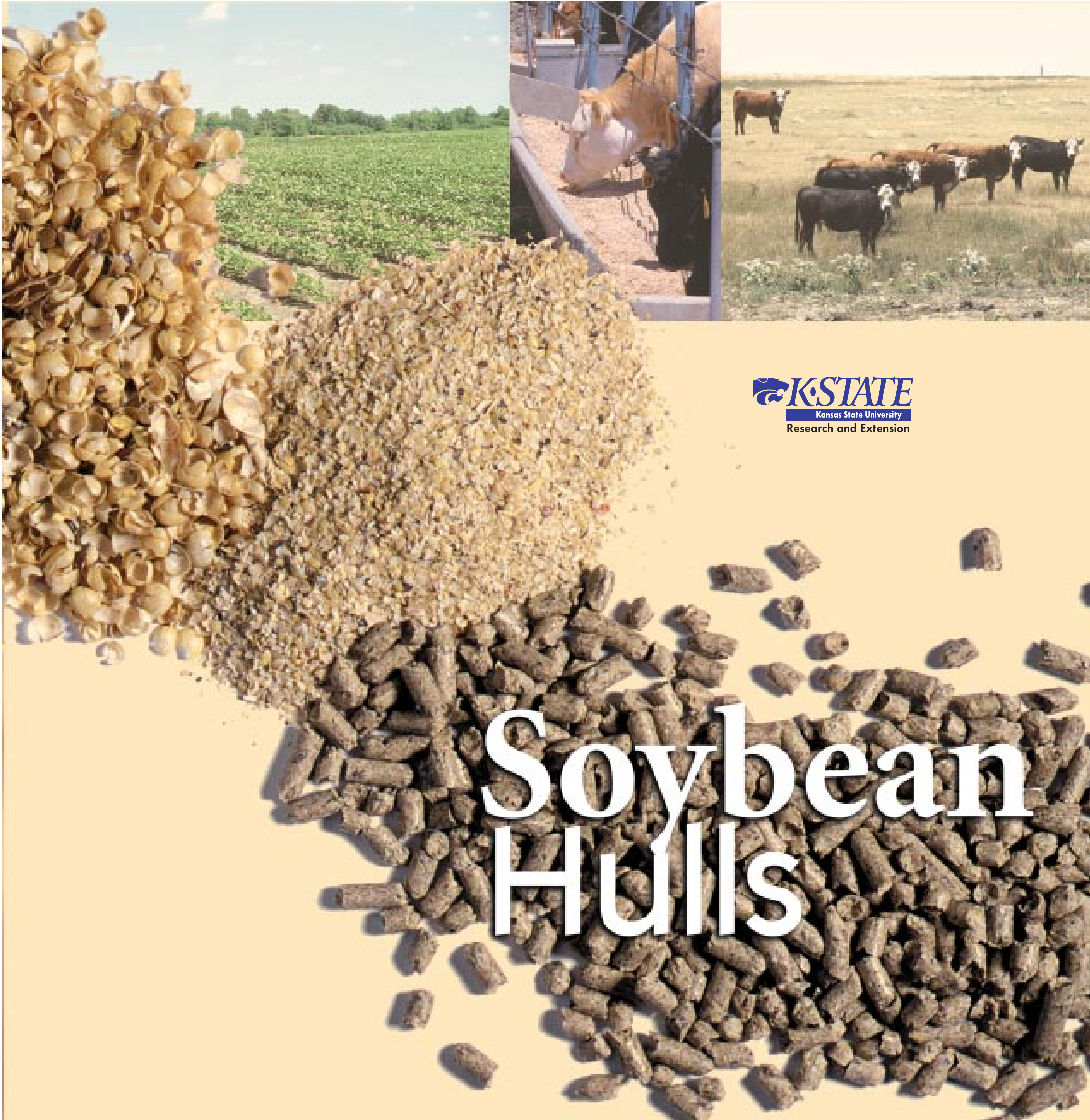

K-STATE
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# Soybean Hulls

## Composition and Feeding Value for Beef and Dairy Cattle

# Introduction

Kansas' stature as a dominant agricultural state is attributed heavily to its ranking as a producer of crops and cattle. Although Kansas often is referred to as the Wheat State, few realize the significant effects of other crops such as soybeans on the state's economy. For example, the approximately $500 million dollars generated annually by the soybean industry in Kansas ranks 10th in the nation. According to USDA estimates, there are more than 14,000 identified soybean farmers in Kansas, and each operator averages 186 acres.

Over the past 5 years alone, Kansas soybean production has increased in terms of both acres planted and bushels harvested. In 1998, soybean acreage increased to 2.55 million acres from 2.40 million acres planted in 1997. As a result, about 4 million additional bushels of soybeans were harvested (29 bushels/acre average yield). K-State agricultural economists predict continued expansion of soybean acreage; more than 2.60 million acres were planted to soybeans in 1999. This acreage increase potentially represents an additional 1.5 million bushels of soybeans harvested.

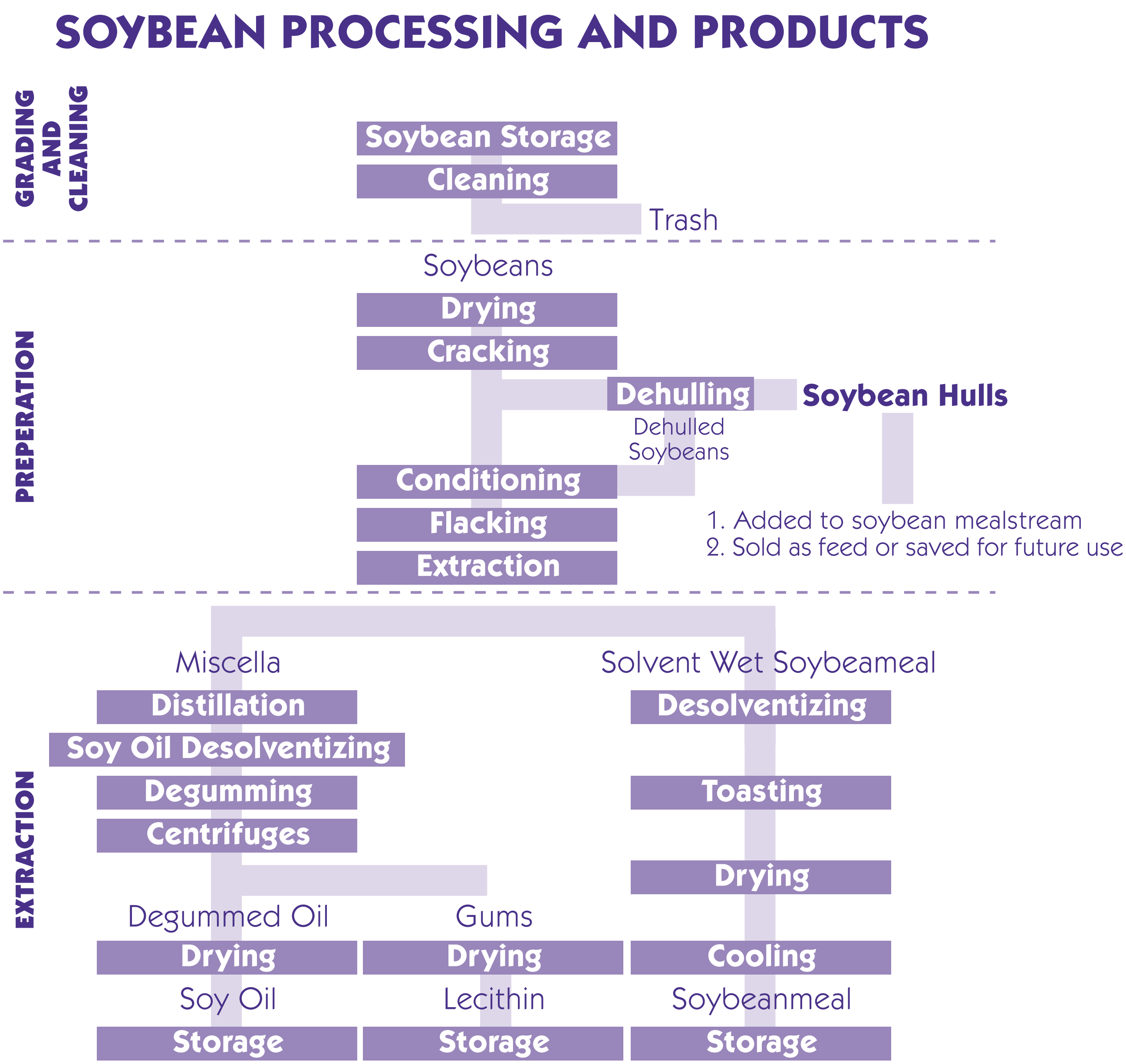
The Kansas beef industry is a dominant one; a combination of more than 4 million stockers and feeders imported into the state and the calves derived from the 1.5-million-head resident population of beef cows contribute to the demand created by the 5-million head capacity of the Kansas feedlot industry. Additionally, the Kansas dairy industry includes about 90,000 cows that produce approximately 1.6 billion pounds of milk each year. Feed costs, which account for approximately 50% of total costs, are major considerations for efficient production of beef and dairy cattle. Because of their location in the Midwest, where large volumes of feed grains and oilseeds are grown and processed, Kansas beef and dairy producers have tremendous opportunities to significantly reduce feed costs through the use of by-products such as soybean hulls.

If readily accessible and priced competitively with other feedstuffs, soybean hulls can reduce feed input costs. The estimated yield of soybean hulls from a 60-pound bushel of soybeans is about 3 pounds, or approximately 5% of the original raw soybean weight. Based on this yield, the harvest projections for the 1999 Kansas soybean crop could result in the production of almost 115,000 tons of soybean hulls. This publication contains information related to the nutrient composition and feeding management of soybean hulls, which will help Kansas livestock producers capitalize on the opportunity to use soybean hulls.

## The Soybean Crushing Process

Nearly all soybeans are processed by solvent extraction procedures. Essentially, the solvent extraction process is a component separation to produce oil and the protein-carbohydrate-fiber meal. Typically, 11 pounds of oil and 44 pounds of meal result from processing a 60-pound bushel of soybeans. A simplified flow chart of the soybean crushing process and the by-products that result at each step are illustrated in Figure 1 (American Soybean Association). A typical solvent extraction, or crushing, operation can be divided into three steps: (1) soybean preparation; (2) oil extraction, and (3) soybean meal formulation.

**Figure 1.**



**Stage 1. Preparation—**All soybeans are graded and cleaned before processing. After passing across a screen to separate all foreign material and fine particles, the soybeans are cracked with a roller to break the whole beans into smaller pieces. This facilitates the removal of hulls as well as reduces the size of the bean meat, so that proper flaking can occur. The beans are cracked to a size of $\frac{1}{6}$ to $\frac{1}{8}$ inch, small enough to facilitate the release of the hull but coarse enough to limit the amount of meat fines. All of the hulls and a fraction of the meat fines are removed via aspiration after the initial cracking step. The hull fraction then passes over a sifter and is separated into three categories: (1) large hulls and meats, (2) small hulls and meats, and (3) fines.

The fines are returned to the primary soybean stream, while the soybean hull and meat fractions go to the secondary dehulling step. During this process, the hulls are removed from the soybean meats and passed to the hull toaster to destroy urease activity.

Following toasting, the remaining hull fraction is ground to the desired particle size and either pelleted or sold as bulk. Pelleting soybean hulls significantly reduces transportation cost. However, many commercial feed companies prefer the unpelleted bulk form for inclusion into their products.

The soybean meats are conditioned to an appropriate temperature (140 to 160°F) and moisture content (8.5 to 10%) for the final flaking step. They then are passed through a set of rollers with the intent of creating flakes .01 to .015 inch thick, which is optimum for handling during extraction and for oil removal.

**Stage 2. Oil Extraction—**Oil is extracted from the flakes with an organic solvent, usually hexane, and reclaimed to yield crude soybean oil, which then undergoes a "degumming" process to separate crude lecithin from the oil. The extracted soybean oil is refined further to produce products such as cooking oil, margarine, and shortening. During the extraction process, the oil contained in the flakes is reduced virtually to zero (from 18% to 0.3–0.7%). The defatted flakes are desolventized and toasted to destroy the urease activity.

After leaving the desolventizer-toaster, the flakes are referred to as soybean meal. This meal is transferred to a meal toaster where it is dried from approximately 18% to 12% moisture. After going through the toaster, the meal goes through a cooler, where the temperature is reduced from over 200°F to less than 100°F, and then is allowed to cool in preparation for meal formulation.

**Stage 3. Soybean Meal Formulation—**In the final step, the flakes are ground and screened to make soybean meal or a variety of soy protein products including soy flour, soy concentrates, and soy isolates. Previously separated hulls can be introduced to the soybean meal to lower the protein content to product specifications (44%). Residual soybean hulls, sometimes referred to as mill run, can be saved for future use or sold.

## Pelleting Soybean Hulls

The bulk density of whole soybean hulls is extremely low and must be increased to lower the transportation costs and, thus, increase the marketing radius of this by-product. Grinding or pelleting can be used to increase density. In general, pelleting increases bulk density 3 to 3.7 times (Table 1). Pelleting whole or ground soybean hulls does not affect intake or dry matter (DM) and neutral detergent fiber (NDF) digestibilities of rations (Merrill and Klopfenstein, 1985). A growth trial (Table 2) conducted with 120 head of 587-pound steers revealed no differences in daily gains when 6 pounds of pelleted soybean hulls were top-dressed daily to a brome/alfalfa hay fed ad libitum (Drouillard and Klopfenstein, 1988).

**Table 1.** Effects of pelleting on bulk density (BD) and pellet durability index (PDI)[a] of soybean hulls.

| | BD ($lb/ft^3$) | PDI (%) |
|---|---|---|
| Whole soybean hulls (WSH) | 10.63 | -- |
| Pelleted WSH | 32 | 68.1 |
| Pelleted WSH + 6.25% $H_20$ | 35.44 | 85.1 |
| Pelleted WSH + 6.0% molasses | 39 | 95.7 |
| Pelleted WSH + 3.85% molasses | 38.5 | 93.6 |
| Pelleted WSH + 2.7% $H_2O$ + 2.7% Masonex[b] | 38.25 | 93 |

[a] *Merrill and Klopfenstein, 1985.*
[b] *Commercial pellet binder.*

**Table 2.** Forage intake (DMI), average daily gain (ADG), and feed efficiency (feed:gain) of steers supplemented with pelleted soybean hulls[a].

| Pellet type | DMI (lbs)[bc] | ADG (lb/day)[d] | Feed:Gain[ef] |
|---|---|---|---|
| Pelleted, whole | 14.9 | 2.06 | 7.32 |
| Pelleted, ground | 15.3 | 2.13 | 7.18 |

[a] *Drouillard and Klopfenstein, 1988.*
[b] *Dry matter intake/hd/day of mixed-grass hay.*
[c] *Not different (P<.32).*
[d] *Not different (P<.18).*
[e] *Forage DMI:ADG.*
[f] *Not different (P>.72).*

Garrigus et al. (1967) fed soybean hulls supplemented only with bonemeal, salt, and vitamin A to 431-pound steers for 168 days; soybean hulls were provided ad libitum in either a ground or pelleted form. Intakes were similar between the two forms of soybean hulls and averaged about 2.0% of body weight. However, gains were greater for steers fed the pelleted soybean hulls (1.49 versus 1.12 pound/day), despite the fact that DM digestibilities were similar between the two forms.

## Factors Affecting the Nutrient Content of Soybean By-Products

The difference between the value of soybean meal and oil and the purchase price of raw soybeans often is referred to as the crush margin and assumes that 1 bushel of raw soybeans (60 pounds) yields about 44 pounds of 44% protein soybean meal and 11 pounds of extracted oil. When soybean meal is manufactured for intended use by poultry and swine, the majority of the soybean hulls are removed, because these monogastric species cannot utilize the high fiber content. Thus, the relative availability of soybean hull supplies is largely dependent upon whether soybean meal is produced for swine and poultry versus beef and dairy cattle. However, the dairy industry does utilize some high protein soybean meal because it may show less variation compared to the 44% product.

The rules set forth by the National Oilseed Processors Association (NOPA) provide procedures, practices, and arbitration protocols for the trading between raw soybeans and soybean products. Although voluntary, these rules are followed regularly by U.S. companies. Unless previously adjusted between the seller and buyer, any shipment of soybean meal must meet the standard specifications for moisture, fiber, and protein contents or be subject to penalties or reshipment without expense to the buyer (NOPA Yearbook and Trading Rules, 1998–1999).

## Standard Specifications

A. Soybean flakes and 44% protein soybean meal are produced by cracking, heating, and flaking soybeans and reducing the oil content of the conditioned product by the use of hexane or homologous hydrocarbon solvents. The extracted flakes are cooked and marketed as such or ground into meal.

Standard specifications are as follows:

Protein ---------------------------------------------------- Minimum 44.0%
Fat -------------------------------------------------------- Minimum 0.5%
Fiber------------------------------------------------------- Maximum 7.0%
Moisture--------------------------------------------------- Maximum 12.0%

B. Soybean flakes and high protein or solvent-extracted soybean meal are produced by cracking, heating, and flaking dehulled soybeans and reducing the oil content of the conditioned flakes by the use of hexane or homologous hydrocarbon solvents. The extracted flakes are cooked and marketed as such or ground into meal.

Standard specifications are as follows:

Protein ---------------------------------------------------- Minimum 47.5 to 49%
Fat -------------------------------------------------------- Minimum 0.5%
Fiber------------------------------------------------------- Maximum 3.3 to 3.5%
Moisture--------------------------------------------------- Maximum 12.0%

C. Any of the above meal products may contain a nonnutritive, inert, nontoxic, conditioning agent to reduce caking and improve flowability, in an amount not to exceed that necessary to accomplish its intended effect and in no case to exceed 0.5% by weight of the total meal product. The name of the conditioning agent must be shown as an added ingredient.

The following international feed numbers and descriptions of soybean byproducts were obtained from the Association of American Feed Control Officials (AAFCO, 1996).

**84.3** **Soybean Hulls** consist primarily of the outer covering of the soybean. (Adopted 1948). IFN 1-04-560 soybean seed coats (hulls).

**84.8** **Soybean Mill Feed** is composed of soybean hulls and the offal from the tail of the mill that result from the manufacture of soy grits or flour. It must contain not less than 13% crude protein and not more than 32% crude fiber. (Proposed 1960, Adopted 1961, Amended 1964.)

**84.9** **Soybean Mill Run** is composed of soybean hulls and such bean meats that adhere to the hulls that result from normal milling operations in the production of dehulled soybean meal. It must contain not less than 11% crude protein and not more than 35% crude fiber. (Proposed 1960, Adopted 1961, Amended 1964.) IFN 4-04-595 soybean mill run.

**84.7** **Soybean Meal, Dehulled, Solvent Extracted** is obtained by grinding the flakes remaining after removal of most of the oil from dehulled soybeans by a solvent extraction process. It must contain not more than 3.5% crude fiber. It may contain calcium carbonate or an anticaking agent not to exceed 0.5% as defined in section 87 (Special Purpose Products) to reduce caking and improved flowability. The name of the conditioning agent must be shown as an added ingredient. When listed as an ingredient in a manufactured feed, it may be identified as "Dehulled Soybean Meal." The words "Solvent Extracted" are not required when listing as an ingredient in a manufactured feed. (Proposed 1989, Adopted 1992) IFN 5-04-612 soybean seeds without hulls meal solvent extracted.

**84.60** **Soybean Meal, Mechanical Extracted** is the product obtained by grinding the cake or chips that remain after removal of most of the oil from soybeans by a mechanical extraction process. It must contain not more than 7.0% crude fiber. It may contain calcium carbonate or an anti-caking agent not to exceed 0.5% as defined in section 87 (Special Purpose Products) to reduce caking and improve flowability. The name of the conditioning agent must be shown as an added ingredient. The words "Mechanical Extracted" are not required when listing as an ingredient in a manufactured feed. (Proposed 1989, Adopted 1992) IFN 5-04-600 soybean seeds meal mechanical extracted.

**84.61** **Soybean Meal, Solvent Extracted** is the product obtained by grinding the flakes that remain after removal of most of the oil from soybeans by a solvent extraction process. It must contain not more than 7% crude fiber. It may contain calcium carbonate or an anticaking agent not to exceed 0.5% as defined in section 87 (Special Purpose Products) to reduce caking and improve flowability. The name of the conditioning agent must be shown as an added ingredient. The words "Solvent Extracted" are not required when listing as an ingredient in a manufactured feed. (Proposed 1989, Adopted 1992) IFN 5-04-604 soybean seeds meal solvent extracted.

## Factors Affecting the Nutritional Value of Soybean Hulls

An understanding of the crushing constituents derived from the soybean seed is essential for determining the feeding value of soybean by-products. Various book values reflecting the "average" nutrient contents of soybean seeds and hulls that result from the soybean crushing process are shown in Table 3. However, the nutritional value of soybean hulls is so heavily dependent upon the nature and composition of the diets that such standardized values are almost meaningless. Moreover, the chemical composition of soybean hulls can vary widely among sources. A large portion of this variation is due partly to the occasional erroneous classification of soybean mill feed and soybean mill run as soybean hulls (Titgemeyer, 2000). As described in detail previously (AAFCO, 1996), both soybean mill feed and soybean mill run contain a portion of the soybean meat as well as the hull. Soybean hulls, when well cleaned, typically contain 9.4% crude protein and 74% NDF (Anderson et al., 1988). However, products classified as soybean hulls have been observed to contain up to 19.2% crude protein with only 53.4% NDF (Batajoo and Shaver, 1998). These results further emphasize that livestock producers who incorporate soybean hulls into diets should accept the challenges of nutrient variation and know the nutrient content of the by-product. Uses of soybean hulls for various feeding scenarios will be addressed in greater detail in remaining sections of this publication.

**Table 3.** Nutrient comparison of soybean seeds and by-products resulting from the soybean crushing process[a].

| Nutrient | Soybean Seeds | Soybean Meal Solvent Extracted 49% protein | Soybean Meal Solvent Extracted 44% protein | Soybean Hulls[b] |
|---|---|---|---|---|
| Crude protein, % | 40 | 55 | 51 | 9.4 |
| Nem (Mcal/lb)[c] | 1.04 | 0.96 | 0.92 | 0.82c |
| Neg (Mcal/lb)[c] | 0.71 | 0.64 | 0.61 | 0.53c |
| Nel (Mcal/lb)[c] | 0.97 | 0.9 | 0.87 | 0.79c |
| Total digestible nutrients, %[c] | 93 | 87 | 84 | 77c |
| Ether extract, % | 19.4 | 1.2 | 2 | 2.5 |
| Crude fiber, % | 8 | 3 | 5 | 35 |
| Neutral detergent fiber, % | 15 | 10 | 13 | 74 |
| Acid detergent fiber, % | 11 | 6 | 11 | 47 |
| Ash, % | 5 | 6 | 7 | 5 |
| Calcium, % | 0.27 | 0.28 | 0.4 | 0.6 |
| Phosphorus, % | 0.64 | 0.7 | 0.73 | 0.22 |
| Potassium, % | 2 | 2.2 | 2.4 | 1.7 |
| Sodium, % | 0.02 | 0.03 | 0.04 | 0.01 |
| Sulfur, % | 0.24 | 0.48 | 0.47 | 0.09 |
| Magnesium, % | 0.29 | 0.32 | 0.3 | -- |
| Cobalt, ppm | -- | 0.07 | 0.1 | 0.12 |
| Copper, ppm | 20 | 22 | 25 | 18 |
| Iodine, ppm | -- | 0.12 | 0.15 | -- |
| Iron, ppm | 91 | 148 | 133 | 324 |
| Manganese, ppm | 39 | 41 | 32 | 11 |
| Selenium, ppm | 0.12 | 0.11 | 0.34 | -- |
| Zinc, ppm | 53 | 61 | 48 | 24 |

[a] *1995 Feed Industry Red Book and United States - Canadian Tables of Feed Composition, 1982.*
[b] *On a DM basis, soybean hulls contain 46% cellulose, 18% hemicellulose, and 2% lignin.*
[c] *The energy value of soybean hulls is heavily dependent upon feeding regimes.*

## Soybean Hulls for Beef Cattle Grazing Forages

The results of several beef cattle studies clearly demonstrate that soybean hulls are comparable to corn as an energy source for beef cattle that are grazing low and moderate quality forages (Brown et al., 1981; Highfill et al., 1987; Anderson et al., 1988; Duff et al., 1993; Galloway et al., 1993). Martin and Hibberd (1990) conducted an intake and digestibility study whereby cattle were fed a low quality native grass (3.7% crude protein) with increasing increments (0, 2.2, 4.4, or 6.6 pounds) of soybean hulls daily. Maximum hay intake was observed with 2.2 pounds soybean hulls. Moreover, a low substitution rate of soybean hulls for hay was observed when soybean hulls were fed at the highest level (hay intake was decreased by only 1.5 pounds compared to the control), which supported their conclusion that soybean hulls enhanced the energy status of animals (Table 4). Subsequent work by Chan et al. (1991) revealed that total energy intake was similar between corn and soybean hulls when fed in combination with low quality native hay, despite the large difference in the book values for total digestible nutrients (TDN) of corn and soybean hulls (91 versus 77%, respectively). In a feeding environment containing low quality forages, supplementing with corn alone has led to a reduction in forage intake and decreased forage (fiber) digestion.

**Table 4.** Digestibility and intake of low-quality native grass hay with soybean hull supplementation[a].

| | Soybean Hulls, lb/day | | | |
|---|---|---|---|---|
| **Item** | **0** | **2.2** | **4.4** | **6.6** |
| DM, digestibility, %[b] | 45.8 | 46.1 | 46.6 | 48.6 |
| Intake, lb/day | | | | |
| Hay[c] | 23.1 | 24.2 | 23.4 | 21.6 |
| Dry matter[c] | 25.4 | 28 | 28.8 | 28.5 |
| Digestible DM[d] | 10.6 | 11.8 | 12.3 | 12.7 |

[a] *Martin and Hibberd, 1990.*
[b] *Linear treatment response (P<.01).*
[c] *Quadratic treatment response (P<.05).*
[d] *Linear treatment response (P<.0001).*

This observed phenomenon is commonly referred to as a negative associative effect and oftentimes occurs when a grain such as corn is fed with forage. This presumably is a result of favoring starch-fermenting microbes over fiber digesters, thereby reducing overall fiber digestion. Alternatively, including corn in the diet may lead to a deficiency of degradable protein, which also could limit fiber digestion. The value of soybean hulls as a source of degradable intake protein for ruminants grazing low quality forage should not be dismissed, particularly for those products containing soybean meats.

One unique aspect of soybean hulls is that the fiber content is low in lignin and highly digestible; therefore, the energy provided by soybean hulls in a high fiber diet is quite similar to that of corn. Research in Kansas, Oklahoma, Nebraska, and Missouri indicates that soybean hulls are excellent energy sources in supplements for poor quality roughages when fortified with protein and other essential nutrients. Results from recent trials with grazing animals supplemented with soybean hulls support that conclusion (Merrill and Klopfenstein, 1984).

Marston et al. (1992) compared soybean hull- to soybean meal-based supplementation (isonitrogenous basis) for gestating beef cows grazing dormant native range (Table 5). The cows receiving the high soybean hull-based supplement consumed less forage. Although few differences in the forage TDN content (indicating no effects of supplementation on base forage) were observed, cows receiving the soybean hull supplement gained 39 pounds (about body condition score) more than cows fed the traditional soybean meal-based supplement.

Kerley and Williams (1995) conducted a winter feeding experiment with dry, gestating, beef cows to determine the feasibility of using soybean hulls in lieu of hay as a winter feed. Cows grazed on stockpiled tall fescue and were fed tall fescue hay ad-libitum when pasture became scarce. Cows were fed 4.0 pounds of soybean hulls to substitute for 5.3 pounds of hay daily. Over the course of a 118-day trial, cows

**Table 5.** Effects of soybean hull- and soybean meal-based supplements on intake and performance of beef cows[a].

| Item, lb | Soybean Hulls (20% crude protein) | Soybean Meal (40% crude protein) |
|---|---|---|
| Feeding rate (lb/day) | 6.7 | 3 |
| Forage DM intake | 14.8 | 16.4 |
| Diet DM intake | 22.6 | 19.9 |
| Forage TDN, % | 50.9 | 51.7 |
| Forage TDN intake | 7.5 | 8.5 |
| Cow weight change | 80[b] | 41[c] |

[a] *Marston et al., 1992.*
[b,c] *Means within the row with different superscripts differ (P<.05).*

**Table 6.** Use of soybean hulls as a hay substitute for beef cows grazing stockpiled tall fescue from December through March (118 days)[a].

| Treatment[b] | Soybean Hulls (lb/hd) | Hay (lb/hd) | Body Weight Loss (lb/hd) |
|---|---|---|---|
| Hay | 0 | 2369 | 86 |
| Soybean hulls | 471 | 1747 | 13 |

[a] *Kerley and Williams, 1995.*
[b] *Hay = supplemented with hay ad libitum.*
*Soybean hulls = supplemented with hay ad libitum and soybean hulls (4 lb/head/day).*

supplemented with soybean hulls lost 73 pounds less than the cows consuming hay. Moreover, approximately 620 pounds of hay were conserved for each cow supplemented with soybean hulls (Table 6).

Soybean hulls have been incorporated successfully into supplementation programs for cattle grazing higher quality forages as well. Cravey et al. (1993) compared high-starch (corn) versus high-fiber (soybean hulls/wheat middlings) supplements for fall-weaned steer calves grazing wheat pasture fed at approximately .65% of body weight. Performance was similar for steers receiving either supplement (P>.45). Supplement conversions (feed:gain) were 5.4 and 5.0 for the high-starch and hull-based supplements, respectively. In addition to increasing stocking rate by one-third, supplementation also increased daily gains by .33 pound.

## Soybean Hulls as an Energy Source for Calf Creep Rations

Faulkner et al. (1994) evaluated soybean hulls and corn as sources of supplemental creep feed for nursing beef calves. They concluded that a highly digested fiber source such as soybean hulls can successfully replace corn as a creep feed source when economically feasible (Table 7).

**Table 7.** Effects of creep feed source on calf performance during the creep period[a].

| Item | Corn | Soybean Hulls |
|---|---|---|
| Supplement intake, lb/day[b] | 3.90[c] | 3.40[d] |
| Calf gain, lb/day | 2.20 | 2.07 |
| Supplement feed/gain | 5.6 | 5.9 |
| Initial wt, lb | 295 | 307 |
| Final wt, lb | 540 | 543 |

[a] *Faulkner et al., 1994.*
[b] *DM basis.*
[c] *Means differ (P<.05).*

## Soybean Hulls as an Energy Source for Growing and Finishing Cattle

Because soybean hulls are recognized as an excellent source of readily available energy in forage-based diets, their usage in backgrounding and replacement heifer diets seems logical. Several studies conducted previously with growing beef cattle have yielded consistent results with soybean hulls (Marston et al., 1993; Wofford et al., 1994). Hibberd et al. (1987) evaluated self-fed rations for 443-pound growing calves that consisted entirely of soybean hulls or with 30% replaced by ground sorghum. During the 51-day trial, the soybean hull-fed and soybean hull/sorghum-fed calves gained 1.40 and 1.69 pound/day, respectively. Ration consumption averaged 13.8 pound/day for both groups (2.6% of body weight; DM basis). The feed efficiency (gain:feed) of calves fed soybean hulls was 9.8 versus 8.6 when 30% sorghum was added to the diet. Moreover, a subjective bloat scoring system was employed because fibrous feeds such as soybean hulls swell and rapidly ferment. Producers should not be surprised if cattle fed large amounts of soybean hulls exhibit some ruminal distension.

Allison and Poore (1993) compared corn to soybean hulls in a 107-day study with 520-pound growing calves. All calves were allotted 7.30 pounds of the grain mix in addition to free access to a 12% crude protein grass/clover hay. As was observed in previous trials, the authors concluded that soybean hulls have similar feeding value to corn in a hay-based diet.

Limited research has been conducted evaluating soybean hulls as a major component of high-concentrate diets that are limit-fed. Limit feeding represents an alternative to traditional roughage-based growing rations. It involves feeding restricted quantities of a nutrient-dense diet in order to satisfy the nutrient requirements of the animal with a lesser volume of feed. Pelleted soybean hulls are excellent candidates as the predominant energy source in feedlot diets for limit-fed, growing calves because (1) they are nearly as easy to transport and handle as grain; (2) they are highly digestible, reducing manure production especially when compared to forage-based diets; and (3) they have a fairly stable fermentation pattern when compared to grain.

Two hundred and thirty crossbred beef heifers were used in a 98-day trial to compare the growth performance of cattle fed roughage-free soybean hull diets to that of cattle fed more traditional roughage-based or corn-based diets (Löest et al., 1998). A traditional roughage-based diet (29% corn, 45% alfalfa, 20% prairie hay, and 6% molasses and supplement) was fed at 2.75% body weight and used as a control. A high-concentrate corn diet (77% corn, 15% alfalfa, and 8% molasses and supplement) was fed at 1.5% or 2.25% of body weight. Similarly, a soybean hull diet (92% soybean hulls and 8% molasses and supplement) was fed at 1.5% or 2.25% of body weight.

Calves fed soybean hulls when fed at 2.25% of body weight, showed gains comparable to those of cattle fed the more traditional roughage-based diet at 2.75% of body weight (Table 8). Feed efficiency was improved by approximately 12% in comparison to the roughage-based diet. Soybean hull diets yielded gains that were approximately 73% of those obtained with the limit-fed corn diets, presumably due to lower digestibility. Soybean hulls can be used effectively as the primary ingredient in limit-fed diets. However, restriction of feed intake will not lead to appreciable improvements in soybean hull digestion for diets that contain insignificant quantities of forage.

**Table 8.** Performance of cattle fed roughage-, corn-, and soybean hull-based diets[a].

| | Day 0 to 98 Performance | | |
|---|---|---|---|
| **Treatment[b]** | **Intake, lb/d** | **Daily Gain, lb/d** | **Feed:Gain** |
| ROUGHAGE | 16.79[c] | 1.80[d] | 9.35[de] |
| CORN (1.5%) | 9.29 | 1.13 | 8.20[d] |
| CORN (2.25%) | 14.36[d] | 2.34[c] | 6.13[c] |
| SOYHULL (1.5%) | 9.07 | .84[ef] | 10.87[e] |
| SOYHULL (2.25%) | 13.97[d] | 1.71[d] | 8.20[d] |

[a] *Löest et al, 1998.*
[b] *ROUGHAGE = roughage-based diet fed at 2.75% of body weight (BW), CORN 1.5 = corn-based diet fed at 1.5% of BW, CORN 2.25 = corn-based diet fed at 2.25% of BW, SH 1.5 = soybean hull-based diets fed at 1.5% of BW, SH 2.25 = soybean hull-based diets fed at 2.25% of BW.*
[cdef] *Means within the same column differ (P<.01).*

Relatively few studies have considered the use of soybean hulls in full-fed grain-based diets. This is likely because the microbial populations and the ruminal environment generated by the feeding of a grain-based diet would not be considered conducive to fermentation of a fibrous by-product such as soybean hulls. Coffey and Lomas (1989) conducted a 107-day finishing trial to determine if soybean hulls could replace a portion of the grain sorghum in a finishing ration without negatively affecting animal performance. The results of their study indicated that soybean hulls could be included in a finishing ration for cattle at up to 25% of the energy source without adversely affecting gain or feed efficiency. Although it is tempting to suggest that the increases in intakes and gains were the results of decreased digestive disturbances, these diets contained relatively high levels of roughage (20% corn silage). Thus, soybean hulls may have a feeding value in finishing diets similar to that of ground grain sorghum. The data of Ludden et al. (1995) suggested a feeding value equal to 74% of corn when soybean hulls were added to finishing diets in amounts up to 60% of DM. The lower energy value for soybean hulls than for corn appears to be due to lower digestibilities.

## Utilization of Soybean Hulls in Diets for Dairy Cattle

Soybean hulls are utilized in diets for dairy cattle as partial replacements for forage and concentrate. The fiber of soybean hulls is very digestible and coupled with a very low nonstructural carbohydrate content results in an excellent energy and fiber source. Ruminal fiber fermentation by dairy cattle is necessary for optimal milk and milk fat production. Fiber fermentation can be reduced by the addition of excessive amounts of nonstructural carbohydrates to the diet. This often occurs when lower quality forages are fed and additional grain is added to increase the energy content of the diet. Replacing a portion of the forage in these diets with soybean hulls will increase the energy content without increasing the nonstructural carbohydrate content, resulting in a more favorable ruminal fermentation pattern.

Data from several studies (Table 9) summarized by Grant (1997) indicate that up to 25% of the forage DM could be replaced by soybean hulls under certain conditions. When the forage in diets was equal to or less than 50% DM, the replacement of forage with soybean hulls resulted in reduced production of fat-corrected milk (FCM) in some cases. However, when control diets contained greater than 50% forage, the replacement of forage with soybean hulls resulted in increases in FCM. Grant attributed the reduction in FCM to the lack of effective fiber in some of the diets. When forage particle size is small, diets containing less than 50% forage should contain less than 10% soybean hulls, but in diets with greater than 50% forage, up to 15% soybean hulls can be added on a DM basis. Diets that contain greater than 50% forage of adequate particle size can include up to 25% soybean hulls, which will result in increased FCM production.

**Table 9.** Replacement of dietary forage with soybean hulls.

| | | | | NDFR[2] | | Change from Control | | |
|---|---|---|---|---|---|---|---|---|
| Reference | Control Diet Forage Level | Forage Type[1] | Forage Replacement | Control | Test Diet | NDF Intake | DMI | FCM |
| | (% of DM) | | (% of DM) | --(%)-- | | --(% of BW)-- | | (lb/d) |
| Sarwar et al. (1992) | 43.2 | AH:CS | 4.6 | 80.0 | 70.0 | -2.6 | -2.7 | -1.8 |
| | | (1:1)[3] | 9.1 | 80.0 | 60.0 | -2.6 | | 9.7 |
| Cunningham et al. (1993) | 50 | AH:CS | 12.5 | 75.6 | 57.8 | 3 | -2.2 | -3.7 |
| | | (1:4)[3] | 25.0 | 75.6 | 39.6 | | -4.5 | -11.4 |
| Stone et al. (1993) | 52.6 | AHL:CS | 14.1 | 76.6 | 51.3 | 25.6 | 9.4 | 8.2[4] |
| | | (1:1)[3] | | | | 31.3 | 14.7 | 8.4[5] |
| Weidner and Grant (1994a) | 60 | AS:CS (1:1)[3] | 25 | 80 | 45 | 23.7 | 7.2 | 11.76 |
| Weidner and Grant (1994b) | 60 | AS:CS (1:1)[3] | 25 | 80 | 45 | 26.6 | — | 10.6 |

[1] *AH = alfalfa hay, AHL - alfalfa haylage, CS = corn silage.*
[2] *Percentage of dietary NDF from roughage (forage).*
[3] *Ratio of forage sources (wt/wt).*
[4] *Data for primiparous cows.*
[5] *Data for multiparous cows.*
[6] *Data for diet including coarsely chopped alfalfa hay to increase particle size.*
*Adapted from Grant (1997)*

Soybean hulls also have been utilized in diets for dry cows as a forage replacement. Underwood et al. (1998) replaced 0%, 15%, 30%, and 45% of the grass hay in a transition diet with soybean hulls. Cows were fed these diets for 21 days prepartum. Adding soybean hulls increased postpartum intakes as compared to controls. In addition, cows fed the diet containing 30% hulls peaked earlier and had greater peak milk production than the control cows. These data indicate that replacing up to 30% of the forage in transition diets with soybean hulls can improve lactation performance.

Diets for dairy cattle typically contain 35 to 55% concentrate. Diets containing greater amounts of concentrate may result in depressed milk fat production, acidosis, lameness, displaced abomasum, and digestive upsets. Even with normal levels of concentrate, the total nonstructural carbohydrate content of the diet may be excessive. Because soybean hulls are low in nonstructural carbohydrate, yet contain adequate amounts of digestible energy, inclusion in the diet will reduce nonstructural carbohydrate levels with minimal impacts upon the energy content. Bernard and McNeill (1991) substituted soybean hulls for two-thirds of the corn and a portion of the soybean meal in a control diet and observed that intake, milk production, and milk components were not different from those of cows fed the control diet. In another study, Coomer et al. (1993) altered the level of nonstructural carbohydrate by replacing corn and wheat in the control diet with corn gluten feed and soybean hulls. Dry matter intake, milk production, and milk components were unaffected by dietary treatment. Thus, soybean hulls can effectively replace a portion of the corn and soybean meal of dairy diets. Based on the data available, 10 to 20% of the concentrate portion of the diet has been replaced successfully with soybean hulls.

Soybean hulls also have been utilized in combination with whole soybeans as a replacement for whole cottonseed in diets for lactating dairy cows. Whole cottonseed contains highly digestible fiber and significant amounts of dietary fat. Although feeding whole cottonseed has many benefits, economic factors and availability may prohibit including it in the diet. Able-Caines et al. (1997) demonstrated that a mixture of whole soybeans and soybean hulls was an alternative to whole cottonseed. Cows fed a diet containing 15% soybeans, 8% soybean hulls, and .7% sodium bicarbonate had intakes and FCM production similar to those of cows fed a diet containing 15% whole cottonseed. The combination of whole soybeans and soybean hulls efficiently replaced the fiber and energy of the whole cottonseed.

Soybean hulls can be forage or energy sources in diets for lactating dairy cows. When hulls are used as a forage replacement, it is critical to maintain adequate levels of both forage and forage particle size. Greater amounts of soybean hulls can be included in diets that contain greater amounts of forage and larger forage particle size. If soybean hulls are replacing concentrate, they can provide up to 20% of the diet DM without reducing the performance of mid-lactation dairy cows.

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