JULY 2002

SOYBEAN MEAL
INFO source

PUBLISHED BY SOYBEAN GROWERS FOR THE FEED INDUSTRY

SPECIAL PORK EDITION

Soybean Meal in Swine Nutrition

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Early History of Soybean Meal Use in Swine Diets

Soybean meal is the most popular source of supplemental protein in livestock feeds (Table 1). That popularity derives from its nutrient content, its relative freedom from intractable antinutritional factors, and other issues.

In the 1920s and 1930s, an "animal protein factor" found in liver extracts and other concentrates of animal origin was known to stimulate the growth of farm animals, although its chemical nature was literally unknown. In 1948, a crystalline material similar to the animal protein factor was isolated from liver and named vitamin B-12. Previous to this elucidation, the primary sources of vitamin B-12 in swine diets were animal products or meals. The discovery of the chemical structure of vitamin B-12 allowed for its manufacture on a commercial basis. Animal products were no longer required in the diet, as vitamin B-12 could be supplemented along with other vitamins. The ability to manufacture vitamin B-12 has allowed for soybean meal to be the preferred source of protein in swine diets.

Shortly after vitamin B-12 became commercially available, Dr. D. E. Becker of the University of Illinois demonstrated that an adequate swine diet could be prepared by blending corn and soybean meal with a few pounds of minerals and vitamins. The formulation of this basic diet had an enormous impact on swine feeding in the Midwest. Simple, rather than complex diets, were now an option for swine producers. Soybean meal and corn could serve as the basis for swine diets, thereby eliminating the need for expensive supplements. In addition, Becker conducted research in the protein and amino acid nutrition area that influenced the National Research Council's publication "Nutrient Requirements of Swine." From this research, he concluded that corn-soybean meal-based diets provide an adequate balance of amino acids.

Simple diets have become the popular choice for on-farm mixing of swine feeds in the United States and many other parts of the world. These diets typically are based on corn and soybean meal, fortified with supplemental minerals and vitamins. The simplicity of these diets eliminates the cost and time associated with purchasing, storing and handling several high-protein feed ingredients.

Table 1. World Protein Meal Consumption*

Protein Source	Million Metric Tons	Percent
Soybean meal	114.9	67
Cottonseed meal	11.2	6
Rapeseed meal	21.4	12
Sunflower meal	9.6	5
Copra meal	1.8	1
Palm kernel meal	3.6	2
Peanut meal	5.4	3
Fish meal	6.1	4
TOTAL	**173.9**	**100**

** Soy Stats (2001)*

Nutritive Value of Soybean Meal

Soybean meal has a very good nutrient composition that enables it to be the preferred source of protein in swine diets. It is quite high in protein compared to other protein sources used in swine feed (Table 2). Some ingredients of animal origin have higher protein content than soybean meal, but these ingredients have other characteristics that limit their use in swine diets. Conventional soybean meal is lower in crude protein than dehulled soybean meal because soy hulls are used to standardize the protein content to 44 percent. The percentage of protein in dehulled soybean meal can range from 47 to 49 percent. Soybean meal also has a considerably higher energy value than most other protein sources (Table 2). Soybean meal contains significant amounts of carbohydrates that are well utilized by swine. The oligosaccharides in soybean meal have not been shown to negatively affect performance when fed in swine diets.

Soybean meal, whether conventional or dehulled, is an excellent source of amino acids for swine. True ileal digestibility coefficients for most amino acids in soybean meal are higher compared to other plant protein sources

(Table 3). Soybean meal is a rich source of lysine (Table 4), the first limiting amino acid in most commercial swine diets. Because lysine is first limiting, the ratio of lysine to total protein is a crude measure of protein quality in feed ingredients. The lysine content of soybean meal is high, and as a percent of total protein is exceeded only in peas, fish, blood and milk proteins (Table 4). This high lysine content enables soybean meal to be a good complement to cereal grains commonly fed to swine. Corn, wheat, barley and grain sorghum are all very deficient in lysine. In addition, soybean meal is an excellent source of tryptophan, threonine and isoleucine, thereby providing sufficient levels of these limiting amino acids in various cereal grain-based diets. The only amino acids limiting in soybean meal are the sulfur amino acids, particularly methionine. As a percentage of total protein, cereal grains are relatively high in sulfur amino acids; therefore, soybean meal is an excellent choice as a protein supplement for cereal grain-based diets.

The use of soybean meal in swine diets allows formulation of diets that contain less total protein compared to other oilseed meals. Soybean meal is very high in lysine. Therefore, the pig's lysine requirement is met without feeding excessive amounts of nonessential nitrogen, thereby reducing the nitrogen load on the environment. Also, the amino acids in soybean meal are highly digestible relative to other protein sources of plant origin (Table 3), increasing the efficiency of amino acid utilization. The quality and composition of soybean meal produced throughout the world is relatively consistent. This is largely attributed to the many technological advances that have been made in soybean processing.

Antinutritional Factors in Soybean Meal

Like most other high-protein plant materials, soybean meal contains antinutritional factors (Table 5). However, these antinutritional factors are heat labile and are removed by heat processing. Antinutritional factors in other plant protein sources – notably gossypol in cottonseed meal, both glucosinolates and erucic acid in rapeseed meal, alkaloids in lupin, and tannins in peas – are not heat labile and must be managed in other ways.

The processing of soybean meal involves a series of heat treatments that include conditioning, rolling, flaking and extraction followed by desolventizing and toasting. Toasting is the process in which soybean meal is cooked at 105 to 110° C for a period of 15 to 30 minutes, and is a critical step in controlling the nutritive quality of soybean meal. Undercooking results in insufficient destruction of protease inhibitors and other antinutritional factors, whereas overcooking decreases amino acid availability. Lysine, in particular, is very heat sensitive.

The industry monitors soybean meal quality by using urease activity to detect underheating and potassium hydroxide (KOH) solubility to detect overheating. The urease assay measures urease activity based on the pH increase caused by ammonia release from the action of the urease enzyme. Destruction of the urease activity is correlated to destruction of trypsin inhibitors and other antinutritional factors. The level of urease activity should not exceed a pH rise of 0.2 units. To measure KOH solubility, soy products are mixed with 0.2 percent KOH, and the amount of nitrogen solubilized is measured. The amount of nitrogen solubilized decreases as heating time increases, indicating decreased amino acid availability. The solubility index should be 80 to 85 percent in commercial soybean meal.

Table 2. Nutrient Composition of Various Protein Sources Used in Swine Diets*

	Dry Matter %	DE kcal/kg	Crude Fat %	Protein %
Plant Protein Sources				
SBM, conventional	89	3490	1.5	43.8
SBM, dehulled	90	3685	3.0	47.5
Cottonseed meal	90	2575	1.5	41.4
Rapeseed meal	90	2885	3.5	35.6
Sunflower meal	93	2840	2.9	42.2
Lupin	89	3450	9.2	34.9
Peas	89	3435	1.2	22.8
DGS**	93	3200	8.4	27.7
Animal Protein Sources				
Milk, dried skim	96	3980	0.9	34.6
Whey, dried	96	3335	0.9	12.1
Fish meal, Menhaden	92	3770	9.4	62.9
Blood meal, spray- or ring-dried	93	3370	1.3	88.8
Meat meal	94	2595	12.0	54.0
Meat and bone meal	93	2225	10.9	51.5

**NRC (1998)*
***Distillers' grain with solubles*

Summary

Soybean meal is the dominant source of supplemental protein in swine diets worldwide, for good reasons. Its amino acids levels are a superb complement to cereal grain proteins in meeting the nutritional needs of pigs. That characteristic allows it to be used as the only supplemental protein source in simple diets that can be prepared conventionally on farms. Soybean meal is also higher in energy than most competing ingredients. Furthermore, its antinutritional factors are easily managed through heating.

Table 3. True Meal Digestibility Coefficients for Amino Acids in Various Plant Protein Sources Used in Swine Diets*

Amino Acid	Soybean Meal	Cottonseed Meal	Rapeseed Meal	Sunflower Meal	Lupin	Peas	DGS**
Lysine	89	64	78	83	79	88	59
Arginine	93	89	85	93	92	90	77
Histidine	90	79	85	85	88	89	61
Isoleucine	88	71	78	84	83	85	73
Leucine	88	73	81	85	83	86	79
Methionine	91	75	86	90	68	84	75
Cystine	84	69	83	81	84	79	60
Phenylalanine	88	81	82	86	85	87	79
Tyrosine	90	78	79	88	85	87	77
Threonine	85	68	76	84	79	83	65
Tryptophan	87	65	75	NA	NA	81	NA
Valine	86	72	77	82	80	83	67

**NRC (1998)*
***Distillers' grain with solubles*

Table 4. Lysine Content of Protein Sources Used in Swine Diets*

	Protein %	Lysine %	Lysine % of Protein	Relative to Soybean Meal
Plant Protein Sources				
SBM, conventional	43.8	2.83	6.4	100
SBM, dehulled	47.5	3.02	6.4	100
Cottonseed meal	41.4	1.72	4.2	65
Rapeseed meal	35.6	2.08	5.8	91
Sunflower meal	42.2	1.20	2.8	44
Lupin	34.9	1.54	4.4	69
Peas	22.8	1.50	6.6	103
DGS**	27.7	0.62	2.2	34
Animal Protein Sources				
Milk, dried skim	34.6	2.86	8.3	129
Whey, dried	12.1	0.90	7.4	116
Fish meal, Menhaden	62.9	4.81	7.6	119
Blood meal, spray- or ring-dried	88.8	7.45	8.4	131
Meat meal	54.0	3.07	5.7	88
Meat and bone meal	51.5	2.51	4.9	76
Cereal Grains				
Corn	8.3	0.26	3.1	49
Barley	11.3	0.41	3.6	56
Wheat, soft	11.5	0.38	3.3	51
Grain sorghum	9.2	0.22	2.4	37
Oats	11.5	0.40	3.5	54

**NRC (1998)*
***Distillers' grain with solubles*

Table 5. Principal Antinutritional Factors (ANF) Present in Different Plant Feedstuffs*

ANF	Soybean Meal	Cottonseed Meal	Rapeseed Meal	Sunflower Meal	Lupin	Peas	DGS*
Alkaloids					+		
Antivitamins	+						
Erucic acid			+				
Glucosinolates			+				
Goitrogens	+						
Gossypol		+					
Lectins	+						
Tannins						+	
Trypsin inhibitors	+					+	

**Distillers' grain with solubles*

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