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Using Cotton Byproducts in Beef Cattle Diets

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Introduction

Winter feeding accounts for about 40 percent of yearly brood cow maintenance costs. Hay is the primary wintering feed source for beef cattle, but feeding crop residues has long been a way to reduce these costs. For example, cattle can eat many cotton production byproducts that remain in the field after harvest, including cottonseed, cottonseed meal, cottonseed hulls, gin trash and cotton stalk residue. Cottonseed, cottonseed meal and cottonseed hulls are widely used as feed ingredients in beef cattle diets. Although cattle producers do not commonly use gin trash or cotton stalk residue, they also can be fed as the sole feedstuff or with little supplementation.

Potential as a Feed Source

The southeastern states east of the Mississippi River typically produce 4.5 million acres of cotton each year, with a yield of 1.5 bales per acre. One 480-pound bale of cotton also yields approximately 740 pounds of seed and 150 to 200 pounds of cotton gin trash, which can be used in beef cattle diets. Cattle located near cotton fields can also graze cotton stalk residue after the harvest if temporary fencing is constructed. In cotton-producing areas, these are excellent alternatives for cattle producers to lower production costs by feeding cotton byproducts.

Nutrient Composition

The nutrient composition of cotton byproducts is listed in Table 1.

Table 1. Nutrient composition of cotton byproducts (dry matter basis).

Nutrient	Whole Cottonseed	Cottonseed Meal	Cottonseed Hulls	Gin Trash
Dry matter, %	92.0	92.0	91.0	90.0
Crude protein, %	23.0	46.1	4.1	11.7
TDN, %	95.0	75.0	42.0	46.6
NEm (mcal/lb)[a]	1.08	0.81	0.31	0.38
NEg (mcal/lb)[a]	0.76	0.53	0.07	0.13
Fat, %	17.5	3.1	1.7	----
Ash, %	5.0	7.0	2.8	11.1
Calcium, %	0.16	0.16	0.15	0.9
Phosphorus, %	0.75	0.76	0.09	0.2
Potassium, %	1.2	1.22	0.87	1.45
Magnesium, %	0.35	0.35	0.14	0.2
Sulfur, %	0.26	0.26	0.09	----
Copper, ppm	54.0	53.9	13.0	67.3
Iron, ppm	151.0	160.0	131.0	963.0
Manganese, ppm	10.0	12.2	119.0	0.26
Sodium, ppm	0.03	0.03	0.02	121.0
Zinc, ppm	37.7	68.0	22.0	30.3

[a] NEm and NEg = Net Energy for maintenance and Net Energy for gain, respectively.

Whole cottonseed is used as a protein and energy source, although its use is limited due to high fat content (17.5 percent) and the potential for gossypol toxicity. The energy content of whole cottonseed is primarily derived from the oil.

Cottonseed meal is used as a protein source and does not generally make up more than 15 percent of the diet (dry matter). Both whole cottonseed and cottonseed meal are good sources of phosphorus and contain approximately twice the amount recommended for beef cattle diets.

Cottonseed hulls are used primarily as a roughage source in grain-based diets; use is limited by low energy content.

Gin trash is used as a roughage source in grain-based diets and can supply a portion of the energy needs for cattle with low nutrient requirements.

The calcium level of cotton byproducts is low and should be supplemented in a free choice mineral mix along with trace mineral salt.

Whole Cottonseed

Whole cottonseed is a unique feed because it can supply protein, energy and fiber. Whole cottonseed is an excellent supplement to poor quality grass hay for dry and lactating cows because it supplies both energy and protein in a single feed ingredient. Use cottonseed in the diets of cows and stocker calves, but do not feed it to young, pre-ruminant calves.

Each pound of cottonseed will provide 0.2 pounds of crude protein and 0.87 pounds of TDN on a dry matter basis. Include up to 7 pounds per day in mature cow diets to provide 1.5 pounds of supplemental crude protein and 6.1 pounds of TDN. Whole cottonseed provides sufficient supplements for lactating cows fed a diet containing hay that is at least 9 percent crude protein and 50 percent TDN. If supplementation is required beyond 7 pounds per day, then other feeds must be blended with the cottonseed.

Research in Georgia showed that lactating cows fed average quality bermudagrass hay had equal rates of gain when fed either 4.7 pounds of whole cottonseed per day or 4 pounds of corn and 1.5 pounds of

soybean meal per day. With prices of $120 per ton for cottonseed, $100 per ton for corn and $300 per ton for soybean meal, supplemental feed costs were $0.28 per day for cottonseed supplemented cows and $0.43 per day for cows supplemented with corn and soybean meal. Conduct a forage analysis to accurately determine the amount of cottonseed needed to meet the cows' protein and energy requirements.

Whole cottonseed's high fat content is the primary limiting factor for inclusion in beef cattle diets. Supplementing cottonseed at the maximum recommended feeding rate (7 pounds per day) will provide 1.1 pounds of supplemental fat, which is the maximum amount that should be fed to prevent significant reduction in fiber digestion.

The fat in whole cottonseed has also been shown to improve reproductive performance. Fat is a precursor to reproductive hormones, and increases these hormones in the blood. Higher levels of reproductive hormones may improve pregnancy rates and reduce calving interval. This effect is greatest in cows with a body condition score of less than 5.

Stocker calves should consume less whole cottonseed than mature cows, since whole cottonseed intake exceeding 15 percent of diet dry matter decreases stocker calf feed intake, daily gains and feed efficiency. A research trial in North Carolina showed a reduction in daily gains of 0.2 pounds when steers were fed a corn silage-based diet containing 24 percent cottonseed, compared with 24 percent of a corn-soybean meal mix. A feedlot study in Texas also showed a slight reduction in daily gain of 4 percent and a 10 percent reduction in feed efficiency when whole cottonseed was fed at 15 percent of diet dry matter in a 90 percent concentrate diet. If needed, additional supplemental protein can be derived from soybean meal, another high protein byproduct feed or urea.

Feeding Methods

Hand feeding whole cottonseed in a trough each day prevents over-consumption and is the most ideal method of feeding. Provide at least 2 feet of bunk space per cow so all cows will be able to eat at the same time.

In dry weather, whole cottonseed may be fed on sod under a temporary electric fence with little wastage.

Once cattle are adapted to whole cottonseed, some producers feed cottonseed in a self-feeder. On average, cattle may eat recommended daily amounts; however, individual animal intake is highly variable. Poor quality feed may greatly increase intake. One study reported an intake of 14 pounds of cottonseed per day when self-feeding first-calf heifers. If intake from self-feeders is greater than recommended feeding rates, limiting intake to avoid overeating and providing another source of feed to reduce risk of poor performance and possible reproductive losses would be most economical.

Do not feed whole cottonseed in self-feeders with a V shape because the cottonseed will bridge in the feeder.

Take care when self-feeding bulls because they may eat more than the recommended rates, resulting in possible reduced fertility due to excessive gossypol intake.

Storage and Handling

There is no advantage to cracking or grinding whole cottonseed, and it should be fed whole. Do not store cottonseed in a grain bin since it is very bulky and will not flow through an augur system. Whole cottonseed is most easily handled with a scoop or front-end loader.

Protect whole cottonseed from rain, and store it under a shelter that provides good ventilation to prevent moisture accumulation and mold. Do not feed moldy seed; it may contain aflatoxins, which are toxic to cattle.

Cattle producers with large operations should consider building a commodity shed with a concrete floor to store cottonseed and other byproducts. Small producers can pick up cottonseed directly from the gin and store it in a peanut wagon or any type of gravity flow wagon. The wagon can then be placed near the feeding area and the required amount scooped into a trough each day.

Cottonseed Meal

Cottonseed meal is a common source of protein in beef cattle diets and is usually cheaper than soybean meal. Cottonseed meal contains 45 percent protein on a dry matter basis and is an excellent source of supplemental phosphorus (1.2 percent). Soybean meal has about 17 percent more protein than cottonseed meal; however, it is often 25 to 35 percent more expensive than cottonseed meal. Cottonseed meal also has similar rates of protein degradability as soybean meal and can replace the soybean meal in most diets, except for young calves under 4 months of age. An alternative protein source should be fed to these calves.

Cottonseed meal is often mixed with salt in a 2:1 ratio and fed as a protein supplement to mature cows. Intake of this mix will be approximately 3 pounds per day. In addition, cottonseed meal can be mixed with salt and fed as a high protein creep feed to nursing calves. The creep feed supplement should contain approximately 8 to 10 percent salt. It may be necessary to mix only 2 to 3 percent salt to encourage calves to eat the feed initially.

Cottonseed Hulls

Cottonseed hulls are a very high fiber, poorly digested feedstuff used primarily as a roughage source in grain-based, high concentrate diets and as an intake regulator of high grain diets fed in self-feeders. The low bulk density of cottonseed hulls usually confines the use of this feedstuff to areas surrounding production plants or for special uses, such as a roughage source in rations for show cattle.

Cottonseed hulls are very low in crude protein, phosphorus and calcium. They are highly palatable to cattle and have been shown to stimulate intake in young cattle fed grain-based diets.

Cottonseed hulls are usually fed at 25 to 50 percent of the diet, depending on desired performance level. They can be the sole source of roughage in feedlot diets, and they have been shown to be as effective as alfalfa hay in feedlot diets when fed at half the level of alfalfa hay. Because of high levels of NDF (neutral detergent fiber), cottonseed hulls are a more effective source of roughage in high grain diets than alfalfa hay or silages.

Although cottonseed hulls can replace part of the forage in mature cow diets, they are priced relatively high in terms of energy value when compared to most hay and grain products. They are not economical to feed in high dietary amounts to beef cows. Cottonseed hulls should not exceed more than 50 percent of the diet when fed to brood cows.

Grazing Cotton Stalk Residue

Substantial amounts of potential feed residue remain on the cotton plant after harvest, including cotton lint, cottonseed, leaves and burrs. Cotton producers in the Southeast primarily harvest cotton with spindle-type pickers, which leave much more cotton lint, leaves and bolls than stripper-type pickers. Therefore, there is a significantly underused source of available winter feed for cattle with low nutrient requirements. The costs of grazing cotton stalk residue include fencing, water and a mineral supplement.

Dry pregnant cows can be maintained on cotton stalk residue and achieve equal performance to cows fed hay. In a Georgia study, cows were allowed to graze cotton stalks, and performance and feed costs were compared to cows fed round-baled coastal bermudagrass hay. Performance and body condition score changes are shown in Table 2.

One acre of cotton stalk residue provided feed for one cow for 44 days. Total weight gain was 48 pounds for the cows fed hay and 15 pounds for cows grazing cotton stalks. Because both groups of cows were in good condition, little weight gain was desired. Likewise, body condition was essentially unchanged during the trial for each group. Producers can expect similar performance when feeding mature gestating cows either hay that is at least 8 percent crude protein and 50 percent TDN, or by grazing cotton stalk residue. If the body condition of cows is less than 5, supplemental feed will be needed to increase body condition score.

Table 2. Effects of grazing cotton stalk residue on intake performance and condition score of dry pregnant cows.

Item	Hay	Cotton Stalk Residue
Initial weight, lb.	1359	1359
Final weight, lb.	1407	1374
Weight change, lb.	+48	+15
Initial body condition score[a]	5.5	5.6
Final body condition score	5.7	5.5
Body condition score change	+0.2	-0.1
Hay intake, lb./day	21.2	----
Cotton stalk residue intake, lb./day	----	36.6
Hay savings, $/day[b]	0.90	----

[a] Body condition score of 1 = thin and 9 = fat.
[b] Hay valued at $70 per ton.

Remove cows when they become restless, lose body condition, or when all cotton lint and leaves are eaten. Cows will eat little, if any, of the actual stalk.

Determining Available Residue

In the Georgia study, approximately 4,487 pounds per acre of cotton stalk residue were available for grazing (Table 3).

Table 3. Pounds per acre of cotton stalk residue available for grazing.

Item	Pounds/acre
Initial cotton stalk residue	4487
Final cotton stalk residue	2873
Cotton stalk residue disappearance	1614
Grazing days per acre	44

Cows consumed 1,614 pounds of the residue, which resulted in a use rate of 36 percent. Producers can expect cattle to consume about one-third of the available cotton stalk residue, which can easily be estimated to plan a winter feeding program. The amount of residue available will vary greatly among cotton fields, but some estimates of grazing days available can be made. For example, to determine the amount of residue per acre in a field with 36-inch rows, you can do the following:

1. Cut each stalk in a row to no taller than 1 inch for a distance of 9 feet.
2. Weigh the amount of cotton stalk residue collected.
3. Calculate the amount of square feet harvested. Each section cut was 3 feet wide by 9 feet long, so the total area harvested per sample would be 3 x 9 = 27 square feet.
4. Calculate the amount of residue per square foot. For example, use 3 pounds of residue for the average weight of the 27-square-foot area. Thus, in 27 square feet, there are 3 pounds of residue, or 0.11 pounds per square foot (3 ÷ 27 = 0.11).
5. To determine the amount of residue per acre, you must multiply the number of square feet in an acre by the pounds of residue per square foot (43,560 ft2 x 0.11 = 4,792 pounds of residue per acre).
6. Determine total feed residue available per acre for grazing. With a utilization rate of 33 percent, the expected residue available per cow is 1,581 pounds (4,792 pounds x 0.33 = 1,581 pounds).
7. Determine the number of days 1 acre will supply grazing for one cow. Assume a cow will use 2.7 percent of her body weight per day in available cotton stalk residue; thus, a 1,200-pound cow would use 32.4 pounds per day (1,200 x .027 = 32.4 pounds). Next, divide the total pounds of available residue by 32.4 to determine the number of days 1 acre of residue would supply feed for the 1,200-pound cow (1,581 ÷ 32.4 = 48.8 days).

The general rule of thumb is that 1 acre will maintain a cow for 30 days. In this study, 1 acre maintained a cow for 44 days. Grazing days will vary greatly from field to field and from year to year.

Some producers have had success providing free-choice hay while grazing cows on cotton stalk residue, and using the hay consumption as a guide for when to remove cows from the cotton stalk residue. As mentioned previously, remove cows when no cotton lint or leaves are available for grazing. Cattle will consume little hay if sufficient cotton stalk residue is available.

Some potential problems can occur when grazing cotton stalk residue. The Georgia study was done with dry pregnant cows, and results should not be applied to lactating cows. Lactating cows will likely need supplemental energy and/or protein if grazed on cotton stalk residue. Bulls may have reduced fertility because of the gossypol toxicity. To be safe, do not allow bulls to graze cotton fields.

Grazing Mowed Stalk Residue

Most cotton producers prefer to mow cotton stalks soon after harvest, in part to comply with boll weevil eradication programs. The residue, however, may be trampled or deteriorate more rapidly than standing cotton stalk residue. One Georgia study compared the number of grazing days between standing cotton stalk residue and residue mowed prior to grazing.

The cows were allowed to graze 10 acres of standing cotton stalk residue or 10 acres of mowed cotton stalk residue for a total of 30 days. Total weight gain was 56, 55 and 32 pounds for cows consuming hay, standing cotton residue and mowed cotton residue, respectively (Table 4). Total hay fed per day to each group during the trial was 27, 1.3 and 10.7 pounds for cows consuming hay, standing cotton residue and mowed cotton residue, respectively. Savings from reduced hay feeding were $0.90 per day for cows grazing standing cotton stalk residue and $0.58 per day for cows grazing mowed cotton stalk residue.

Mowing cotton stalk residue prior to grazing reduced grazing days per acre by 35 percent compared with grazing standing cotton stalk residue. Therefore, producers should expect about one-third fewer grazing days per acre when grazing mowed versus standing cotton stalk residue. The mowed cotton stalk residue, however, substantially reduced feeding costs compared with feeding hay free choice.

Table 4. Performance and hay requirement of cows fed hay, standing cotton residue or mowed cotton residue.

Item	Hay	Standing Residue	Mowed Residue
Initial weight, lb.	1,354	1,369	1,354
Final weight, lb.	1,410	1,424	1,386
Weight gain, lb.	56	55	32
Hay fed, lb/day	27.0	1.3	10.7
Hay savings, $/day	----	0.90	0.58

[a] Hay valued at $70 per ton.

Gin Trash

Each 480-pound bale of cotton produces approximately 150 to 200 pounds of gin trash. The gin trash itself is usually free, and the only costs are those associated with transporting it from the gin and storing it at the feeding site. The total amount of gin trash produced in states east of the Mississippi River totals 500,000 to 700,000 tons, which could potentially feed 300,000 to 400,000 cows for 100 days with little additional supplement.

Nutrient composition of gin trash varies greatly, as does the success of gin trash feeding programs. Gin trash averages approximately 11 percent crude protein, 11 percent ash, 41 percent crude fiber, 46 percent total digestible nutrients, 0.9 percent calcium and 0.2 percent phosphorus (Table 1). Moisture content will vary with cotton gin management. Some gins wet the gin trash to reduce dust problems, but wetting also can lead to molding and reduced palatability. In addition, some molds can be toxic to cattle. If it's stored prior to feeding, protect gin trash from the weather. Because of the wide range in nutrient content, a nutrient analysis is essential to properly design a feeding program using gin trash.

Cotton gin trash has a low bulk density and is expensive to transport. An alternative to reduce transportation costs is to put the gin trash into cotton modules and transport the modules or bales of gin trash to the producer. The modules of gin trash can be fed by placing an electric fence wire in front of the module to restrict access and decrease waste. Work in North Carolina has shown that cows will use approximately 75 percent of the gin trash fed this way.

Researchers in Georgia have tried to improve gin trash digestibility through chemical processing and composting; however, composting gin trash reduced digestibility and is not recommended. Treating gin trash with urea or ammonium hydroxide resulted in improved in vitro dry matter digestibility of 6 percent and 21 percent, respectively. Only small differences in digestible energy intake were realized with these chemical treatments due to low digestibility of unprocessed gin trash. Although chemical treatment of cotton gin trash shows some promise, a practical and economical system has not been developed.

Feeding Gin Trash to Cows

Gin trash is best used in diets of dry pregnant cows. Cows have the lowest nutrient requirements of any class of animals and can be maintained on diets containing high levels of gin trash. If cows are in a body condition score of 5 or greater, then they need to maintain body weight and condition score. Gin trash is generally lower in digestibility than bermudagrass hay and may require supplementation even when feeding dry cows. A study comparing the feeding of gin trash alone or with 3 pounds per day of cracked corn is shown in Table 5. Cows were able to maintain body weight only when fed supplemental corn. Gin trash used in this study was 13.6 percent crude protein and 39 percent TDN. Requirements of cows used in this study were 8 percent crude protein and 48 percent TDN.

Gin trash is initially unpalatable to cattle, and cows may take several days to adapt to and consume the gin trash at acceptable levels. In addition, high amounts of soil contamination will decrease palatability. Closely monitor intake and adjust supplemental feeding accordingly.

Table 5. Performance, feed intake and feed costs of dry pregnant cows fed gin trash.

Item	Gin Trash	Gin Trash + 3 lb/day Corn
Initial weight, lb.	1215	1215
Final weight, lb.	1198	1217
Daily gain, lb. per day	-0.30	+0.04
Initial body condition score[a]	4.9	4.6
Final body condition score	4.3	4.4
Gin trash intake, lb. per day	32.0	33.0
Feed cost, $/d[b]	0.32	0.48

[a] Body condition score of 1 = thin and 9 = fat.
[b] Feed cost calculated using gin trash at $20 per ton and corn at $100 per ton.

Cows are unlikely to need additional protein supplementation with gin trash, but an energy supplement will usually be required. Energy supplements can include high quality hay, winter pasture, silage, corn, soybean hulls, sorghum, corn gluten feed, wheat middlings and other grain, and byproduct feed sources. Feeding free-choice gin trash plus a liquid supplement may cause weight loss in dry pregnant cows. Liquid supplements primarily provide supplemental protein and may not supply enough energy to maintain cow weight. In addition, young cows have higher nutritional requirements than older, mature cows. Do not feed gin trash as the primary feed ingredient until cows are pregnant with their third calf.

Feeding Gin Trash to Calves

Cotton gin trash can be used as a roughage source in feedlot diets. Inclusion rate should be 5 to 10 percent of diet dry matter. Higher rates are not recommended in feedlot diets due to low energy content. Stocker cattle require moderate rates of gain, and research has evaluated cotton gin trash at significant portions of the diet for stocker calves. In a Georgia trial, cotton gin trash was fed at 76, 67, 55 and 43 percent of the diet, with the remainder of the diet being corn. Feeding gin trash at 43 percent of the diet with 57 percent corn dramatically reduced diet digestibility compared with other diets. Stocker calves need to gain at least 1.5 pounds per day to be profitable. It is unlikely, however, that daily gains of steer calves could be maintained above 1.5 pounds per day on any of the experimental diets because of insufficient energy intake. The only viable use of gin trash for growing cattle appears to be as a roughage source in high concentrate diets.

Gossypol Toxicity

Gossypol is a yellow pigment found throughout the cotton plant, but the highest concentrations are found in the seeds. Gossypol is toxic to cattle if consumed in large quantities. Gossypol exists as two steroisomers, the (+) isomer or the (-) isomer. The minus isomer has the greatest biological activity and is more detrimental to reproduction than the plus isomer. The Upland and Pima varieties of cotton have different levels of these two isomers. The Upland varieties of cotton usually contain less gossypol and a lower percentage of the detrimental minus isomer than Pima varieties. In the Southeast, most of the cotton is an Upland variety, and feeding cottonseed from this region of the United States may be safer in regard to reduced fertility than feeding cottonseed from other regions.

Whole cottonseed and cottonseed meal are the primary sources of gossypol in beef cattle diets. Cottonseed hulls contain very little gossypol, and gin trash will be highly variable depending on its cottonseed content. Because gossypol is digested more slowly when feeding whole cottonseed compared with feeding cottonseed meal, cattle can tolerate higher levels of gossypol when fed whole cottonseed versus cottonseed meal.

The most common concern with gossypol toxicity is reproductive failure of bulls. Although young, developing bulls are more affected than mature bulls, no decline in semen quality was noted when young Brahman bulls were fed a diet that contained 41 percent whole cottonseed. Furthermore, no reported data shows impaired fertility caused by feeding recommended levels of cottonseed or cottonseed meal to bulls. Even feeding twice the recommended level of gossypol has showed little negative effect; however, this would be above practical feeding levels and would reduce growth rates of bulls.

Females appear to be more resistant to gossypol-induced reproductive failure than bulls.

It is unlikely that any negative consequences to reproduction or health will occur when feeding cottonseed and cottonseed meal at recommended levels. Although gossypol can cause death in cattle, the amount needed is far above recommended feeding levels and is unlikely to occur.

Chemical Residues in Cotton Byproducts

Chemical residues are often a concern when feeding gin trash or grazing cotton stalk residues. Many of the chemicals used in cotton production are not cleared for use on feedstuffs consumed by cattle.

Arsenic is no longer used in cotton defoliants and is no longer a concern when feeding cotton byproducts. A Georgia study evaluated cotton gin trash for evidence of residue from pesticides used during cotton production. The only residue found was tribufos (DEF), which is a commonly used defoliant. The average level found was 4.49 ppm, which is a low level. The tolerance for DEF in whole cottonseed is 4 ppm and in cottonseed hulls is 6 ppm. Feeding gin trash does pose liability issues because tolerance levels for chemical residues have not been established.

Summary

Cotton byproducts offer a variety of feed ingredients that can lower the cost of beef cattle production. Cottonseed meal and whole cottonseed can be used in rations for any class of cattle. Gin trash and cottonseed hulls are low-energy feedstuffs that are used as a roughage source in high energy diets or as a partial energy replacement in mature cow diets. Cotton stalk residue can maintain a dry pregnant cow and will provide enough grazing for approximately 1 month if left standing or for three weeks if mowed prior to grazing. A reduction in fertility should not be a concern when recommended feeding rates are followed.

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