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Effects of live cultures of *Lactobacillus acidophilus* (Strains 45 and 51) and *Propionibacterium freudenreichii* PF-24 on performance and carcass characteristics of finishing beef steers

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Introduction

Direct-fed microbials, particularly strains of *Lactobacillus acidophilus*, are used extensively by the cattle feeding industry; however, effects on cattle performance have often been equivocal, and the mode of action of direct-fed microbials remains unclear. Combining *Lactobacillus acidophilus* strains with *Propionibacterium* strains that inhibit lactate accumulation in the rumen might prove beneficial for cattle being adapted to high-concentrate diets, or for finishing cattle that experience fluctuations in feed intake. Additional field-level research is needed to determine the most appropriate combinations of these strains with respect to cattle performance and carcass merit. Our objective was to compare performance by growing/finishing cattle fed a control diet with no added microbials or three different combinations of *Lactobacillus acidophilus* and *Propionibacterium freudenreichii*.

Experimental Procedures

Cattle. Two hundred seventy steers (Angus, Angus x Herford, Angus x Charolais, and British x Continental) were received at the Texas Tech University Burnett Center from the Lexington Livestock Auction, Lexington, NE on 12/11/99. Pay weight averaged 624 lb. Steers were sorted to seven dirt-floor pens (38 to 39 steers per pen) and offered a 45% concentrate starter diet (25.9% dry rolled corn, dry matter [DM] basis). The starter diet was top-dressed with approximately 2 lb/steer of alfalfa hay for the first 2 d after arrival. On 12/16/99, all steers were processed through the Burnett Center working facility, which included an individual body weight (BW) measurement, insertion of a uniquely numbered ear tag, and label doses of the following products: 1) Ultra Choice Clostridial Vaccine (Pfizer Animal Health); 2) Bovishield 4 + Lepto (Pfizer); and 3) Dectomax (Pfizer). After processing, steers were returned to pens in which they had been housed previously, and they continued to receive the 45% concentrate starter diet.

Experimental Design. All cattle were weighed on 1/7/00 to determine a sorting BW. Based on this BW, cattle were stratified by BW and assigned randomly to one of 12 weight blocks. Treatments (described below) were assigned randomly to cattle within weight blocks, resulting in four pens (one per treatment) of five steers within a weight block. On 1/13/00 steers were implanted with Ralgro (Schering Plough Anim. Health), and each of the 240 steers was sorted to its assigned Burnett Center pen. All cattle were weighed to start the study on 1/18/00. Each pen was fed a 62% concentrate diet (with the assigned microbial treatment added during mixing) to provide an intake of NEg equal to that

consumed from the 45% concentrate diet the previous day. Over the course of the next 17 d, the cattle were stepped through a series of diets (Table 1), with the final step to the 92% concentrate diet on 2/4/01.

Four treatments were used in a randomized complete block design. Pen was the experimental unit (12 pens per each of the four treatments with five steers per pen for a total of 240 steers). The four treatments were coded by color as follows:

- **Red (R)** – standard 92% concentrate diet with carrier (lactose) only mixed in water and added to the diet at the time of feeding;

- **Green (G)** – standard 92% concentrate diet with 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 45 plus 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal mixed in water and added to the diet at the time of feeding;

- **Yellow (Y)** – standard 92% concentrate diet with 1 x 10^4 CFU *Lactobacillus acidophilus* Strain 45 plus 1 x 10^4 CFU *Lactobacillus acidophilus* Strain 51 plus 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal mixed in water and added to the diet at the time of feeding;

- **Blue (B)** – standard 92% concentrate diet with 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 45 plus 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 51 plus 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal mixed in water and added to the diet at the time of feeding.

Each treatment culture (lactose for the R [control] treatment) was prepackaged in aluminum foil packets, and each aluminum packet had a colored dot that corresponded to the treatment codes of R, G, Y, and B. The contents of two packets were sufficient to supply the desired dose of microbial culture for the 12 pens of cattle on each treatment. The contents of the two packets per treatment were mixed with 0.67 gal of distilled water in a plastic sprinkler can, after which the contents of the sprinkler can were poured onto the diet as it mixed in a Rotomix 84-8 mixer/delivery unit. Four sprinkler cans were used, each with a colored tape wrapped on the nozzle of the sprinkler can that corresponded to the color code for one of the four treatments.

Experimental Diets. Ingredient composition of the diets fed during the experiment is shown in Table 1. These data reflect adjustments for the average DM matter content of feed ingredients for the period during which a given diet was fed. Each diet contained the same intermediate premix (Table 2), which supplied protein, various minerals and vitamins, Rumensin (30 g/ton, DM basis), and Tylan (8 g/ton, DM basis).

Management, Feeding, and Weighing Procedures. The four treatment diets were mixed in a 45-cubic foot capacity Marion paddle mixer. Once the total amount of feed for a given treatment was mixed, the mixed batch was released from the paddle mixer and delivered by a drag-chain conveyer to a Rotomix 84-8 mixer/delivery system. As feed was being delivered, and the mixer unit for the Rotomix 84-8 unit was operating, the contents of the sprinkler can for a given treatment were poured onto the diet. After mixing for approximately 4 to 5 min, the quantity of feed allotted to each of the 12 pens per treatment was then weighed to the nearest 2 lb by use of the load cells and

indicator on the Rotomix 84-8 unit. Feeding order of treatment diets throughout the experiment was R, G, Y, and B. Clean out of the Rotomix 84-8 was monitored closely to avoid cross-contamination of diets.

Dry matter determinations on ingredients used in the experimental diets were made every 2 wk during the experiment. In addition, samples of feed delivered to feed bunks were taken weekly. Bunk sample DM values were used to compute average DM intake (DMI) by each pen of cattle. Samples of feed taken from the bunk were composited for each interval (typically 28-d intervals) in which cattle were weighed during the experiment. Composited samples were ground to pass a 2-mm screen in a Wiley mill and analyzed for DM, ash, CP, ADF, Ca, and P (AOAC, 1990; Table 3).

Each feed bunk of the 48 pens was evaluated visually at approximately 0700 to 0730 daily. The quantity of feed remaining in each bunk was estimated, and the suggested daily allotment of feed for each pen was recorded. Feed bunks were cleaned, and unconsumed feed was weighed (Ohaus electronic scale, ± .1 lb) at intervals corresponding to intermediate weigh dates throughout the trial, and DM content of these bunk weighback samples was determined in a forced-air oven by drying overnight (typically 20 h) at 100°C. The DMI by each pen was calculated by multiplying the DM content of the delivered feed by the total feed delivery to each pen, with correction for the DM of weighback from each pen.

After 28, 56, 84, and 112 d on feed, steers in all pens were weighed before the morning feeding. All BW measurements were obtained using a single-animal scale (C & S Single-Animal Squeeze Chute set on four load cells). The scale was calibrated with 1,000 lb of certified weights (Texas Dept. of Agriculture) on the day before each scheduled weigh day. These intermediate BW measurements were taken to assess performance of the cattle on a regular basis.

On d 56, at the time of a regularly scheduled BW measurement, each steer was implanted with Revalor S (Intervet). The status of each implant was checked by palpation of the implant site at the time of the d-84 BW measurement. After the d-112 BW measurement, it was estimated that steers in Blocks 7 through 12 would have sufficient finish to grade USDA Choice within 3 to 4 wk. Hence, all steers in Blocks 7 through 12 were weighed starting at approximately 0600 on May 30, 2000 (d 133) and shipped to the Excel Corp. slaughter facility in Plainview, TX. Steers in Blocks 1 through 6 remained on feed for an additional 14 d, were weighed (approximately 0600) and shipped on June 13, 2000 (d 147) to the Excel Corp. slaughter facility in Plainview, TX. Of the original 240 steers that started the experiment, eight steers either died or were removed from the experiment for reasons unrelated to treatment, resulting in a total of 232 steers being sent to the Excel Corp. facility.

Carcass Evaluation. Personnel of the West Texas A&M University Beef Carcass Research Center obtained all carcass measurements, which included hot carcass weight, longissimus muscle area, marbling score, percentage of kidney, pelvic, and heart (KPH) fat, fat thickness measured between the 12th and 13th ribs, yield grade, quality grade, and liver abscess score. In the present experiment, of the 232 steers sent to the slaughter plant, complete data were obtained on 231 carcasses.

Statistical Analyses. All data were analyzed with pen as the experimental unit. A complete randomized block design was employed, and computations were made with the GLM procedure of SAS (1987). Pen means for daily gain and average daily DMI were included in the data file, and feed:gain ratio was computed as the quotient of daily DMI divided by daily gain. The effect of treatment and block were included in the model for pen-based data. Carcass data were entered on an individual animal basis and analyzed with a model that included effects of treatment, block, and block x treatment. Block x treatment was specified as the error term for testing treatment effects with carcass data. Residual mean square in this model for carcass data (not used for testing) would include individual animal variation. The following orthogonal contrasts were used to test treatment effects: 1) R treatment vs the average of the G, Y, and B treatments; 2) G treatment vs the average of the Y and B treatments; and 3) Y vs B treatment. Carcass quality grade data were analyzed by Chi-square procedures (SAS, 1987) using individual animal data. Liver score data were not statistically analyzed because of the low number of observations in several of the categories.

Results and Discussion

Performance Data. Average composition of the experimental diets is shown in Table 3. Analyzed nutrient content was similar among the four treatment diets and generally in close agreement with formulated values. Crude protein content, however, was approximately 1% greater than expected from formulation, most likely because the CP value for steam-flaked corn used in formulation (8.5%) was less than the actual CP of the corn supply used during the experiment (9 to 9.5% based on samples collected during the experiment).

Initial BW (Table 4) did not differ among treatments, averaging 695 lb. Final BW was increased 2.1% ($P < .04$) for the average of steers in the G, Y, and B treatments compared with steers in the R (control) treatment; however, no differences were noted in final BW within the three treatments receiving microbial cultures (G, Y, and B). Adjusted final BW (final BW based on hot carcass weight divided by the overall average dressing percent) also was greater ($P < .05$) for the average of steers fed microbial cultures compared with control steers. Corresponding to increased final BW, daily gain was consistently greater for the average of G, Y, and B treatments vs the R treatment throughout the study, with significant differences for d 0 to 56 ($P < .08$) and d 0 to end ($P < .06$). Adjusted daily gain (calculated from adjusted final BW) also was greater ($P < .08$) for the average of the G, Y, and B treatments than for the R treatment. The only difference noted among the three microbial culture treatments was a greater ($P < .07$) daily gain for d 0 to 28 by cattle on the G treatment vs the average by cattle on the Y and B treatments.

The increase in gain for the average of the microbial culture treatments was 4.3% for the overall study, which compares favorably to a 6.9% increase in daily gain reported by Rust et al. (2000) for cattle given similar microbial culture treatments to those in the present study. The increase in overall gain during the present study for the average of the G and Y treatments vs R was 5.3%. Microbial cultures used by Rust et al. (2000) were the same as those in the present study, with two of four treatments being identical to treatments R and G in the present study. Two treatments in the Rust et

al. (2000) study also included *Lactobacillus acidophilus* Strain 51 in addition to Strain 45; however, doses were slightly different than the Y and B treatments in the present study. Moreover, the grain component of the diet used by Rust et al. (2000) was a mixture of cracked corn and rolled wheat compared with steam-flaked corn in the present study.

Although not statistically significant at any of the cumulative periods of the study, daily DMI (Table 4) was consistently greater by the average of cattle in the microbial culture (G, Y, and B) treatments than by those in the control (R) treatment. For the overall feeding period, DMI was 2.4% greater for microbial culture treatments than for the control treatment, with most of this difference attributable to the G and Y treatments (3.2% increase relative to R). Rust et al. (2000) reported no difference in DMI by cattle fed control vs microbial culture treatments in their 115-d study. Differences in DMI among the microbial culture treatments were generally not evident during the present study, except from d 0 to 28 when cattle on the G treatment consumed more ($P < .03$) DM than the average of cattle on the Y and B treatments.

Feed:gain ratio (Table 4) was improved for the average of the G, Y, and B treatments compared with the R treatment; however, differences were significant only from d 0 to 56 ($P < .01$) and d 0 to 112 ($P < .10$). For the overall study (d 0 to end and adjusted d 0 to end data), the improvement in feed:gain ratio was approximately 2% for the average of the G, Y, and B treatments vs the R treatment. In contrast, Rust et al. (2000) reported a 7.3% improvement in feed:gain ratio for microbial culture treatments (similar to treatments G and Y in the present study) compared with a control diet. The greater feed:gain response noted by Rust et al. (2000) might have resulted from the use of grains in the diet with a lower ruminal fermentability (cracked corn and rolled wheat) than the steam-flaked corn used in the present study.

It is unlikely that differences in the status of the Revalor S implants given on d 56 affected performance by the steers in this study. No missing implants were detected among the 236 steers evaluated. Implant abnormalities determined by palpation of the implant site 28 d after the implant was given (d 84) averaged 10.2% across treatments and are shown in the following table (values are numbers of animals observed in each category).

	Treatment			
Item	**Red**	**Green**	**Yellow**	**Blue**
No abnormality	54	54	54	50
Abscess with pellets	4	1	2	4
Implant in cartilage	0	2	1	1
Implant separated	2	2	2	3
TOTAL ANIMALS	**60**	**59**	**59**	**58**

Net Energy Calculations. Dietary NEm and NEg concentrations calculated (NRC, 1996) from performance data were as follows: 2.31 and 1.61, 2.32 and 1.63, 2.32 and 1.63, and 2.32 and 1.63 Mcal/kg of DM for the R, G, Y, and B treatments, respectively. These values are not markedly different among treatments, which agrees with performance data indicating that the primary effect of the microbial cultures added to the diets was to increase DMI, with a corresponding increase in daily gain at approximately the same efficiency as the

control diet. Tabular values (NRC, 1996) for the finishing diet were only 2.17 and 1.48 Mcal/kg of DM; however, if one assumes that the NEm and NEg values for steam-flaked corn are 2.50 and 1.77, respectively, the agreement between performance-based values and tabular values is quite close. The NRC (1996) tabular values for steam-flaked corn are 2.33 and 1.62 Mcal/kg for NEm and NEg, respectively. Zinn (1987) suggested values of 2.54 and 1.77 Mcal/kg for NEm and NEg, respectively.

Carcass Data. Carcass data are shown in Table 5. Hot carcass weight was 2.2% greater (P < .05) for the average of the G, Y, and B treatments than for the R treatment. No differences were noted among the treatments for dressing percent, longissimus muscle area, fat thickness, kidney, pelvic, and heart fat, yield grade, or marbling score.

The distribution of Choice and Select-plus-Standard USDA quality grades (Table 4) did not differ (P > .83) among treatments, with an average of 46.33% of the carcasses grading USDA Choice (Table 5). Select and Standard grades were pooled for this analysis because of the small number of Standard carcasses.

Liver score data were not analyzed statistically because of the low or missing frequency of observations in certain categories, which would result in a potentially invalid Chi-Square analysis. No major differences were noted in liver score categories among treatments (data not shown). Percentage of abscessed livers was 10, 8.9, 3.4, and 10.5 for the R, G, Y, and B treatments, repectively. The remainder of the condemnations (approximately 5 to 10% of the total) resulted from other causes (telangiectasis, distoma, and contamination at the plant).

Summary and Conclusions

Under the conditions of the present experiment, adding live cultures of *Lactobacillus acidophilus* Strain 45 and(or) Strain 51 plus *Propionibacterium freudenreichii* (PF-24) increased daily gain 2.2 to 5.4% by growing finishing steers compared with a control diet. On average, for the three microbial culture treatments used in the study, daily gain was increased 4.3% (P < .06) relative to the control treatment. Microbial cultures increased daily dry matter intake slightly above that of the control treatment, but differences were not statistically significant. Feed:gain ratio was numerically improved for microbial culture treatments, but calculated NEm and NEg values for the treatment diets suggested that cattle on the microbial culture diets converted feed intake to gain at approximately the same efficiency as control cattle. With the exception of hot carcass weight, which was greater (P < .05) for cattle fed microbial cultures than for control cattle, carcass characteristics were not markedly different among treatments. Overall, the present results suggest economically important positive effects on live and carcass weight from the feeding of microbial cultures that contain *Lactobacillus acidophilus* Strain 45 and(or) Strain 51 plus *Propionibacterium freudenreichii* (PF-24) at the doses used.

Literature Cited

AOAC. 1990. Official Methods of Analysis (15th Ed.). Association of Official Analytical Chemists. Washington, DC.

NRC. 1996. Nutrient Requirements of Beef Cattle (7th Ed.). National Academy Press, Washington, DC.

Rust, S. R., K. Metz, and D. R. Ware. 2000. Effects of Bovamine™ Rumen Culture on the performance and carcass characteristics of feedlot steers. J. Anim. Sci. 78(Suppl. 2):82 (Abstr.).

SAS. 1987. SAS/STAT Guide for Personal Computers (Version 6 Ed.). SAS Inst. Inc., Cary, NC.

Zinn, R. A. 1987. Influence of lasalocid and monensin plus tylosin on comparative feeding value of steam-flaked versus dry-rolled corn in diets for feedlot cattle. J. Anim. Sci. 65:256-266.

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Table 1. Ingredient composition (%, DM basis) of the experimental diets

	Percentage of dietary concentrate			
	62	72	82	92
Alfalfa hay, ground	19.32	14.27	9.31	4.00
Cottonseed hulls	19.71	14.65	9.44	4.04
Steam-flaked corn	45.57	55.09	64.63	75.14
Cottonseed meal	6.18	6.08	5.96	6.07
Molasses	3.85	3.90	3.87	4.29
Fat (yellow grease)	2.04	2.56	3.21	2.99
Urea	0.76	0.86	0.98	0.98
Premix[a]	2.57	2.59	2.60	2.49

[a]Premix composition is shown in Table 2.

Table 2. Composition of the premix used in experimental diets

Ingredient	%, DM basis
Cottonseed meal	23.9733
Limestone	42.1053
Dicalcium phosphate	1.0363
Potassium chloride	8.0000
Magnesium oxide	3.5587
Ammonium sulfate	6.6667
Salt	12.0000
Cobalt carbonate	.0017
Copper sulfate	.1572
Iron sulfate	.1333
EDDI	.0025
Manganese oxide	.2667
Selenium premix, .2% Se	.1000
Zinc sulfate	.8251
Vitamin A, 650,000 IU/g[a]	.0122
Vitamin E, 275 IU/g[a]	.1260
Rumensin, 80 mg/lb[a]	.6750
Tylan, 40 mg/lb[a]	.3600

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

Table 3. Chemical composition of the experimental diets[a]

	Percentage of dietary concentrate			
Ingredient	62	72	82	92
Dry matter, %[b]	83.06	81.61	78.92	82.93
Ash, %	6.05	5.34	4.90	4.93
Crude protein, %	15.05	14.92	14.53	15.08
ADF, %[c]	22.78	18.14	14.84	7.94
Calcium, %	0.64	0.64	0.57	0.54
Phosphorus, %	0.29	0.27	0.31	0.36

[a]Values are averaged over the four treatments (see Table 4 for a description of the treatments) within dietary concentrate level.

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

[c]ADF = Acid detergent fiber.

Table 4. Effects of live cultures of *Lactobacillus acidophilus* Strain 45 and(or) Strain 51 and *Propionibacterium freudenreichii* PF-24 on performance by finishing beef steers

	Treatment[a]					Contrast[c]		
Item	Red (R)	Green (G)	Yellow (Y)	Blue (B)	SE[b]	R vs GYB	G vs YB	Y vs B
Initial BW, lb	693.1	695.2	697.9	693.6	1.91	NS	NS	NS
Final BW, lb	1,208.2	1,239.8	1,241.1	1,221.0	10.49	.04	NS	NS
Adj. final BW, lb[d]	1,207.7	1,240.1	1,241.5	1,221.0	11.23	.05	NS	NS
Daily gain, lb								
d 0 to 28	3.41	3.69	3.45	3.25	0.147	NS	.07	NS
d 0 to 56	3.63	3.92	3.82	3.84	0.107	.08	NS	NS
d 0 to 84	3.75	3.99	3.89	3.81	0.100	NS	NS	NS
d 0 to 112	3.83	4.04	4.03	3.89	0.085	NS	NS	NS
d 0 to end[e]	3.69	3.89	3.88	3.78	0.072	.06	NS	NS
Adj. 0 to end[d]	3.69	3.89	3.88	3.77	0.077	.08	NS	NS
Daily DMI, lb/steer								
d 0 to 28	15.06	15.42	14.77	14.82	0.221	NS	.03	NS
d 0 to 56	15.99	16.49	15.89	15.95	0.277	NS	NS	NS
d 0 to 84	16.45	17.06	16.65	16.48	0.274	NS	NS	NS
d 0 to 112	17.16	17.76	17.63	17.12	0.271	NS	NS	NS
d 0 to end[e]	17.66	18.24	18.21	17.81	0.254	NS	NS	NS
Feed:gain								
d 0 to 28	4.46	4.20	4.44	4.62	0.153	NS	.09	NS
d 0 to 56	4.43	4.23	4.17	4.16	0.070	.01	NS	NS
d 0 to 84	4.39	4.28	4.29	4.34	0.056	NS	NS	NS
d 0 to 112	4.49	4.40	4.38	4.40	0.050	.10	NS	NS
d 0 to end[e]	4.80	4.70	4.70	4.72	0.050	NS	NS	NS
Adj. d 0 to end[d]	4.81	4.70	4.70	4.72	0.058	NS	NS	NS

Table 4 (continued). Effects of live cultures of *Lactobacillus acidophilus* Strain 45 and(or) Strain 51 and *Propionibacterium freudenreichii* PF-24 on performance by finishing beef steers

[a]Red = standard TTU Burnett Center 92% concentrate diet with carrier (lactose) only mixed in water and added to the diet at the time of feeding; Green = Red + 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 45 + 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per amimal; Yellow = Red + 1 x 10^4 CFU *Lactobacillus acidophilus* Strain 45 + 1 x 10^4 CFU *Lactobacillus acidophilus* Strain 51 + 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal; and Blue = Red + 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 45 + 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 51 + 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal.

[b]Pooled standard error of main-effect means, n = 12 pens per treatment.

[c]Observed significance level for orthogonal contrasts. NS = not significant, P > .10.

[d]Adjusted final BW was calculated as follows: (Hot carcass weight/average dress of 61.85%). Adjusted daily gain was calculated as follows: (Adjusted final BW – initial BW)/days on feed. Adjusted feed:gain was the ratio of daily DMI and adjusted daily gain.

[e]Cattle in Blocks 7 through 12 were on feed for 133 d, whereas cattle in Blocks 1 through 6 were on feed for 147 d, resulting in an average of 140 d on feed.

Table 5. Effects of live cultures of *Lactobacillus acidophilus* Strain 45 and(or) Strain 51 and *Propionibacterium freudenreichii* PF-24 on carcass characteristics of finishing beef steers

	Treatment[a]					Contrast[c]		
Item	Red (R)	Green (G)	Yellow (Y)	Blue (B)	SE[b]	R vs GYB	G vs YB	Y vs B
Hot carcass wt, lb	747.0	767.0	767.9	755.2	6.95	.05	NS	NS
Dressing percent	61.80	61.87	61.88	61.84	0.199	NS	NS	NS
LM area, sq. in.[d]	13.62	13.59	13.83	13.71	0.185	NS	NS	NS
Fat thickness, in.	0.44	0.46	0.48	0.45	0.023	NS	NS	NS
KPH, %[e]	1.93	2.00	1.97	1.93	0.041	NS	NS	NS
Yield grade	2.46	2.61	2.59	2.50	0.081	NS	NS	NS
Marbling score[f]	390.5	405.5	401.3	389.8	9.74	NS	NS	NS
Choice, %[g]	45.00	48.21	50.00	42.11	-	-	-	-
Select, %	53.33	48.21	48.28	52.63	-	-	-	-
Standard, %	1.67	3.58	1.72	5.26	-	-	-	-

[a]Red = standard TTU Burnett Center 92% concentrate diet with carrier (lactose) only mixed in water and added to the diet at the time of feeding; Green = Red + 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 45 + 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per amimal; Yellow = Red + 1 x 10^4 CFU *Lactobacillus acidophilus* Strain 45 + 1 x 10^4 CFU *Lactobacillus acidophilus* Strain 51 + 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal; and Blue = Red + 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 45 + 1 x 10^6 CFU *Lactobacillus acidophilus* Strain 51 + 1 x 10^9 CFU *Propionibacterium freudenreichii* PF-24 per animal.

[b]Pooled standard error of main-effect means, n = 12 pens per treatment.

[c]Observed significance level for orthogonal contrasts. NS = not significant, P > .10.

[d]LM = longissimus muscle.

[e]KPH = kidney, pelvic, and heart fat.

[f]300 = Slight^0; 400 = Small^0; 500 = Modest^0.

[g]Distribution of Choice and Select + Standard carcasses did not differ among treatments (P > .83).