COOKED SOYBEANS FOR FEED

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Cooked whole soybeans, a feed ingredient useable in making mixed feeds, has recently been developed through research and practical experience of private industry, several State Agricultural Experiment Stations, and the U. S. Department of Agriculture. This product is also identified as heat-processed soybeans; toasted soybeans; cooked, full-fat soybeans; and cooked, unextracted soybean meal.

Information in this report is based on market research on the relative costs and feasibility of using soybeans in this way and on fat-in-feed usage among livestock producers. 1/ 2/

Many farmers in the late 1930's and during World War II used raw soybeans as a grain-type feed for livestock. Small amounts of raw soybeans are still fed although their use in raw form is not nutritionally desirable, according to research studies.

Use of whole, cooked soybeans for livestock feeds could be advantageous to farmers and feed mixers, following developments of recent years. Research has shown that cooking greatly enhances the nutritional value of soybeans by detoxifying the enzymes hindering digestion of the raw product. In addition, the economic situation of fats and oils has changed. These products are no longer in short supply and oil prices have generally declined in recent years except for the upturn this current year.

How Cooked Soybeans Are Fed

Soybean meal and soybean oil have high protein and energy values. Feeding of soybean meal and fat or oil to livestock has increased in recent years. Cooked, unextracted soybeans contain both meal and oil.

In a feeding ration, ingredients are used to make a composite product. Protein, fat, nitrogen-free extract, fiber, minerals, and vitamins are essential factors in a ration. Modern, high efficiency rations, developed through nutritional research and most widely used in the broiler industry, are high-protein, high-energy feeds. To formulate these feeds, protein concentrates (such as soybean meal) and added fats (usually tallow) are used. Soybeans converted to a feed ingredient by cooking, without removal of the oil, produces a single granular ingredient rich in protein and oil.

1/ Poats, F. J., Doty, Jr., H. O., and Eley, C. P., Cooked, Unextracted Soybean Meal, Its Economic Feasibility in Poultry Feeds (Preliminary Report). U. S. Department of Agriculture, Economic Research Service, ERS-32, October 1961.

2/ Doty, Harry O. Jr., Fats Added to Feeds--An Economic Analysis, U. S. Department of Agriculture, Economic Research Service, Mktg. Res. Rpt. 498, Sept. 1961.

Nutritional research and experience with poultry, swine, beef cattle, calf, sheep, and pet feeds show added fat in formula feeds improves the feed's efficiency. However, high level use of soybean oil in swine feed causes "soft pork." Broiler feeds formulated with added feed-grade fat are now a standard practice. Experimentally, broiler feeds containing over 30 percent added fat have been successfully fed. Up to 10 percent added fat has been used by large commercial feed manufacturers in high-energy, high-protein broiler feeds. Most present day broiler feeds contain 2-4 percent added fat.

The merit of using cooked soybeans in mixed feeds has been proved. Extensive testing was carried out in poultry and hog feeds. Cooked soybeans are also suitable for use in making all mixed feeds now containing added fat. In formulating such rations, soybeans contain an average of 38 percent protein (based on chemical analysis) and have an average oil crushing yield of 18.3 percent.

Feed formulas can be adjusted to desired levels of fat or protein when cooked, unextracted soybeans are used. In most high-energy (added fat) content mixed feeds, oil in cooked soybeans can supply all the added energy necessary. For additional protein in a formula feed than provided by cooked soybeans, solvent-extracted soybean meal or other low-fat content protein concentrates may be added.

Why Cooked Soybeans Can Be Economical

Heat treatment of soybeans at local plants in soybean-growing areas is a new way to obtain cooked, full-fat soybeans for livestock feeds at a low cost. Availability of local facilities could reduce transportation, storage, and handling costs that farmers and feed mixers now incur in obtaining their protein and fat requirements. Depending upon location, oil mills now processing soybeans into meal and oil could also become economical cooked, full-fat soybean product sources.

Farmers' soybeans go to oilseed processors who extract the oil and sell the meal for livestock feed uses. At present, meal is the more valued component on a total weight basis. In recent years, livestock farmers have been unable to purchase soybean meal in some locations, and at times local soybean meal prices have increased sharply above those at Decatur, Ill., the price-basing point for soybean products.

Many soybean-growing areas are also livestock and poultry feeding areas. The protein in cooked soybeans can replace an equal amount of protein from soybean meal. Cooking soybeans could solve local soybean meal shortages that do occur.

Soybean oil, an edible oil, normally sells at about double the price of feed-grade tallow. Nutrition research shows that soybean oil provides about 29 percent more energy than tallow in broiler feeds. Feed-grade tallow has 3230 calories per pound compared to 4172 calories for soybean oil. 1/

1/ Renner, Ruth and Hill, F. W., "Metabolizable Energy Value of Fats and Fatty Acids for Chickens." Feedstuffs, Vol. 30 (46), Nov. 15, 1958, p. 15. "Studies of the Effect of Heat Treatment on the Metabolizable Energy Value of Soybeans and Extracted Soybean Flakes for the Chick." The Journal of Nutritions, Vol. 70 (2), Feb. 1960, p. 222.

Therefore, soybean oil, at 8.0 cents per pound, equals feed-grade tallow, at 6.2 cents per pound, to the feed mixer. Or, to put it another way, the greater energy value of soybean oil makes it worth almost 2 cents a pound more than feed-grade tallow at these prices. Price spreads between crude soybean oil and feed-grade tallow have, in recent years, ranged from 2 to 5 cents a pound.

Price of soybean meal used by feed mixers varies widely throughout the United States. Usually, freight charges on soybean meal are from the Decatur, Ill., price-basing point to the local feeding area, and account for most of this price variation. So, if cooked soybeans were processed in local soybean-producing, livestock-feeding areas, most of the transportation costs associated with obtaining soybean meal would be eliminated. This can be a big factor in favor of cooking soybeans in local growing areas for local livestock feeding. Freight charges of $8 per ton and more are not uncommon.

Special storage, heating, pumping, handling, and mixing equipment is needed to add fat to feeds. Fat retained in a feed ingredient (such as cooked soybeans) that is handled like a dry ingredient, eliminates the need for equipment and costs associated with adding fats to feeds.

Other advantages for locating cooked soybean product facilities in soybean-producing, livestock-feeding areas are: Savings on transportation charges for fat; buying of soybeans at local farmers' prices with little or no delivery charge to the cooking facility; higher nutritive value of the protein from properly cooked soybeans as compared to soybean meal; lack of a solvent residue normally contained in the feed material; and the growth-stimulating properties of soybean oil.

How To Determine Whether Cooked Soybeans Are Economical In Local Areas

The cost of preparing cooked soybeans in a particular location depends on the price received by farmers for soybeans plus cost of cooking. A comparison of these costs with the cost of an equivalent amount of protein and energy from 44 percent soybean meal and feed-grade tallow (present ingredients used in mixed feeds) at local delivered prices, indicates the relative economics of use of the alternative sources of these ingredients. The advantage or disadvantage of substitution may be computed by substituting applicable local area figures for the unknowns in the following equation:

$$A = (0.8636 \cdot Y) + (W \cdot 1.292) \cdot (Z) - (S + \$5.00)$$

A is the cost advantage or disadvantage for making cooked soybeans. Y is the local price per ton to farmers for 44 percent soybean meal. W is the percentage of oil in local soybeans, minus 0.5 percent times 2,000 pounds, 1/ or the soybean crushing yield of oil per ton. Z is the local cost per pound for feed-grade fat and S is the price per ton received by farmers for soybeans. The 0.8636 constant factor is the relative protein content of whole soybeans

1/ Percentage of oil in local soybeans is reduced by 0.5 percent to compensate for oil left in solvent-extracted soybean meal since only the extractable oil is subject to substitution.

(38 percent) to soybean meal (44 percent). The 1.292 constant is the relative energy value of soybean oil (4172 calories) to feed-grade tallow (3230 calories), and the $5.00 constant is the estimated cost of processing a ton of cooked, whole soybeans. 1/ The application of this formula in table 1 shows the economic advantage that would have occurred from using cooked soybeans under conditions that existed in some areas of the United States for the 1963-64 marketing year (September-August).

The Arkansas situation (see table 1) is computed for 1963-64 by using the equation in this way:

$A = (0.8636 \cdot Y) + (W \cdot 1.292) \cdot (Z) - (S + \$5.00)$

Substitute values for Y, Z, and S from table 1. In calculating W, the U. S. average soybean crushing yield of 18.3 percent oil was used.

$A = (0.8636 \cdot \$90.80) + (18.3\% \cdot 2000) \cdot (1.292) \cdot (\$0.058) - (\$2.53 \cdot 33.333 + \$5.00)$

$A = \$78.41 + (366) \cdot (1.292) \cdot (\$0.058) - (\$84.33 + \$5.00)$

$A = \$78.41 + (473) \cdot (\$0.058) - \$89.33$

$A = \$78.41 + \$27.43 - \$89.33$

$A = \$105.84 - \$89.33$

$A = \$16.51$

For 1963-64, the estimated average economic advantage in Arkansas of using cooked soybeans as compared to using 44 percent soybean meal and inedible tallow in mixed feeds (equivalent feed value basis) was $16.51 per ton.

Wherever prices farmers received for soybeans have been less than the cost of 44 percent soybean meal to farmers, the conversion of soybeans to a whole-cooked feed product has shown an advantageous margin above processing costs.

Commercial Equipment for Cooking Soybeans

Many existing soybean processors can make a cooked or toasted full-fat soybean meal using present equipment. Equipment specially designed or adapted for the new-type processing is becoming commercially available. Three types of cooking equipment using different ways of processing are available. These are the infra-red cooker, the expander-extruder cooker, and the high-pressure steam cooker.

1/ Based on highest estimate supplied by equipment manufacturers.

Table 1 .--Estimated economic advantage of using cooked soybeans as compared to using 44 percent soybean meal and feed-grade fat in mixed feeds (equivalent feed value basis) in various locations, 1963-64 crop year

Locality	Soybean meal plus inedible tallow			Cooked soybeans				Estimated advantage favoring cooked soybeans
	Prices paid by farmers for 44% soybean meal 1/	Prices paid for feed-grade fat 2/	Total cost 3/	Prices received by farmers for soybeans 1/	Cost of cooking 4/	Total cost		
	Ton 1,727 lbs. 5/	Cents per lb.	473 lbs. 5/		Bu.	Ton	Ton	Ton	Ton
Arkansas:	$90.80	$0.058			$2.53				
	$78.41		$27.43			$84.33	$5.00		
				$105.84				$89.33	$16.51
Delmarva: 6/	103.40	0.058			2.50				
	89.30		27.43			83.33	5.00		
				116.73				88.33	28.40
Georgia:	97.20	0.058			2.54				
	83.93		27.43			84.67	5.00		
				111.37				89.67	21.70
Ohio:	102.40	0.058			2.52				
	88.42		27.43			84.00	5.00		
				115.86				89.00	26.86

1/ Season average price, Sept. 1963-Aug. 1964. Price of 44 percent soybean meal is based on average of mid month prices per 100 pounds, Agricultural Prices, SRS-USDA.

2/ Average price of tallow, inedible, packers' prime, tank cars, C.A.F. Chicago, Ill., Sept., 1963-Aug. 1964, Fats and Oils Situation, ERS-USDA

3/ Does not include costs associated with adding fats to mixed feeds.

4/ Based on highest estimate furnished by equipment manufacturers. It includes labor, fuel, power requirements, amortization of equipment, maintenance, taxes and insurance.

5/ To equal the nutritional value of one ton of cooked soybeans it takes 1,727 pounds of 44% protein soybean meal and 473 pounds of tallow. These figures are based on soybeans containing 38% protein and having an average crushing yield of 18.3% oil. Total oil content of soybeans is not used because only oil which can be extracted is subject to substitution. In this fat substitution, 4172 calories per pound was used for soybean oil and 3230 calories per pound was used for tallow.

6/ Average of Delaware and Maryland.

The method used and the size of plant affects the cost of cooking soybeans. The estimated cost of cooking soybeans by the infra-red method in a 1-ton-per-hour plant is $5.00 per ton. 1/ Cost of cooking soybeans by the expander-extruder method in a 4-ton-per-hour plant is also estimated at about $5.00 per ton. 1/ 2/ Cooking soybeans by the high-pressure steam method in a 10-ton-per-hour plant is estimated at less than $1.00 per ton. 1/ These figures include labor, fuel, power, amortization, maintenance, taxes, and insurance. Storage of soybeans and delivery of cooked soybeans to feed mixers would be added costs.

Whole or dehulled soybeans can be handled in each type of equipment. Dehulling makes possible the production of a cooked soybean product having a higher protein content than the average 38 percent found in whole soybeans.

Cooked soybean products can be stored for a long period. Infra-red cooked soybeans can be stored in the hull. Since oil cells are not ruptured, the product may be stored indefinitely. Storage tests run on the expander-extruder processed soybean product show it to be stable. It probably can be stored up to 1 year. Soybeans contain large quantities of lecithin, a natural preservative that makes longer periods of storage of processed fat products possible.

Infra-Red Cooker

Inconel screens, heated by burning LP or natural gas, radiate infra-red rays that cook soybeans by internal heat. Soybeans are dropped past the heat source from a rotating perforated cylinder. Infra-red rays cook the soybeans as they fall. Cooked soybeans are removed from the bottom by a gravity feed and then allowed to dissipate their heat. The cooking time for soybeans is about 6 to 8 minutes. After cooking and cooling, soybeans are ready for storage, grinding through a hammer mill, and use as a feed ingredient. The capacity of this equipment is approximately 1 ton per hour.

Expander-Extruder Cooker

Steam plus compression provide the heat necessary to cook soybeans in this process. Ground and heat-conditioned soybeans are fed into a unit consisting of a screw housed in a steam-jacketed barrel and designed to extrude material through a restricted die opening at one end. Subjecting the feed material to pressures and temperatures about equal to those of atmospheric steam amounts to a pressure-cooking system. The screw forces the soybean material out a narrow diehead opening. As the material emerges through the opening, a fast reduction in pressure takes place. The material expands rapidly and ruptures most of the oil cells. With soybeans, the emerging extruded product

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1/ Based on estimate supplied by equipment manufacturer.

2/ Based on preliminary studies made at the U. S. Department of Agriculture, Northern Utilization Research and Development Division Laboratory for a 4-ton per-hour expander-extruder plant.

quickly reabsorbs the freed oil. The material runs through a dryer-cooler, then, where desired, passes over crumble rolls to reduce agglomerates. A cooked soybean product made this way requires about 3 to 4 minutes in the cooker. Capacities of present expander-extruder equipment range from ½ to 4 tons per hour with several sizes available. These capacities are for producing a soybean product having optimum biological feed value.

High Pressure Steam Cooker

A continuous high-pressure steam cooker can be used for converting whole soybeans to a feed ingredient. Ground or whole soybeans are fed into a steam pressure vessel and are moved through it by a screw conveyor or by mechanical agitation. The product is cooked in high-pressure steam for a short time. After cooking the product should be cooled, flaked, and dried from 18-20 percent moisture to 12 percent before use or storage. Some expansion of the soybean material takes place, and some rupture of starch and fat cells occurs. Some high-pressure steam processing equipment, with slight modification, can also do animal byproduct rendering. If a rendering plant is also wanted in the local area, it may serve both needs. The capacity of equipment ranges from 6 to 20 tons per hour.

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