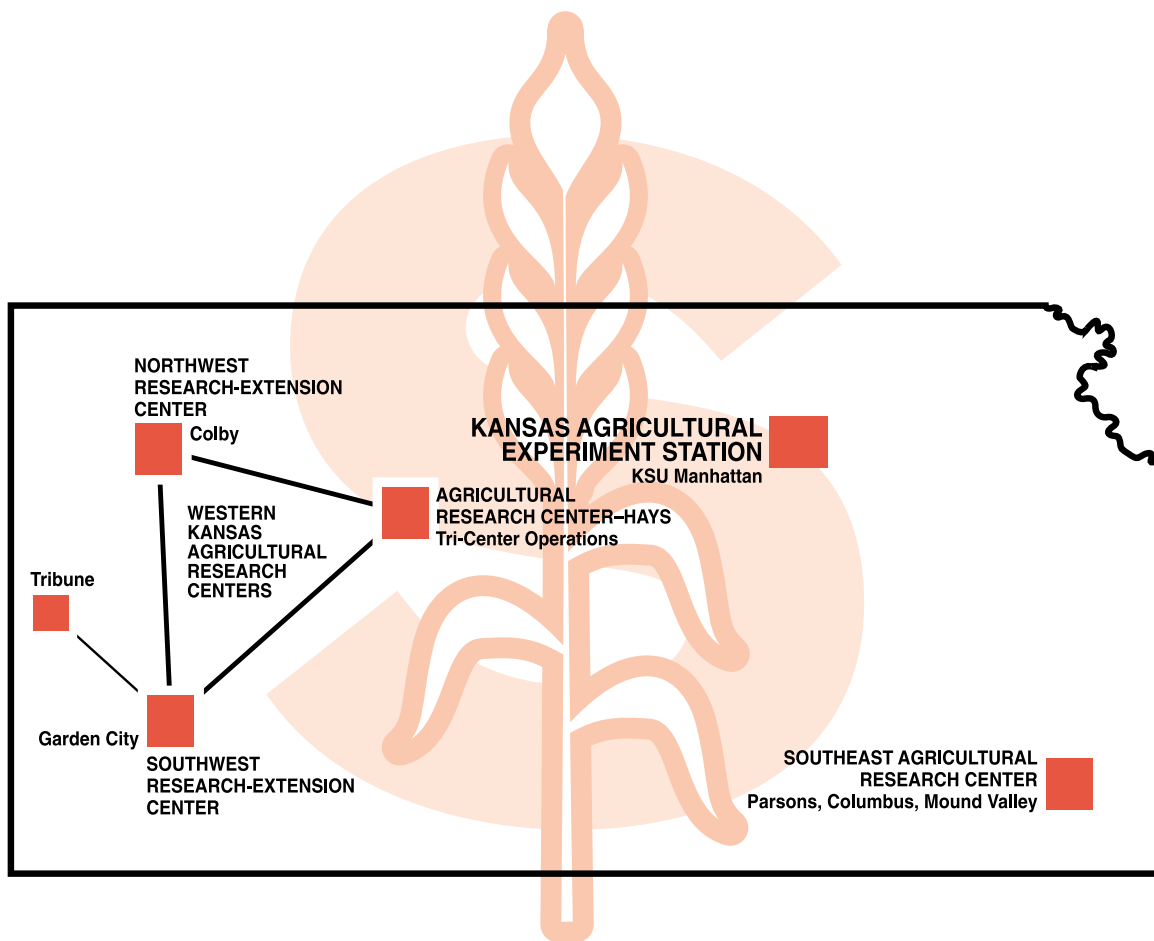


# *Economic Issues with Soybeans*



## **Agricultural Industry Competitiveness**

Enhance the value of Kansas Agricultural goods



# Economic Issues with Soybeans

The United States is the largest producer and exporter of soybeans worldwide. While Kansas ranks 10th in U.S. soybean production, it only accounts for approximately three percent of the total production (Kansas Ag Statistics). Although Kansas' soybean production has been a relatively small share of total U.S. production, soybeans are becoming an increasingly important crop to the state. Soybean acreage has nearly doubled in the last 20 years from 1.55 million acres in 1980 to 2.95 million acres in 2000 (Figure 1). From 1981 to 1985 the annual average acres planted to soybeans in Kansas was approximately 1.63 million acres, however, acres planted from 1996 to 2000 to soybeans increased to 2.56 million annually (an increase of 57 percent). During this same time period, acres planted to soybeans in the United States increased by only 6.4 percent. Figure 2 illustrates U.S. and Kansas' soybean production from 1980 through 2000. Historically, about 75 percent of the production in Kansas has come from the eastern third of the state, however, soybeans have become increasingly more important statewide since the 1996 Farm Bill (Figure 3). This publication describes new uses for soybeans and illustrates differences in value across soybean varieties.

## Demand for Soybeans

Much of the soybean's popularity is attributed to its versatility. The soybean's many uses can be categorized into three groups: industrial, human food, and livestock feed.

Currently, industrial uses of soybeans are a small portion of total soybean use. However, many new products are becoming available as scientists find new uses for soybeans. Many of these products are substitutes for petroleum-based products. For example, soybean oil-based pesticide spray adjuvants are widely used by farmers and custom applicators. They provide a safe, cost-effective tank mix that aids the

Figure 1. Planted Soybean Acres in Kansas and United States, 1980 to 2000

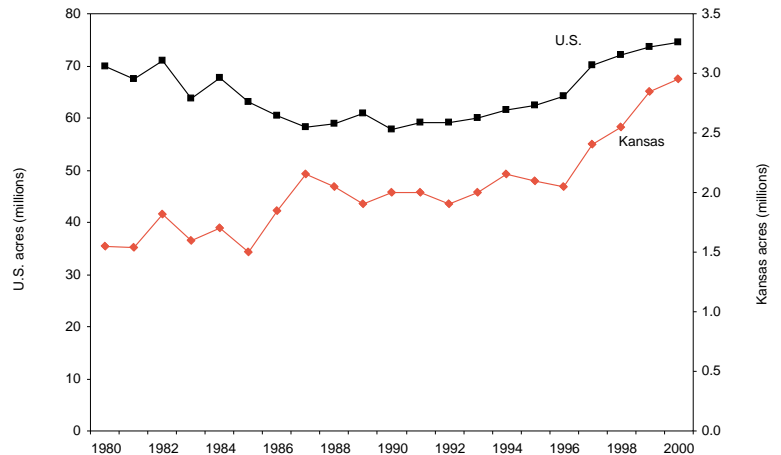


Figure 2. Soybean Production in Kansas and United States, 1980 to 2000

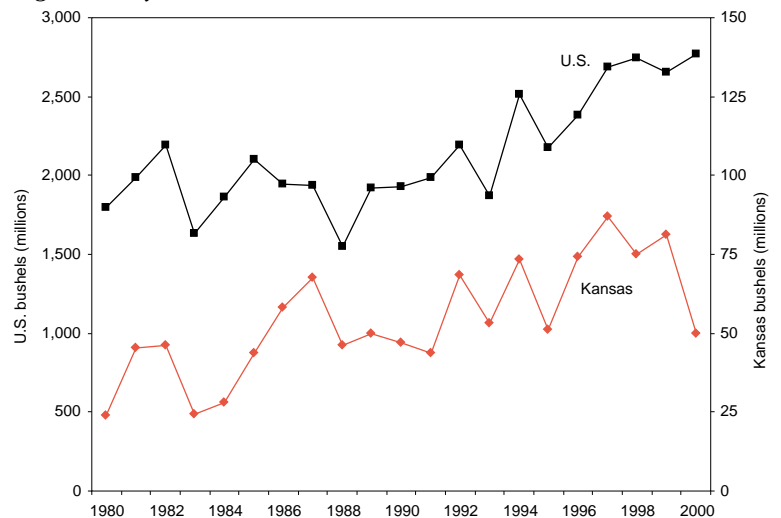
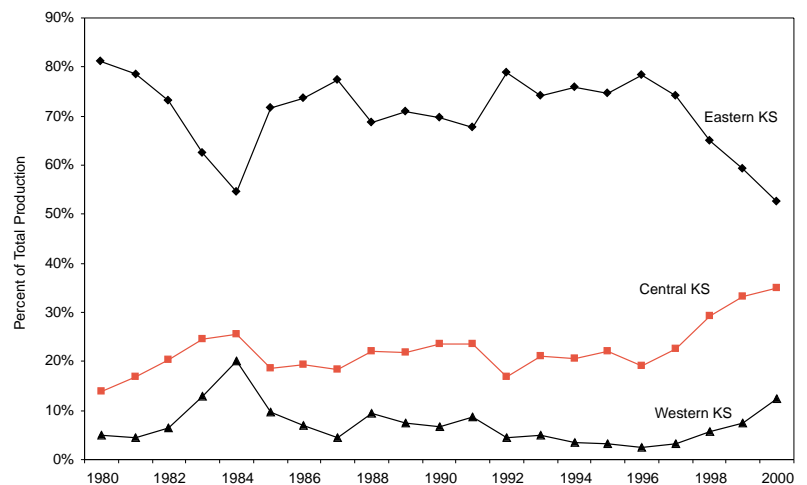


Figure 3. Distribution of Soybean Production in Kansas by Region, 1980 to 2000



active ingredients in performing their task. Soybean oil-based lubricants and cleaners are relatively new, but the demand for them as an environmentally friendly alternatives to petroleum-based products is

increasing. Biodiesel includes a partial blend of a soy-based product that improves lubricity and reduces harmful emissions after combustion.

About 7.4 billion pounds of adhesives are used annually in the United States for applications in plywood, particleboard, paper manufacturing, bookbinding, and packaging and labeling. The various forms of wood use represent the largest and most diverse market for adhesives today. Petroleum-based adhesives for plywood or fiber cardboard applications often contain phenol/urea formaldehyde as a cross linking agent. These applications cause unpleasant environmental effects due to formaldehyde emission and toxicity problems during product manufacturing and distribution. The plywood industry is currently seeking new types of wood adhesives from renewable resources, potentially increasing the demand for soybeans.

Researchers at Kansas State University are developing formaldehyde-free adhesives from soybean proteins, and evaluating their adhesive performance for plywood and particleboard applications (Sun). While many new uses for soybeans exist, most are cost prohibitive relative to petroleum-based products based on current market conditions.

Another soybean use is human consumption. Soybeans provide a valuable source of protein and are considered a “heart healthy” product by the U.S. Food

and Drug Administration. Tofu, tempeh, and natto are soyfood products common in Asia. Soy flour often is mixed with other flours to increase the protein content. Soybeans are also used as a soy analog in meat products. Soybean oil has many uses in the food industry.

A large majority of the U.S. soybean production is for livestock feed. Soybeans are the most cost effective source of protein in many feed rations. Usually the soybean is crushed, separating the oil from the remaining flake or meal. Soybean meal typically contains 44 to 50 percent protein. Figure 4 shows a steady increase in monthly meal and oil production from 1992 through 2000 (USDA). The lines for soybean oil and soybean meal lie on top of each other because, on average, a bushel of soybeans yields oil and meal in constant proportions.

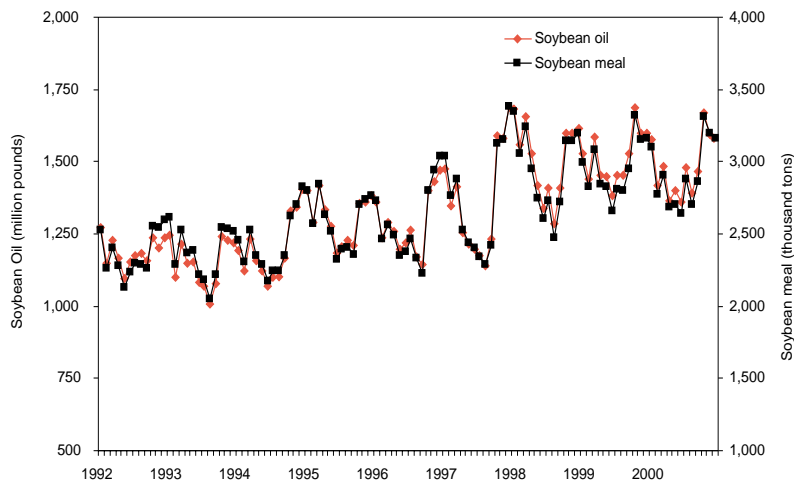
## Overview of New Soybean Varieties

Small, niche markets exist for several types of specialty soybeans. Care at harvest is critical to ensure food-grade soybeans meet quality standards. Many of these specialty or “value-added” soybeans are grown under a production contract (see MF-2431 *Economic Issues with Vertical Coordination* for a discussion of the differences between marketing and production contracts).

Tofu or clear hilum food-grade soybeans are usually produced for human consumption in the form of soymilk or tofu. Soymilk is a milk-like liquid, processed by the soaking and grinding of whole soybeans with water. Soymilk is a substitute for dairy milk for lactose-intolerant people. Tofu is a soybean curd, made by mixing soymilk with a coagulating agent. It can be eaten in its original form, fried, baked or used as a meat or dairy substitute.

Organic food-grade soybeans have gained tremendous popularity in the last decade. A sizable market has developed demanding organically grown food, although the supply of organic crops is still

**Figure 4.** Monthly Soybean Oil and Soybean Meal Production in the United States, 1992 to 2000



less than 0.5 percent of all food produced in the United States (Greene). The USDA has set certification guidelines for organic products that rely on sustainable production processes without the use of synthetic fertilizers and pesticides.

High sucrose soybeans decrease abdominal discomfort and improve flavor, which are two problems commonly associated with regular soybeans. These varieties contain higher levels of sucrose and lower levels of oligosaccharides, the indigestible sugars that cause abdominal discomfort. High sucrose soybeans also offer improved flavor, enabling larger amounts of health beneficial soy product to be present in food products.

High oleic soybeans produce a bean that is high in oleic acid and monounsaturated fatty acid and low in polyunsaturated fat. This gives the high oleic soybean greater heat resistance and health benefits than the regular soybean. The soybean's makeup also permits it to be used for many industrial applications because of its greater stability, lubricity and biodegradability.

Low saturate soybeans contain half the saturated fat of commodity soybeans, while maintaining flavor. Low saturate soybean oil has only 7 to 8 percent saturated fats, making it similar to canola oil. Salad dressings and sauces made with low saturate soybean oil have very little or no saturated fat.

Low linolenic soybeans produce cooking oil that has 50 percent less linolenic acid than commodity soybean oil. This reduces the need for hydrogenated oils that are high in unhealthy transfatty acids, thereby lowering LDL "bad" cholesterol levels and raising HDL "good" cholesterol levels.

High protein soybeans are mainly targeted for the soy food market. Products like soymilk and tofu exhibit improved qualities due to the increased protein content from high protein soybeans.

Non-genetically modified soybeans (non-GMO) produced in the United States currently account for less than 50 percent

of all soybeans. Mandatory labeling in certain countries is in its early stages and it is unclear whether a premium exists for non-GMO soybeans. For example, Parcell concluded that the price differential between the futures contract for Tokyo Grain Exchange's new genetically enhanced soybean (of U.S. origin) and that for its existing conventional soybean (of U.S. origin), was probably not sufficient to recoup the costs of the identity-preserved system for the genetically enhanced soybean. Additional information on genetically modified soybeans can be found in MF-2449 *Economic Issues with Genetically Modified (GM) Food and Feed Grains*.

## **Soybean Processing**

As of 1997 there were 93 soybean-processing plants in the United States with payrolls totaling \$237 million and value added by manufacturing worth \$1.7 billion (U.S. Department of Commerce). Kansas had four processing plants that employed 201 people with a value added by manufacturing worth \$7 million in 1997.

### ***The Crush Process***

Before soybeans are processed, they first need to be dried to a moisture content of 10 percent. After cooling, the soybeans are cleaned by removing inert matter. The soybeans are then weighed before they move to the next step, which is the cracker. During this process, the soybeans move through a series of rollers that crush the beans into smaller pieces. After crushing, the hulls (outer skin) are removed before steam heating the soybean pieces. Once the soybean pieces are brought to 11 percent moisture content, they go through a series of rollers that produce thin flakes.

After the soybean pieces are rolled into thin flakes, the oil extraction process begins. Hexane, an organic solvent, is washed with the flakes, dissolving the oils into a 75 percent oil and 25 percent hexane mixture (Gianessi). The mixture goes through a solvent recovery system that extracts the hexane so it can be reused. The

flakes have their solvent removed by a desolventizer-toaster that also inactivates trypsin inhibitors with heat (Snyder).<sup>1</sup> The hulls may or may not be mixed back into the flakes to bring the protein content down to 44 percent. Grinding the flakes to the correct particle size for feed produces the finished product, soybean meal.

### ***Oil Refining***

Crude soybean oil must go through a series of processes in order to get a high quality, edible soybean oil. Gums (phospholipids or lecithin), present in crude soybean oil, are removed because they are insoluble in oil and precipitate out during storage (Snyder). The gums are removed by adding water to the oil, which attracts to the polar phospholipids. The oil and water are separated by centrifugation (Gianessi). Some water may remain in the oil, but it is evaporated during a drying process. The gum or lecithin that is removed is a valuable by-product that can be used by the food industry as an emulsifier and anti-sticking agent.

Free fatty acids are then removed from the oil through a lye washing and centrifugation separation. Free fatty acids cause the oil to smoke at a lower temperature and increase foaming. Pigments or traces of gums, fatty acids, and minerals are usually removed because it produces a more desirable oil. This is done by bleaching, a process of adding clay to the oil to adsorb the unwanted material that is then removed through filtration. The flavor of soybean oil is considered undesirable, so the oil undergoes a process called deodorization that is a high temperature steam distillation under vacuum to remove the flavor compounds (Snyder).

### ***The “Crush” Margin***

The “crush” margin is the value of processing commodity soybeans into meal and oil. It is computed by taking the difference between the soybean price and the

combined prices of the processed soybean oil and meal. The Chicago Board of Trade futures prices are often used to compute the theoretical “crush” margin, which is more commonly referred to as the “board” margin. The board margin is based on yields of 48 pounds of soybean meal and 11 pounds of soybean oil per soybean bushel.

The following is an example of a board margin: on March 23, 2001 the futures prices of soybeans, soybean meal, and soybean oil for January 2002 delivery were \$4.49 per bushel, \$144.60 per ton, and \$0.17 per pound, respectively. The revenue from soybean meal and soybean oil on a per bushel basis is estimated as  $(\$144.60 \div 2000 \times 48) + (\$0.17 \times 11) = \$5.34$ , where 48 and 11 are the expected extraction rates (lbs per bushel) for meal and oil, respectively. The board margin is the difference between the sum of the estimated values of soybean meal and soybean oil and the price of soybeans. Thus, in this example the board margin: is  $\$5.34 \text{ per bu} - \$4.49 \text{ per bu} = \$0.84 \text{ per bu}$ .

Many processors use a board margin to minimize the financial risks of sudden increases in soybean costs and/or decreasing values of finished soybean meal and oil (Soy Importer’s Handbook). A processor who wants to lock-in the board margin would buy soybean futures and simultaneously sell soybean oil and meal futures. This would eliminate price risk, but extraction rates (meal and oil yields) and basis risks (cash price versus futures price) would still exist.

A cash crush margin is computed similarly using soybean prices purchased and soybean oil and meal prices sold at one location. Figure 5 shows an example of the monthly crush margin at Decatur, Illinois, from 1990 to 2000. Like many food and agricultural industries, soybean processors expanded capacity in anticipation of stronger export demand in the mid-1990s. When global demand did not increase as fast as capacity, margins decreased in 1998, and have since increased as several plants have been shut down.

<sup>1</sup>Trypsin inhibitors prevent the proper use of protein by nonruminants.

## Study of Soybean Variety Selection on Estimated Processing Value

Kansas soybean varieties were evaluated based on their estimated processing value (EPV), which is the value of output through the processing of soybeans into meal and oil. A major soybean processor that purchases soybeans from Kansas producers uses a value-based marketing program that pays producers, in part, on the percentage of soybean oil in the soybeans. Soybean variety selection decisions are important for Kansas' soybean producers and information on the relative value of oil, and protein is important if marketing under such a program.

The data for this analysis consisted of protein, oil, fiber, and moisture content from Kansas State University irrigated soybean variety trials in Colby, Kansas (unpublished data). Protein, oil, fiber, and moisture content of soybean samples were obtained using a GrainSpec model 211/8284 whole grain NIR instrument. The samples used in this study represented 52 Round-up Ready and conventional varieties.<sup>2</sup> The EPV was calculated using the Stratsoy EPV Calculator funded by the United Soybean Board that is available online through the University of Illinois at [www.stratsoy.uiuc.edu/epv/](http://www.stratsoy.uiuc.edu/epv/). The estimated processing value was calculated with input values for meal and oil price, percentage protein, oil percentage, moisture percentage, fiber percentage, and other requirements for 48 percent protein meal.

Initially, the EPV was calculated for a sample for each variety by inputting their respective protein, oil, and moisture percentages while holding soybean meal and oil prices constant at long-run historical average prices (1991 to 2000) of \$191.96 per ton and \$0.2231 per lb.<sup>3</sup> The results of this analysis, displayed in Figure

<sup>2</sup> While the samples came from 52 different soybean varieties, it is important to remember that this data only represents one year and one location. Calculated EPV values provide evidence as to the variability that exists in soybeans but it is unknown how consistent these differences will be for specific varieties. Thus, specific varieties are not identified.

<sup>3</sup> Soybean hull (fiber) prices were held constant at \$75 per ton for all EPV analyses.

Figure 5. Monthly Soybean Crush Margin at Decatur, Illinois, 1990 to 2000

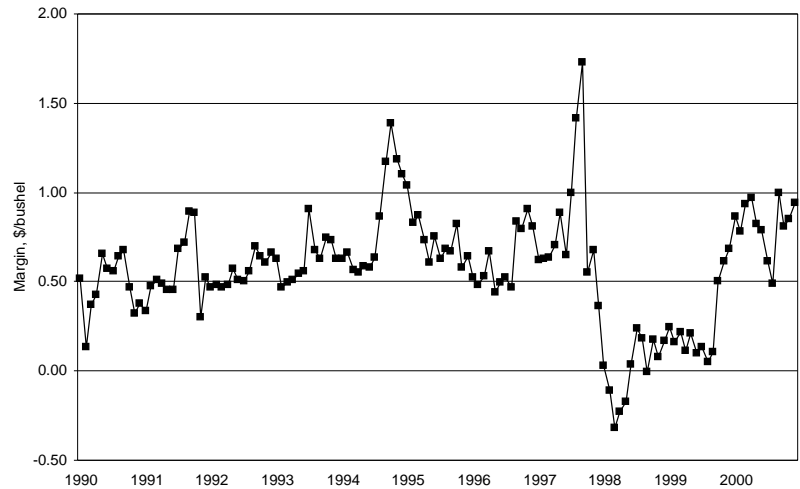
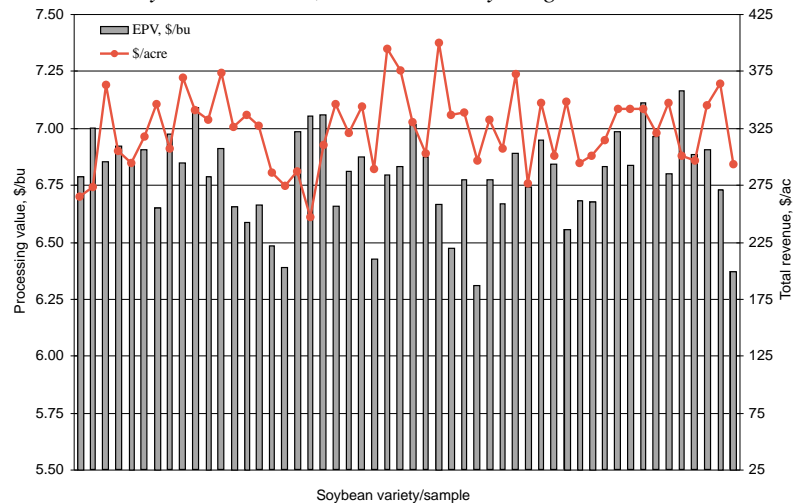


Figure 6. Estimated Processing Value and Revenue of 52 Different Soybean Varieties, Thomas County Irrigated Trial

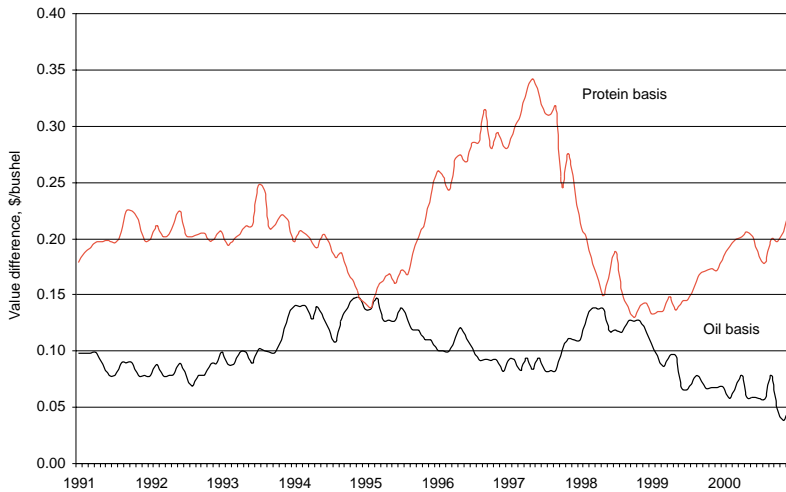


6, indicate there is considerable variability in dollars per bushel value between the different samples (range of \$6.31 to \$7.16 with an average of \$6.79). The correlations between oil percentage, protein percentage, yield, EPV and revenue per acre (yield  $\times$  EPV) are shown in Table 1.<sup>4</sup>

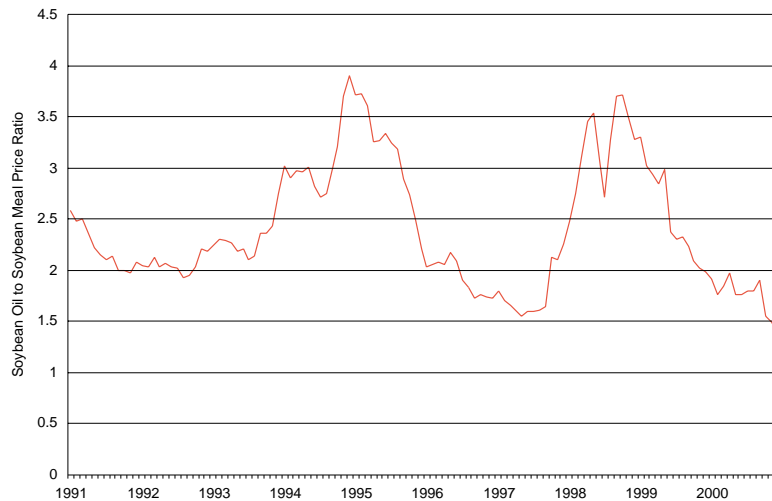
Results from the study indicate that there is a trade-off between oil percentage and yield, and oil percentage and protein percentage (i.e., negative correlation in Table 1). In other words, for the 52 varieties examined, varieties with high yields tended to have lower oil contents. Likewise, varieties with high oil contents had low protein contents and vice versa as would be expected. There was essentially

<sup>4</sup> Correlations range from -1 to +1 where high positive (negative) values indicate a strong positive (negative) relationship between the variables. Values close to zero indicate little or no relationship between the two variables.

**Figure 7.** Monthly Differences in Estimated Processing Value between the Top 15 Percent of Samples for Percentage Oil and Protein and the Average Variety, 1991 to 2000



**Figure 8.** Ratio of Soybean Oil Price to Soybean Meal Price, 1991 to 2000



no relationship between the protein content and yield (i.e., the correlation is close to zero). The estimated processing value (EPV) is positively related to both oil and protein content indicating higher oil or protein levels are associated with higher processing values. The relationship between EPV and yield is slightly nega-

tive, which is attributable to high yields having lower oil contents (i.e., the negative correlation between yields and oil content).

The correlation between revenue per acre and EPV was only slightly positive, indicating producers should continue to focus on yield and not simply try to maximize EPV. This relationship is demonstrated in Figure 6 where it can be seen that some of the varieties having the highest revenue per acre did not necessarily have the highest EPV. Because these results are based on only one year and one location, further research needs to be done to determine how stable these results are under various growing conditions (e.g., weather, geographical location, cultural practices) so producers can identify the optimal varieties for their particular marketing opportunities (e.g., participation in an oil premium program).

The large variation that existed led to further analysis in which the top 15 percent of oil samples and the top 15 percent of protein samples were compared to the average of the 52 varieties and evaluated over 10 years of monthly meal and oil prices (1991 to 2000). Results show that the 15 percent of samples with the highest protein percentage had the largest average EPV of \$6.99 per bushel. The 15 percent of samples with the highest oil percentage had an average EPV of \$6.89 per bushel. The average oil, protein, fiber and moisture content of all varieties produced an average EPV during the 10 years of \$6.79 per bushel. Figure 7 shows the monthly differences in EPVs between the top oil and top protein samples relative to the average of all varieties.

**Table 1.** Correlation between Soybean Characteristics for 52 Different Varieties

	Protein, %	Oil, %	Yield, bu/a	EPV, \$/bu	Revenue, \$/a
Protein, %	1.0000				
Oil, %	-0.2034	1.0000			
Yield, bu/a	0.0367	-0.3997	1.0000		
EPV, \$/bu	0.8423	0.3268	-0.1853	1.0000	
Revenue, \$/a	0.2684	-0.3210	0.9636	0.0830	1.0000

The results shown are specific to the data analyzed. In this case, protein content was the limiting factor in producing 48 percent protein meal. Thus, the varieties with the highest protein percentage had a higher EPV. A point is reached where there is no incentive to increase the protein content of soybeans due to the lack of premium for protein levels in meal above 48 percent, as shown by Brumm and Hurburgh. Also, given higher levels of protein content than occurred in our data, the relative prices of oil and meal dictate whether an increase in oil or protein percentage will lead to a larger EPV. Figure 8 shows the ratio of oil and meal prices from 1991 to 2000. The spikes on the graph in 1995 and 1999 correspond to the same time periods in Figure 7 when the high oil soybean varieties have similar EPVs to the high protein varieties.

## Summary

New uses are being found for soybeans. Many of these uses involve substituting ingredients made from soybeans for those made from petroleum by-products. However, cost effective methods of manufacturing these soybean-based ingredients so they become a low-cost substitute relative to petroleum-based products may take several years.

Two key soybean ingredients are oil and protein. These two ingredients have different values and are related to yield in different ways. In data analyzed here, soybean oil percentage was negatively related to yield, whereas there was almost no relationship between protein (i.e., meal) and yield. Using data from a Kansas State University irrigated soybean trial in Thomas County, we found significant differences in end user value among 52 varieties. While yield remains an important consideration for producers, if the use of value-based marketing programs, such as that being used for soybean oil increases, producers may seek to focus more closely on the trade-off between oil and yield.

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