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Cotton gin byproduct: Effects on feed intake, quality, and safety for use in diets of gestating beef cows*

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ABSTRACT

Objective: The effects of cotton gin byproduct processing and feed safety characteristics are not well defined in beef cattle systems. Our objective was to determine the effects of feeding loose or baled cotton gin byproduct on animal performance and safety of use in beef cattle diets.

Materials and Methods: Twenty-four nonlactating, crossbred cows and heifers (average BW = 613 ± 77 kg) were assigned to 1 of 2 treatments: *ad libitum* (1) baled cotton gin byproduct or (2) loose cotton gin byproduct. Animal BW and BCS were collected at d 0, 30, and 60 of the study. Jugular blood samples were collected weekly during the trial and again at 30 and 60 d after the study to monitor hematologic responses due to consumption of cotton gin byproduct containing defoliant residue (4.84 and 1.98 mg/kg tribufos for baled and loose, respectively).

Results and Discussion: Cattle consuming loose cotton gin byproduct had greater ($P < 0.0001$) daily DMI (2.0% of animal BW) than those consuming baled byproduct (1.8% of animal BW). Cattle gained BW and maintained BCS across treatments during the study. White and red blood cell count, hematocrit, and hemoglobin concentrations were within the acceptable range for normal health conditions in beef cattle, and animals displayed no clinical symptoms of altered neurological status due to consuming gin byproduct.

Implications and Applications: Results indicate that cotton gin byproduct in either loose or baled form can be used to maintain nonlactating, bred cows with additional supplementation during a short-term feeding period (60 d).

Key words: cotton byproducts, cotton gin trash, cotton burrs, beef cattle

INTRODUCTION

Cotton gin byproduct consists of leaves, soil, stems, boles, burs, lint, and cottonseed leftover from the cotton ginning process (Myer, 2007). It is sometimes referred to as cotton burrs, cotton gin trash, or gin trash waste product and generally has nutritive value characteristics similar to low-quality hay (Mullenix and Rankins, 2014). Beef cow-calf operations in the Southeast United States occasionally use cotton gin byproduct for winter feeding programs or during times of drought or forage-availability deficits (Rogers et al., 2002). Most cotton gins store gin byproduct outdoors in large, open-faced stacks where it is exposed to weather conditions at the gin, which may alter gin byproduct quality depending on the length of storage (Mullenix and Rankins, 2014). Some gins have begun compacting gin byproduct into rectangular bales using the same press as for cotton (0.6 m × 0.6 m × 1.8 m) with an average target weight of 227 kg. Bales are bound with plastic lashing strips to preserve the structure of the bale and facilitate transport, handling, and storage for beef cattle producers. Baling gin byproduct increases its bulk density to approximately 593 kg/m^3 compared with 160 kg/m^3 for loose gin byproduct. Bulk packaging of gin byproduct may add value to a traditionally limited-use cotton byproduct through increased accessibility to beef cattle producers. Beef cattle farmers and selected cotton gins in Alabama periodically submit feed samples for basic nutrient analysis to the Auburn University Soil, Forage, and Water Testing laboratory. A review of the Auburn University database (n = 18 baled gin byproduct samples from 2018 and 2019) revealed that feed nutritive value aspects from a limited number of baled gin byproduct samples presented greater CP values (12.8 vs. 9.6% CP, SE 0.71) than loose gin byproduct (n = 34 samples) and a variable range of values for fiber fractions and ash, which

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generated Extension questions from beef cattle farmers regarding whether bale processing alters feed value of this product on farm (Auburn University Soil Testing Laboratory, 2020).

Potential residues from pesticides, herbicides, or harvest-aid chemicals are of possible concern for animal health and consumer perceptions of byproduct use in livestock diets (Smith, 2020). In addition to feed quality aspects of cotton gin byproduct, defoliant residue threshold values have not been defined for cotton gin byproduct. Stewart and Rossi (2010) reported that average residue concentrations found in cotton gin byproduct (4.49 mg/kg) were similar to tolerable concentrations for whole cottonseed (4.0 mg/kg) and cottonseed hulls (6.0 mg/kg). Understanding the safety and efficacy of using cotton gin byproduct in beef cattle diets will enable further refinement of current feeding recommendations for this byproduct in beef cow-calf operations.

The objective of this study was to determine the effects of cotton gin byproduct form (loose or baled) on animal performance and safety of use in beef cattle diets.

MATERIALS AND METHODS

Care and Use of Animals

A feed intake trial was conducted at the Auburn University Beef Cattle Evaluation Center, Auburn, Alabama, to determine overall consumption and performance of beef cows consuming cotton gin byproduct. All experimental procedures were reviewed and approved by the Auburn University Institutional Animal Care and Use Committee (2020-3811).

Gin Byproduct Intake Trial

Sixteen crossbred, nonlactating, gestating cows (average BW = 646 kg) and 8 crossbred, gestating heifers (average BW = 516 kg) were stratified to 1 of 2 groups according to BW that consisted of 8 cows and 4 heifers per group. Cattle were transported to the Auburn Bull Test and Evaluation Center and trained to the Calan Gate system (American Calan Inc.) in preparation for collecting individual-animal intake measures. Cattle were allowed *ad libitum* access to bermudagrass–bahiagrass hay and received 2.2 kg per head per day of a 50:50 mixture of corn gluten feed and soyhull pellets (**50:50 SH:CGF**; J and R Feed Services Inc.) in open bunks that were observed each morning to determine which bunk each cow had frequented for the first 7 d. On d 8 of training, cattle were assigned a magnetic collar to open the gate that was frequented, and the Calan Gate system was activated to allow cattle to learn to open the allotted gate. On d 9 through 14 of training, cotton gin byproduct was added at morning feeding to acclimatize cattle to the palatability and texture of the byproduct feedstuff and access to hay was restricted. Following the training and acclimation period, each group was assigned to receive *ad libitum* baled cotton gin byproduct or *ad libitum* loose cotton gin byproduct for a 60-d feed intake trial.

Gin byproduct was obtained from 2 different cotton gins in Alabama during the study. Two sources of cotton gin byproduct were used because gins that have adopted the use of baling their gin byproduct primarily exclusively market gin byproduct using this mechanism and no longer stack loose byproduct. The number of cotton gins in Alabama baling gin byproduct is limited in number (n = 3 of 29 active gins), whereas loose gin byproduct is still more abundant in availability. Loose gin byproduct was thus acquired from the closest ginning facility to the Auburn University Beef Cattle Evaluation Center for the purpose of the study. Baled cotton gin byproduct was obtained from the Henry County Gin LLC. Both sources of gin byproduct originated from cotton ginned during the 2020 production season. Baled cotton gin byproduct was produced by compressing loose gin byproduct into modules approximately 0.6 m × 0.6 m × 1.8 m and binding them with plastic lashing strips. Following baling, bales were immediately transported to the Auburn University Beef Cattle Evaluation Center and stored outside, on the ground covered with a plastic tarp. Loose cotton gin byproduct was obtained from Milstead Farm Group Inc. The loose cotton gin byproduct was obtained from an outdoor stack from the 2020 production season and transported to the Auburn University Bull Test and Evaluation Center. Loose gin byproduct was stored under shelter on a concrete pad to minimize waste and allow easier access for feeding. Loads of gin byproduct were obtained every 2 wk during the feeding trial (n = 4 loads during the duration of the study). In addition to gin byproduct, all cattle received 2.2 kg per head per day of a 50:50 mixture of corn gluten feed and soyhull pellets at morning feeding to meet target energy requirements for their respective stage of production based on nutrient requirement tables published by the NASEM (2016) and gin byproduct feed nutritive value analysis. Orts were weighed each morning and recorded. Cow BW and BCS (scale 1–9, where 1 = emaciated and 9 = obese; Richards et al., 1986; Wagner et al., 1988) were recorded at d 0, 30, and 60 during the trial.

Gin Byproduct Quality Analyses

Samples of both baled and loose cotton gin byproduct were collected weekly for nutritive value analysis at the Auburn University Soil, Forage and Water Testing Laboratory (Auburn, AL). Concentrations of CP and DM were determined according to procedures of AOAC International (2019), and concentrations of NDF and ADF were determined sequentially according to procedures of Van Soest et al. (1991). Concentrations of ash were determined via combustion in a muffle furnace at 500°C (AOAC International, 2019). Additional samples of both baled and loose cotton gin byproduct were collected every other week and sent to Waters Agricultural Laboratories Inc. (Camilla, GA) for herbicide and pesticide residue analysis. Samples were evaluated for potential residue concentrations from 30 general herbicide chemistries and postharvest aids, 9 organophosphate pesticides, 11 phenoxy herbicides, and 20 chlorinated pesticides using gas chromatography with an electron capture detector. The following herbicides and postharvest-aid residues were screened for: alachlor, atrazine, benfluralin, bromacil, butachlor, butylate, cycloate, EPTC, ethalfluralin, glyphosate, hexazinone, isopropalin, metolachlor, metribuzin, molinate, norflurazon, oxadiazon, oxyfluorfen, pebulate, pendimethalin, prodiamine, profluralin, prometon, propachlor, propazine, simazine, terbacil, tribufos, trifluralin, and vernolate. Organophosphate pesticides analysis included carbophenothion, diazinon, chlorpyrifos, ethion, methyl parathion, malathion, parathion, and tetrachlorvinphos. The phenoxy herbicide screen included 2,4,5-TP; 2,4,5-T; 2,4-D; 2,4-DB, dicamba, dichlorprop, dinoseb, MCPA, MCPP, picloram, and trichlopyr. Chlorinated pesticides analyzed were 4,4′-DDD, 3,3′-DDE, 4,4′-DDT, aldrin, α-BHC, α-chlordane, β-BHC, delta-BHC, dieldrin, endosulfan I, endsulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, gamma-BHC, gamma-chlordane, heptachlor, heptachlor epoxide, and methoxychlor. Mean nutritional and residue values detected for both baled and loose gin byproduct used during the feeding trial are presented in Table 1.

Gin Byproduct Feed Safety Monitoring

Blood samples were collected weekly from cattle during the gin byproduct feeding trial and again at 30 and 60 d after study removal to monitor hematologic response to cotton defoliant organophosphate residue exposure. Following the feeding trial, cattle were allocated to annual ryegrass pastures and continued to be supplemented with the 50:50 SH:CGF feed mixture until early summer. Blood was collected weekly from the jugular vein using a vacutainer system consisting of a 10-mL EDTA blood collection tube (BD Vacutainer), Vacutainer needle holder, and an 18-gauge, 3.8-cm Vacutainer needle (VWR). Blood samples were processed by the Auburn University College of Veterinary Medicine Clinical Pathology Laboratory (Auburn, AL) and analyzed for complete blood counts. Red blood cell count, hemoglobin, hematocrit, and white blood cell count were analyzed across treatments, day of measure, and their interaction. Animals were also visually monitored at the time of daily feeding for clinical signs of neurological effects due to the presence of defoliant residue in gin byproduct.

Statistical Analysis

Intake data were analyzed using PROC MIXED of SAS 9.4 (SAS Institute Inc.). Gin byproduct type (loose or baled) was considered the independent variable. Day of measure was treated as a repeated measure, and an independent variable where day or treatment × day of measure is reported. Animal type (cow vs. heifer) was initially included in the model as an independent variable for blood parameter analysis but was nonsignificant. Thus, this variable was removed from the model. Gin byproduct intake trial dependent variables were individual-animal intake, BW, BCS, and blood parameters. Treatment means were separated using the DIFF option of the LSMEANS procedure (SAS Institute Inc.) and were determined to be significant when $P \leq 0.05$.

RESULTS AND DISCUSSION

Intake and Quality of Gin Byproduct and Animal Performance

Cotton gin byproduct intake was greater ($P < 0.0001$) for cattle consuming loose rather than baled gin byproduct. Average daily DMI for cattle consuming loose gin byproduct was 12.2 ± 0.15 kg, whereas average intake for cattle consuming baled gin byproduct was 10.9 ± 0.15 kg. Cattle assigned to the loose gin byproduct treatment consumed approximately 2.0% of BW compared with 1.8% of BW for cattle assigned to the baled gin byproduct treatment on a DM basis. The intake levels observed in the

Table 1. Nutritive value parameters (%, DM basis) and pesticide concentration (mg/kg) of cotton gin byproduct sources used in a beef cattle intake trial[1]

Item	DM (%)	TDN (%)	CP (%)	NDF (%)	ADF (%)	Ash (%)	Tribufos concentration (mg/kg)
Baled gin byproduct	87.6	40.4	13.9	71.5	56.0	10.4	4.84
Loose gin byproduct	79.1	39.1	11.0	74.5	56.6	15.4	1.98
SE	3.95	0.71	1.66	0.75	0.97	1.75	1.01
50:50 SH:CGF[2]	91.7	71.3	17.5	50.0	28.8	—	—

[1]Values represent mean nutritive value for composite samples per batch of gin byproduct (n = 4 batches) during the study.

[2]50:50 SH:CGF = a 50:50 mixture of corn gluten feed and soyhull pellets.

present study were lower than the estimated DMI (12.8 kg or 2.0% of BW) of cattle of similar size and production stage as reported by the NASEM (2016).

There are relatively few published studies evaluating cow performance using cotton gin byproduct, especially where DMI was measured or where gin byproduct is used as the primary ingredient in the diet for meeting nutritional requirements in beef cattle. Hill et al. (2000) conducted a study on feeding cotton gin byproduct to 24 nonpregnant beef cows for 55 d. Diets consisted of free-choice cotton gin byproduct alone or free-choice cotton gin byproduct supplemented daily with 1.36 kg/d corn. The authors reported an average DMI of 12.7 kg per head for dry brood cows consuming cotton gin byproduct alone during the feeding trial. These findings are similar to the loose gin byproduct intake of the present study. In the trial by Hill and others, intake of cotton gin byproduct was low during the first 10 d of the trial but increased rapidly thereafter. In the current study, no decrease in intake was observed during the first 10 d of the trial, likely due to the inclusion of gin byproduct throughout the training period to the Calan Gate system.

No differences were observed in initial, final, or mean cow BW during the 60-d feeding period for loose or baled gin byproduct feeding treatments (Table 2). Although BW values were not statistically significant, there was a numerical increase in cow BW gain across both gin byproduct feeding treatments, which likely corresponds with increased fetal growth during mid to late gestation (Putnam and Henderson, 1946; Bohnert, et al., 2013). Both treatments, loose and baled, were able to maintain cow BW and condition appropriate for stage of production throughout the duration of the study when supplemented daily with 50:50 SH:CGF. Hill et al. (2000) noted that daily supplementation with 1.36 kg/d corn was needed to support maintenance and marginal gain (0.02 kg/d) in nonpregnant beef cows when feeding loose gin byproduct in a 55-d feeding study. Sagebiel and Cisse (1984) conducted a series of cotton gin byproduct feeding trials with gestating beef cows in a similar stage of pregnancy as the current study. Trials ranged from 56 to 90 d in length and assessed cow BW gain when cotton gin byproduct was fed at varying levels of inclusion in the diet along with sorghum silage, molasses, or whole cottonseed. Cow BW increased across the feeding period when supplemented with sorghum silage or whole cottonseed compared with feeding cotton gin byproduct alone.

There were no treatment, day, or treatment × day interaction effects for beef cow BCS when cows were fed loose or baled gin byproduct ($P \geq 0.05$). Cows receiving baled gin byproduct had a greater BCS ($P = 0.017$) than those consuming loose gin byproduct (Table 2). Despite differences in BCS between treatments, all cattle maintained a desirable and recommended level of BCS (Richards et al., 1986) before entering the calving period regardless of dietary treatment. Rogers et al. (2002) reported the use of cotton gin byproduct as an option for wintering dry beef cows in North Carolina during the last 60 d before calving. Over a 2-yr evaluation, dry, mature beef cows were provided access to limit-grazed gin byproduct modules and supplemental hay (4.5 kg/d) or hay fed *ad libitum*. Mature cows on the cotton module–hay treatment gained weight and maintained BCS during the first year. In the second year, cows fed cotton gin byproduct were offered additional energy supplementation from whole cottonseed and gained both BW and BCS (Rogers et al., 2002).

Gin byproduct used in the present study had an average of 40% TDN, 12.5% CP, 73% NDF, 56% ADF, and 12.9% ash across gin byproduct processing strategies (loose or baled) on a DM basis (Table 1). Griffin (1976) noted that gin byproduct combustible energy value and ash content varied significantly in ginned cotton residue depending on harvest machinery, type of cotton grown, and gin processing methods. Stewart et al. (1998) collected gin byproduct samples from various gins (n = 28) in Georgia that represented differing harvest seasons, date of ginning, and storage methods. Average DM, TDN, and CP were 79.5%, 46.6%, and 11.7%, respectively. Ozkan et al. (2014) reported CP values of 6.6 to 12.4% in extruded cotton gin byproduct produced from 5 feed companies in Turkey. The authors also observed a range of 8.9 to 15.5% for ash, 49.2 to 62.2% NDF, and 40.7 to 48.3% ADF for gin byproduct collected from these processing facilities as well. Total digestible nutrients of gin byproduct may often be lower than warm-season perennial grasses, but CP concentrations of gin byproduct are often similar to or greater than these forage species (Mullenix and Rankins, 2014). Loose gin byproduct in the present study contained less CP and greater NDF and ash than baled gin byproduct, although predicted TDN value was similar between the 2 (Table 1).

Table 2. Body weight change and BCS in mid- to late-gestation beef cows fed loose or baled cotton gin byproduct[1] in a 60-d feeding trial

Item	d 0	d 30	d 60	d 0 to 60 mean[2]
BW (kg)				
Baled	603	618	621	614
Loose	602	613	623	613
SE	23	23	23	13
BCS				
Baled	6.5	6.6	6.3	6.5[a]
Loose	6.1	6.3	6.0	6.1[b]
SE	0.2	0.2	0.2	0.1

[a,b]Within a column, BCS means without common superscripts differ ($P < 0.05$).

[1]Treatments included daily feeding of compressed bales or loose gin byproduct to beef cattle.

[2]Mean values represent the average values for BW and BCS across d 0 to 60 of the feeding trial.

Table 3. Complete blood count measures from mid- to late-gestation cows fed loose or baled cotton gin byproduct from d 0 to d 60 of a feeding trial

Treatment[1]	Red blood cell count	Hemoglobin (g/dL)	Hematocrit (%)	White blood cell count
Baled	7.1	11.9	33.3	8.3
Loose	7.1	12.2	33.9	8.0
Mean	7.1	12.1	33.6	8.1
SE	0.14	0.15	0.32	0.24
Tolerable range[2]	5.0–10.0	8.0–15.0	24.0–46.0	5.0–10.0

[1]Treatments included daily hand feeding of compressed bales or loose gin byproduct to beef cattle.

[2]Reference ranges defined through assays and database generation through the Auburn University College of Veterinary Medicine Clinical Pathology Laboratory (Auburn, AL).

Although nutritive value characteristics of loose gin byproduct were lower than those of baled cotton gin byproduct, one potential difference in increased intake observed for loose gin byproduct may be due to the physical form of gin byproduct at feeding. Baled gin byproduct was physically separated into flake-like sections at the time of feeding. Sections allocated to feed bunks remained relatively compressed in nature, whereas loose gin byproduct had greater volume but less bulk density in bunks at the time of feeding. This may in part alter animal intake observed for loose versus baled gin byproduct.

As noted in previous research trials described herein, beef cow-calf operations in the Southeast United States sometimes use gin byproduct as an alternative to low-quality warm-season perennial grass hay (Mullenix and Rankins, 2014). Voluntary intake of bermudagrass hay has been reported to range from 1.6% of BW to upwards of 2.9% BW, depending on animal stage of production, forage variety, nutritive value, and supplementation strategy (Galloway et al., 1993; Cabral et al., 2006; Burns, 2011). With decreasing forage nutritive value characteristics, intake potential of warm-season perennial grasses is more limited (Moore et al., 1999), and low-quality warm-season grass intake potential is similar to gin byproduct intake reported in the present trial. Lemus et al. (2020) summarized nutritive value from hay samples from various warm-season grass species submitted to the Louisiana State University Forage Laboratory from 2006 to 2014. Average bermudagrass TDN and CP (n = 594 samples) was 54.4% TDN and 10.6% CP, whereas bahiagrass (n = 306) was 50.1% TDN and 8.3% CP. Stage of maturity at the time of harvest influences forage nutritive value characteristics, and these data demonstrate low to moderate quality of warm-season perennial grasses often produced in the US Southeast region.

No detectable concentrations of herbicide or pesticide residues were reported in samples submitted for chemical profiling with the exception of S,S,S-tributyl phosphorotrithioate (tribufos), which is a chemical defoliant used as a harvest aid in cotton production systems. Baled gin byproduct had a tribufos concentration of 4.84 mg/kg, whereas loose gin byproduct contained 1.98 mg/kg. These residue levels are similar to those reported for defined parameters in other cotton byproducts, where tolerance levels have been defined in whole cottonseed (4 mg/kg) and cottonseed hulls (6 mg/kg; Stewart and Rossi, 2010).

Previous feeding trials, along with the present study, indicate that cotton gin byproduct alone may be unable to support maintenance requirements for nonpregnant or gestating beef cows when used as a roughage replacement in the diet. These studies illustrate various strategies for using cotton gin byproduct as a way to replace or extend hay use in diets, where animal performance responses were more adequately supported when energy and protein supplementation is provided in dry cow diets. Feed nutritive value analyses and subsequent development of strategic supplementation approaches given the animal production goals are needed for application in beef cow-calf systems, especially in situations where cotton gin byproduct is considered a complete replacement for roughage needs.

Gin Byproduct Feed Safety Monitoring

Hematologic response was evaluated to determine whether defoliant residues present in gin byproduct could affect animal health during and after feeding. Average reported values across all blood parameters analyzed were within tolerable ranges for cattle provided by the Auburn University College of Veterinary Medicine Clinical Pathology Laboratory (Table 3). Red blood cell (**RBC**) counts reflect the total number of RBC within a given sample. In general, beef cattle have greater RBC counts than dairy cattle, and dry cows have greater RBC counts than lactating cows (Roland et al., 2014). Changes in RBC may be indicators of anemia, which can potentially occur due to prolonged exposure to a toxin (Roland et al., 2014; Alfaro et al., 2021). White blood cells are essential for immune system function, and their relative count may provide an

Table 4. Hemoglobin concentrations (g/dL) of mid- to late-gestation cows fed loose or baled cotton gin byproduct at d 0 and 60 of a cotton gin byproduct feeding trial, and 30 or 60 d after study removal

Time of sampling[1]	Hemoglobin (g/dL)
d 0	12.7[a]
d 60	11.3[c]
d 0 to 60	12.1[b]
30 d after the study	11.9[b]
60 d after the study	12.9[a]
SE	0.11

[a–c]Within a column, means without common superscripts differ (P < 0.05).

[1]Represents mean value across feeding treatments with either baled or loose gin byproduct.

indicator of stress in response to toxin in livestock. There were no treatment differences or treatment × day of measure interactions ($P \geq 0.05$) for RBC or white blood cells of cattle consuming loose or baled gin byproduct in the present study. Hemoglobin is the oxygen-transporting protein in RBC, and hematocrit is the percentage of RBC by volume in the blood. Differences were observed for day of measure ($P < 0.0001$) for hemoglobin, but no treatment × day interaction was observed ($P = 0.906$). Hemoglobin concentration decreased across day of measure during the study from 12.7 g/dL on d 0 to 11.3 g/dL at d 60 of the feeding trial (Table 4). However, by 60 d after the study, hemoglobin concentration did not differ from initial values at d 0. Low levels of hemoglobin may be associated with anemia (Roland et al., 2014) and have been observed with other cotton byproducts, such as gossypol toxicity from feeding whole cottonseed (Davis, 2020). Another potential concern and factor that may influence complete blood counts is the potential presence of chemical residues in cotton gin byproduct. Decreases in RBC counts, hemoglobin, and hematocrit have been reported following oral exposure of experimental animals to tribufos (ATSDR, 2020), which was detected in gin byproduct used in the current study. The Agency for Toxic Substances and Disease Registry (2020) reports relatively few clinical safety studies with tribufos inhalation or consumption by animals, and all reported Environmental Protection Agency trials are with rats or dogs. In these studies, the nervous system was identified as the most sensitive target of tribufos toxicity. Possible neurological effects including altered gait, decreased movement, sensitivity to touch, salivation, and decreased RBC counts and brain acetyl-cholinesterase activity have been associated with oral exposure. Stewart and Rossi (2010) reported a mean value of 4.5 mg/kg of tribufos in 21 cotton gin byproduct samples from various gins screened for residues of pesticides used in cotton production, which is similar to the highest values reported in the present study for baled gin byproduct. Changes in hemoglobin concentration over the duration of the study may be in part due to tribufos in cotton gin byproduct. However, although hemoglobin concentrations decreased with increasing length of the feeding trial, concentrations did not fall below the tolerable threshold values denoted in Table 3. There were no treatment differences or treatment × day interactions for hematocrit ($P \geq 0.115$). Throughout the duration of the study, cattle showed no visible signs of stress or reduced feed intake, which further supports hematologic response observations that cattle were not experiencing negative health effects from the short-term feeding of cotton gin byproduct in this study.

More extended periods of feeding gin byproduct (greater than 60 d) may further elucidate hematological responses in beef cattle. Data describing the transmission of chemical residues from byproduct feeds into beef products are limited; however, best practices to mitigate concerns and minimize possible agrochemical residue contamination of beef have been suggested as a 30- to 60-d withdrawal period before animal slaughter (Smith, 2020). In the Southeast United States, in practice, gin byproduct is primarily used during short-term feeding periods as a supplement or roughage replacement for first-calf heifers and mature cows or animals not immediately destined for the finishing sector (Mullenix and Rankins, 2014). Rogers et al. (2002) noted that caution should be taken when developing a feeding program using cotton gin byproduct, but short-term feeding of cattle not destined for slaughter for an extended time generally does not pose risk.

APPLICATIONS

Gin byproduct is readily available to beef producers in cotton-producing areas and can be incorporated into winter feeding strategies or used to replace low- to medium-quality hay in beef cow-calf operations. Due to the low bulk density, transportation of loose gin byproduct long distances is not practical; therefore, baled gin byproduct availability may widen accessibility of this byproduct to end users. Nutritive value analysis of loose or baled gin byproduct before use in beef cow diets allows for more strategic supplementation in cow-calf operations and maintenance of cow BW and BCS. Herbicide and pesticide residues are a potential concern; however, residue screening and animal behavioral observations can help mitigate concern. No negative clinical animal health or hematologic effects were observed for short-term feeding of gin byproduct for animals not immediately destined for slaughter at the tribufos residue levels described in the current trial. Future research to clearly define herbicide and pesticide residue tolerance levels for gin byproduct to help ensure the safety and efficacy in beef cattle diets is recommended. Both loose and baled gin byproduct can be used to maintain nonlactating, bred cows with additional energy-protein supplementation and provide an outlet for cotton byproduct waste to be used in beef cow-calf operations in the Southeast United States.

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