
<tr>
<td>10-25-85</td>
<td>56</td>
<td>34.6</td>
<td>19.6</td>
</tr>
<tr>
<td>10-29-85</td>
<td>11</td>
<td>34.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Overall</td>
<td>322</td>
<td>34.2</td>
<td>19.7</td>
</tr>
</tbody>
</table>

| Standard deviation, percentage points | 1.0 | 0.5 |
| Average standard deviation on a day, percentage points | 0.82 | 0.41 |
| (Range in standard deviations, percentage points) | (0.63-0.94) | (0.32-0.56) |

*Protein and oil percentages reported at 13.0% moisture.
samples collected in any single day. The standard deviation of composition values was about 1.25 times greater over the entire season than on a single day.

The accuracy of this NIR unit, as well as others in our laboratory, was monitored by comparison to wet chemical methods as described by Hurburgh et al. (1988). In the three years since the basic calibration was formulated, there have been no significant biases or slopes of NIR-predicted values relative to reference analyses. Instrument drift was monitored daily by retesting 10 samples from the previous day’s group. There were no significant (P = 0.05) differences between the first and second tests. Sampling errors (in the whole beans) appeared to create more chance for poor results than did instrument drift.

Data (1985) for the eight branch elevators are given in Table 2. It is clear that there were consistent compositional differences among them. Each branch-elevator group was composed of approximately five samples gathered on eight different days through the harvest season. Geographical patterns were evident. The low-protein, high-oil locations (2 and 8) are only about 8 km (5 miles) apart and received less rainfall, according to area observers, than the other locations. The location of elevator 1 received two rains during the pod-fill season (August through early September) that no other elevator location received.

Despite average differences among elevator locations, variability at a given location (standard deviation) was remarkably consistent. Thirty samples from location 9 were retested when the NIR was in the laboratory. The average difference between the field test and the laboratory test was a non-significant 0.06 percentage points, with a standard deviation of differences of 0.25 percentage points.

1986-87 Results
The data for 1986 and 1987 samples collected at locations 1-9 are also given in Table 2. The average protein and oil content were clearly different (protein higher, oil lower) in 1986 than in 1985 or 1987. Most locations had 1-2 percentage points higher protein content in 1986 than 1985, a much larger difference than the LSD value of 0.2 percentage points. However, in all years, the variability at an individual elevator was again close to the original estimate from the 1983-84 survey. Some local differences (e.g., location 1 vs. location 8) persisted across all three years, while others did not (e.g., location vs. location).

In 1986 and 1987, three other large rail terminal elevators were included in the study. Data from these elevators (location numbers 10, 11, and 12) plus location 9, are given in Table 3. Differences among these locations were slightly larger than those among the nine nearby locations. The overall averages for the four locations were not always the same as reported for Iowa soybeans in nationwide surveys sponsored by the American Soybean Association (Hurburgh et al., 1988a), but these four locations do not cover the entire state of Iowa.

Yet again, the standard deviation at an elevator was about 1.0% point for protein and 0.5% points for oil. The variation at individual elevators represented about 70% of the total variation in the data. This was determined by comparing the total variance (sums of squares) to the sums

<table>
<thead>
<tr>
<th>Elevator Location</th>
<th>Number of Samples</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>139</td>
<td>47</td>
<td>35.1</td>
</tr>
<tr>
<td>10</td>
<td>67</td>
<td>40</td>
<td>35.9</td>
</tr>
<tr>
<td>11</td>
<td>40</td>
<td>42</td>
<td>34.7</td>
</tr>
<tr>
<td>12</td>
<td>61</td>
<td>44</td>
<td>35.3</td>
</tr>
<tr>
<td><strong>Averages</strong></td>
<td></td>
<td></td>
<td>35.3</td>
</tr>
</tbody>
</table>

Table 2: Protein and oil content of 1986 and 1987 soybeans delivered at harvest to four central Iowa rail terminal elevators.

Table 3: Protein and oil content of 1986 and 1987 soybeans delivered at harvest to four large central Iowa rail terminal elevators.

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of squares attributable to variability at a location, as opposed to that attributable to differences among location means. The potential to isolate soybean lots by composition apparently is much greater at an individual elevator than at a processing plant or an export terminal buying beans from many country elevators. The plant would experience variation among location means, not among lots delivered to an individual location. If protein and oil content pricing is to be effective, the identification of composition must be made at the first point of sale.

**GENERAL DISCUSSION**

The diagram shown in Fig. 2 depicts the distribution of protein and oil at one location. Quadrant I is high protein and high oil (H-H), II is low protein and high oil (L-H), III is high protein and low oil (H-L), and IV is low protein and low oil (L-L). High and low are established relative to the mean value at that elevator.

Of the 42 samples from location 11 in 1987, 12% were in the H-H (I), 12% in the L-L (IV), 35% in the L-H (II), and 41% in the H-L (III) quadrants. With protein and oil pricing, samples in quadrant I would always receive some premium relative to the average value, and samples in quadrant IV always some discount, regardless of meal and oil prices. But the majority of samples fell in quadrants II and III, such that meal and oil prices would determine their relative value. Segregation by protein or oil percentages individually will not guarantee economically advantageous marketing opportunities.

The dashed lines represent the averages for all samples collected in 1987. This is the quadrant analysis from a processor’s viewpoint (assuming our sample mean is the true mean for soybeans in Iowa). Overall, 15% of the 1987 samples fell in quadrant I, 15% fell in quadrant IV, 37% fell in quadrant II, and 33% fell in quadrant III. This distribution remained quite constant from year to year, based on 1985-1987 data, using the respective year’s mean to define quadrants.

The mean of elevator II falls in quadrant I. Therefore, all growers in the trade area of elevator 11 could receive a higher average price in this particular year with protein and oil pricing. Conversely, customers of elevators falling in Quadrant IV could face lower than average prices. This analysis demonstrates why processors attempt to selectively buy more soybeans from certain country locations than others.

**CONCLUSIONS**

The following conclusions are drawn from protein and oil data collected in 1985-1987 from 12 central Iowa elevators located within a 120-km (75 mile) diameter circle.

1. The standard deviation of protein and oil content in soybean deliveries to country elevators is 1.0 and 0.5 percentage points, respectively.

2. In all three years, about 15% of samples were above average for both protein and oil, and about 15% were below average for both nutrients. The remaining 70% were divided about evenly between high protein–low oil and between low protein–high oil.

3. There were protein and oil differences among locations, even in this relatively small area. The differences were, in some cases, consistent from year to year. The least significant differences (P = 0.05) among elevator average protein and oil contents were 0.2% and 0.1% points, respectively.

4. About 70% of the total variations in protein and oil content were caused by lot-to-lot differences at an individual location. Only 30% could be attributed to geographic location patterns.

5. The near-infrared analyzer was capable of operating in an elevator environment, although extra labor was required for sample grinding and preparation.

These conclusions are significant advances to the understanding of how protein and oil analysis will function at market points.

**REFERENCES**


