BURNETT CENTER INTERNET PROGRESS REPORT

No. 17 – December 2003

Effects of whole cottonseed on performance, carcass characteristics, and *Escherichia coli* O157 shedding of finishing beef steers

J. J. Cranston, J. D. Rivera, N. A. Elam, J. T. Richeson, M. D. Abney, S. M. Younts-Dahl, M. M. Brashears, and M. L. Galyean

Department of Animal and Food Sciences
Texas Tech University, Lubbock 79409-2141

Introduction

Whole cottonseed has been used extensively in dairy cattle diets for many years; however, its use in the beef industry has been comparatively limited, despite its high protein and fat content. Previous research has suggested that whole cottonseed may decrease the shedding of *Escherichia coli* O157 in cattle (Hancock et al., 1994; Garber et al., 1995). Decreasing the prevalence of this organism at the production level may help decrease the incidence of carcass contamination as well as disease outbreaks in the human population. Therefore, the possible benefits of whole cottonseed in the beef finishing diet may be twofold: 1) it could provide an alternative source of protein and fat in the diet without detrimental effects on animal performance; and 2) it might provide a possible method to decrease the prevalence of *E. coli* O157 that could be readily implemented in practice. The present study was designed to examine the effects of feeding whole cottonseed on performance, carcass characteristics, and the prevalence of *E. coli* O157 in the feces and on hides before slaughter of finishing beef steers.

Experimental Procedures

Cattle. One hundred thirty-four crossbred, British x Continental, steers were shipped from a facility in Meridian, MS in the Fall 2002. All the animals were processed in the same manner and housed in soil-surfaced pens. Following a period during which the animals were adapted to a high-concentrate diet, the steers were fed a grower diet (85% concentrate) in quantities sufficient to achieve an average daily gain (ADG) of 0.91 kg for approximately 4 mo. On February 18, 2003, all cattle were moved from soil-surfaced pens into partially slotted-concrete-floor pens in the Texas Tech University Burnett Center.

Experimental Design, Treatment, and Pen Assignment. Three dietary treatments were used in a randomized complete block design. Pen was the experimental unit (eight pens per treatment with five steers per pen for a total 24 pens). The three treatments were as follows:

- **STD** – standard finishing diet based on steam-flaked corn, formulated to contain 5% alfalfa hay and 5% cottonseed hulls (dry matter [DM] basis) as the roughage sources;

- **WCS** – steam-flaked corn-based finishing diet formulated to contain 15% whole cottonseed (replacing steam-flaked corn), with 5% alfalfa hay, and 5% cottonseed hulls (DM basis) as the roughage sources;

- **EQU** – steam-flaked corn-based finishing diet formulated to contain the individual components of whole cottonseed (cottonseed hulls, cottonseed meal, and cottonseed oil to provide equal protein, fiber, and fat to whole cottonseed) replacing

steam-flaked corn, with 5% alfalfa hay with 5% cottonseed hulls (DM basis) as the roughage sources.

Steers were weighed individually (C & S Single-Animal Squeeze Chute [Garden City, KS] set on four Rice Lake Weighing Systems [Rice Lake, WI] load cells) on March 28, 2003, to obtain a sorting weight. One hundred twenty animals with the most uniform body weight (BW) were selected for the study. The animals selected for study were stratified by BW into blocks consisting of 15 animals per block. The 15 heaviest steers were allotted to Block 1, the next 15 heaviest steers were allotted to Block 2, and so on until all 120 steers were grouped into eight weight blocks. Within each block, steers were then randomly assigned to pens. After each of the 24 pens had five steers assigned, each pen within a weight block was randomly assigned to one of three treatments. On April 8, 2003, cattle were again weighed individually, and fed their assigned treatment diets (start of trial; d 0).

Experimental Diets. Ingredient composition of the experimental diets is shown in Table 1. All diets were formulated to contain equal percentages of fat. The WCS and EQU diets were formulated to contain equal percentages of neutral detergent fiber (NDF). Vitamins, minerals, Rumensin (30 g/ton DM basis), and Tylan (10 g/ton DM basis) were provided by a premix (Table 2).

Management, Feeding, and Weighing Procedures. The three diets in this trial were each mixed in a 1.27-m^3-capacity paddle mixer (Marion Mixers, Inc., Marion, IA) and delivered by a drag chain conveyor to a Rotomix 84-8 mixer/delivery unit (Rotomix, Dodge City, KS). Diets were mixed for an average of 3 min in the Rotomix 84-8 mixer/delivery unit and then delivered to the treatment pens (± 0.45 kg) by the use of load cells and indicator on the Rotomix 84-8 unit. Feed bunks were appraised visually every morning before feeding to determine the quantity of feed remaining from the previous day. The amount of feed to be delivered to the pen was then suggested, prepared, and delivered. This process was designed so that little or no feed would be left in the bunk. When a pen of cattle left no feed in the bunk at the time of the bunk evaluation, feed delivered to the pen was increased 0.2 kg/steer to allow for maximum feed intake. At the end of each weigh period, feed bunks were cleaned, and orts were weighed (Ohaus electronic scale, ± 0.045 kg; Pine Brook, NJ). A sample of orts from each bunk was taken and dried in a forced-air oven at 100ºC for approximately 24 h to determine its DM content. Average DM intake (DMI) by a pen was calculated by subtracting the DM content of the refused feed at the end of the period from the amount of DM delivered to the pen for the entire period. The corrected total of DM delivered was then divided by the number of animal days to determine average DMI by each steer in the pen.

Feed samples for each treatment were collected weekly from the Rotomix 84-8 mixer/delivery unit, and DM was measured by drying overnight in a forced-air oven at 100ºC. At the end of each 28-d period, samples were composited and ground in a Wiley mill to pass a 2-mm screen. Crude protein and ADF were analyzed following each period. Ether extract, ash, NDF, Ca, and P were analyzed from a sample composited across periods at the end of the trial. With the exception of NDF (Goering and Van Soest, 1970), all chemical analyses of the diets were performed according to the AOAC (1990).

Cattle were weighed individually on d 0, 56, and on their respective shipping dates.

On d 0, steers in Blocks 1, 2, and 3 were implanted with a single Revalor S implant (Intervet, Millsboro, DE), whereas steers in Blocks 4 through 8 were implanted with a single Ralgro implant (Schering Plough Anim. Health, Union, NJ). On d 56, steers in Blocks 4 through 8 were reimplanted with a single Revalor S implant. Cattle were weighed on a pen basis using a platform scale (± 2.27 kg) on d 28, 84, and 112. On the day before scales were used, they were calibrated with 453.6 kg of certified weights (Texas Department of Agriculture). Cattle in Block 1 were shipped on d 84, cattle in Blocks 2 and 3 were shipped on d 105, and cattle in Blocks 4 through 8 were shipped on d 133. All cattle in the study were shipped to the Excel Corp. slaughter facility in Plainview, TX. One steer in the STD treatment died from causes unrelated to treatment (urinary calculi).

Carcass Evaluation. Personnel from Texas Tech University obtained carcass data. Liver abscess scores were measured as X = no abscesses, A-, A, or A+. Complete carcass data were obtained for all 119 animals sent to slaughter.

Microbiological Analyses. Fecal samples were taken directly from the rectum of each steer on d 0 and 56, and on the day of shipment to slaughter. Hide swabs were taken over a 600-cm^2 area near the perineum on the right side of each animal on shipping dates. These samples were analyzed for the presence of *E. coli* O157. The method used to determine the presence of *E. coli* O157 was described by Leagreid et al. (1999). An *E. coli* O157 latex agglutination kit (Remel, Lenexa, KS) was used as the final verification for the presence or absence of the organism in each sample.

Statistical Analyses. All data were analyzed with pen as the experimental unit. Performance data was analyzed as a randomized complete block design using the Proc Mixed procedure of SAS Release 8.02 (SAS Institute Inc., Cary, NC), with block defined as a random effect. Non-discrete carcass data were analyzed in the same manner, except that the block x treatment effects also was specified as a random effect because the data were entered on an individual animal basis. Non-parametric USDA quality grade data, liver abscess data, and *E. coli* O157 shedding data were transformed using Cochran's test for related observations (Conover, 1999) and then analyzed by the same previously described procedure. When the overall F-value for treatment was significant ($P \leq 0.10$), least squares means were separated using the PDIFF statement in SAS.

Results and Discussion

Diet Analyses. Chemical composition of the diets is shown in Table 3. Values were generally in agreement with expectations based on diet formulation, with the exception of ether extract. All diets were formulated to contain approximately 5.7% crude fat, but results from ether extract analysis indicated much higher values. Actual dietary fat may have been slightly higher than formulated because of higher fat values for feedstuffs than indicated by the NRC (1996). However, because the dietary ether extract values should not be as high as the analyzed values, it is possible that the petroleum ether extract procedure used for this analysis extracted feed constituents in addition to the lipids contained in the diets. Although the ether extract analysis resulted in higher values than expected, the range in fat levels among the treatment diets was fairly narrow, so relative effects of treatments would not likely have been affected by the higher than expected fat values.

Net Energy Calculations. Dietary NEm and NEg contents of each diet were calculated by two different methods. The first method used the tabular energetic values for each feedstuff in the diet provided by NRC (1996). The second method used animal performance data to estimate the energy content of the diets. This quadratic equation was derived from other equations in the NRC (1996). Based on values used for diet formulation, the NEm and NEg values (Mcal/kg of DM) for the STD and WCS diets were similar (NEm = 2.13 and 2.11; NEg = 1.45 and 1.44, respectively), with slightly lower values for the EQU diet (NEm = 2.01; NEg = 1.35). When calculating NEm and NEg values from animal performance, values (Mcal/kg of DM) increased relative to formulation-based values (NEm = 2.31, 2.21, and 2.24; NEg = 1.62, 1.53, and 1.55 for the STD, WCS, and EQU diets, respectively), suggesting a slight underestimation of the energetic value of the feedstuffs by tabular values. Moreover, performance-based estimates did not increase by the same proportion among treatments; increases in the estimates of NEm and NEg were greatest for the EQU diet, intermediate for the STD diet, and least for the WCS diet. This finding suggests that the energetic values of cottonseed oil or cottonseed meal, major components of the EQU diet, may have been underestimated more than the other ingredients. The possibility of cottonseed oil being energetically underestimated may be plausible because cottonseed oil is highly unsaturated and would likely inhibit ruminal methanogenic bacteria (Jenkins, 1993). Because the production of methane represents a loss in energy, cottonseed oil may have greater effects on the dietary energy concentration than more highly saturated fats.

Performance Data. Results for DMI, ADG, and feed conversion are presented in Table 4. Differences in DMI were detected among treatments for the entire trial ($P = 0.056$), and for d 0 to 28 ($P = 0.006$), d 0 to 56 ($P = 0.010$), and d 0 to 84 ($P = 0.024$). Steers fed the WCS diet consumed more feed by period, as well as throughout the entire trial, than steers fed the STD or EQU diets ($P \leq 0.091$). The DMI intake data did not differ between the STD and EQU diets by period or for the overall trial ($P \geq 0.439$). The increase in DMI by cattle fed the WCS diet is likely attributable to the higher NDF content of the WCS diet. The NDF content of the WCS diet was determined to be more 12 percentage points greater than the NDF content of the STD diet (30.03 vs. 17.77% of DM). A similar intake response has been noted in previous studies. Defoor et al. (2002) reported increased DMI by finishing beef heifers as the NDF content of the diet increased. In one experiment by Bartle et al. (1994), steers linearly increased DMI ($P < 0.001$) as the roughage level of the diet increased. Galyean and Defoor (2003) suggested that energy dilution of the diet might cause greater feed intakes in cattle fed high-concentrate diets when diets with large differences in NDF content are compared.

Although the EQU diet contained almost 9 percentage points more NDF than the STD diet (26.61 vs. 17.77% of DM), no increase in DMI was detected for the cattle consuming the EQU diet over those fed the STD diet. One possible explanation for this finding is that some of the fat from the WCS diet was protected within the seed coat, as discussed by Baldwin and Allison (1983). It is therefore reasonable to assume that the EQU and STD diets resulted in more free fat within the rumen. This increase in fat could have decreased ruminal digestibility of the fibrous portion of the diet. Unsaturated fatty acids can greatly inhibit ruminal microbes, particularly the cellulolytic organisms in the rumen, resulting in decreased fiber digestion (Jenkins, 1993; Pantoja et al., 1994). As the

fiber portion of the diet was less digestible, it could have been retained within the rumen for longer periods of time, resulting in greater ruminal fill. The EQU diet contained more fiber than the STD diet; hence, fiber might have accumulated in the rumen resulting in little response in DMI by cattle fed the EQU diet because of limits in ruminal capacity. This conclusion is supported by the findings of Moore et al. (1986), who evaluated different sources of supplemental fat with a high-fiber basal diet (61.8 to 68.9% wheat straw). Ruminal DM digestibility was greater ($P < 0.05$) for a diet containing WCS than the ruminal DM digestibilities of diets containing cottonseed oil or animal fat. The ruminal dispersion characteristics of cottonseed hulls could have compounded the effects of fat within the rumen. Cottonseed hulls have been found to mix with ruminal contents rather than forming a fibrous mat within the rumen (Church, 1998; Moore et al., 1990). Thus, it may then be reasonable to assume that the negative effects of the unsaturated fat on fiber digestion were exacerbated in cattle fed the EQU diet because cottonseed hulls mixed with ruminal contents and remained in the rumen for longer periods of time than fiber from WCS. As a result, steers consuming the EQU diet could have been limited in DMI by ruminal fill because the fibrous portion of the diet was less digestible and passed more slowly through the rumen.

Overall F tests were significant for ADG from d 0 to 28 ($P = 0.024$) and from d 0 to 56 ($P = 0.076$). Overall F tests were not significant for ADG from d 0 to 84 ($P = 0.137$), nor was the F test significant for the entire feeding period ($P = 0.521$). Carcass-adjusted ADG was calculated using an adjusted final BW by dividing hot carcass weight (HCW) by the average dressing percent for all the animals. The overall F test for carcass-adjusted ADG did not differ ($P = 0.305$) among treatments. Steers fed the WCS diet gained weight more rapidly than the steers fed the EQU diet from d 0 to 28 ($P = 0.008$) as well as d 0 to 56 ($P = 0.027$). Steers fed the STD diet gained more rapidly than steers fed the EQU diet from d 0 to 28 ($P = 0.055$). Because of the differences in fiber level among the diets, period differences in ADG may have been influenced by differences in gut fill and should therefore be viewed with caution.

Overall F tests for feed efficiency, expressed as feed-to-gain ratio (F:G), were significant for d 0 to 28 ($P = 0.088$) and d 0 to 84 ($P = 0.009$). Separation of the treatment means revealed that the conversion ratio for the cattle fed the EQU diet was greater (less efficient) than that for the cattle fed the STD and WCS diets from d 0 to 28 ($P \leq 0.10$). Steers fed the STD diet used feed more efficiently from d 0 to 84 than steers fed the WCS and EQU diets ($P \leq 0.036$). Overall F tests were not significant for d 0 to 56 ($P = 0.132$) and the entire trial ($P = 0.225$). As differences in gut fill could have influenced period differences in ADG, the same can be said for period differences in feed efficiency. The overall F test was significant for carcass-adjusted feed conversion ($P = 0.009$), which was calculated by dividing DMI by the carcass-adjusted ADG. The carcass-adjusted feed efficiency of the cattle fed the STD diet was lower (more efficient) than that of the cattle fed the WCS and EQU diets ($P \leq 0.010$). This result was most likely caused by the increase in gut fill by the cattle fed the WCS and EQU diets compared with the STD diet. The WCS and EQU diets contained greater amounts of fiber; therefore, cattle fed the WCS and EQU diets consumed more fiber, likely causing an increase in ruminal volume and mass. Church (1988) noted that ruminal volume is greater when diets contain more roughage. Harvatine et al. (2002) reported a linear increase ($P < 0.01$) in the mass of ruminal DM with increasing concentrations

of WCS in the diet. Therefore, when cattle are slaughtered at an equal final BW, cattle that are fed more fiber will have greater gut contents and lighter HCW. As noted previously, adjusted final BW was calculated by dividing the HCW by the average dressing percent for all the steers in the trial. If steers fed the WCS and EQU diets had more gut fill, the dressing percent of steers fed the WCS and EQU diets would be lower than that of steers fed the STD diet, resulting in heavier adjusted final BW for steers fed the STD diet. This would explain the more efficient carcass-adjusted F:G ratio for steers fed the STD diet. Lighter carcass weights with steers fed diets containing WCS compared with steers fed a control diet have been previously noted by Preston et al. (1989) and Huerta-Leidenz et al. (1991).

Carcass Data. A summary of carcass characteristics are presented in Table 5. Overall F tests were significant for marbling score of the longissimus muscle ($P = 0.058$) and dressing percent ($P = 0.061$). Separation of the treatment means for marbling score revealed that steers fed the STD diet had higher marbling scores of the longissimus muscle than steers fed the WCS and EQU diets ($P \leq 0.081$). Analysis of dressing percent data indicated that steers fed the STD diet had higher dressing percents than steers fed the WCS and EQU diets ($P \leq 0.058$). No other carcass characteristics were affected by treatment ($P > 0.10$). One possible explanation for differences detected in marbling score among treatments in the present study may be related to fiber level in the diet. However, differences found in marbling score among treatments may be of limited importance because they did not relate to differences in USDA quality grade. A majority of the steers in each treatment graded low Choice or higher (64.1%, 57.5%, and 57.5% for steers fed the STD, WCS, and EQU diets, respectively). Although not significant, steers fed the STD diet had numerically higher HCW than steers in the other two groups (357.3, 353.9, and 346.9 kg for steers fed the STD, WCS, and EQU diets, respectively). Moreover, steers fed the STD diet had a higher ($P \leq 0.058$) dressing percent than steers fed the WCS and EQU diets. This finding supports the previous discussion relative to differences in gut fill among the treatments. Hence, it is probable that steers fed the WCS and EQU diets consumed greater amounts of fiber increasing ruminal volume and mass, resulting in a lower dressing percent than in steers fed the STD diet.

Microbiological Data. The *E. coli* O157 prevalence data are presented in Table 6. No differences were detected among treatments for fecal shedding on d 0 ($P = 0.229$), d 56 ($P = 0.342$), or at slaughter ($P = 0.739$). Moreover, hide prevalence did not differ among treatments at slaughter ($P = 0.973$). No explanation was offered for the decrease of fecal *E. coli* O157 in cattle fed diets containing WCS found in two previous studies (Hancock et al., 1994; Garber et al., 1995). Perhaps this decrease in *E. coli* O157 shedding resulted from the fact that unsaturated fat in WCS is protected by the seed coat and avoids ruminal biohydrogenation. This unsaturated fat could then possibly be released in the intestines, inhibiting the growth of *E. coli*; however, it seems this was not the case in the present study. Similar to the present results, no changes in *E. coli* O157 shedding by cattle fed diets containing WCS have been reported by Dargatz et al. (1997), Herriott et al. (1998), and Buchko et al. (2000).

Summary and Conclusions

Under the conditions of the present experiment, adding whole cottonseed to the diet increased dry matter intake by an

average of 7.3% for the total duration of the trial. Unless adjustment is made for total dietary fiber when WCS is added into the diet, cattle will most likely perform similarly to those fed a standard finishing diet when measurements are taken on a live weight basis. However, cattle fed WCS-supplemented diets that are not adjusted for fiber content may tend to convert feed to weight gain less efficiently, especially when gut fill is taken into account. If total dietary fiber is increased by addition of WCS, cattle fed WCS will also likely exhibit a lower dressing percent than those fed a standard finishing diet, which may be of significance when marketing finishing cattle on a formula or grid basis. Finally, based on our results, WCS-supplemented diets are not likely to have any effects on the prevalence of *E. coli* O157in finishing cattle.

Literature Cited

AOAC. 1990. Official Methods of Analysis (14th Ed.). Association of Official Analytical Chemists, Arlington, VA.

Baldwin, R. L., and M. J. Allison. 1983. Rumen metabolism. J. Anim. Sci. 57 (Suppl. 2):461-477.

Bartle, S. J., R. L. Preston, and M. F. Miller. 1994. Dietary energy source and density: Effects of roughage source, roughage equivalent, tallow level, and steer type on feedlot performance and carcass characteristics. J. Anim. Sci. 72:1943-1953.

Buchko, S. J., R. A. Holley, W. O. Olson, V. P. J. Gannon, and D. M. Veira. 2000. The effect of different grain diets on fecal shedding of *Escherichia coli* O157:H7 by steers. J. Food Prot. 63:1467-1474.

Church, D. C. 1988. The Ruminant Animal: Digestive Physiology and Nutrition. Prentice-Hall, Englewood Cliffs, NJ.

Conover, W. J. 1999. Practical Nonparametric Statistics. John Wiley and Sons, Inc., New York, NY.

Dargatz, D. A., S. J. Wells, L. A. Thomas, D. D. Hancock, and L. P. Garber. 1997. Factors associated with the presence of *Escherichia coli* O157 in feces of feedlot cattle. J. Food Prot. 60:466-470.

Defoor, P. J., M. L. Galyean, G. B. Salyer, G. A. Nunnery, and C. H. Parsons. 2002. Effects of roughage source and concentration on intake and performance by finishing heifers. J. Anim. Sci. 80:1395-1404.

Galyean, M. L., and P. J. Defoor. 2003. Effects of roughage source and level on intake by feedlot cattle. J. Anim. Sci. 81 (E. Suppl. 2):E8-E16.

Garber, L. P., S. J. Wells, D. D. Hancock, M. P. Doyle, J. Tuttle, J. A. Shere, T. Zhao. 1995. Risk factors for fecal shedding of *Escherichia coli* O157:H7 in dairy calves. J. Am. Vet. Med. Assoc. 207:46-49.

Goering, H. K., and P. J. Van Soest. 1970. Forage Fiber Analyses (Apparatus, Reagens, Procedures, and Some Applications). Agric. Handbook No. 379. ARS-USDA, Washington, DC.

Hancock D. D., T. E. Besser, M. L. Kinsel, P. I. Tarr, D. H. Rice, and M. G. Paros. 1994. The prevalence of *Escherichia coli* O157:H7 in dairy and beef cattle in Washington State. Epidemiol. Infect. 113:199-207.

Harvatine, D. I., J. E. Winkler, M. Devant-Guille, J. L. Firkins, N. R. St-Pierre, B. S. Oldick, and M. L. Eastridge. 2002. Whole linted cottonseed as a forage substitute: fiber effectiveness and digestion kinetics. J. Dairy Sci. 85:1988-1999.

Herriott, D. E., D. D. Hancock, E. D. Ebel, L. V. Carpenter, D. H. Rice, and T. E. Besser. 1998. Association of herd management factors with colonization of dairy cattle by shiga toxin-positive *Escherichia coli* O157. J. Food Prot. 61:802-807.

Huerta-Leidenz, N. O., H. R. Cross, D. K. Lunt, L. S. Pelton, J. W. Savell, and S. B. Smith. 1991. Growth, carcass traits, and fatty acid profiles of adipose tissues from steers fed whole cottonseed. J. Anim. Sci. 69:3665-3672.

Jenkins, T. C. 1993. Lipid metabolism in the rumen. J. Dairy Sci. 76:3851-3863.

Laegreid, W. W., R. O. Elder, and J. E. Keen. 1999. Prevalence of *Escherichia coli* O157:H7 in range beef calves at weaning. Epidemiol. Infect. 123:291-298.

Moore, J. A., M. H. Poore, and R. S. Swingle. 1990. Influence of roughage source on kinetics of digestion and passage, and on calculated extents of ruminal digestion in beef steers fed 65% concentrate diets. J. Anim. Sci. 68:3412-3420.

Moore, J. A., R. S. Swingle, and W. H. Hale. 1986. Effects of whole cottonseed, cottonseed oil, or animal fat on digestibility of wheat straw by steers. J. Anim. Sci. 63:1267-1273.

NRC. 1996. Nutrient requirements of beef cattle (7th Ed.). National Academy Press, Washington, DC.

Pantoja, J., J. L. Firkins, M. L. Eastridge, and B. L. Hull. 1994. Effects of fat saturation and source of fiber on site of nutrient digestion and milk production by lactating dairy cows. J. Dairy Sci. 77:2341-2356.

Preston, R. L., S. J. Bartle, and D. C. Rule. 1989. Effect of whole cottonseeds in cattle finishing diets. Anim. Sci. Research Rep. No. T-5-263, Texas Tech Univ., Lubbock.

Acknowledgements

This experiment was supported, in part, by a grant from the International Cotton Research Center, Lubbock TX. The authors thank Kirk Robinson (Burnett Center Manager) and Ricardo Rocha (Burnett Center Assistant Manager) for their assistance with the experiment. Additionally, we thank Elanco Animal Health, Schering-Plough Animal Health, Intervet, Fort Dodge Animal Health, and Kemin Industries for product support.

Table 1. Ingredient composition (% DM basis) of a standard finishing diet (STD), a diet formulated to contain 15% whole cottonseed (WCS), and a whole cottonseed equivalent diet (EQU) formulated to contain percentages of fat and NDF equal to the WCS diet

	Treatment		
Ingredient	STD	WCS	EQU
Steam-flaked corn	76.58	67.53	66.49
Whole cottonseed	-	15.10	-
Cottonseed meal	3.59	-	7.12
Cottonseed oil	-	-	2.32
Alfalfa hay	4.92	4.92	4.92
Cottonseed hulls	4.99	4.99	11.68
Molasses	4.18	4.17	4.17
Tallow	2.14	-	-
Urea	0.87	0.55	0.55
Limestone	0.25	0.25	0.25
Premix[a]	2.48	2.49	2.50

[a]Composition of the premix is shown in Table 2.

Table 2. Composition of the premix used in the experimental diets

Ingredient	%, DM basis
Cottonseed meal	23.363
Endox (antioxidant)[a]	0.500
Limestone	42.105
Dicalcium phosphate	1.036
Potassium chloride	8.000
Magnesium oxide	3.559
Ammonium sulfate	6.667
Salt	12.000
Cobalt carbonate	0.002
Copper sulfate	0.157
Iron sulfate	0.133
EDDI	0.003
Manganous oxide	0.267
Selenium premix, 0.2% Se	0.100
Zinc sulfate	0.845
Vitamin A, 650,000 IU/g[bd]	0.012
Vitamin E, 275 IU/g[bd]	0.126
Rumensin, 176.4 g/kg[cd]	0.675
Tylan, 88.2 g/kg[cd]	0.450

[a]Kemin; Des Moines, IA.

[b]Roche; Nutley, NJ.

[c]Elanco Animal Health; Indianapolis, IN.

[d]Concentrations noted by the ingredient are on a 90% DM basis.

Table 3. Chemical composition of a standard finishing diet (STD), a diet formulated to contain 15% whole cottonseed (WCS), and a whole cottonseed equivalent diet (EQU) formulated to contain percentages of fat and NDF equal to the WCS diet[a]

	Treatment		
Item	STD	WCS	EQU
Dry matter, %	83.13	83.13	82.44
Acid detergent fiber, %	9.33	17.26	15.48
Neutral detergent fiber, %	17.77	30.03	26.61
Crude protein, %	12.74	13.42	12.72
Ether extract, %	9.93	10.79	9.34
Ash, %	4.18	4.87	4.65
Ca, %	0.59	0.62	0.63
P, %	0.27	0.30	0.30

[a]All values excluding Dry matter, % are expressed on a DM basis.

Table 4. Dry matter intake, average daily gain, and feed efficiency by cattle fed a standard finishing diet (STD), a diet formulated to contain 15% whole cottonseed (WCS), and a whole cottonseed equivalent diet (EQU) formulated to contain percentages of fat and NDF equal to the WCS diet

	Treatment			
Item	STD	WCS	EQU	SE[a]
DMI, kg/d				
d 0 to 28	7.65[d]	8.27[e]	7.59[d]	0.174
d 0 to 56	8.11[d]	8.75[e]	8.13[d]	0.237
d 0 to 84	8.15[d]	8.80[e]	8.30[d]	0.241
d 0 to end[b]	8.11[d]	8.70[e]	8.29[d]	0.250
ADG, kg/d				
d 0 to 28	1.96[d]	2.05[d]	1.77[e]	0.115
d 0 to 56	1.86[de]	1.93[d]	1.73[e]	0.086
d 0 to 84	1.75	1.80	1.66	0.059
d 0 to end[b]	1.57	1.61	1.53	0.076
Adj. d 0 to end[c]	1.63	1.56	1.50	0.059
Feed:gain				
d 0 to 28	4.01[d]	4.08[d]	4.33[e]	0.170
d 0 to 56	4.40	4.55	4.71	0.119
d 0 to 84	4.67[d]	4.89[e]	5.01[e]	0.084
d 0 to end[b]	5.22	5.42	5.43	0.127
Adj. d 0 to end[c]	5.00[d]	5.59[e]	5.54[e]	0.126

[a]Pooled standard error of the means, n = 8 pens per treatment.

[b]Cattle in Block 1 were on feed for 84 d; cattle in Blocks 2 and 3 were on feed for 105 d; and cattle in Blocks 4 through 8 were on feed for 133 d.

[c]Adjusted final BW was calculated as hot carcass weight/average dress of 0.622. Adjusted daily gain was calculated as (adjusted final BW minus initial BW)/days on feed. Carcass-adjusted feed:gain was the ratio of daily DMI and adjusted daily gain.

[d,e]Within row, means that do not have a common superscript differ ($P \leq 0.10$).

Table 5. Carcass characteristics by cattle fed a standard finishing diet (STD), a diet formulated to contain 15% whole cottonseed (WCS), and a whole cottonseed equivalent diet (EQU) formulated to contain percentages of fat and NDF equal to the WCS diet

	Treatment			
Item	STD	WCS	EQU	SE[a]
Hot carcass wt, kg	357.3	353.9	346.9	5.27
Dress, %	63.00[g]	61.71[h]	61.91[h]	0.441
LM area, cm^{2}[b]	92.32	89.97	91.74	1.909
Grade fat[b]	0.949	0.959	0.826	0.052
KPH, %[c]	2.78	2.60	2.64	0.087
Yield grade	2.40	2.47	2.20	0.110
Marbling score[d]	481[i]	438[j]	422[j]	16.4
Choice, %[e]	64.10	57.50	57.50	-
Select, %[e]	35.90	42.50	42.50	-
Liver abscess, %[f]	7.69	2.50	12.50	-

[a]Pooled standard error of the means, n = 8 pens per treatment.

[b]LM = longissimus muscle; grade fat was measured at the ¾ measure of the split lean surface at the 12/13th rib interface.

[c]KPH = percentage of kidney heart and pelvic fat.

[d]300 = Slight 00; 400 = Small 00; 500 = Modest 00.

[e]Distribution of Choice + Prime vs. Select + Standard carcasses did not differ among treatments (P = 0.821).

[f]Distribution of liver abscesses did not differ among treatments (P = 0.272).

[g,h]Within row, means that do not have a common super script differ (P ≤ 0.058).

[i,j]Within row, means that do not have a common super script differ (P ≤ 0.081).

Table 6. Fecal and hide presence of *Escherichia coli* O157 by cattle fed a standard finishing diet (STD), a diet formulated to contain 15% whole cottonseed (WCS), and a whole cottonseed equivalent diet (EQU) formulated to contain percentages of fat and NDF equal to the WCS diet[a]

	Treatment		
Item	STD	WCS	EQU
Fecal, d 0[b]	0.00	2.50	10.00
Fecal, d 56[c]	53.85	67.50	70.00
Fecal, slaughter[df]	33.33	27.50	35.00
Hide, slaughter[ef]	28.21	30.00	30.00

[a]No differences detected among treatments for any sampling date ($P \geq 0.229$)

[b]Percentage of steers positive for the detection of *E. coli* O157 in the feces at the initiation of the trial.

[c]Percentage of steers positive for the detection of *E. coli* O157 in the feces on d 56 of the trial.

[d]Percentage of steers positive for the detection of *E. coli* O157 in the feces immediately before shipment to slaughter.

[e]Percentage of steers positive for the detection of *E. coli* O157 on the hide immediately before shipment to slaughter. Hide swabs were taken over a 600-cm^2 area near the perineum on the right side of each animal.

[f]Cattle in Block 1 were on feed for 84 d; cattle in Blocks 2 and 3 were on feed for 105 d; and cattle in Blocks 4 through 8 were on feed for 133 d.