SOYBEAN MEAL INFO center FACT SHEET

SOYBEANS | PROCESSING

Soybean Processing

Dr. Lawrence Johnson, Crops Utilization Center, Iowa State University

Dr. Keith Smith, Keith Smith and Associates

UNITED SOYBEAN BOARD™

Soybean Processing

Soybeans are a relatively new crop in the United States; first commercially grown in the 1920s as a forage crop and for "green manure" fertilizer, and then as a source of vegetable oil for food and protein for livestock feeding. In the 1950s and 1960s, soybeans were referred to as "The Cinderella Crop," and later in the 1970s and 1980s as"The Gold that Grows." Soybeans are extremely important to the U.S. farm economy, valued at about $15 billion dollars, annually. Soybeans have changed U.S. agriculture in many ways.

Soybeans have value due to their high quality oil and protein.

Historically, soy protein products account for about two-thirds of the value of soybeans with the balance coming from the oil fraction. For this reason, many refer to soybeans as a protein crop as opposed to an oil crop. The protein fraction of soybeans finds its way into soybean meal as a livestock feed ingredient, as soy protein ingredients for the food industry and for industrial uses (paper coatings, adhesives, etc.).

Soybean oil has found many food uses due to its excellent nutritional qualities, widespread availability, economic value and wide-use functionality. Soybean oil is also an important ingredient for industrial products such as paints, plastics, lubricants and biofuels. Other byproducts of soybean processing include soybean hulls — mainly used in animal feeds and as a source of soy fiber, and soy lecithin phospholipids — a nutritional supplement and functional emulsifying food ingredient.

Researchers at Iowa State University developed a computer program that estimates the process value of soybeans based on their composition and current prices of soybean meal and oil. This program demonstrates the direct relationship between the composition of the soybean and the valueof the products that can be produced. The program also documents the added pounds of product and the value of soybeans containing higher amounts of oil and protein. In general, the processor will obtain from each bushel of soybeans (60 pounds) about 10.5 pounds of oil and 48 pounds of meal, and the remainder is shrinkage and moisture loss.

Soybean Processing

Soybean Processing Description

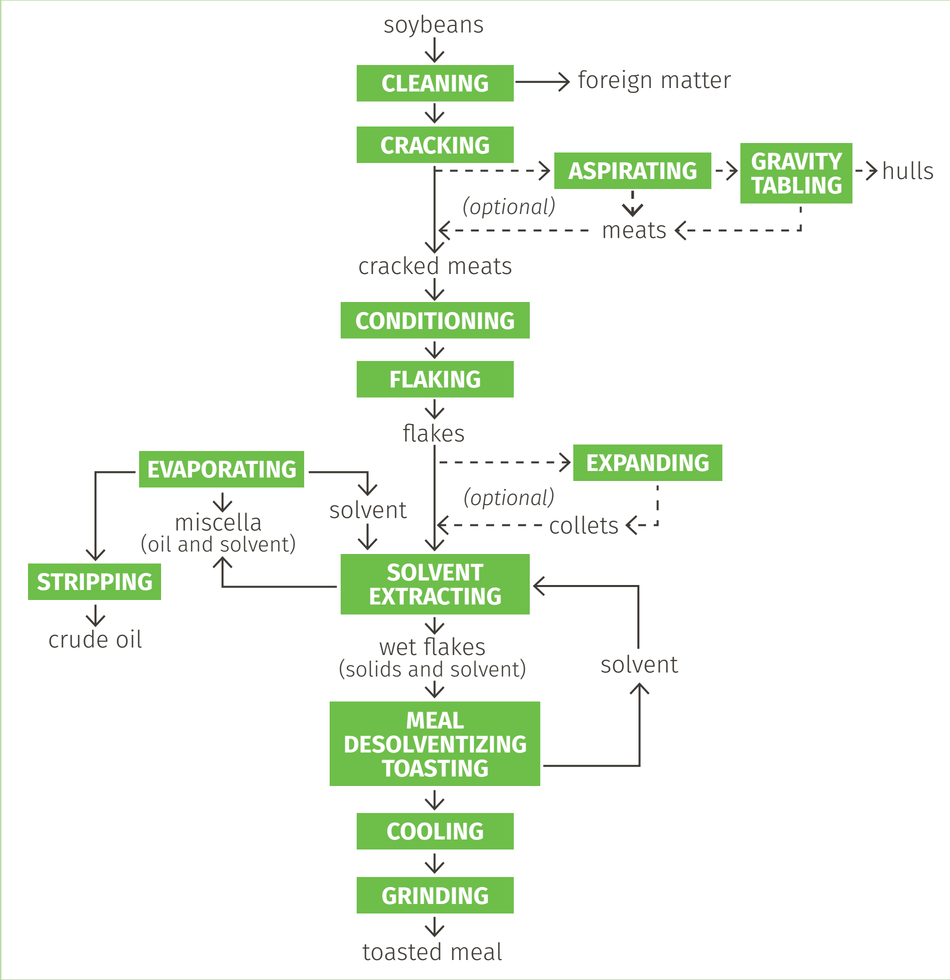
In the 1930s, soybeans were mechanically processed using hydraulic or screw presses (often known in the industry as expellers), which squeezed out the oil of the heated or cooked soybeans. In the late 1940s and early 1950s, most of the industry converted to the solvent-extraction process, which removes more oil from the soybean. Today, more than 99 percent of the U.S. processing capacity is using the solvent extraction process. U.S. soybean meal is produced in large crushing facilities that produce meals of consistent high quality. Several of these plants process more than 3,000 tons per day.

The solvent extraction process is shown in Figure 1. The first step in the solvent-extraction process involves cleaning the soybeans to remove the foreign material and drying the soybeans to approxmately 9.5 percent moisture. The beans are tempered where the moisture content is allowed to equilibrate to loosen the hull, which improves dehulling. The beans are cracked into 8 to 16 pieces by passing them through corrugated rolls of rollermills. A consistent bean size is important to assure that the small beans will be cracked properly.

The soybean hulls, which account for about 8 percent of the soybean, are removed by aspiration. The dehulled soybeans are known as meats. Often, the hull fractions from the aspirators are passed over a gravity table to salvage small pieces of meats that are aspirated along with the hulls. There are several advantages for removing the hull: less total volume to process, which means greater extraction output per day and improved protein content of the meal.

The cracked soybean meats are heated to about 165°F to soften them prior to flaking.

Figure 1 | ***Solvent Extraction***



If the soybean meats are not properly cracked and conditioned, the flaking may not achieve the desired cell rupture or distortion necessary for efficient extraction and/or produce excessive fine material that interferes with efficient extraction. Highly distorted cells extract more easily. The heated and cracked meats are passed through a roller mill equipped with smooth surfaced rolls to produce flakes about 10-12 thousandths of an inch in thickness.

The flakes are then conveyed either directly to the extractor or alternatively to an expander. In recent years, the industry has adopted a practice first used in Brazil, where soybean flakes are passed though an extruder-like device known as an expander. Expanders produce a porous pellet with increased cell rupture and greater density. The advantages of using expander equipment are the ease of extracting oil from flakes, the solvent drains more completely, thus reducing the amount of solvent that must be evaporated from the meal, and the through-put capacity of the extractor is increased. Plants vary in the amount of flakes being expanded from one-third to all flakes produced. Some plants have problems with excessive solvent drainage and reduced extraction when expanding more than one-third of the flake stream.

There are several different types of extractors (chain and basket types), but they all operate in a similar manner, involving percolation of the solvent through a bed of flakes and/or expanded material. The flakes are washed in a countercurrent manner with hexane, a petroleum distillate. This solvent solubilizes the soybean lipid material, and through a series of steps, the hexane-oil mixture is separated. The oil-rich extract called miscella is evaporated and the solvent is recycled to the extractor.

The soybean flakes, with the oil removed, are called "spent flakes." From the extractor, the spent flakes are conveyed to a desolventizer-toaster for removing undrained hexane. The process involves heating the spent flakes to evaporate the hexane and sparging steam to carry away hexane vapors.

Soybean Processing

This process also provides for toasting of the meal to inactivate enzymes like urease and trypsin inhibitors that may reduce the digestibility and nutritional value of the meal.

From the desolventizer-toaster, the meal will go to a dryer-cooler where the meal is dried to about 13-14 percent moisture and cooled for safe storage. The meal is then screened and ground with a hammer mill to produce a uniform particle size prior to shipment to the end user.

The finished meal from dehulled soybeans will contain less than 1.5 percent crude fat and about 48 percent protein, and is referred to as high protein meal. In some soybean processing operations, soybean hulls, or soybean mill-run, are added back to the meal to adjust the protein levels of the meal prior to grinding. This allows the soybean processor to produce soybean meals that meet the end-user specifications for protein and fiber.

Soybean meal can also be produced by mechanically extracting the oil from soybeans (Figure 2). The screw-press process involves heating whole soybeans and the oil is mechanically squeezed out of the beans. The heat generated by friction of the screw presses destroys the anti-nutritional factors in raw soybeans. These specialized meals have higher levels of residual oil (energy), lower protein contents, greater rumen bypass values and are more palatable than other oilseed meals. These meals find great use in dairy rations to balance the amino acids supplied by alfalfa forage, or corn-based byproducts.

Recently a third process, known as extruding-expelling, has been developed in which a dry extruder replaces other steam-heating devices ahead of the screw presses and eliminates the need for generating steam (Figure 3). These plants are relatively small, typically processing 5 to 25 tons of soybeans per day. Approximately 70 extruding-expelling plants have been built for soybeans in the United States. Usually they are farmer owned and provide meal to nearby livestock feeders. These plants are also ideally suited for identity-preserved processing and for marketing certified organic or non-genetically modified products or, in some cases, soybean meals and oils with specific traditional breeding or genetic engineering. The characteristics of extruded-expelled meal are substantially similar to screw-pressed meal.

Figure 2 | *Screw Pressing*

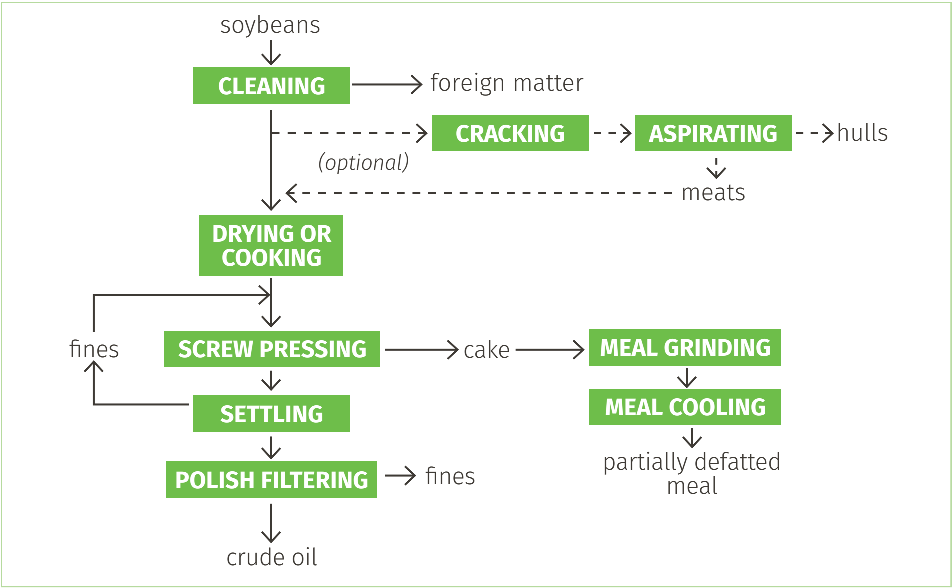
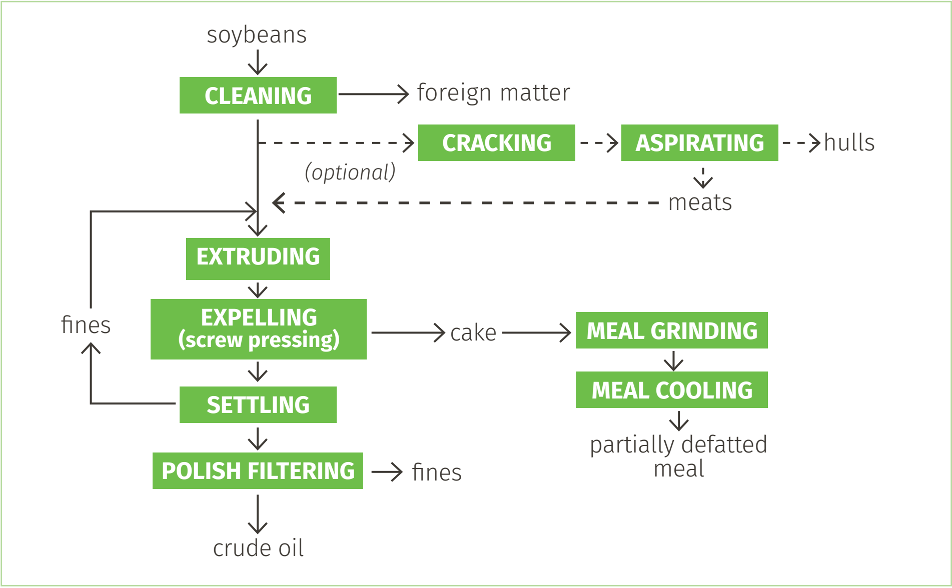


Figure 3 | *Extruding/Expelling Process*



Composition of Soybean Products

Soybean meal is a concentrated source of protein and energy, and is lower in fiber than most other oilseed meals available to the feed manufacturer. The higher protein, energy and lower fiber content of soybean meal allow nutritionists to formulate higher-energy diets that are more efficient in the conversion of feed to meat. The table on page 5 provides the typical compositions of several soybean products that are available to the feed manufacturer.

Over the years, the soybean processor has developed processes that produce soybean meals of consistent quality. The heat generated during processing and/or desolventizing/toasting assures the protease inhibitors present in raw soybeans are denatured, and the digestibilities of the protein are maximized. Soybean meal can be included in animal diets at relatively high levels without affecting performance.

Soybean Processing

Soybean Meal Quality Assays

Even though soybean meal is one of the most consistent and high-quality protein sources available to the professional nutritionists, several animal and laboratory assays have been developed to monitor the quality of soybean meal. In recent years, several research groups have used the illeal-cannulated pig assay and/or the precision-fed cecectomized rooster assay to determine the digestibility of the protein in soybean meal. These methods use surgically modified animals to reduce the effects of intestinal microflora on amino acid excretion. The methods are known to detect differences in protein quality and amino acid digestibility between protein sources and meals processed using different heat treatments.

There are numerous references in the literature showing the digestibilities of the amino acids in soybean meal are near 90 percent and significantly greater than other oilseed protein sources available to the feed formulator. Using these assays to formulate diets on the basis of available amino acids can more accurately target the species' amino acid requirements, reduce feed levels of supplemental protein and reduce nitrogen in animal waste.

The nutritionists have long sought a rapid chemical assay that could relate to protein quality. Simple crude protein or amino acid assays provide information on the protein, but do not provide useful information on the quality of the protein. Chemists have used trypsin inhibitor analyses, urease activity, protein solubility in potassium hydroxide, protein solubility in water and dye binding methods to assay for protein quality (heat damage). While urease activity has merit in detecting under heating of the meal and KOH protein solubility is related to over processing; the search goes on for a simple, quick, cheap and accurate method of measuring protein quality.

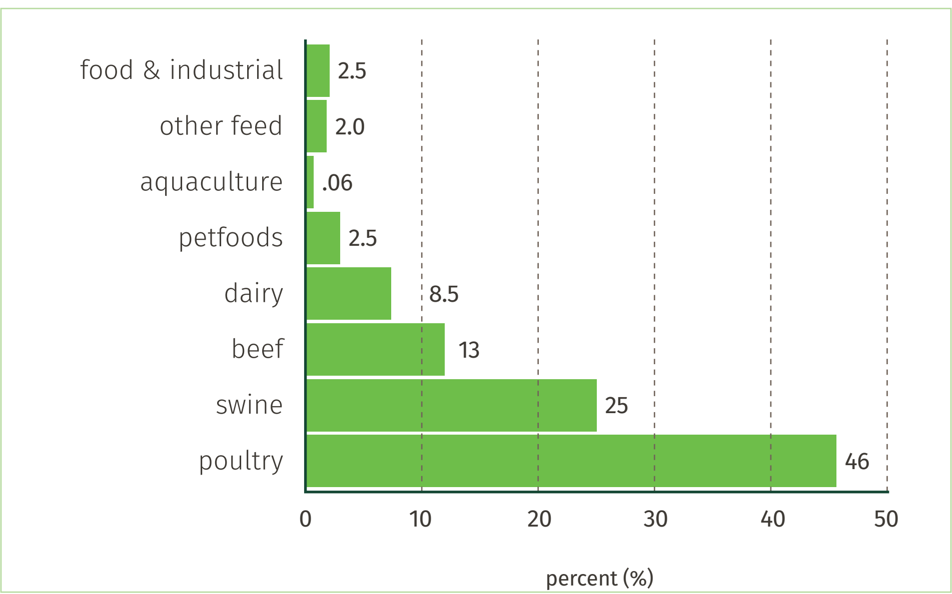
The variation in compositional values for soybean meal is small: some variation is seen between processing plants, and the greatest variation is between soybean processors located in various countries. Monitoring quality and modifying the feed formulation accordingly reduces concern over minor variation. Studies have shown that soybean meal is one of the most consistent protein ingredients available to the feed formulator.

Soybean Meal Use

The United Soybean Board has estimated that about 46 percent of the soybean meal produced in the United States is used by broilers, layers and turkeys (Figure 4). Swine uses another 25 percent of soybean meal production. Ruminants, beef cattle, dairy and sheep account for about 21 percent and the remaining 8 percent finds its way into a large variety of uses (petfoods, aquaculture, minor feed uses, food and industrial uses). The combination of price and nutrient characteristics favor soybean meal use by swine and poultry. The highly digestible protein in soybean meal provides high levels of available amino acids that can complement amino acids in cereal grain for least-cost rations for swine and poultry. It has often been stated that efficient swine and poultry rations are dependent on soybean meal and cereal grain.

In ruminant rations, soybean meal has long been competitive with other protein ingredients, while soybean growers see great growth in the use of soybean meal in aquaculture. Soybean meal is replacing fishmeal in aquaculture feeds due to price, wide availability and nutritional properties.

Figure 4 | ***Soybean Use** (2002/03)*



Soybean Processing

Table 1 | **Composition of Soybean Feed Ingredient Products**

		SOYBEAN MEAL SOLVENT	DEHULLED-SOLVENT	EXPELLER	SOYBEANS FULL-FAT	SOYBEAN HULLS	SOYBEAN MILLRUN
PROXIMATE ANALYSES							
Dry Matter	%	90	88	89	90	91.0	88.0
Crude Protein	%	44	47.8	42	38	12.1	13.6
Ether Extract	%	0.5	1.0	3.5	18	2.1	1.4
Crude Fiber	%	7	3	6.5	5	40.1	40.7
Ash	%	6	6	6	4.6	5.1	5.1
RUMINANT VALUES							
Ruminant Dig. Protein	%	37.5	46.6	35.5	34.1		
Ruminant TDN	%	78	79	78	85	77	44
ENERGY VALUES							
Poultry ME	Kcal/lb Kcal/lb	1020 1405	1125 1425	1100 1360	1520 1610		
AMINO ACIDS							
Methionine	%	0.65	0.7	0.6	0.54		
Cystine	%	0.67	0.71	0.62	0.55		
Lysine	%	2.9	3.02	2.7	2.4		
Tryptophan	%	0.6	0.7	0.58	0.52		
Threonine	%	1.7	2.0	1.7	1.69		
Isoluecine	%	2.5	2.6	2.8	2.18		
Histidine	%	1.1	1.3	1.1	1.01		
Valine	%	2.4	2.7	2.2	2.02		
Leucine	%	3.4	3.8	3.8	2.8		
Arginine	%	3.4	3.6	3.2	2.8		
Phenylalanine	%	2.2	2.7	2.1	2.1		
MINERALS							
Calcium	%	0.25	0.20	0.20	0.3	0.69	0.42
Total Phosphorus	%	0.60	0.65	0.60	0.6	0.21	0.21
Available Phosphorus	%	0.20	0.21	0.20	0.2		
Sodium	%	0.04	0.04	0.04	0.04		
Potassium	%	1.97	1.90	1.71	1.70	1.27	
Chloride	%	0.02	0.02	0.02	0.03		
Magnesium	%	0.27	0.27	0.25	0.21		
Sulfur	%	0.43	0.43	0.33	0.30		
Manganese	ppm	27.5	27.5	32.3	30.0		
Iron	ppm	120	120	160	75		
Copper	ppm	28	28	18	15		
Zinc	ppm	60	60	59	35		
Selenium	ppm	0.1	0.1	0.1	0.1		

Reference: Feedstuffs, 75(38):16 (September 17, 2003).

Soybean Processing

Summary

Soybeans have greatly changed U.S. agriculture.

The soybean processing industry has grown over the years and is producing a high-quality protein ingredient that has the respect of professional nutritionists. Probably no other feed ingredient has been tested so thoroughly over the past 75 years as soybean meal. Soybean-based diets set the performance standards to evaluate other protein ingredients and to establish prices for alternative protein ingredients.

For more information, please contact:

Dr. Lawrence Johnson

Crops Utilization Research Center
Iowa State University
Ames, IA 50010

Dr. Keith Smith

Keith Smith and Associates
15 Winchester Road
Farmington, MO 63640