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Evaluation of a Direct Fed Microbial and/or an Enzymatically Hydrolyzed Yeast Product in Diets Containing Monensin Sodium on Feedlot Phase Growth Performance, Efficiency of Dietary Net Energy Utilization, and Carcass Characteristics in Newly Weaned Beef Steers Fed in Confinement for 258 Days

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Objective

The objective of this research was to determine the influence a direct fed microbial (DFM) and/or yeast cell wall (YCW) product (both from Arm & Hammer Animal Nutrition, Princeton, NJ) have on growth performance and carcass characteristics in beef steers.

Study Description

Single-sourced, newly weaned steers (n = 256; initial body weight (BW) = 542 ± 3.7 lb) were allotted to 32 pens (n = 8 pens/treatment with 8 steers/pen). Steers were blocked by location in a 2x2 factorial treatment arrangement of DFM (Certillus CP B1801 Dry; Bacillus subtilis, Lactobacillus plantarum; 28 g/steer·d-1) and YCW (Celmanax; 18 g/steer·d-1). Steers were vaccinated and poured at processing and individually weighed on d 1, 14, 42 (end of receiving phase; implanted), 77, 105 (end of growing phase), 133, 161 (implanted), 182, 230 (start ractopamine HCl) and 258. Growth performance and carcass measurements were recorded.

Take Home Points

No DFM×YCW interactions ($P \geq 0.05$) were observed for cumulative growth performance. Steers from YCW had lower ($P = 0.04$) dry matter intake compared to DFM and had a tendency ($P < 0.08$) for improved measures of applied energetics by 1%. Use of DFM and YCW alone or in combination had minimal effects on growth performance and carcass traits.

Introduction

Foodborne pathogens have accounted for approximately 9.4 million illnesses annually with 55,961 cases that resulted in hospitalizations and 1,351 of the illnesses that resulted in death (Scallan, 2011). *Salmonella* was the leading cause of foodborne pathogen related deaths accounting for approximately 28% of deaths (Scallan, 2011). Pathogenic bacteria (i.e. *Salmonella* and *E. coli O157:H7*) reside in the gastrointestinal tract of cattle that appear healthy. Feces (both *Salmonella* and *E. coli O157:H7*) as well as carcass associated lymphatic tissue (primarily *Salmonella*) are potential sources of food supply contamination. In January of 2020, a citizen petition requested the USDA Food Safety and Inspection Service to declare 31 *Salmonella* strains as adulterants in meat products (USDA-FSIS, 2020). Should this come into action, this could pose problems for cattle producers as 4.8% of foodborne *Salmonella* outbreaks and 0.3% of foodborne *E. coli* O157:H7 outbreaks can be attributed to beef products (Xie et al., 2016). Antimicrobials have been used in livestock feeds in attempt to combat this issue. However, on January 1, 2017, all medically important antimicrobials to human medicine were listed in the Veterinary Feed Directive (VFD; FDA, 2021). The VFD requires veterinarian oversight and the prescription of feed-based antimicrobials from a veterinarian that has a working patient-client relationship with the producer (FDA, 2021). Antimicrobial resistance is a large concern to animal producers, livestock product processors, and consumers. Continued and unwarranted use of antimicrobials in livestock production results in increased pools of antimicrobial resistant genes among bacteria (FDA, 2021). Specifically, antimicrobial resistance in pathogenic bacteria capable of causing food borne illness, such as *Salmonella* and *E. coli O157:H7*, is of greatest concern to beef producers, processors, and consumers. *Bacillus subtilis* based direct fed microbial feed additives have been shown to reduce harmful pathogenic bacteria in the gastrointestinal tract. Enzymatically hydrolyzed yeast product components of *Saccharomyces cerevisiae* have been shown to reduce inflammation and modulate immune function. There is potential that the use of these products can aid in controlling systemic inflammation. Therefore, the objective of this research was to determine the influence a direct fed microbial (DFM) and/or an enzymatically hydrolyzed yeast product (YCW; both from Arm & Hammer Animal Nutrition, Princeton, NJ) have on growth performance and carcass characteristics in beef steers.

Experimental Procedures

Cattle Management

Single-sourced, newly weaned steers (n = 256; initial BW = 542 ± 3.7 lb) were transported approximately 319 miles from Western South Dakota to the Ruminant Nutrition Center (RNC) in Brookings, SD in October of 2020. The morning following arrival, all steers were subjected to an individual BW measurement used for allotment purposes, application of a unique identification ear tag, vaccination against viral respiratory diseases (Bovishield Gold 5, Zoetis) and clostridial species (Ultrabac 7/Somubac, Zoetis) and administered pour-on moxidectin (Cydectin, Bayer) according to label directions. The afternoon following initial processing steers selected from the larger population based upon temperament, health, and uniformity of body weight were allotted to 32 pens (n = 8 pens/treatment with 8 steers/pen).

Dietary Treatments and Feeding Management

Steers were blocked by location in a 2 x 2 factorial treatment arrangement of DFM (Certillus CP B1801 Dry; *Bacillus subtilis, Lactobacillus plantarum*; 28 g/steer·d^{-1}) and YCW (Celmanax; 18 g/steer·d^{-1}). Steers were individually weighed on d 1, 14, 42 (end of receiving phase), 77, 105 (end of growing phase), 133, 161, 182, 230, and 258. Steers were implanted with a Synovex-S (Zoetis) implant containing 200 mg progesterone and 20 mg estradiol benzoate (EB) at 42 d and a Synovex Plus (Zoetis) implant containing 200 mg trenbolone acetate and 28 mg EB at 161 d. At 230 d, all treatments were started on ractopamine HCl at 300 mg/steer·d^{-1} until the conclusion of the study at 258 d.

Throughout the entire study, feed was manufactured twice daily (0800 h and 1500 h), and bunks were managed according to a slick bunk management system allowing for *ad libitum* access to feed. All diets (Tables 1 and 2) contained monensin sodium (Rumensin-90, Elanco Animal Health) at 27.6 mg/kg during the receiving and growing phase and 33.1 mg/kg during the finishing phase; all diets were fortified with vitamins and minerals to exceed nutrient requirements for growing and finishing beef steers (NRC, 1996).

Growth Performance Calculations

Growth performance (BW, average daily gain (ADG), feed efficiency (F:G and G:F), dry matter intake (DMI)) was determined from receiving through finishing. All interim period growth performance data is based upon live weight reduced by 4% to account for digestive tract fill. Cumulative growth performance was based upon initial BW (average BW from initial processing and d 1 with a 4% shrink applied to account for digestive tract fill) and final BW (shrunk 4%). ADG was calculated as the difference between BW and initial shrunk BW, divided by days on feed for the respective period; feed efficiency was calculated from ADG/DMI.

Applied energetics measures (observed dietary NE; the ratio of observed-to-expected dietary NE, DMI, and ADG; and MQ) were assessed from d 1 to 258 for the cumulative post-weaning feeding period. Observed dietary NE was calculated from daily energy gain (EG; Mcal/d): EG = $ADG^{1.097} \times 0.0557W^{0.75}$, where W is the mean equivalent (Eq) BW [average initial shrunk BW and ending period shrunk BW × (1053/AFBW), lbs; (NRC, 1996)], using shrunk (4%) growth performance. Maintenance energy required (EM; Mcal/d) was calculated by the following equation: EM = $0.077BW^{0.75}$ (Lofgreen and Garrett, 1968) where BW is the mean shrunk BW (average of initial shrunk BW and ending period BW). Using the estimates required for maintenance and gain**,** the observed dietary NEm and NEg values (Owens and Hicks, 2019) of the diet were generated using the quadratic formula: $x = \frac{-b\pm\sqrt{b^2-4ac}}{2c}$, where x = NEm, Mcal/kg, a = -0.41EM, b = 0.877EM + 0.41DMI + EG, c = -0.877DMI, and NEg was determined from: 0.877NEm – 0.41 (Zinn and Shen, 1998; Zinn et al., 2008). The ratio of observed-to-expected NE ratio was determined from observed dietary NE for maintenance or gain/tabular NE for maintenance (tNEm) or gain (tNEg). Expected DMI was determined based observed ADG and equivalent BW according to the following equation (NRC, 1996): expected DMI, kg/d = (EM/tNEm)+(EG/tNEg), where tNEm and tNEg are NE values based upon tabular composition of the diet. Expected ADG (kg/d) was determined from feed available for maintenance (FFM), feed available for gain (FFG), retained energy (RE; Mcal/d), median feeding weight and equivalent BW (EqBW), where FFM = EM/tNE_M, FFG = DMI - FFM, and RE = FFG × tNE_G according to the following equation: expected ADG, kg/d = $(13.91 \times RE^{0.9116} \times EqBW^{-0.6837})$. Maintenance coefficient (MQ) was determined using the following equation: MQ, Mcal/ $W^{0.75}$=[(DMI-(EG/NEg))NEm]/$W^{0.75}$.

Carcass Trait Determination

Steers were harvested after 258 d on feed post-weaning. Steers were shipped the afternoon following final BW determination and harvested the next day at a commercial harvest abattoir. Liver abscess prevalence and severity was determined following evisceration according to the Elanco Scoring System as: Normal (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 1 in diameter), or A+ (1 or more large active abscesses greater than 1 in diameter with inflammation of surrounding tissue). Hot carcass weight (HCW) was captured immediately following the harvest procedure. Video image data were obtained from the packing plant for rib eye area (REA), rib fat (RF), kidney pelvic heart fat (KPH), and USDA marbling scores. Yield grade (YG) was calculated according to the USDA regression equation (USDA, 1997). Dressing percentage (DP) was calculated as HCW/(final BW × 0.96). Estimated empty body fat (EBF) percentage and final BW at 28% EBF (AFBW) were calculated from observed carcass traits (Guiroy et al., 2002), and proportion of closely trimmed boneless retail cuts from carcass round, loin, rib, and chuck (Retail Yield, RY; (Murphey et al., 1960).

Statistical analysis

Growth performance, carcass traits, and efficiency of dietary NE utilization were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. The model included the fixed effect of DFM, YCW and their interaction; block was included as a random variable. Least squares means were generated using the LSMEANS statement of SAS 9.4. Treatment effects were analyzed using the pairwise comparisons PDIFF and LINES option of SAS 9.4. Distribution of USDA Yield and Quality grade data, as well as liver abscess prevalence and severity were analyzed as binomial proportions in the GLIMMIX procedure of SAS 9.4 with fixed and random effects in the model as previously mentioned. An α level of less than or equal to 0.05 determined significance and tendencies were discussed at an α level between 0.05 and 0.10.

Results and Discussion

No DFM × YCW interactions ($P \geq 0.10$) were observed for cumulative growth performance responses (Table 3). The use of DFM had no influence ($P \geq 0.10$) on live weight, ADG, DMI, G:F, observed dietary NE, the ratio of observed-to-expected dietary NE, DMI, and ADG, or MQ. Steers from YCW had reduced ($P \leq 0.04$) intake by 1.8%. Observed dietary NEm and NEg tended ($P \leq 0.07$) to be increased by 1.2 to 1.5% when YCW was fed. The ratio of observed-to-expected dietary NEm and NEg tended ($P \leq 0.07$) to be increased by 1.0 to 1.5% when YCW was fed. The ratio of observed-to-expected DMI tended ($P = 0.08$) to be decreased by 1.0% when YCW was fed. The ratio of observed-to-expected ADG tended ($P = 0.08$) to be decreased by 2.0% when YCW was fed. The MQ tended ($P \leq 0.06$) to be reduced by 3.9% when YCW was supplemented compared to non-supplemented controls. No other effects ($P \geq 0.14$) of YCW supplementation were observed for growth performance responses.

Carcass characteristic measures are presented in Table 4. A DFM × YCW interaction ($P = 0.02$) was noted for the distribution of USDA YG1 carcasses. Steers from control had a greater ($P \leq 0.05$) proportion of carcasses classified as USDA YG1 compared to all other treatments. Additionally, a DFM × YCW interaction ($P = 0.04$) was observed for the distribution of USDA Prime carcasses. Steers from DFM × YCW had a greater ($P \leq 0.05$) proportion of carcasses classified as USDA Prime compared to DFM and YCW but did not differ ($P \geq 0.10$) from the control carcasses, which were similar ($P \geq 0.10$) to DFM and YCW carcasses. No other DFM × YCW interactions were noted for other carcass measurements ($P \geq 0.06$). Supplemental DFM had no significant impact ($P \geq 0.10$) on any carcass trait responses. Use of YCW resulted in 31.9% reduction in carcasses classified as USDA Average Choice ($P = 0.05$). Supplementation of YCW during the entire post-weaning production phase had no other effects ($P \geq 0.10$) on any carcass trait measurements in the present experiment.

Implications

Results from this study indicate the use of DFM and YCW alone or in combination had minimal effects on growth performance and carcass merit. Collectively, these data suggest cumulative post-weaning gain efficiency was not appreciably influenced by DFM or YCW supplementation. However, differences in the efficiency of energy utilization of the diet revealed that steers from YCW had an increase in the efficiency of dietary energy utilization by 1%. The basis for this improvement may be attributed to improved ruminal health, or reduced inflammation that resulted in a reduced MQ requirement. Further investigation is warranted to determine the impact direct fed microbials and enzymatically hydrolyzed yeast product components have on ruminal health.

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References

FDA. 2021. United States Food and Drug Administration. Veterinary Feed Directive (VFD).

Guiroy, P. J., L. O. Tedeschi, D. G. Fox, and J. P. Hutcheson. 2002. The effects of implant strategy on finished body weight of beef cattle. J. Anim. Sci. 80(7):1791-1800. doi: 10.2527/2002.8071791x

Hahn, G. 1999. Dynamic responses of cattle to thermal heat loads. J Anim Sci 77(suppl_2):10-20.

Lofgreen, G. P., and W. N. Garrett. 1968. A System for Expressing Net Energy Requirements and Feed Values for Growing and Finishing Beef Cattle. J. Anim. Sci. 27(3):793-806. doi: 10.2527/jas1968.273793x

Murphey, C. E., D. K. Hallett, W. E. Tyler, and J. C. Pierce. 1960. Estimating yields of retail cuts from beef carcass. Proc. Am. Soc. Anima. Prod., Chicago, IL.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7 ed.

Owens, F. N., and R. B. Hicks. 2019. Can net energy values be determined from animal performance measurements? A review of factors affecting application of the California Net Energy System. Transl. Anim. Sci. 3(3):929-944. doi: 10.1093/tas/txy130

Preston, R. L. 2016. 2016 feed composition table BEEF Magazine. https://www.beefmagazine.com/sites/beefmagazine.com/files/2016-feedcomposition-tables-beef-magazine.pdf. (Accessed February 1, 2019).

Scallan, E., Hoekstra, R. M., Angulo, F. J., Tauxe, R. V., Widdowson, M., Roy, S. L....Griffin, P. M. (2011). Foodborne Illness Acquired in the United States—Major Pathogens. Emerging Infectious Diseases, 17(1), 7-15. https://doi.org/10.3201/eid1701.p11101.

USDA. 1997. Official United States Standard for Grades of Beef Carcasses Agric. Marketing, USDA Washington DC.

USDA-FSIS. (2020). United States Department of Agriculture Food Safety and Inspection Service. Marler Clark Petition for an Interpretive Rule Declaring 'Outbreak' Serotypes of Salmonella enterica subspecies enterica to be Adulterants Within the Meanings of 21 U.S.C. § 601(m)(1) and 21 U.S.C § . 453(g)(1).

Xie Y, Savell JW, Arnold AN, Gehring KB, Gill JJ, Taylor TM. Prevalence and Characterization of Salmonella enterica and Salmonella Bacteriophages Recovered from Beef Cattle Feedlots in South Texas. J Food Prot. 2016 Aug;79(8):1332-40. doi: 10.4315/0362-028X.JFP-15-526. Erratum in: J Food Prot. 2018 Dec;81(12):1920. PMID: 27497120.

Zinn, R. A., A. Barreras, F. N. Owens, and A. Plascencia. 2008. Performance by feedlot steers and heifers: Daily gain, mature body weight, dry matter intake, and dietary energetics. J. Anim. Sci. 86(10):2680-2689. doi: 10.2527/jas.2007-0561

Zinn, R. A., and Y. Shen. 1998. An evaluation of ruminally degradable intake protein and metabolizable amino acid requirements of feedlot calves. J. Anim. Sci. 76(5):1280-1289. doi: 10.2527/1998.7651280x

Tables

Table 1. Diet composition for the receiving, growing, and transition diets for steers fed Control, DFM and/or YCW diets from d 1 to 126[1].

	d 1 to 42 (Receiving)				d 43 to 112 (Growing)				d 113 to 119 (Transition 1)				d 120 to 126 (Transition 2)			
Item	**CON**	**DFM**	**YCW**	**DFM + YCW**	**CON**	**DFM**	**YCW**	**DFM + YCW**	**CON**	**DFM**	**YCW**	**DFM + YCW**	**CON**	**DFM**	**YCW**	**DFM + YCW**
DRC, %	-	-	-	-	14.68	14.68	14.68	16.47	16.85	16.85	16.85	16.85	24.34	24.33	24.33	24.33
HMC, %	-	-	-	-	-	-	-	-	15.65	15.65	15.65	15.64	22.56	22.56	22.56	22.55
DDGS, %	19.21	19.20	19.21	19.20	19.70	19.69	19.70	19.69	17.19	17.18	17.19	17.18	15.13	15.13	15.13	15.12
Corn Silage, %	52.16	52.14	52.16	52.13	51.66	51.65	51.66	51.64	42.61	42.60	42.61	42.60	30.35	30.34	30.34	30.33
Oat Hay, %	18.96	18.96	18.96	18.95	4.74	4.74	4.74	4.75	-	-	-	-	-	-	-	-
Sorghum Silage, %	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelleted Supplement, %	5.82	5.82	5.82	5.82	6.54	6.54	6.54	6.53	-	-	-	-	-	-	-	-
Liquid Supplement, %	-	-	-	-	-	-	-	-	5.14	5.14	5.14	5.14	5.10	5.10	5.10	5.10
Treatment Supplement, %	3.85	3.88	3.85	3.89	2.67	2.71	2.69	2.72	2.55	2.58	2.56	2.59	2.53	2.56	2.54	2.57
DM, %	47.80	47.82	47.80	47.82	50.89	50.91	50.90	50.92	49.24	49.25	49.25	49.26	56.01	56.02	56.01	56.03
NEm, Mcal/cwt	78.25	78.25	78.25	78.26	84.18	84.18	84.18	84.18	87.41	87.42	87.42	87.42	91.01	91.02	91.02	91.02
NEg, Mcal/cwt	49.10	49.11	49.10	49.11	55.05	55.06	55.05	55.06	58.35	58.35	58.35	58.35	61.50	61.50	61.50	61.50

[1] All diets were fortified with vitamins and minerals to exceed nutrient requirements for growing and finishing beef steers (NRC, 1996) and contained monensin sodium (Rumensin-90, Elanco Animal Health) at 27.6 mg/kg within the liquid supplement until d 113 where the liquid supplement contained 33.1 mg/kg, CON: Control:, No DFM or YCW, DFM: direct-fed microbial (*Certillus*), YCW: enzymatically hydrolyzed yeast product (*Celmanax*).

Table 2. Diet composition for the finishing diet for steers receiving Control, DFM and/or YCW diet from d 127 to 258[1].

	d 127 to 230 (Finisher 1)				d 231 to 245 (Finisher 2)				d 246 to 258 (Finisher 3)			
Item	CON	DFM	YCW	DFM + YCW	CON	DFM	YCW	DFM + YCW	CON	DFM	YCW	DFM + YCW
DRC, %	32.74	32.74	32.74	32.74	35.54	35.34	35.54	35.54	69.10	69.10	69.10	69.10
HMC, %	32.43	32.43	32.43	32.43	34.98	34.98	34.98	34.98	-	-	-	-
DDGS, %	15.03	15.03	15.03	15.03	15.29	15.29	15.29	15.29	15.11	15.11	15.11	15.11
Corn Silage, %	12.25	12.25	12.25	12.25	-	-	-	-	-	-	-	-
Oat Hay, %	-	-	-	-	-	-	-	-	1.99	1.99	1.99	1.99
Sorghum Silage, %	-	-	-	-	6.80	6.80	6.80	6.80	6.46	6.46	6.46	6.46
Pelleted Supplement, %	-	-	-	-	-	-	-	-	-	-	-	-
Liquid Supplement, %	5.24	5.24	5.24	5.24	5.27	5.27	5.27	5.27	5.24	5.24	5.24	5.24
Treatment Supplement, %	2.31	2.31	2.31	2.31	2.11	2.12	2.11	2.12	2.10	2.11	2.10	2.10
DM, %	68.24	68.25	68.24	68.24	71.52	71.52	71.52	71.52	77.89	77.90	77.89	77.90
NEm, Mcal/cwt	95.85	95.85	95.85	95.85	96.22	96.22	96.22	96.22	94.05	94.05	94.05	94.05
NEg, Mcal/cwt	65.46	65.46	65.46	65.46	65.63	65.63	65.63	65.63	63.58	63.58	63.58	63.58

[1] All diets were fortified with vitamins and minerals to exceed nutrient requirements for growing and finishing beef steers (NRC, 1996), and contained monensin sodium (Rumensin-90, Elanco Animal Health) at 33.1 mg/kg within the liquid supplement, CON: Control: No DFM or YCW, DFM: direct-fed microbial (*Certillus*), YCW: enzymatically hydrolyzed yeast product (*Celmanax*).

Table 3. Effect of Control, DFM and/or YCW on cumulative growth performance responses (d 1 to 258)[1].

Item	Control	DFM	YCW	DFM+YCW	SEM	*P* - value YCW	*P* - value DFM	*P* - value DFM+YCW
Pens, n	8	8	8	8	-	-	-	-
Steers, n	62	62	61	59	-	-	-	-
Growth Performance								
Initial BW, lb	543	543	544	543	-	-	-	-
258 d BW, lb	1447	1445	1431	1447	16.7	0.55	0.56	0.46
ADG, lb/d	3.50	3.50	3.44	3.51	0.064	0.52	0.48	0.43
DMI, lb/d	20.76	20.76	20.30	20.47	0.238	0.04	0.62	0.64
G:F[2]	0.169	0.169	0.169	0.171	0.0021	0.26	0.54	0.47
F:G[3]	5.92	5.92	5.92	5.85	-	-	-	-
Applied Energetic Measures								
Dietary NEm, Mcal/cwt	89.05	89.10	89.86	90.39	0.779	0.07	0.60	0.66
Dietary NEg, Mcal/cwt	59.50	59.54	60.21	60.67	0.682	0.07	0.61	0.66
O-E dietary NEm[4]	1.00	1.00	1.01	1.01	0.008	0.07	0.61	0.66
O-E NEg[4]	1.00	1.00	1.01	1.02	0.011	0.07	0.60	0.66
O-E DMI[4]	1.00	1.00	0.99	0.99	0.010	0.08	0.54	0.66
O-E ADG[4]	1.00	1.00	1.01	1.03	0.016	0.08	0.48	0.62
MQ, Mcal/MBS	0.078	0.077	0.075	0.074	0.0020	0.06	0.59	0.66

[1] A 4% shrink was applied to all BW measures to account for gastrointestinal tract fill, Deads and removals excluded from final calculations, Control: No DFM or YCW, DFM:direct-fed microbial (*Certillus*), YCW:enzymatically hydrolyzed yeast product (*Celmanax*).
[2]Gain to feed ratio = average daily gain / dry matter intake.
[3]Feed to gain ratio = dry matter intake / average daily gain. *P*-values are equal to G:F values for each respective treatment.
[4]O-E: Observed-to-expected ratio for net energy for maintenance, gain, dry matter intake, or average daily gain.

Table 4. Effect of Control, DFM and/or YCW on carcass trait responses[1].

Item	Control	DFM	YCW	DFM+YCW	SEM	*P* - value YCW	*P* - value DFM	*P* - value DFM+YCW
Pens, n	8	8	8	8	-	-	-	-
Steers, n	62	62	61	59	-	-	-	-
Carcass Traits								
HCW, lbs	941	937	929	937	11.1	0.49	0.75	0.43
DP[a], %	64.88	64.83	64.95	64.82	0.216	0.84	0.58	0.79
REA, in^2	15.35	15.32	15.32	15.36	0.175	0.95	0.97	0.81
RF, in	0.47	0.49	0.50	0.50	0.025	0.34	0.68	0.78
Marbling[b]	492	484	481	481	18.1	0.59	0.74	0.74
KPH, %	1.75	1.79	1.78	1.77	0.026	0.76	0.40	0.27
Calculated YG[c]	2.70	2.73	2.72	2.75	0.075	0.69	0.57	0.96
RY[d], %	51.17	51.09	51.11	51.06	0.162	0.71	0.54	0.89
EBF[e], %	29.86	29.91	29.94	30.03	0.376	0.71	0.78	0.95
AFBW[e], lbs	1403	1396	1384	1393	17.8	0.37	0.93	0.50
Yield Grade Distribution, %								
1	12.9[a]	1.6[b]	3.3[b]	4.9[b]	2.55	0.23	0.07	0.02
2	48.7	73.4	62.5	57.3	7.53	0.88	0.21	0.06
3	38.4	23.4	34.2	36.0	6.75	0.54	0.34	0.23
4	0.0	1.6	0.0	1.7	1.18	0.93	0.17	0.93
5	-	-	-	-	-	-	-	-
Quality Grade Distribution, %								
Select	19.6	13.0	14.5	18.8	4.96	0.94	0.81	0.25
Low Choice	38.4	44.8	52.2	46.9	6.63	0.21	0.93	0.35
Average Choice	27.5	35.9	23.0	20.2	5.62	0.05	0.56	0.26
High Choice	11.2	6.3	10.3	10.1	3.96	0.69	0.49	0.52
Prime	3.3[ab]	0.0[b]	0.0[b]	3.9[a]	1.68	0.88	0.88	0.04
Liver Abscess Severity and Prevalence[f], %								
Normal	90.0	93.2	90.4	95.3	3.37	0.71	0.23	0.81
A-	3.3	2.1	4.7	1.6	2.05	0.78	0.15	0.53
A	1.6	0.0	0.0	3.1	1.29	0.55	0.55	0.08
A+	5.1	4.7	4.9	0.0	2.48	0.33	0.29	0.38

[1] Control: No DFM or YCW, DFM: direct-fed microbial (*Certillus*), YCW: enzymatically hydrolyzed yeast product (*Celmanax*).
[a] Dressing Percent = (HCW/final BW shrunk 4%) × 100.
[b] 400 = small[00]
[c] According to the regression equation described by USDA (1997) for USDA Yield Grade.
[d] Retail yield as a percentage of hot carcass weight according to Murphey et al. (1960).
[e] Empty body fat percentage and average final body weight at 28% empty body fat calculated according to the equations described by Guiroy et al. (2002).
[f] According to the Elanco Liver Scoring System: Normal (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 1 in. diameter), or A+ (1 or more large active abscesses greater than 1 in. diameter with inflammation of surrounding tissue).