EFFECTS OF CORN BY-PRODUCT SUPPLEMENTATION IN SOUTHEASTERN STOCKER SYSTEMS

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ABSTRACT

An 84 d stocker trial was conducted to evaluate two corn by-products as CP supplements in corn silage-based stocker systems in the Southeastern United States. Eighty-one weaned steers (BW=306 kg± 56.69 kg) were stratified by weight and assigned to one of three corn silage based diets: 1) dried distillers grains plus solubles (DDGS), 2) corn gluten feed (CGF) or 3) soybean meal and ground corn (SBM). On d 0, 28, 56, and 84, measurements of BW, hip height, and BCS were recorded, also, ribeye area and intramuscular fat were assessed via ultrasound. During the stocker phase, steers fed SBM had increased BW ($P<0.05$) compared to cattle fed DDGS or CGF. Average daily gain was increased ($P<0.05$) for steers fed DDGS or SBM on d 28 compared to CGF, but by 84 d, ADG was similar among treatments ($P>0.05$). Corn gluten feed tended to decrease G:F ($P=0.06$) compared to DDGS and SBM. Cost per kg of gain tended to be less ($P=0.07$) for DDGS than for SBM or CGF. Measurements for BCS and hip heights did not differ ($P>0.05$) across treatment, but did increase over time ($P<0.05$). Ultrasound data indicated steers fed SBM had greater ribeye areas than those fed CGF and DDGS ($P<0.05$), and intramuscular fat was more abundant ($P<0.05$) in CGF fed calves than those fed DDGS or SBM. However, after 84 d of supplementation there was no difference among the treatments for rump fat thickness ($P>0.05$). These performance and predicted carcass advantages, combined with comparable economic efficiency, indicate that CGF and DDGS can be utilized in Southeastern stocker systems without substantially compromising economically important traits.

INTRODUCTION

Recent volatility of feed prices and economic instability have forced beef cattle producers to reevaluate nutritional programs in order to become more sustainable without sacrificing animal performance. Due to this volatility and the increasing access to local grain processing plants, there is a growing interest in the utilization of corn byproducts in Southeastern cattle production. Data comparing distiller's grains and corn gluten feed to conventional sources of nutrients in Southeastern beef cattle stocker systems are limited; however, in western stocker systems it has been shown that using wet distillers byproducts (wet distillers grains plus thin stillage) to supplement protein from 0-40% of the diet increases performance while decreasing DM intake and feed to gain ratios (Klopfenstein 1996).

The value of dried distillers grains as a protein source is well documented (Klopfenstein et al. 2007; Firkins et al. 1985; Ham et al. 1994). Possibly the largest contributing factor to the value of dried distillers grains as a protein supplement is the increased availability of rumen undegradeable protein (RUP; Klopfenstein et al. 2007). Dried distillers grain protein appears

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to be partially protected from rumen degradation giving it a higher biological value for growing cattle. Rumen escape values that are 2.6 times that of soybean meal make feedstuffs such as dried distillers grains plus solubles an appealing alternative for producers who plan to stocker their cattle prior to feeding (Aines, 1987).

Corn gluten feed has also been shown to be an effective source of supplemental protein for beef steers fed grass silage-based diets (Nelson, 1997). Firkins et al. (1985) demonstrated a more rapid dry matter disappearance for lambs fed wet and dry corn gluten feed compared to those fed wet or dry distillers grains with solubles. Readily digestible fiber content makes dried distillers grains plus solubles and corn gluten feed excellent sources of energy, but neither are good sources of eNDF or "roughage" (Benton et al. 2007). This principle indicates that dried distiller's grains plus solubles and corn gluten feed could pair well with corn silage based-diets to give added growth and value to steers during the stocker phase. Therefore, the objective of this study was to evaluate dried distiller's grains and corn gluten feed compared to soybean meal/corn as protein supplements in silage-based beef cattle stocker systems. Specifically, the aim of this research was to determine the weight gain, feed efficiency, muscularity, and marbling of beef steers during the stocker phase of production when corn byproducts are used as protein supplements.

MATERIALS AND METHODS

All practices and procedure used in this study were examined and approved by the University of Georgia Animal Care and Use Committee.

Animal and Diet Management

The experiment was conducted at the Georgia Mountains Experiment Station located south of Blairsville, GA. In late October, 2008 110 Angus-based crossbred steers were delivered from the Central Georgia Research and Experiment and Education Center at Eatonton, GA. Steers were vaccinated at weaning with Triangle 4, Type II BVD, Ultra Vac 7, and Pyramid 5 (Fort Dodge Animal Health, Overland Park, KS), and dewormed using transdermal ivermectin (Pfizer, New York, NY). Steers were backgrounded for 55 d on stockpiled fescue and orchardgrass and were supplemented with hammered ear corn (1.36 kg/hd/d). In early December, 81 test animals (BW=306 kg± 56.69 kg) were identified, stratified by weight, and randomly assigned to one of nine pens. Pen feed bunks assured 41 cm bunk space for each steer. Pen (pen = 9 hd) was used as the experimental unit. Each pen was randomly assigned to one of three corn silage based diets: 1) soybean meal and hammered ear corn (SBM), 2) dried distillers grains plus soluble (DDGS), or 3) corn gluten feed (CGF). Diets (Table 1) were formulated to be isocaloric and isonitrogenous, and were fed once each morning to achieve a gain of 1.13 kg/d. On d 0, 28, 56 and 84 BW, hip heights (HH) and BCS (Richards et al., 1986) were measured, and ultrasound data for ribeye area (REA), fat thickness (FT), intramuscular fat (IMF) and rump fat (RF) were recorded.

Laboratory Analyses

Feed samples from each delivery were collected and mixed for determination of nutritive content. The mixed feed samples were dried in a forced-air oven at 55°C for 72 h and ground to pass a 1 mm plate in a Model 4 Wiley Mill (Thomas Scientific, Swedesboro, NJ). Dry matter was calculated by (dry wt/wet wt) x 100. Ash content was determined after placing samples in a 550°C muffler furnace for 3 h. Samples were then cooled to room temperature for approximately 30 min and transferred to a 110˚C forced-air oven for 1 h. Samples were then placed in a desiccator for 20 min before weights were determined and recorded. Crude protein was determined by analyzing N content with a nitrogen auto-analyzer (LECO FP-528 Nitrogen Analyzer, LECO Company, St. Joseph, MI).

Neutral detergent fiber and ADF were analyzed with an Ankom 200 Fiber Analyzer (Ankom Technology Corp., Macedon, NY) as described by Van Soest et al. (1991) with slight modifications. The NDF analysis reagent was prepared by dissolving 180 gm of sodium lauryl sulfate in an Erlenmeyer flask with 2 L of distilled water. Separately, 27.42 g of anhydrous $Na_2H\ PO_4$ was added to 500 ml of distilled water and thoroughly mixed. Then, 111.72 g of EDTA and 40.92 g of sodium borate were added and stirred thoroughly. The solution was brought to volume (700 ml) with distilled water. The mixture was then added to the sodium lauryl sulfate solution with constant stirring and the Erlenmeyer flask was filled to 6 L by adding distilled water and 60 ml of ethylene glycol monoethyl ether. When the solution was thoroughly mixed, it was left to sit overnight. The following day, pH was neutralized to 7.0 with 1.0 – 1.5 ml of HCl. The solution was transferred to and stored in a carboy until used. For NDF analysis, approximately 0.5 g of sample was placed in filter bags previously weighed and labeled with an acetone resistant pen and sealed with a heat sealer machine. The bags were placed in a suspender and agitated under heat in an Ankom 200 Fiber Analyzer (Ankom Corp. Fairport, NY) containing 2 L of the NDF solution, 20 g of Sodium Sulfite, and 4 ml of heat stable α–amylase for 60 min. After agitation, samples were rinsed twice for 3 min with 2 L of hot water and 4 ml of α–amylase and a final rinse of water. After rinsing, the bags were removed from the agitation vessel, compressed to remove excess water, and soaked in acetone for 3 min to remove residual moisture. The bags were then compressed lightly to remove excess acetone and left to sit for 30 min to let the remaining acetone evaporate. They were then placed in a forced–air oven set at 105˚C for approximately 2 h. After drying, the bags were placed in a desiccator for 15 min and then weighed and recorded.

Acid detergent fiber was subsequently analyzed. The ADF solution was a mixture of 304 g of sulfuric acid and 6 L of distilled water. Normality of the solution was checked by adding 3 drops of bromocresol green and 10 ml of ADF into a small beaker. The solution was titrated with tromeThamine until the solution changed from yellow to blue. The normality was then calculated by dividing the amount of tromeThamine necessary for color change by 10 (ml of ADF). When 1.00 N solution was achieved, 118.2 gm of cetyltrimethylammonium bromide was added to the ADF solution, mixed thoroughly, and transferred to carboy. After ADF wash, samples were rinsed in hot tap water and soaked in acetone for 3 min to remove excess water. Samples were then compressed and left to sit at ambient temperature to allow excess

acetone to evaporate before being placed in a forced–air oven at 105˚C for 4 h. After drying, samples were placed in a desiccator for 15 min, weighed, and recorded.

Ultrasound Data

Ultrasound data for body composition were collected for REA, FT, IMF, and RF by a trained technician from the University of Georgia Meat Science Technology Center. The ultrasound system included an Aloka 500V equipped with a 17cm-3.5 MHz transducer (Aloka Inc. Tokyo, Japan). Vegetable oil was used as a sound wave copulant, and a wave guide (Designer Genes Technologies Inc., Harrison, AR) was used to ensure proper fit for collection of REA and FT data. Ultrasound images were captured and measured using Beef Image Analysis (BIA) Feedlot software (Designer Genes Technologies Inc, Harrison, AR). Ultrasound images were collected on the steer's right side. Ribeye area and FT were collected between the 12^{th} and 13^{th} rib juncture, perpendicular to the spinal column. Intramuscular fat images were collected parallel to the spine and perpendicular to the 11^{th}, 12^{th}, and 13^{th} ribs. Rump fat data were collected between the *tuba coxae* of the *ilium* and *tuba ischiadicum* of the *ishium*. The ultrasound location was clipped free of hair and curried clean prior to image collection.

Statistical Analysis

Data were analyzed using the Proc MIXED Procedure of SAS (SAS Institute Inc. Cary, NC) for a fully randomized design with three protein supplements and three replicates (3 pens/treatment). Pen was defined as the experimental unit used to determine differences across the three supplements. Animal by pen nested in treatment was used as the random error term and was used to test sources of variation. Ultrasound data, BCS, HH, and BW were analyzed within time period while ADG was analyzed across periods for main effects as well as treatment by time interactions. Least squares means were generated and separated using the p-diff option. Differences were considered significant at $\alpha=0.05$ and tendencies were considered at $\alpha<0.10$.

RESULTS AND DISCUSSION

Performance Traits

Treatment did not affect BW ($P=0.21$) at 84 d, but ADG for steers fed DDGS were greater ($P<0.05$) compared to CGF steers after d 28 and 56 (Table 1). Steers fed CGF as a protein supplement were observed to have the lowest ADG after 28 d on feed. However, CGF steers showed the greatest increase ($P<0.05$) in ADG between d 28 and 56 when compared to DDGS and SBM steers. Treatment tended ($P=0.06$) to affect G:F, with CGF steers being slightly less efficient; however, no differences ($P > 0.10$) were detected between DDGS and SBM diets. Cost of gain (COG) tended ($P=0.07$) to be lower for steers fed DDGS compared to those fed CGF or SBM.

Palatability of the protein supplement could be one reason initial performance was lower for CGF steers. At the start of feeding, the initial load of CGF was observed to be darker in

color and smelled slightly charred indicating damage could have been incurred during the drying process. If the CGF was excessively heated, the product may be less palatable, thereby increasing acclimation time. However, it appears that if a longer acclimation period was needed the steers may have experienced some compensatory gain with increased time on feed.

Santos et al. (1984) reported that lysine and methionine are the most limiting amino acids for cattle fed corn or corn silage diets. While CGF is not corn grain, lysine content is similar (NRC, 2000), and it has been demonstrated that grains that are charred or burnt from drying have reduced lysine availability compared to those that are dried more correctly (Cromwell et al., 1993). It is therefore possible that over drying of the initial load of CGF could have contributed to decreased ADG through multiple mechanisms.

Another explanation for performance differences among the diets is the amount of rumen degradability of the protein supplement. The value of DDGS as a source of RUP superior to that of SBM or CGF is well researched (Klopfenstein et al., 2007; Santos et al., 1984; Waller et al. 1980). Zein is the primary form of protein found in corn and DDGS (Klopfenstein et al., 2007), and it is resistant to degradation by rumen microbes (Waller et al., 1980). Protein utilization efficiency of DDGS was reported to be 180% that of SBM, and it has been reported that RUP is necessary for "maximum production efficiency" in young growing ruminants (Waller et al., 1980). Fleck et al. (1989) reported elevated rumen ammonia production, as well as increases in molar concentrations of propionate and butyrate 4 h after feeding CGF when compared to cows fed soybean meal. Those data indicated the protein in CGF may be more degradable than that provided in SBM or DDGS. Increased digestibility of corn gluten feed was also reported by DeHann et al. (1983) when an in vitro experiment showed greater protein degradation for corn gluten feed compared to soybean meal.

Steers fed SBM had greater ($P<0.05$) BCS scores than did CGF or DDGS steers. Steers fed CGF or DDGS were similar ($P=0.50$). Although differences were detected, steers from all 3 treatment groups were in a moderate condition ranging from 6-7. Hip heights increased ($P<0.05$) with time, but did not differ ($P>0.05$) among treatments indicating that treatment did not affect skeletal growth.

Ultrasound Data

Although all predicted carcass traits (REA, IMF, FT, and RF) increased over time, only REA and IMF were affected by treatment (Table 3). The REA of SBM fed steers was larger ($P<0.05$) than CGF and DDGS fed steers by 4.48 cm^2 and 4.75 cm^2, respectively at the end of the trial, while the REA for CGF and DDGS steers was similar ($P>0.05$). Twelfth rib fat thickness was similar ($P>0.05$) among treatments at 0 and 84 d. However, DDGS steers tended ($P=0.08$) to have less fat than CGF and SBM fed steers. Percent IMF was less ($P<0.05$) for steers fed DDGS when compared to SBM and CGF steers at the end of 84 d. Significance of IMF varied among periods; however, steers fed SBM or CGF were similar ($P>0.05$) after 84 d.

Though statistically significant, treatment effects for REA and IMF are biologically negligible and would likely be seen as uniform from a practical standpoint. The slightly increased muscularity denoted by differences in REA could be explained by increased microbial protein synthesis, and subsequent increased amino acid flow to the small intestine. This principle was hypothesized by Veira et al. (1995) and Nelson (1997) as an explanation of performance data from their respective trials. Increasing post-ruminal amino acid flow by protein supplementation of silage-based diets allows growing steers the opportunity to achieve their potential for lean growth (Veira et al., 1995). The idea that microbial amino acid synthesis could be increased in cattle fed silage-based diets by soybean meal supplementation was illustrated by Rooke et al. (1986) where microbial protein flow and protein efficiency were increased by soybean meal supplementation in Jersey cows fed a grass silage-based diet.

It is also known that lysine is typically one of the most limiting amino acids in corn and corn silage based diets (Santos et al., 1984). In terms of undegraded intake protein (UIP), soybean meal has 6.08% vs. 2.06% in DDGS, while CGF has a UIP lysine percentage of 1.57. However, it has been shown that high levels of amino acids can be synthesized in the rumen of steers fed CGF (Bowman et al. 1988).

Minor differences in IMF could have been due to a number of factors. In the case of SBM steers, ground corn was used to dilute soybean meal and avoid overfeeding protein. It is possible that the increased readily fermentable energy could account for the increased IMF as well as the numerical increase in FT (P=0.08). Corn gluten fed steers may have shown increased IMF due to the increased rumen digestibility of CGF. Firkins et al. (1985) illustrated an increased rate of rumen DM disappearance in steers fed CGF. Also, lambs fed corn gluten feed showed increased acetate:propionate ratios in the rumen compared to those fed DDGS indicating a greater partitioning of nutrients toward fat deposition (Firkins et al., 1985).

As previously stated, there was some suspicion of burning in the first load of CGF. A high correlation was established by Cromwell et al. (1993) between physical color, smell, and protein availability of dried distillers grains plus solubles. Overheating of soybean meal, fish meal, and milk products reduces their nutritional value because of the binding of lysine and partial reduction of cysteine in the formation of advanced Maillard Reaction products (Hancock et al., 1990; Parsons et al., 1992). Decreased protein availability could have therefore caused a change in the partitioning of nutrients toward increased fatness due to the nature of diet components available for digestion.

CONCLUSIONS

With continuing expansion of the ethanol industry into the Southeastern United States and the subsequent availability of corn processing by-products, it is important that further research be conducted to evaluate feed sources in various roles in southeastern production systems. This research has shown corn gluten feed and dried distillers grains plus solubles to be comparable to soybean meal/corn supplementation in terms of performance and predicted carcass merit for winter stockering systems using corn silage as a roughage source. The

added instability of today's economy has caused a renewed interest in finding lower cost alternatives to the norm in terms of nutrient sources for ruminants. This research demonstrates that utilizing dried distillers grains plus solubles or corn gluten feed in place of a soybean meal/corn mix to supplement protein in growing cattle will not negatively impact economically important traits such as growth and carcass composition.

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Table 1. Dry matter composition of stocker diets based on corn silage and supplemented with corn gluten feed (CGF), dried distillers grains plus soluble (DDGS) or soybean meal/corn (SBM).

	Diet		
	CGF	DDGS	SBM
Ingredient[1]*, %*			
Corn Silage	75	75	75
Ground corn	0	0	15
Soybean meal	0	0	10
Dried distillers grains	0	25	0
Corn gluten feed	25	0	0
Chemical Composition,%			
DM	47.67	48.31	47.02
CP	16.52	18.57	16.94
NDF	51.72	52.38	53.33
ADF	18.91	19.53	17.58
Ash	3.68	3.33	3.13

[1]All sources were procured from the same distributor and are expressed on a DM basis. Different loads of CGF, DDGS and SBM were averaged.

Table 2. Growth performance for beef steers on a corn silage based diet receiving corn gluten feed (CGF), dried distillers grains plus solubles (DDGS) or soybean meal/corn (SBM) as a protein source.

	Protein source			
Item	CGF	DDGS	SBM	SEM
BW, kg				
0	304^{y}	304^{y}	303^{y}	5.80
84	387^{x}	399^{x}	401^{x}	5.80
ADG[1], kg/d				
28	1.14^{b,y}	2.17^{a,y}	2.25^{a,x}	0.15
56	1.98^{b,x}	2.50^{a,xy}	2.35^{ab,x}	0.15
84	2.23^{x}	2.57^{x}	2.64^{x}	0.15
G:F	0.15	0.17	0.17	0.004
COG[2], $/kg	0.33	0.28	0.35	0.06
BCS				
0	6.1	6.2	6.3	0.08
84	6.1^{ab}	5.9^{b}	6.3^{a}	0.08
HH[3], cm				
0	121.5	121.2	120.8	0.93
84	128.0	127.6	126.7	0.70

^{abc} Means within a row without a common superscript differ ($P<0.05$).
^{xyz} Means within a column and item without a common superscript differ ($P<0.05$).
[1] Cumulative average daily gains.
[2] COG = Cost (in dollars) per kg of gain.
[3] HH= Hip height.

Table 3. Ultrasound-based estimates of carcass traits using ultrasound for stocker steers fed corn silage and supplemented with corn gluten feed (CGF), dried distillers grains plus soluble (DDGS), or soybean meal/corn (SBM)

	Protein Source			
Item[1]	CGF	DDGS	SBM	SEM
REA, cm^2				
0	47.92	47.32	50.19	1.13
84	59.12^{b}	58.85^{b}	63.60^{a}	1.15
FT, cm				
0	0.31	0.27	0.31	0.02
84	0.44	0.39	0.48	0.03
IMF, %				
0	3.8	3.4	3.6	0.10
84	4.3^{a}	3.9^{b}	4.2^{a}	0.10
RF, cm				
0	0.39	0.35	0.36	0.02
84	0.57	0.55	0.65	0.04

^{abc}Means within a row without a common superscript differ ($P<0.05$).
[1] REA=ribeye area, FT=12th rib fat thickness, IMF=intramuscular fat, RF=rump fat thickness.