Composition and Feeding Value of

Cottonseed Feed Products for Beef Cattle



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Introduction

For more than 200 years, cotton has played a key role in the history and development of American agriculture. This important dual-use crop produces not only lint that is used to clothe the world's increasing population, but also a variety of nutrition products such as cooking oil, cottonseed meal, and hulls that benefit both consumers and livestock.

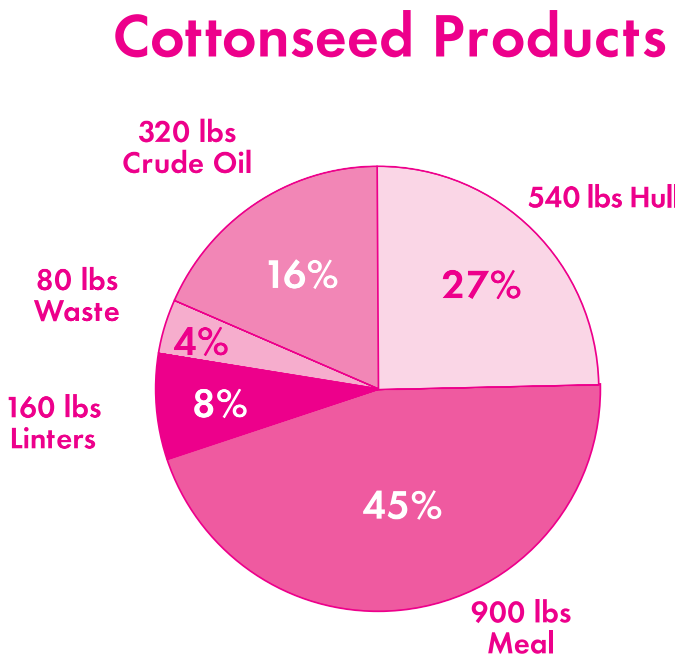
The invention of the cotton gin by Eli Whitney in 1793 resulted in the accumulation of cottonseed. It was used as a source of planting seed, but not for its nutritional value until the 1800s. Today, the value of cottonseed represents about 18% of a cotton producer's income.

For a variety of reasons, the percentage of cottonseed destined for crushing has steadily declined from a high of about 90% in 1950 to an estimated 45% in 2000 and 2001 (USDA, 2000b). The unique protein, energy and fiber content of whole cottonseed has resulted in its popularity as a staple component in dairy rations. The price and availability of whole cottonseed depends upon the size of the cotton crop and oil demand, as well as competition for positions in the market during harvest.

Figure 1 illustrates the respective yield of each by-product produced for each ton of cottonseed that is crushed for oil and meal purposes. Linters, the short fibers still attached to the seed after the ginning process, represent about 8% and are used by several manufacturing industries to produce a variety of industrial products. The crude oil fraction represents about 16% before it is refined to produce an edible oil. The hulls and meal represent almost three-fourths of the crushed cottonseed and are used primarily as feedstuffs for livestock.

This publication contains information related to the nutrient composition and feeding management of whole cottonseed, cottonseed meal and hulls. This will help beef producers capitalize on the opportunity to use cottonseed by-products, where opportunities exist, reducing costs of production.

Figure 1. Cottonseed products yield per ton of seed crushed[a]



[a] National Cottonseed Products Association, 2000

The Cottonseed Crushing Process

Whether cottonseed is bound for direct use in dairy and beef cattle rations or for oil extraction in crushing plants, it must be handled and stored properly to maintain seed quality. A simple flow chart of the cottonseed crushing process and the by-products that result at each step are illustrated in Figure 2.

Cleaning – The initial step in crushing involves passing the cottonseed through a series of screens that revolve and shake to remove extraneous material such as leaves, stems or dirt.

Delinting – After the removal of foreign matter the attached short fibers, known as linters, are cut by machines similar to gins, but with circular saws and finer teeth, and pneumatically removed through a series of revolutions. This creates various grades of linters that are classified by length and composition. For example, most seed is circulated through the system twice to produce first-cut and second-cut linters with proportions that may vary within limits (NCPA, 2000).

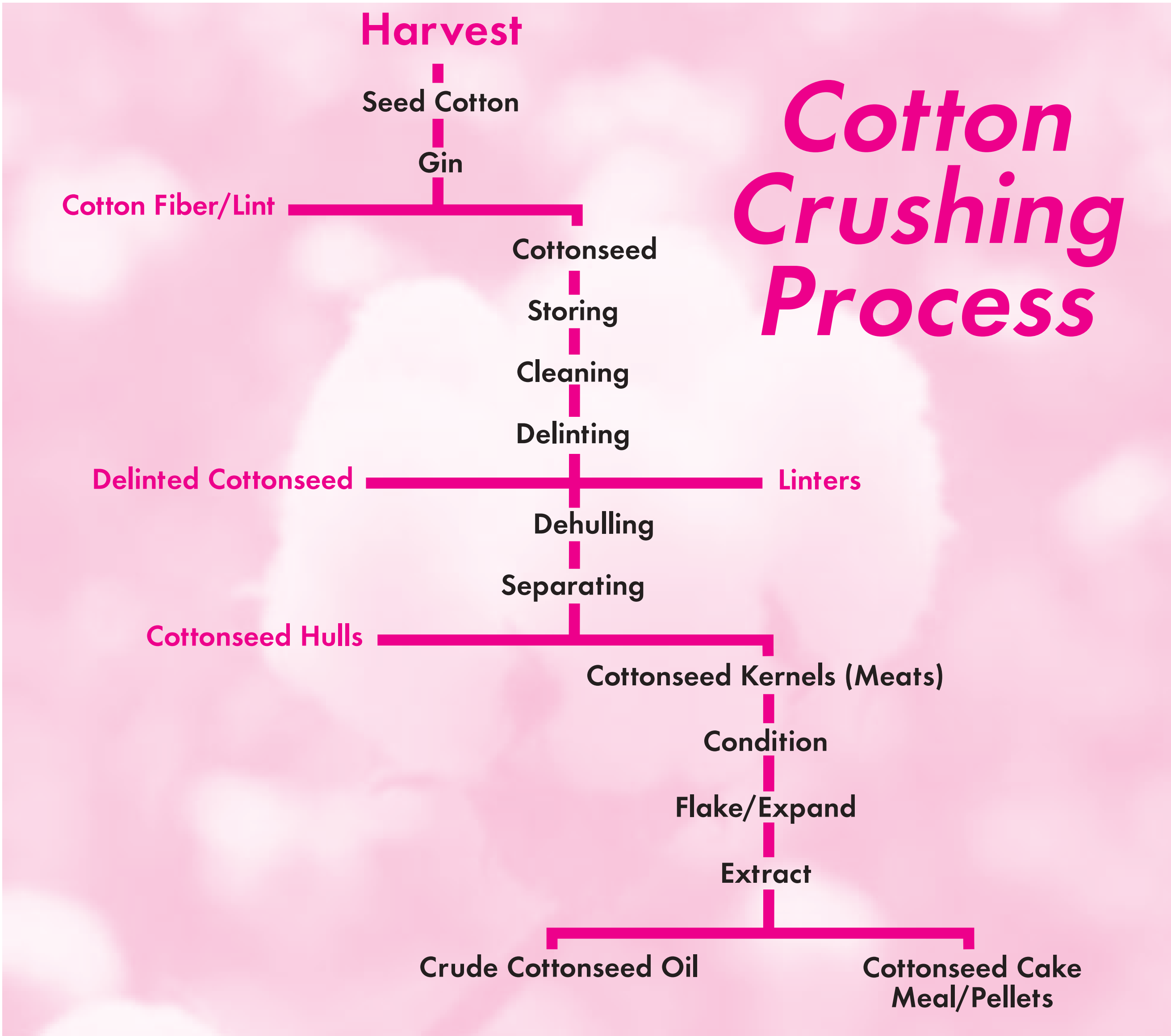
Hull removal – Once the seed is delinted, it is dehulled using a machine outfitted with a series of knives which progressively nick the hulls, loosening the tough outer covering surrounding the cotton meat. An additional series of shaker screens helps facilitate the separation of the hulls from the meat. Once this step is complete, the hulls can be marketed either in bulk or pellet form as a sole ingredient, or blended with approximately 35% cottonseed meal to produce a product that offers distinct advantages in terms of transportation, ease of handling and protein content.

Kernels – The remaining seed meats are conditioned to an appropriate temperature and moisture content for the final flaking step. Then they are passed through a set of rollers with the intention of creating flakes .01 to .015 inches thick, which is optimum for handling during oil removal by mechanical pressing or solvent extraction. Expanders have been introduced into the solvent process, which helps dramatically reduce free gossypol levels (Calhoun et al., 1995a).

Oil extraction – Oil is extracted from the flakes with an organic solvent, usually hexane, and reclaimed to yield crude cottonseed oil, which then undergoes an initial refining process to separate the free fatty acids from the oil. The extracted cottonseed oil is further refined to produce products such as cooking oil, margarine and shortening. During the extraction process, the oil content of the flakes is reduced to less than 0.6%. The defatted flakes are desolventized, toasted and ground into meal.

Cottonseed meal formation – Refinery by-products are then added back to the meal to increase its energy content. After leaving the desolventizer-toaster, the flakes are referred to as cottonseed meal. This meal is transferred to a meal dyer where it is further dried to approximately 10% to 12% moisture. After drying, the meal may go through a cooler, where it may be ground into meal or processed into pellets.

Figure 2. Cottonseed Crushing Process



Description Of Cotton By-products

The following international feed numbers and descriptions of cottonseed by-products were obtained from the Association of American Feed Control Officials (AAFCO, 2001).

24.10 **Cottonseed Meal, Mechanical Extracted** is the product obtained by finely grinding the cake that remains after removal of most of the oil from cottonseed by a mechanical extraction process. It must contain not less than 36% crude protein. It may contain an inert, nontoxic conditioning agent either nutritive or non-nutritive or any combination thereof, to reduce caking and improve flowability in an amount not to exceed that necessary to accomplish its intended effect and in no case exceed 0.5%. 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 1984). IFN 5-01-625 Cotton seeds meal mechanical extracted 36% protein.

24.12 **Cottonseed Meal, Solvent Extracted** is the product obtained by finely grinding the flakes which remain after removal of most of the oil from cottonseed by a solvent extraction process. It must contain not less than 36% crude protein. It may contain an inert, nontoxic conditioning agent either nutritive or non-nutritive or any combination thereof, to reduce caking and improve flowability in an amount not to exceed that necessary to accomplish its intended effect and in no case exceed 0.5%. 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 1984) IFN 5-01-632 Cotton seeds meal solvent extracted 36% protein.

24.14 **Ammoniated Cottonseed Meal** is obtained by the treatment of cottonseed meal with anhydrous ammonia until a pressure of 50 pounds per square inch gauge is reached. It is to be used in the feed of ruminants as a source of protein and/or as the sole source of non-protein nitrogen in an amount not to exceed 20% of the total ration.

The label of the additive and of any feed additive supplement, feed additive concentrate, or feed additive premix prepared from it, must contain the following information in addition to any other required information:

1. The name of the additive
2. The maximum percentage of equivalent crude protein from non-protein nitrogen.
3. Directions for use to provide not more than 20% of the additive in the total ration and a prominent statement: “Warning - This feed should be used only in accordance with the directions furnished on the label.” (Reg. 573.140; Proposed 1969, Adopted, 1970).

24.4 **Whole-Pressed Cottonseed, Mechanical Extracted** is composed of sound, mature, clean, delinted, and unhulled cottonseed, from which most of the oil has been removed by mechanical pressure. It must be designated and sold by its crude protein content. If ground, it must be so designated. The words “mechanical extracted” are not required when listing as an ingredient in a manufactured feed. (Proposed 1964, Adopted 1966, Amended 1968). IFN 5-01-609 Cotton seeds meal mechanical extracted.

24.51 **Low Gossypol Cottonseed Meal, Solvent Extracted** is a meal in which the gossypol is not more than 0.04% free gossypol. The words "solvent extracted" are not required when listing as an ingredient in a manufactured feed. (Proposed 1964, Adopted 1966, Amended 1968). IFN 5-01-633 Cotton seeds low gossypol meal solvent extracted.

24.6 **Cottonseed Hulls** consist primarily of the outer covering of the cottonseed. (Proposed 1964, Adopted 1966.). IFN 1-01-599 Cotton hulls.

24.8 **Cotton Plant By-Product** is the residue from the ginning of cotton. It consists of cotton burrs, leaves, stems, lint, immature seeds, and sand and/or dirt. It shall not contain more than 38% crude fiber, nor more than 15% ash. It must be labeled with minimum guarantees for crude protein and crude fat and maximum guarantees for crude fiber and ash. If it contains more than 15% ash, the words "sand and/or dirt" must appear in the product name. (Proposed 1980, Adopted 1983, Amended 1984). IFN 1-08-413 Cotton gin by-product.

Nutrient Composition of Cottonseed and By-products

Tables 1 and 2 outline the basic properties and the nutrient composition of cottonseed and the primary by-products derived from two oil-extraction processes. Calhoun et al. (1995b) conducted a large scale survey in cooperation with oilseed crushers to determine the relative nutrient content of cottonseed, cottonseed meal, and hulls that arise from the primary oil extraction processes used during the 1993-94 processing year. Before this study, the most comprehensive determination of nutritional values was conducted during the 1960s. Since then there have been significant changes in oil extraction technologies and periodic introductions of newer cotton varieties, which might have altered the nutrient composition of the various by-products being used today.

Generally, the survey revealed significant reductions in ether extract and higher fiber values for cottonseed since the 1960s. According to Calhoun et al. (1995b) these results were consistent with the downward trend in average seed index that has been observed during the past 18 years. Energy and protein values of cottonseed hulls were consistent with published values. Trace mineral elements were considerably different. Potassium was higher although sulfur, copper, iron, manganese and zinc were much lower in the collected samples compared to the published values.

The nutrient content of cottonseed meals varied depending on the process used to extract the oil. Compared to those produced 25 to 30 years ago, cottonseed meals produced today were shown to be higher in crude protein, magnesium, potassium, and sulfur, and lower in crude fiber, copper and manganese. Generally speaking, the major effect of extraction process on cottonseed meal is on fat content. As a rule, mechanically extracted cottonseed meals tend to have higher residual oil content than either pre-pressed solvent or solvent cottonseed meal. However, this may not always be the case because it is common practice to return refinery by-products (sodium salts of fatty acids) obtained during the refining process back into the meal stream immediately before the desolventizer-toaster process.

Table 1. Basic properties of cottonseed and cottonseed products.[a]

Product	Bulk density (lb/ft^3)	Bulk volume (ft^3/ton)	Weight (lb/bu)	Specific count (seed/lb)
Whole seed				
Loose on conveyor	20	100		
<24 ft. deep	25	80	32	1,800 - 2,400
24-50 ft. deep	27	75		
>50 ft. deep	30	70		
Machine delinted	35	57	44	2,400 - 3,200
Acid delinted	34-37	54	42-46	4,800 - 5,600
Meal (extracted)	38	53		
Hulls	12	167		
Pelleted Hulls	36	55		
Oil	57	35		

[a] Willcut et al., 1987

Table 2. Nutrient composition of cottonseed and by-products resulting from the cottonseed crushing process.[a]

Nutrient	Whole Cottonseed	Cottonseed Meal Expander Solvent Extracted NRC[a]	Cottonseed Meal Expander Solvent Extracted NCPA[b]	Cottonseed Hulls NRC[a]	Cottonseed Hulls NCPA[b]
Dry matter, %	92	91	89.1	91	89.9
Crude protein, %	23.0	45.2	47.6	4.1	5.0
NEm (Mcal/lb) [b]	1.10	.83		.31	
NEg (Mcal/lb) [b]	.76	.54		.07	
TDN, %	95	76		42	
Acid detergent fiber, %	20	17	17.3	64	67
Neutral detergent fiber, %	40		24.5	90	86.9
Crude fiber, %	20.8	13.3	11.2	47.8	48.6
Ether extract, %	17.50	1.6	2.2	1.7	1.9
Ash, %	5.0	7.1	7.5	2.8	2.8
Calcium, %.	16	.18	.22	.15	.15
Phosphorus, %	.75	1.21	1.20	.09	.08
Magnesium, %	.35	.59	.66	.14	.15
Potassium, %	1.21	1.52	1.72	.87	1.13
Sodium, %	.31	.05	.14	.02	.01
Sulfur, %	.26	.28	.44	.09	.05
Copper, ppm	54	22	12.5	13	3.6
Iron, ppm	151	228	126	131	30.1
Manganese, ppm	10	23	20.1	119	16.8
Molybdenum, ppm			2.5		.37
Zinc, ppm		68	63.7	22	9.9

[a] NRC = Nutrient Requirements of Beef Cattle, 6th ed., 1984.
NCPA = Calhoun, et al., 1995b.
[b] NEm and NEg = Net energy, maintenance and growth, respectively.

Feeding Value of Whole Cottonseed

Over the past 20 years, the percentage of whole cottonseed (WCS) fed directly to cattle has increased dramatically. Although its bulky physical form makes it a rather inconvenient feedstuff to handle, dairy producers have increasingly embraced the use of WCS as a source of energy, protein, and fiber in lactating dairy cow diets. Levels, as high as 25% of the ration, are fed with mostly positive results (Coppock and Wilks, 1991). Recent research has shown the benefits of feeding limited amounts of oilseeds (about 4% of total dry matter intake) to beef cows in marginal body condition before the breeding season (Williams and Stanko, 1997). For example, feeding about 3.5 pounds of WCS daily to a mature, 1,100 pound cow will help many cows begin cycling as early as possible.

Levels containing up to 50% whole cottonseed in the concentrate portion have been previously evaluated for beef cattle growing rations (Marion et al., 1976). After 68 days of receiving the diet, yearling cattle fed 50% WCS began scouring when they consumed 12 pounds of WCS per head daily. The concentration of whole cottonseed in the diet was reduced to 25%, then gradually increased to 40% by the end of the 112-day trial, and no further digestive disturbances were reported. Arizona research (Hale et al., 1983; Swingle et al., 1983) determined that increasing levels of WCS in beef cattle finishing diets resulted in a concomitant decrease in the energy utilization from WCS, and that a level of 20% showed a small advantage in cattle performance.

Lane, Jr. (2001) outlined the following guidelines for feeding cottonseed to beef cattle:

1. Feed only gin-run cottonseed. These are whole, non-delinted and untreated seed.
2. Feed only dry seeds that are not moldy.
3. Grinding whole fuzzy cottonseed does not improve feeding value.
4. Whole cottonseed should be hand-fed as it does not flow well through self-feeders. Cottonseed does not mix well with salt or other intake limiters.

To further elaborate on No. 2 above, WCS destined for livestock feeding should be clean, free of foreign debris, white to whitish-gray in color, and should rattle when shook. Storing cottonseed that is too wet at harvest may result in heating and/or molding which may predispose it to risks associated with aflatoxin and other mycotoxins. To minimize increases in aflatoxin during storage, Russell (1983) recommended storing seed at less than 10% moisture; forcing air through the seed; sheltering seed from rain; and storing seed on concrete that has a slight slope.

Gossypol Considerations

All cottonseed contains gossypol, a naturally occurring plant pigment found most commonly in cotton (Gossypium Spp.) and okra, as well as in most plants in the family Malvaceae. Gossypol is a polyphenolic compound that, in cotton, is localized in pigment glands found throughout the plant. These glands are especially concentrated in the seed. Cottonseed has been shown to contain from 0.40 to 2.0% free gossypol. The level of gossypol is affected by species, variety, fertilization, growing conditions, and insect pressure. The presence of gossypol affords the plant some protection against predators such as insects, field mice, and raccoons that might otherwise feed on these plants and/or their seeds (Boatner, 1948; Berardi and Goldblatt, 1969).

Gossypol exists as two stereoisomers, or mirror images of each other, which are designated as (+) and (-) isomers. The minus or “(-)” isomer has been shown to be more detrimental biologically within the animal. Upland cottonseed or “fuzzy cottonseed” usually contains less gossypol than PIMA varieties of cotton. PIMA seed also contains more (-) isomer as a percentage (50%) than Upland (40%). These isomers exist in two distinct states: bound and unbound. The unbound form of this compound has been shown to be most biologically active in the animal. The bound gossypol is essentially unavailable to the animal, (because these are chemical determinations) but the possibility for some crossover of biological activity exists (Calhoun et al., 1995a).

Whole cottonseed typically contains 1.5-2.0% gossypol, all in the unbound form, but levels can vary to as low as 0.4% in some commercial species. (Calhoun 1995a, Nomeir and Abou-Donia, 1985). Breakdown and maceration by chewing of this seed by the animal and subsequent exposure of this gossypol to rumen microorganisms allows a number of deactivation, binding, and degradation actions to occur that render the gossypol unavailable to the animal. Due to the nature of the rumen, prolonged exposure time, and extensive physical and chemical breakdown of the whole seed, the ruminant is given some practical protection from the compound. Binding to free epsilon amino nitrogen in the rumen – whether as free amino acids or peptides – attaching to microbial cell walls, or binding to available metal ions such as iron all contribute to the detoxifying action of the rumen.

Whole Cottonseed

Roasting, extruding, and cracking whole cottonseed has improved digestibility in some trials but also has increased the availability of free gossypol in several circumstances. This is especially true with PIMA seed because it has few linter fibers attached to lengthen residence time in the rumen. PIMA is generally ground to increase digestibility, but this exposes more of the glands to the rumen environment more quickly than with whole fuzzy cottonseed, decreasing the rumen's ability to render the gossypol unavailable to the animal (Kirk and Higginbotham, 1999). These processes also make the oil in the seed more readily available and can depress fiber digestion if not compensated for in the overall feeding of the ration.

Cottonseed Meal

Because of the process by which oil is extracted, cottonseed meal yields a predominately bound form of gossypol compared to whole cottonseed. After they are separated from the hull, the cottonseed meats are moistened, flaked and cooked before being put through an expander, extracted, and then desolventized and toasted (in another type of stacked heater called a DTDC) before being ground into a meal (Jones and King, 1996). This processing method binds much of the gossypol leaving only 0.1-0.2% as free gossypol. More than 97% of the meal from plants in the United States is made using this process (National Cottonseed Products Association, personal communication). This level of free gossypol is a decrease of nearly 50% from the 1960s and 1970s because of expander technology introduced to the oilseed industry. Surveys conducted by the National Cottonseed Products Association (NCPA) in the early 1990s and again in 2000 showed that the levels of free gossypol in meal manufactured with expander-solvent technology continue to remain low (< 0.18%, Forster and Calhoun, 1995b; Waldroup/NCPA survey data, 2000).

Cottonseed Hulls

Cottonseed hulls are removed from whole seed. The hull is mainly hemicellulose and lignin compounds with a nearly pure cellulose linter fiber attached (Tharp, 1948). No pigment glands have been reported on the hull fiber or linter fiber fractions. The residual oil and protein that may be present from the decortication or removal of the hull from the cottonseed meats may contain some free gossypol. Advances in mechanical and air separation techniques over the last 20 years have minimized the amount of residual oil and protein found in cottonseed hulls. This results in hulls typically reported as having less than 0.049 % free gossypol content (Forster and Calhoun, 1995). Pelleting hulls for transportation and convenient handling purposes can reduce this small free-gossypol level even further. Pelleted hulls have been shown to have the same feeding characteristics as loose hulls (Brown et al. 1977). Due to the low levels of gossypol found in hulls, gossypol poisoning from feeding hulls alone is not biologically possible.

Clinical signs of gossypol toxicity. Several manifestations of gossypol poisoning or gossypol toxicity are possible. No specific diagnostic test exists for determining gossypol toxicity because clinical signs are similar to other maladies. A history of cottonseed product consumption at above recommended levels, along with dyspnea, decreased growth rate, anorexia, weakness, and gastroenteritis are major indicators. Other signs have included abdominal distension and pulmonary edema. Clearly these symptoms indicate a number of disorders, and the intake of excess levels of gossypol should be the important factor. Plasma gossypol levels have been correlated with level of cottonseed product being fed. Most of the work has been done with dairy cattle. The underlying mode of action is that gossypol, which has not been rendered biologically inactive, passes into the bloodstream and is present in the plasma. Clinical signs of gossypol toxicity in mature cattle can include decreased dry matter intake, decreased milk production, panting, elevated heart rate, ruminal stasis, severe abomasitis, hemoglobinuria and sudden death. (Rogers and Poore, 1995). Decreased hematocrit and hemoglobin concentrations as well as increased erythrocyte fragility also have been linked with gossypol ingestion. The most frequently reported aspect of gossypol effects in beef cattle is on reproductive function in males. Long term or permanent reproduction in females has not been documented. Abnormal or reduced sperm motility in pubescent and growing bulls has been documented (Chase et al, 1989). When levels of whole cottonseed and cottonseed meal have been fed at levels that exceeded normal protein and energy supplementation levels, increased abnormal sperm and decreased normal motility have been seen. Mature bulls seem less susceptible than pubescent and adolescent bulls to gossypol toxicity (Chase et al, 1989). Even in cases where decreased normal sperm have been noted, the effects on herd conception rate have not been clear. Also, long-term effects on young bulls that have been fed excessive amounts of meal or whole seed have not been documented.

Gossypol analysis can be a difficult procedure with a number of compounds affecting the results. Analysis of pure samples of cottonseed products will give consistent results while analysis of mixed feeds can have errant values because a number of compounds can interfere with the Association of Official Analytical Chemists (AOCS) official method. High Performance Liquid Chromotography (HPLC) analysis is more accurate and can be carried out on mixed feeds with good success. Few commercial labs carry out gossypol analysis regularly.

Recommendations for Beef Cattle

These levels are based on the free gossypol intake in the total diet and are different for meal and whole cottonseed. Whole cottonseed has a higher feeding rate across production classes of beef cattle because it is digested slower and has a longer residence time in the rumen. These are taken from Rogers and Poore, 1995, Journal of Veterinary Medicine.

Nursing calves – preruminant calves should not be fed cottonseed products. Exposure can occur when nursing cow are supplemented whole seed or meal. Limits not to exceed 100 ppm free gossypol in the total diet.

Weaned heifer calves and stockers — Limit feeding or creep feeding calves supplements with cottonseed products until after the development of an active rumen. Whole cottonseed should not exceed 15% of the total diet. The limit for whole cottonseed is 900 ppm. Cottonseed meal should not contribute more than 200 ppm of free gossypol in the total ration.

Young bulls – should be limited to keep gossypol from meal below 150 ppm and from seed below 600 ppm. This is less than 3 pounds per day of a typical expander meal and less than 4 pounds of whole seed.

Mature bulls – keep ration below 200 ppm free gossypol from meal, especially during the breeding season.

Cows – Feeding less than 600 ppm from meal and less than 1,200 ppm from seed equates to 4 to 6 pounds per head from either source.

Feeding Value of Cottonseed Meal

Cottonseed meal (CSM) has been used successfully for more than 100 years in beef production in areas of the United States where cotton production and processing is prevalent. For example, CSM is used primarily as a protein source for a variety of beef production operations that include calf creeps and beef cow supplements.

After oil, cottonseed meal is the second most valuable and most abundant by-product of the crushing process (Figure 1). The nutrient analysis of CSM will depend on the process used to extract the cottonseed oil. The standard CSM is 41% crude protein on an as fed basis. The crude fiber level of CSM is significantly higher (13 vs. 5%) than that of soybean meal. Consequently, the protein and energy content of CSM is approximately 10 and 5%, lower respectively than soybean meal. According to Coppock (1987), the nutritional protein degradability of CSM is similar to that of peanut meal, canola meal, and soybean meal for lactating dairy cows, and to that of canola meal and soybean meal for young calves.

From an historical persepctive, when Oklahoma researchers (Hibberd et al., 1987) added increasing levels of CSM to low-quality native grass hay diets containing equal amounts of corn, they observed a significant improvement in digestibility. Several growth trials have supported these results through comparable performance using either hay-based (Brown, 1991) or silage-based (KSU, 1982) diets.

Several research trials with beef cows have estimated the protein and energy value of CSM, relative to other protein sources, under a variety of dietary conditions. A Louisiana study (Coombs, 1996) evaluated the effect of self-feeding supplements containing protein during late gestation and early lactation, or an energy supplement during the second half of the supplementation period, on cow weight change and subsequent calf performance. Cows had ad libitum access to a bermudagrass hay (9.9% crude protein and 49.6% TDN) throughout the supplementation period. The supplement treatments evaluated included CSM with salt (desired daily intake = 1.5 lb), a commercially available high protein (40%), and low protein (20%) block. Throughout the trial, there was no difference among supplement sources on cow weight change and weaning weights.

Using a low-quality native grass hay (4.7% crude protein) as the base diet, Gonzalez et al. (1988) supplemented fall-calving cows at calving with 2.5 lbs of CSM daily. During the first five weeks of lactation, the control treatment (no protein supplementation) lost more than 100 lbs of body weight, while the cows supplemented with CSM gained almost 50 lbs. Hay intake increased 33% for control cows and 110% for the CSM-supplemented cows during the first five weeks after calving. The supplemented cows produced more milk contributing to faster calf weight gain than control cows. This study illustrates that small quantities of CSM efficiently improved the utilization of low-quality forage and performance of lactating beef cows.

Florida researchers conducted two trials that evaluated the effects of supplemental CSM on the performance of nursing beef calves (Kunkle et al., 1991). The nursing calves averaged 430 to 560 lbs at the initiation of the two summer trials. Consumption of the CSM-salt supplement averaged 0.95 lb per head per day in trial 1 and 0.75 lb per head per day in trial 2. The calves creeped with CSM gained 0.45 lb per head per day more in trial 1 and 0.36 lb per head per day more in trial 2 compared to control cattle (Table 3).

Table 3. The effect of CSM used as a high protein creep on the performance of nursing calves[a]

	Trial 1			Trial 2		
	Control	**CSM[b]**	**SE[c]**	**Control**	**CSM[b]**	**SE[c]**
No. of calves	15	17		15	11	
Trial length, days	46	46		77	67	
Initial weight, lb	446	429	13	469	562	13
Final weight, lb	502	506	15	591	693	14
Calf daily gain, lb	1.20	1.65	.09	1.59	1.95	.11
Added gain, lb	—	.45		—	.39	
Supplement						
daily consumption						
lb/head/day	—	.95		—	.75[d]	
Lbs supplement						
per lb added gain	—	2.1		—	2.1	

[a] Kunkle et al., 1991.
[b] Cottonseed meal (100%) fed during the first 2 weeks then a mix of cottonseed meal-salt (92:8) fed to the end of the trial.
[c] SE = Standard error of mean.
[d] Rainwater contamination of feed caused molding. Consumption determined after subtracting estimated spoiled feed.

Feeding Value of Cottonseed Hulls

Cottonseed hulls (CSH) are a highly fibrous, bulky roughage. Nutrient values are given in Table 2. Unless they are pelleted or destined for use in a specific livestock market, such as in receiving diets, the low bulk density of CSH normally confines its use for livestock feeding applications to a fairly restricted market radius. Because of ease of handling, the use of pelleted CSH has increased in recent years (Coombs and Pontif, 1996). These factors, in addition to the variable oil crush and high storage costs, may cause CSH prices to be extremely volatile. Nevertheless, CSH are an important source of roughage and have been used successfully for several different beef feeding scenarios when dictated by economic conditions.

Several trials estimated the energy value of CSH relative to other roughage under a variety of diet conditions for beef cattle. Morrison (1948) reported CSH feed value was equivalent to 88 and 82% of prairie hay and unchopped peanut hay, respectively. Oklahoma researchers evaluated the influence of various types of forages on nutrient utilization with high roughage diets when fed with whole corn (Rust and Owens, 1982). The dietary inclusion level of all forages evaluated, including CSH was 50% with the remaining amount being 42% corn and 8% supplement. Their findings revealed that starch digestion was greatest for the CSH-supplemented diet, and that CSH may enhance the digestibility of whole corn, whereas others such as alfalfa may reduce digestion of whole corn. The CSH diet was 18% more digestible than expected while the alfalfa diet was 7% less. The results of this study agree with Teeter et al. (1981) whose work concluded that CSH fed at a high levels increased starch digestion by increasing rumination, reducing the amount of whole corn passing through the digestive tract.

Numerous university reports have indicated that CSH are a satisfactory source of roughage for beef cows, if the complete ration contains sufficient protein, minerals and vitamins. Morrison (1948) suggested that CSH should be fed with protein-rich feeds and as only part of the roughage, along with a good quality legume hay or silage. Arizona workers (Taylor et al., 1974) conducted a 116-day trial to compare various low-quality forages with beef cows nursing calves in a drylot setting. In one treatment, CSH constituted one-half (13.3 lb) of the experimental diet, which included ground alfalfa hay as the remaining ingredient. They concluded that the lactating cows fed the ration gained 40 lbs during the trial period. Furthermore, the calves from the CSH treatment gained 0.32 lb/day faster than the other two treatments (Treatment A = 21 lbs of ground alfalfa hay + 5 lbs pine sawdust and Treatment B = 20 lbs of ground milo stover + 4.5 lbs whole cottonseed) and consumed only 94 and 85% as much creep feed as calves assigned to treatments A and B, respectively. In a subsequent follow-up trial with dry, mid-gestation beef cows fed in a drylot setting, Taylor et al. (1977) concluded that CSH were superior to a Durum-type wheat straw.

Typically, feed intake of stressed, newly arrived feeder calves is low and extremely variable following transport and introduction into their new environment. Adequate energy intake is critical for mounting an effective immune response, and nutrition in the stressed animal plays a vital role in reducing susceptibility to disease. Consequently, rations fed during the receiving period must be palatable to encourage consumption and fortified with higher levels of protein, energy, minerals, and vitamins. Furthermore, the addition of a roughage source that is palatable and also an effective source of fiber, which promotes ruminal health, is critical throughout the calf's transition to a feedlot diet.

If prices permit, CSH are normally incorporated into commercial cattle receiving feeds. This has been observed by livestock producers and university researchers to assist in promoting feed consumption in newly arrived stocker calves. To quantify the value of CSH in a receiving diet relative to alfalfa hay, a study was conducted at Kansas State University to evaluate the growth performance and morbidity/mortality rates of 625 crossbred heifers in a 28-day receiving study (Blasi et al., 2001). Diets were formulated to contain either 40% of alfalfa hay or of a pellet containing 65% CSH and 35% CSM.

Heifers fed the cotton by-product pellet consumed more feed, but tended to be less efficient than the heifers that were fed alfalfa hay. Daily gains were comparable for heifers fed either diet. While the percentage of heifers diagnosed and treated (or re-treated) for respiratory disease were similar, percent mortality was numerically higher for those heifers fed the cotton by-product pellet (Table 4). Blending and pelleting CSH with CSM, reduces transportation and handling problems and enhances protein content.

Table 4. Performance of feeder heifers fed receiving diets containing alfalfa hay or cottonseed hulls (65%)/cottonseed meal (35%) pellets as sources of roughage.[a]

Item	Pelleted Cottonseed Hull/Meal[b]	Alfalfa Hay[b]	P=
Number of. Pens	12	12	
Number of. Heifers	313	312	
Daily Gain, lb/day			
Deads in basis	2.15	2.22	.83
Deads out basis	2.64	2.52	.72
Dry Matter Intake, lb/day	11.8	10.7	<.01
Feed:Gain			
Deads in basis	5.61	4.78	.27
Deads out basis	4.52	4.23	.54
Mortality	3.2	1.9	.38
Pulled, %	48.8	45.3	.44
Treated, %	35.7	35.2	.89
Retreated, %	26.2	23.2	.38

[a] Blasi et al., 2001.
[b] Contained 40% of a 65:35 CSH:CSM mixture or alfalfa hay; nutrient composition: 15% crude protein, 20% ADF, 0.49 calculated NEg (Mcal/lb).

In another trial conducted previously with alfalfa versus CSH for starting cattle on high concentrate rations, Gill and Owens (1982) fed rations to starting feedlot steers that were diluted with CSH or a mixture of CSH plus alfalfa meal for the first 24 days of a 119-day feeding period. No significant differences were detected in performance, although steers receiving alfalfa meal consumed an average of 1.4% more feed, which increased efficiency by 1.7%. So based upon the results of this study and the one previously discussed, pelleted cottonseed by-products (CSH and CSM) are comparable to alfalfa hay when fed in receiving diets and can be used successfully in areas of the United States. where alfalfa hay is priced at a premium.

Numerous university trials have evaluated CSH as a source of roughage for growing beef calves. During a 3-year period, Bagley et al. (1983) conducted a winter feeding study with a total of 150 head of 485 lb 10-month old replacement heifers. The study compared rations consisting of bermudagrass hay + 1 lb of CSM; CSH + 2 lb of CSM; CSH + 1.7 lb of CSM + 2.7 lb of corn; soybean straw + 2.8 lb of CSM; and, soybean straw + 1.5 lb of CSM + 2.7 lb of corn. All roughage sources were available on a free-choice basis, and diets were formulated to contain 12.5% crude protein. Heifers fed bermudagrass hay and CSM gained faster than did heifers fed CSM and either CSH or soybean straw (Table 5). Heifers fed CSH gained faster and were heavier ($P<.01$) than heifers fed soybean straw diets. Adding corn to both CSH and soybean straw diets increased final weights and daily gain.

Table 5. Roughage consumption and performance of beef heifers fed a roughage-based wintering diet.[a]

	Diet				
Item	**Bermuda-grass hay + CSM protein**[b]	**Cottonseed hulls+ CSM protein**	**Hulls + protein +energy**[c]	**Soybean straw + CSM protein**	**Straw + CSM protein + energy**
Dry matter consumption, lb/day	11.9	11.2	11.1	6.6	6.8
Initial weight, lb	484	484	485	487	483
Daily gain, lb	.68[e]	.44[f]	.77[e]	-.42[g]	.15[d]
Final condition score[i]	9.1[e,f]	7.9[f,g]	9.6[e]	4.5[h]	6.9[g]
Final weight, lb	541	521	550	451	496

[a] Bagley et al., 1983
[b] Cottonseed meal (41 percent crude protein)
[c] Ground yellow corn
[d,e,f,g,h] Means in the same row followed by different letters (P<.05).
[i] Visual rating of condition, 18-point scale: 4 = average utility; 6 = low standard; 9 = low good; 18 = high prime.

Table 6. Summary of Feedlot Performance.[a]

	Ration				
Performance Item	**Basal**	**Hulls**	**Hulls, urea**	**Hulls, soybean meal**	**Hulls soybean meal, and minerals**
CSH Level in Diet As Fed, %	0	10	9	10	7
Initial 83 days					
Starting weight, lb	425	427	424	424	425
Weight at 83 days, lb	623	664	638	654	620
Daily gain, lb	2.3	2.8	2.6	2.7	2.3
Feed consumed, lb/day	17.7	19.9	19.0	18.6	17.0
Feed/Gain	7.7	7.1	7.3	6.9	7.4
Entire 236 days					
Final weight, lb	929	977	960	978	944
Daily gain, lb	2.1	2.3	2.3	2.3	2.2
Feed consumed, lb/day	21.0	22.3	22.1	21.4	20.9
Feed/Gain	10.0	9.7	9.6	9.3	9.5

[a] Thomas et al., 1985.

Thomas et al., (1985) conducted a 236-day growing trial with 425 lb heifers to evaluate adding CSH, CSH + urea, or a combination of CSH + SBM, to a basal diet consisting of 57% ground corn and 43% broiler litter. All diets were calculated to contain equal amounts of energy and protein. On average, addition of roughage as CSH improved feed efficiency by 6.8% over the basal diet, and the CSH-soybean meal diet improved feed efficiency by 10.3% (Table 6). Feed intake increased an average of 5.2% when CSH were added to the basal diet. This may largely account for the improved efficiency for the CSH-supplemented diets.

These researchers concluded that the addition of CSH to the basal diet resulted in faster gains, more feed consumed with a resulting improvement in feed efficiency.

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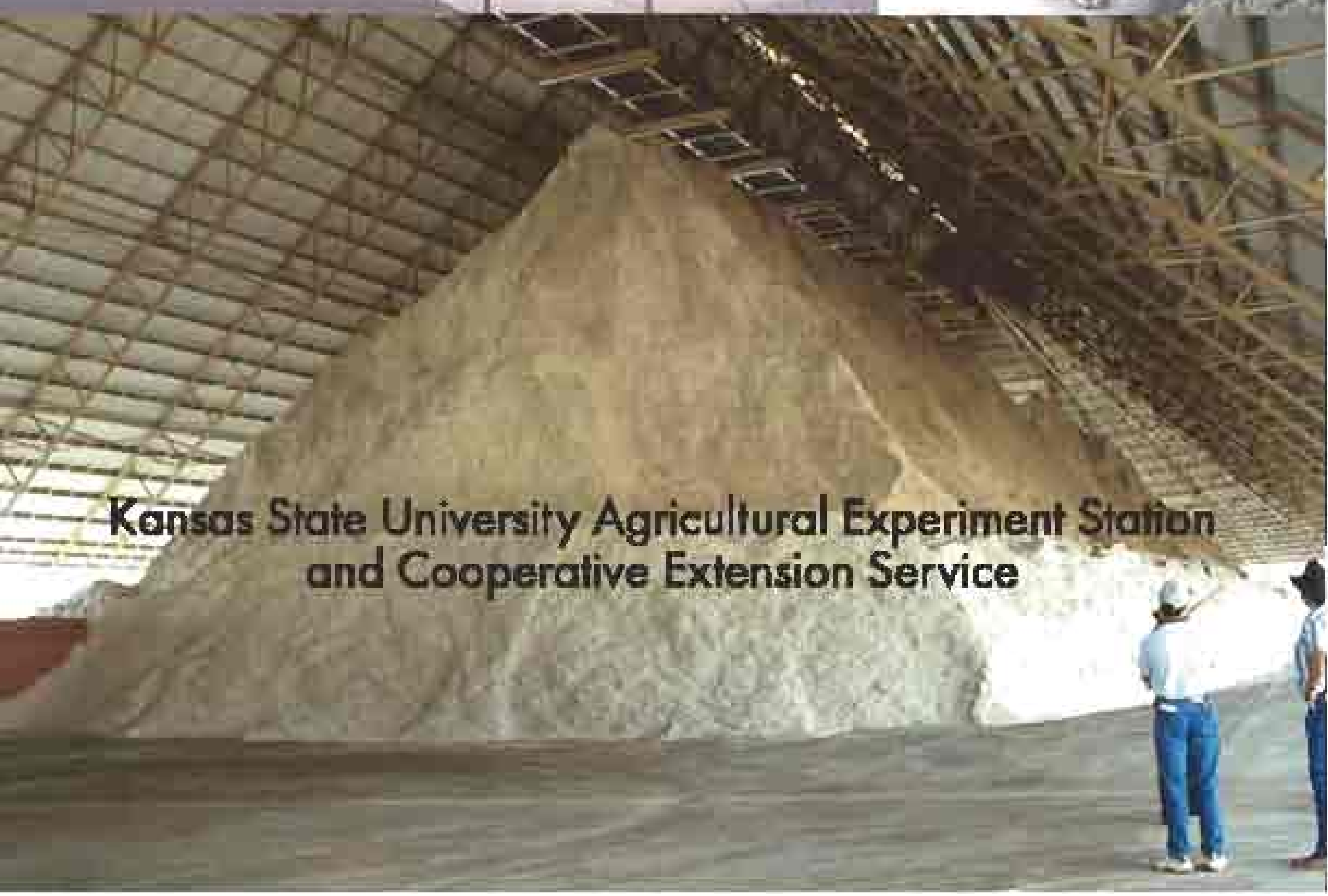

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