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Effects of feeding *Bacillus subtilis* PB6 active microbial on clinical health, performance, and carcass characteristics of feedlot steers

Introduction

Newly received cattle in a feedlot setting face a host of stressors, including: transportation, weaning, environmental changes, and commingling. These stressors can compromise the immune system of calves and lead to illness. Furthermore, morbidity and mortality resulting from bovine respiratory disease (BRD) continue to be the most significant health problems facing the feedlot industry.[1] Traditionally, antibiotics have been the sole solution implemented to address the challenges of these stressors. In recent years, due to pressure from consumers and concerns with future antibiotic resistance, the cattle feeding industry has begun to reduce their usage of antibiotics. As a result, the use of direct fed microbials (DFM) has become more common within commercial feedlots. It has been found that the use of DFM during the receiving period may be advantageous if the DFM can improve performance and decrease morbidity.[1]

In a review article, Krehbiel et al. stated that feeding finishing cattle a traditional DFM can increase average daily gain (ADG) 2.5 to 5.0%, as well as improve feed efficiency by 2.0%.[2] However, the authors concluded in the review that neither dry matter intake (DMI) or overall performance results were consistent across multiple studies.

Unlike traditional DFM, the supplementation of the active microbial CLOSTAT® (*Bacillus subtilus* PB6) altered serum metabolites in Holstein calves when calves were challenged with *Salmonella*.[1] While limited research has been conducted in feedlot settings, previous results indicate that *Bacillus subtilis* PB6 may be able to improve the health and performance of feedlot calves.

Materials and Methods

Processing, body weights, and housing

In the fall, the Willard Sparks Beef Research Center in Stillwater, OK, received calves (n = 397) from Florida ranches. Upon arrival and prior to being processed, the steers were weighed, individually ear tagged and allowed a rest period of 24 to 48 h. On d 0 of the experiment, steers were administered a clostridial bacterium/toxoid (Vision® 7 with Spur®, Merck Animal Health, DeSoto, KS) and were treated for external (StandGuard®, Elanco Animal Health, Greenfield, IN) and internal (Safe-Guard®, Merck Animal Health) parasites, along with receiving an implant (Revalor®-IS, Merck Animal Health). For the entirety of the experiment, the steers were housed in soil surfaced pens with a solid concrete bunk and a concrete apron. Twenty-four pens were utilized for this experiment resulting in 12 pens per treatment and 15 to 20 hd per pen. The steers were weighed every 14 d during the receiving period and every 28 d during the finishing period. The steers were re-implanted (Revalor®-200, Merck Animal Health) on d 28 of finishing. Lastly, the steers were fed ractopamine hydrochloride (Optaflexx®, Elanco Animal Health) at a calculated rate of 300 mg/hd/d for the last 28 d of the trial (d 141 to d 169 finishing) and underwent a 48 h ractopamine hydrochloride withdraw prior to slaughter.

Experimental treatments

The control treatment was a top-dressed supplement which contained ground corn and wheat middlings fed at a rate of 0.5 lb/hd/d. The *Bacillus subtilis* PB6 (PB6) treatment was also a top-dressed supplement fed at 0.5 lb/hd/d and designed to deliver 13 g/hd/d of PB6 (Table 1).

Table 1: Top-dress supplement[1]

	Treatment	
Item, DM %	Control	DFM
Corn, ground	50.00	47.14
Wheat middlings	50.00	47.14
PB6[2]	-	5.73

[1]Treatments were top-dressed daily at 0.5 lb/hd/d, respectively.
[2]9,500,000 CFU to provide 13 g/hd/d.

Feed and bunk management

The steers were fed a prairie hay, alfalfa hay, and wet corn gluten feed receiving diet for 60 d (Table 2). After the receiving period, steers were transitioned to a high-concentrate finishing diet for the remainder of the experiment. The finishing diet primarily composed of dry-rolled corn and wet corn gluten feed (Table 2). Diets were formulated to meet or exceed all nutrient requirements for receiving and finishing steers (NASEM, 2017).

Table 2: Composition of receiving and finishing diets

Item	Receiving	Finishing
Ingredient, % DM		
Prairie hay	25.00	8.00
Alfalfa hay	20.00	-
Wet corn gluten feed[1]	45.00	20.00
Dry-rolled corn	-	62.00
Dry supplement (B-340)[2]	5.00	5.00
Liquid supplement	5.00	5.00
Analyzed nutrient composition (DM basis)[3]		
DM, % (as-fed basis)	72.75	76.38
NE_m, Mcal/kg	1.47	2.18
NE_g, Mcal/kg	0.88	1.51
TDN, %	64.95	88.03
CP, %	17.95	13.32
ADF, %	27.70	9.95
Calcium, %	0.79	0.52
Phosphorus, %	0.65	0.49
Magnesium, %	0.33	0.21
Potassium, %	1.42	0.76

[1]Sweet Bran® (Cargill, Dalhart, TX).
[2]Dry supplement B-340 was formulated to contain (% DM basis) 42.63% ground corn, 27.14% calcium carbonate, 20.60% wheat middlings, 6.51% urea, 0.92% salt, 0.49% magnesium oxide, 0.47% zinc sulfate, 0.15% manganous oxide, 0.12% copper sulfate, 0.08 selenium, 0.29% vitamin A (30,000 IU/g), 0.09 vitamin E (500 IU/g), 0.008% vitamin D (30,000 IU/g), 0.302% monensin (Rumensin® 90, Elanco Animal Health, Greenfield, IN), and 0.186% tylosin (Tylan® 40, Elanco Animal Health).
[3]Feed samples were analyzed for nutrient composition and energy values by an independent laboratory (Servi-Tech Laboratories, Dodge City. KS).

Harvest and carcass characteristics

After the finishing period, the steers were transported to a commercial abattoir in Dodge City, KS. All carcass data was collected by trained individuals from the West Texas A&M Beef Carcass Research Center.

Animal health

Each morning during the experiment, trained personnel visually monitored the steers for clinical signs of BRD and lameness using a modified DART system.[5,6] The visual signs used to pull a steer for suspected BRD included depression, abnormal appetite, and respiratory signs. Severity scores of (1) mild, (2) moderate, (3) severe, or (4) morbid, were assigned to the steers based on observed clinical signs. Steers that received a severity score of 1 to 4 were pulled for further evaluation. After obtaining a rectal temperature from the steer, treatment proceeded as follows: steers that received a severity score of 1 or 2 were only administered an antibiotic when rectal temperature was ≥ 104.0 ˚F. Steers that received a severity score of 3 or 4 were administered antibiotic regardless of rectal temperature.

Results

Performance

Effects of feeding PB6 active microbial on receiving and finishing feedlot steer performance are shown in Tables 3 and 4. Throughout the receiving and finishing periods, there were no differences in final body weight (BW) ($P > 0.05$) or DMI ($P > 0.05$). There was a significant difference in average daily gain (ADG) for PB6 steers from d 28–56 of the finishing period ($P < 0.05$), but there were no differences in ADG during the rest of the days on feed. A significant difference in feed efficiency for the PB6 steers from d 28–56 of the finishing period ($P < 0.05$) was seen. Furthermore, the PB6 steers had a tendency for improved feed efficiency over the entire finishing period ($P < 0.10$; 7.00 vs 7.15, respectively), as well as over the entire 230 days on feed ($P < 0.10$; 6.58 vs 6.69, respectively).

Table 3: Effects of feeding PB6 active microbial on receiving feedlot steer performance

	Treatment[4]			
Item[1]	Control	PB6	SEM	*P*-value
BW[2], lbs				
d 0	556	556	13.1	0.78
d 14	581	584	13.4	0.45
d 28	628	627	15.0	0.77
d 42	685	686	14.6	0.76
Final[3]	753	752	14.1	0.97
ADG, lbs				
d 0 to d 14	1.81	2.06	0.13	0.17
d 15 to d 28	3.36	3.07	0.22	0.14
d 29 to d 42	4.01	4.20	0.16	0.32
d 43 to final	3.75	3.65	0.23	0.55
d 0 to final	3.27	3.28	0.06	0.91
DMI, lbs				
d 0 to d 14	10.2	10.0	0.18	0.39
d 15 to d 28	16.3	16.7	0.50	0.52
d 29 to d 42	21.3	21.0	0.49	0.45
d 43 to final	23.0	22.8	0.42	0.63
d 0 to final	18.0	18.0	0.31	0.77
F: G				
d 0 to d 14	5.84	5.18	0.40	0.25
d 15 to d 28	5.00	5.71	0.34	0.12
d 29 to d 42	5.46	5.01	0.24	0.15
d 43 to final[3]	6.26	7.07	0.79	0.34
d 0 to final	5.52	5.48	0.09	0.78

[1]Data are presented on a deads out basis. For the feed intake data, animals were removed at calculated maintenance intake.
[2]All body weights were shrunk by 4%.
[3]Final receiving BW was recorded on d 61 for group 1 (trucks 1 and 2), d 60 for group 2 (trucks 3 and 4), and d 57 for group 3 (truck 5).
[4]Fed as a supplement at 0.5 lb/hd/d containing corn and wheat middlings (control) or the control with added PB6 to provide 13 g/hd/d.

Table 4: Effects of feeding PB6 active microbial on finishing feedlot steer performance

	Treatment[5]			
Item[1]	Control	PB6	SEM	*P*-value
BW[2], lbs				
d 0[3]	753	752	14.1	0.97
d 28	851	851	15.0	0.97
d 56	931	940	14.8	0.14
d 84	1040	1046	16.0	0.31
d 112	1124	1130	15.2	0.25
d 140	1213	1219	15.2	0.32
Final[4]	1319	1327	15.5	0.40
ADG, lbs				
d 0 to d 28	3.53	3.54	0.09	0.87
d 29 to d 56	2.85	3.17	0.10	0.03
d 57 to d 84	3.88	3.78	0.11	0.50
d 85 to d 112	3.01	3.00	0.09	0.90
d 113 to d 140	3.18	3.19	0.06	0.88
d 141 to final[6]	3.53	3.58	0.10	0.74
d 0 to final	3.33	3.38	0.03	0.25
Overall[7]	3.32	3.35	0.03	0.33
DMI, lbs				
d 0 to d 28	22.9	22.7	0.40	0.70
d 29 to d 56	22.1	22.5	0.39	0.35
d 57 to d 84	23.1	23.0	0.31	0.62
d 85 to d 112	24.0	23.5	0.33	0.22
d 113 to d 140	24.7	24.4	0.31	0.33
d 141 to final	26.2	25.7	0.30	0.15
d 0 to final	23.8	23.6	0.29	0.46
Overall	22.2	22.1	0.27	0.48
F:G				
d 0 to d 28[4]	6.51	6.44	0.16	0.68
d 29 to d 56	7.81	7.16	0.24	0.05
d 57 to d 84	5.97	6.14	0.15	0.43
d 85 to d 112	8.00	7.94	0.28	0.87
d 113 to d 140	7.81	7.67	0.16	0.56
d 141 to final[5,6]	7.50	7.24	0.21	0.36
d 0 to final	7.15	7.00	0.07	0.07
Overall[7]	6.69	6.58	0.06	0.09

[1]Data are presented on a deads out basis. For feed intake, animals were removed based on pen average intake by period.
[2]All body weights were shrunk by 4%.
[3]d 0 of finishing was d 61 for group 1 (trucks 1 and 2), d 60 for group 2 (trucks 3 and 4), and d 57 for group 3 (truck 5).
[4]Final = Total d on study; 231 d for Group 1 (Trucks 1 & 2), 230 d for Group 2 (trucks 3 & 4), and 227 d for Group 3 (truck 5).
[5] Fed as a supplement at 0.5 lb/hd/d containing corn and wheat middlings (control) or the control with added PB6 to provide 13 g/hd/d.
[6]A beta agonist (Optaflexx®, Elanco Animal Health, Greenfield, IN) was fed during this period at a calculated 300mg/hd/d. There was a 48 h withdraw before slaughter.
[7]Overall = entire experiment including receiving and finishing periods.

Carcass Characteristics

Effects of feeding PB6 active microbial on carcass characteristics are shown in Table 5. Similar to final BW, hot carcass weight (HCW) was not different among treatments ($P = 0.58$). Treatments also had similar dressing percentages ($P = 0.47$). There were no differences among the treatments for 12th rib fat ($P = 0.36$), LM area ($P = 0.91$), Marb ($P = 0.82$) or calculated YG ($P = 0.72$). There were also no differences in calculated USDA Quality Grades ($P \geq 0.31$).

Table 5: Effects of feeding PB6 active microbial on feedlot steer carcass characteristics

	Treatment[1]			
Item	Control	PB6	SEM	*P*-value
HCW, lbs	850	852	10.1	0.58
Dressing % [2]	64.4	64.3	0.19	0.47
12th-rib fat[3], in	0.45	0.43	0.01	0.36
LM area[4], in^2	14.6	14.7	0.15	0.91
Marbling[5]	459	456	8.0	0.82
Calculated YG[6]	2.7	2.6	0.06	0.72

[1]Fed a supplement at 0.5 lb/hd/d containing corn and wheat middlings (control) or the control with added PB6 to provide 13 g/hd/d.
[2] Calculated by dividing the HCW by final shrunk BW.
[3]Measurement of the thickness of external fat on the carcass between the 12th and 13th ribs.
[4]Total area of the *longissimus dorsi* muscle measured between the 12th and 13th ribs.
[5]Marbling scores: 400 = small, 500 = modest.
[6]YG = Yield Grade.

Animal health

Effects of feeding a direct fed microbial on receiving health are shown on Table 6. There was not a difference in first BRD treatment percentage ($P = 0.27$) among experimental treatments. However, there was a numerical difference where the PB6 treatment had a lower first BRD treatment percentage than the control (8.39 compared to 12.50, respectively). Similarly, there was not a difference in second BRD treatment percentage ($P = 0.55$). Average rectal temperature and severity scores were also not different ($P > 0.10$).

There was no difference ($P = 0.34$) between experimental treatments for the percentage of BRD related mortalities and off-trials per pen (Table 6). However, there was a difference in percentage of mortalities and off-trials per pen due to lameness and complications from toe abscesses among the treatments. The control treatment had a lower percentage ($P = 0.02$) of dead steers and off-trials per pen compared to the PB6 treatment (2.01 compared to 5.77, respectively).

Table 6: Effects of feeding PB6 active microbial on the clinical health of feedlot steers

	Treatment[1]			
Item	Control	PB6	SEM	*P*-value
1st BRD treatment,[2]%	12.50	8.39	2.53	0.27
2nd BRD treatment,[3]%	1.97	1.04	1.08	0.55
Ave. temp. at BRD treatment, °F	104.66	104.88	0.26	0.50
Ave. severity score at BRD treatment	1.94	2.27	0.22	0.24
BRD related mortalities and off-trials,[4] %	0.00	0.52	0.37	0.34
Other mortalities and off-trials,[5] %	2.01	5.77	1.32	0.02

[1]Fed as a supplement at 0.5 lb./hd/d containing corn and wheat middlings (control) or the control with added PB6 to provide 13 g/hd/d.
[2]Percentage of steers/pen that received BRD treatment.
[3]Percentage of steers/pen that received 2 or more treatments for BRD.
[4]Percentage of BRD mortalities and off-trials. Only 1 mortality was due to confirmed BRD.
[5]Percentage of mortalities and off-trials as a result of lameness and complications with toe abscesses.

Discussion

There were no differences in BW or ADG among experimental treatments in this experiment. These results are similar to those reported by Krehbiel et al. where the authors stated there were no differences in ADG among the traditional DFM and non-DFM treatments.[3] However, numerous tendencies for F:G existed in the current experiment, indicating that PB6-fed steers were more efficient during the finishing period, and overall (receiving and finishing). In a traditional DFM review article by Krehbiel et al., researchers found that in some studies, feeding a traditional DFM to newly received calves improved feed efficiency.[1]

Also, Krehbiel et al. found that providing a DFM to newly received feedlot steers reduced the likelihood for a second BRD treatment compared to a control group.[3] Although in the current experiment there were no significant differences in the first or second BRD antimicrobial treatment data, there were numerical improvements in the calves fed PB6 for first and second BRD treatment percentages. Care should be taken in interpreting these results as the PB6 steers had more off-trials and removals, which could impact these percentages in the PB6 calves.

Only 1 steer died due to confirmed BRD illness. The remainder of the animal deaths or removals were a result of lameness, complications from toe abscesses, and other non-BRD-related health complications. While there was a difference between the experimental treatments for non-BRD mortalities and off-trials, this is not believed to be a result of the experimental treatments.

Possible reasons for the elevated number of off-trial cattle may result from several factors. The cattle used in this experiment were of *Bos indicus* influence and had marginal access to human contact prior to arrival at the feedlot. As a result, the steers had large flight zones, which attributed to slips and falls in the pens and in the processing area. We believe that a majority of the lameness and hoof problems that occurred were ultimately due to cattle temperament, hoof conditions, and the handling of flighty cattle on concrete and not a result of experimental design or experimental treatment.

Conclusion

The results of this experiment suggest that the supplementation of PB6 at 13 g/hd/d improves feed efficiency in feedlot cattle.

References

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