Effects of feeding a *Saccharomyces cerevisiae* fermentation prototype on performance, carcass characteristics, and liver abscess prevalence of beef heifers at a commercial feedlot

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ABSTRACT

Animal agriculture continues to look for new, non-antibiotic feed solutions that can be used in conventional and natural feedlot systems to help improve cattle health and performance. Therefore, crossbred heifers ($n = 1,495$; 359 ± 10.75 kg; 20 pens total) were used in a randomized complete block design study at a commercial feedlot to determine the effects of a proprietary *Saccharomyces cerevisiae* fermentation prototype on performance, carcass characteristics, and liver abscess prevalence when monensin, tylosin, and direct-fed microbials were not included in the diet. Heifers were fed a diet containing (1) monensin, tylosin, and a direct-fed microbials (PC) or (2) a *Saccharomyces cerevisiae* fermentation prototype (PRT; NaturSafe, Diamond V, Cedar Rapids, IA) at 18 g/head daily without PC. Diets were fed twice daily with heifers receiving half of the daily dose of treatment in the TMR at each feeding. Pen BW were collected on d 0 and before slaughter. Daily measurements recorded while cattle were in the feedlot included feed intake, morbidity, and mortality. Cattle were shipped to slaughter on d 125 and 146 (5 pens per treatment per day). Carcass data collected included HCW, DP, QG, YG, KPH, rib fat thickness, LM area, marbling score, and liver abscess scores. Data were analyzed with the MIXED procedure (continuous) and GLIMMIX procedure (categorical) of SAS. Treatments were similar ($P \geq 0.16$) for final BW (580 vs. 580 kg), ADG (1.64 vs. 1.63 kg/d), G:F (0.159 vs. 0.156 kg/kg), HCW (366 vs. 367 kg), other carcass characteristics, morbidity (0.3 vs. 0.0%), and mortality (0.77 vs. 0.70%). Heifers fed PRT had a numerically lower ($P = 0.27$) prevalence of liver abscesses with fewer livers having less severe (i.e., A–) abscesses. Replacing monensin, tylosin, and direct-fed microbials in conventional feedlot diets with NaturSafe

resulted in similar growth performance, carcass characteristics, and liver abscess prevalence in feedlot cattle.

Key words: beef heifer, large pen, performance, *Saccharomyces cerevisiae* fermentation prototype

INTRODUCTION

The Veterinary Feed Directive was implemented by the Food and Drug Administration to minimize the use of antibiotics in animal feed that are similar to those that have application in human medicine. Beginning in January 2017, feed grade antibiotics, such as tylosin, cannot be used unless a veterinarian prescription is provided (US Food and Drug Administration, 2015). Tylosin is used in the beef industry to help minimize abscesses in the liver and has been shown to decrease the growth of *Fusobacterium necrophorum* and *Trueperella* (*Arcanobacterium*) *pyogenes* (the main cause of liver abscesses) in the rumen (Nagaraja and Chengappa, 1998).

Other conventional feed technologies commonly used in beef feedlot diets are monensin and bacterial (*Lactobacillus* and *Propionibacterium*) direct-fed microbials (DFM). Monensin has been shown to improve feed efficiency, reduce the likelihood of feedlot bloat, and play a role in controlling coccidiosis (Long and Jeffers, 1982; Stock et al., 1995; Cheng et al., 1998; Duffield et al., 2012). Direct-fed microbials have had variable results on rumen health and cattle performance when used in feedlot diets (Brashears et al., 2003; Elam et al., 2003; Peterson et al., 2007). Unlike tylosin, the Veterinary Feed Directive does not affect ionophores or DFM.

Universities and companies within animal agriculture continue to research and develop new, non-antibiotic feed solutions that can be used in conventional and natural feedlot systems to help improve cattle health and performance. Therefore, this study was designed to evaluate the effects of a proprietary *Saccharomyces cerevisiae* fermentation prototype on the performance, health, carcass charac-

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teristics, and prevalence of liver abscesses in feedlot cattle when monensin, tylosin, and DFM were not included in the diet.

MATERIALS AND METHODS

Experimental Design

Animals were handled in compliance with applicable local regulations and in accordance with the *Guide for Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2010).

Crossbred heifers ($n = 1,495$; 359 ± 3.4 kg) were received at a Central Kansas feedyard in May 2015. Heifers were purchased from 2 sale barns (Salina, KS, $n = 255$ head; and Pratt, KS, $n = 183$ head) and one backgrounding facility (Central Kansas, $n = 1,057$ head), where the heifers grazed wheat pasture. On arrival, heifers were allowed ad libitum access to fresh water and long-stemmed hay.

On the day after arrival, heifers were individually weighed, processed, and randomly sorted by source into pens (5 animals per pen until the desired head count was achieved in each pen; 67 or 80 head per pen). Pens per

replicate (2 adjacent pens of similar size and head count; 10 replicates total) were assigned to 1 of 2 treatments. A 2-tailed statistical power analysis for ADG [power ($1 - \beta$) = 0.8, $\alpha = 0.05$, SD = 0.136] showed 10 replicates per treatment were necessary to detect an expected difference in ADG of 0.181 kg. Treatments were added to the diet using a micro-ingredient weigh system (mg/head basis; Micro Beef Technologies, Amarillo, TX) and consisted of a diet containing a combination of standard industry technologies (PC), including monensin (300 mg/head daily; Rumensin, Elanco Animal Health, Greenfield, IN), tylosin (90 mg/head daily; Tylovet, Huvepharma, Peach Tree, GA), and a DFM (50 mg/head daily; Bovamine Defend, Nutrition Physiology Company, Overland Park, KS) or a diet containing 18 g/head daily of a *Saccharomyces cerevisiae* fermentation prototype (PRT; NaturSafe, Diamond V, Cedar Rapids, IA) without monensin, tylosin, or the DFM. *Saccharomyces cerevisiae* fermentation prototype is a fermentation prototype containing proprietary levels of functional metabolites such as peptides, organic acids, and antioxidants. All pens received 0.5 mg of melengestrol acetate (MGA, Zoetis Animal Health, Exton, PA) in the diet

Table 1. Ingredient and calculated nutrient composition of corn-based diets fed to yearling heifers

Item	Basal diet			
	Starter	Step 2	Step 3	Finisher
Ingredient, % DM basis				
Steam-flaked corn	30.2	45.8	58.6	66.1
Wet distillers grain with solubles	22.2	19.5	18.0	18.0
Alfalfa hay	38.0	25.0	13.0	0.0
Mixed hay	0.0	0.0	0.0	4.0
Corn silage	7.0	7.0	5.0	4.0
Tallow	0.0	0.0	1.5	2.9
Liquid supplement ¹	2.6	2.7	3.9	5.0
Nutrient composition				
DM, %	55.8	57.0	59.1	60.3
CP, %	17.9	16.4	15.7	15.1
Ether extract, %	4.50	4.57	6.12	7.60
Calcium, %	0.94	0.78	0.80	0.83
Phosphorus, %	0.37	0.37	0.37	0.37
Potassium, %	0.98	0.82	0.66	0.56
Sulfur, %	0.30	0.27	0.24	0.22
NE _m , Mcal/kg	1.83	2.01	2.21	2.36
NE _g , Mcal/kg	1.17	1.32	1.50	1.63

¹Positive control diet contained monensin (Rumensin, Elanco Animal Health, Greenfield, IN), tylosin (Tylovet, Huvepharma, Peach Tree, GA), and a direct-fed microbial (Bovamine Defend, Nutrition Physiology Company, Overland Park, KS) at 300, 90, and 50 mg/animal daily, respectively. Prototype (PRT) diets were formulated to provide 18 g of a prototype *Saccharomyces cerevisiae* fermentation prototype (NaturSafe, Diamond V, Cedar Rapids, IA) per heifer daily throughout the trial. Both treatment groups also received 0.5 mg of melengestrol acetate (Zoetis Animal Health) per heifer daily throughout the trial and 250 mg of ractopamine hydrochloride (Zoetis Animal Health) per heifer daily during the last 28 d on feed.

daily and 250 mg ractopamine hydrochloride (Actogain, Zoetis Animal Health) in the diet daily during the last 28 d on feed.

During processing, heifers were uniquely identified with numbered tags in both ears. The right ear tag contained the lot number and was color coded to treatment (white or red for PC and PRT, respectively). All feedlot personnel were blinded to treatment. The left ear tag contained the lot number and animal ID number. Heifers were vaccinated for infectious bovine rhinotracheitis and parainfluenza-3 using Pyramid 4 cattle vaccine (Boehringer Ingelheim Vetmedica Inc., Ridgefield, CT). In addition, heifers received an injection for internal parasites (Decotomax, Zoetis Animal Health), an oral dose of dewormer (Safeguard, Merck Animal Health, De Soto, KS), and a growth implant (Revalor-IH containing 80 mg of trenbolone acetate + 8 mg of estradiol, Merck Animal Health) under the skin in the posterior aspect of the ear. Approximately 63 d after the initial growth implant and 74 d before slaughter, heifers were revaccinated for infectious bovine rhinotracheitis and parainfluenza-3 (Bovi Shield Gold IBR-BVD, Zoetis Animal Health), vaccinated with an autogenous Foot Rot vaccine (Newport Laboratories Inc., Worthington, MN), and reimplanted (Revalor 200 containing 200 mg of trenbolone acetate + 20 mg of estradiol, Merck Animal Health).

Heifers were housed in 20 soil-surfaced pens providing 36.6 cm of bunk space and 21.5 m² of pen space per heifer. Each pen contained an earthen mound and water fountain that supplied fresh well water. Feed was delivered using horizontal mixing auger trucks, and mixing uniformity was assessed before and during the study (11 assessments total). Heifers received 3 step-up diets (~8 d/diet) before their final finishing diet (Table 1). Pens within a block were treated the same as it pertains to transitioning onto the finishing diet. Diets were fed twice daily at approximately 0830 and 1350 h (± 20 min). Feed bunks were managed so that only a trace amount of feed was left in the bunk at each feeding. All treatment feed additives were stored under manufacturer-recommended conditions, and the amount fed was adjusted monthly, or sooner if necessary, to account for variation in ingredient DM and cattle intakes. Actual formulated intakes were achieved for each feed additive.

Trained animal caretakers individually observed heifers within each pen daily. Heifers were observed for lameness, anorexia, dull eyes, labored breathing, droopy ears, coughing, diarrhea, nasal discharge, and general overall well-being. Heifers experiencing any clinical signs were removed and further evaluated in the hospital pen. Once restrained in the hospital observation chute, BW, rectal body temperature, and lung score were determined. Heif-

Table 2. Effects of a *Saccharomyces cerevisiae* fermentation prototype (PRT) on growth performance of yearling beef heifers

Item	PC ¹	PRT ²	SEM	P-value
Heifers (pens), no.	748 (10)	747 (10)	N/A ³	N/A
Days on feed	136	136	N/A	N/A
Bunk space, cm/head	36.6	36.6	N/A	N/A
Pen space, m ² /head	21.5	21.5	N/A	N/A
Live performance ⁴				
Initial BW, kg	358.3	359.7	3.40	0.33
Final BW, ⁵ kg	579.7	580.6	3.20	0.80
DMI, kg/d	10.3	10.4	0.15	0.09
ADG, kg/d	1.64	1.63	0.020	0.73
G:F, kg/kg	0.159	0.156	0.0018	0.16
Yield-adjusted performance ⁶				
BW, kg	574.3	575.6	9.30	0.64
ADG, kg/d	1.59	1.59	0.019	0.94
G:F	0.155	0.153	0.0028	0.20

¹Positive control (PC) diet contained monensin (Rumensin, Elanco Animal Health, Greenfield, IN), tylosin (Tylovet, Huvepharma, Peach Tree, GA), and a direct-fed microbial (Bovamine Defend, Nutrition Physiology Company, Overland Park, KS) at 300, 90, and 50 mg/animal daily, respectively.

²Prototype (PRT) diet contained *S. cerevisiae* fermentation prototype (NaturSafe, Diamond V, Cedar Rapids, IA) at 18 g/animal daily and no monensin, tylosin, or direct-fed microbial.

³N/A = not applicable.

⁴Live performance included dead and removed animals.

⁵Final BW pencil shrunk 4%.

⁶Yield-adjusted BW calculated by dividing HCW by a common dressing yield of 63.75%.

ers were then treated based on the clinical signs observed in the pen and the results from the chute side diagnostics according to the treatment protocols established by the consulting veterinarian. In general, heifers were treated and returned to their home pen on the same day. However, in some cases, the heifer was kept in the hospital recovery pen until it was well enough to be returned to its home pen. Heifers that did not respond to therapy were pulled from the trial, labeled as a chronic (i.e., railer), held until drug withdrawal requirements were met, and shipped to a rendering facility. The feedlot veterinarian performed necropsies on all heifers that died to determine cause of death.

Heifers were on trial for 125 to 146 d before slaughter. The amount of feed offered was recorded daily. Heifers were weighed by pen on a large platform scale (approximately 3.5 m × 27.5 m) on d 0 and the morning before shipment. On the day of slaughter, heifers were transported approximately 233 km to a commercial abattoir located in Holcomb, Kansas. Heifers were slaughtered on 2 separate shipping dates approximately 3 wk apart (d 125 and 146 for group 1 and 2, respectively). Five pens per treatment were shipped on each shipping date. Heifers were maintained within their pen during shipping and at the abattoir. Heifers were processed by pen, and trained personnel at the abattoir collected carcass measurements using a video image analysis system. Average carcass weight, DP, USDA QG, USDA YG, KPH, 12th rib fat thickness, LM area, and marbling score were collected on each carcass at the abattoir. A calculated YG was determined using the following equation (Boggs and Merkel, 1993):

$$\begin{aligned} \text{Yield grade} = & 2.50 + (6.35 \times \text{fat thickness, cm}) \\ & - (2.06 \times \text{LM area, cm}^2) + (0.2 \times \text{KPH, \%}) \\ & + (0.0017 \times \text{HCW, kg}). \end{aligned}$$

Fecal swab samples and subiliac lymph nodes were also collected during slaughter to be analyzed for food-borne pathogens. However, this is reported elsewhere (Feye et al., 2016). Liver scores were also collected on each carcass using trained personnel from Garden City Community College (Garden City, KS). The liver was evaluated after evisceration using the liver abscess classification method developed by Elanco Animal Health (Brown et al., 1975). Livers were scored as follows:

- (1) O – a normal healthy liver with no abscesses;
- (2) A⁻ – 1 or 2 small abscesses or inactive scars, which are generally under 2.54 cm in diameter, with the remaining liver appearing healthy;
- (3) A – 1 or 2 large abscesses, or several small abscesses, with the remaining liver appearing healthy; or
- (4) A⁺ – multiple large abscesses present, along with inflammation of liver tissue surrounding the abscess. Often, portions of the diaphragm are adhered

to the surface of the liver and have to be trimmed to separate the liver from the carcass.

Statistical Analysis

Growth performance and carcass characteristics (continuous data) were analyzed using the MIXED procedure of SAS (9.3, SAS Institute Inc., Cary, NC). Pen was considered the experimental unit. The model included treatment as the fixed effect, block as the random effect to explicitly account for the lack of independence among pens within block, and treatment × block as the error term. The LSMEANS and corresponding SEM were calculated from model outputs. Categorical data, including binary health and carcass QG, YG, and liver abscess outcomes, were modeled using the GLIMMIX procedure of SAS using a binomial and ordinal distribution, respectively. The Link = Logit option was used in the model statement, and LSMEANS and corresponding SEM were calculated from model outputs following back transformation from

Table 3. Effects of a *Saccharomyces cerevisiae* fermentation prototype (PRT) on animal health characteristics of yearling heifers

Item	PC ¹	PRT ²	SEM	P-value
Morbidity, %				
Respiratory	2.9	2.0	0.74	0.26
Digestive	0.0	0.0	N/A ³	N/A
Foot rot and lameness	17.5	21.8	3.15	0.06
Other	0.3	0.0	0.19	0.98
Pull rate, %				
1st pull	19.0	22.1	3.09	0.14
2nd pull	1.7	1.6	0.51	0.85
3rd pull	0.3	0.13	0.19	0.67
Mortality, %				
Respiratory	0.40	0.13	0.23	0.52
Digestive	0.00	0.27	0.19	0.98
Other	0.40	0.27	0.23	0.73
Total	0.80	0.67	0.33	0.81
Chronic (railer), ⁴ %	0.26	0.77	0.35	0.19

¹Positive control (PC) diet contained monensin (Rumensin, Elanco Animal Health, Greenfield, IN), tylosin (Tylovet, Huvepharma, Peach Tree, GA), and a direct-fed microbial (Bovamine Defend, Nutrition Physiology Company, Overland Park, KS) at 300, 90, and 50 mg/animal daily, respectively.

²Prototype (PRT) diet contained *S. cerevisiae* fermentation prototype (NaturSafe, Diamond V, Cedar Rapids, IA) at 18 g/animal daily and no monensin, tylosin, or direct-fed microbial.

³N/A = not applicable.

⁴Chronic (railer) = heifers that were removed from the study because they did not respond to therapy.

the logit scale. Data were considered significant at $P \leq 0.05$ and a trend at $0.05 > P \leq 0.10$.

RESULTS AND DISCUSSION

Performance

Growth performance data are in Table 2. Heifers fed PRT tended ($P = 0.09$) to consume 0.1 kg more feed per day. However, ADG, G:F, and final BW were not different ($P \geq 0.16$) between treatments. Morbidity and mortality results are in Table 3. No significant ($P \geq 0.16$) differences were observed between treatments.

Heifers were fed a finishing diet that contained 66% steam-flaked corn, 18% wet distillers grains plus solubles, 4.0% mixed hay, 4.0% corn silage, and 2.9% tallow. Heifers receiving PC consumed an average of 10.3 kg of DM daily, which corresponds to an average consumption of 29 mg/kg monensin, 8.7 mg/kg tylosin, and 4.9 mg/kg DFM. The positive DMI response for heifers supplemented with PRT compared with PC may be the result of heifers not receiving monensin and tylosin in the diet, a change in

ruminal kinetics due to supplemental fat and monensin in heifers fed the PC diet (Clary et al., 1993), or a more stable rumen environment due to PRT (Brainard et al., 2014). Previous research with the combination of monensin and tylosin in similar finishing diets to those in this study did not improve DMI in heifers or steers compared with a diet without these additives, but the combination did show a 4.1% improvement in G:F in steers (Depenbusch et al., 2008; Meyer et al., 2013). Research reported by Elanco Animal Health (2012) showed that the combination of monensin and tylosin reduced DMI by 5%. In addition, Duffield et al. (2012) summarized 64 trials that were conducted over the last 40 yr and found that monensin decreased DMI by 3%. Duffield et al. (2012) noted that the effect of monensin on feed conversion has decreased in recent years. In fact, they estimated that the improvement in DM conversion has decreased from 6% observed in the 1970s and 1980s to about 3% in the last 2 decades. However, unlike the Elanco data and the summary data reported by Duffield et al. (2012), feed conversions were not significantly different in the current study when monensin and tylosin were fed.

Table 4. Effects of a *Saccharomyces cerevisiae* fermentation prototype (PRT) on carcass characteristics of yearling beef heifers

Item	PC ¹	PRT ²	SEM	P-value
Carcasses (pens), no.	740 (10)	735 (10)	N/A ³	N/A
HCW, kg	366	367	2.68	0.58
DP, %	63.13	63.20	0.23	0.57
USDA QG, %			N/A	0.51
Prime	1.0	0.4		
Choice	63.9	61.8		
Select	33.5	36.9		
No roll	1.6	1.0		
USDA YG, %			N/A	0.48
YG 1	7.7	7.8		
YG 2	34.1	38.0		
YG 3	45.8	43.7		
YG 4	11.9	9.8		
YG 5	0.5	0.8		
Calculated YG ⁴	3.12	3.05	0.060	0.21
KPH, %	2.11	2.11	0.017	0.65
12th rib fat thickness, cm	1.24	1.22	0.03	0.73
LM area, cm ²	89.55	90.52	0.60	0.28
Marbling score ⁵	420	412	4.09	0.18

¹Positive control (PC) diet contained monensin (Rumensin, Elanco Animal Health, Greenfield, IN), tylosin (Tylovet, Huvepharma, Peach Tree, GA), and a direct-fed microbial (Bovamine Defend, Nutrition Physiology Company, Overland Park, KS) at 300, 90, and 50 mg/animal daily, respectively.

²Prototype (PRT) diet contained *S. cerevisiae* fermentation prototype (NaturSafe, Diamond V, Cedar Rapids, IA) at 18 g/animal daily and no monensin, tylosin, or direct-fed microbial.

³N/A = not applicable.

⁴Calculated YG = $2.5 + (6.35 \times \text{adjusted fat thickness, cm}) + (0.20 \times \text{KPH \%}) - (2.06 \times \text{LM area, cm}^2) + (0.0017 \times \text{HCW, kg})$.

⁵400 = Small 00; 500 = Modest 00; 600 = Moderate 00.

Table 5. Effects of a *Saccharomyces cerevisiae* fermentation prototype (PRT) on liver abscesses of yearling heifers

Item	PC ¹	PRT ²	SEM	P-value
Carcasses (pens), no.	740 (10)	735 (10)	N/A ³	N/A
Liver abscesses, ⁴ %	20.9	16.3	N/A	0.27
A ⁻	7.5	3.7		
A	5.3	3.9		
A ⁺	8.1	8.7		
Contamination, %	7.6	8.3	1.21	0.66
Cirrhosis, %	0.0	0.0	N/A	N/A
Telangiectasis, %	0.0	0.0	N/A	N/A
Flukes, %	0.0	0.1	0.09	0.34

¹Positive control (PC) diet contained monensin (Rumensin, Elanco Animal Health, Greenfield, IN), tylosin (Tylovet, Huvepharma, Peach Tree, GA), and a direct-fed microbial (Bovamine Defend, Nutrition Physiology Company, Overland Park, KS) at 300, 90, and 50 mg/animal daily, respectively.

²Prototype (PRT) diet contained *S. cerevisiae* fermentation prototype (NaturSafe, Diamond V, Cedar Rapids, IA) at 18 g/animal daily and no monensin, tylosin, or direct-fed microbial.

³N/A = not applicable.

⁴Livers were scored using methods described by Brown et al. (1975).

Carcass Characteristics

No differences were observed between treatments for any of the carcass characteristics measured ($P \geq 0.18$; Table 4). Although there are no other studies examining the effects of PRT on carcass characteristics in beef cattle, studies with other *Saccharomyces cerevisiae* fermentation products (SCFP) have shown beneficial effects. In a recent meta-analysis, supplementation of SCFP (Original YC, XP, and XPC, Diamond V) to beef cattle fed conventional diets resulted in an improvement in carcass quality (more low choice and less select carcasses; Wagner et al., 2016). One study included in this meta-analysis was a study by Swyers et al. (2014). In this study, they looked at the interactive effects of monensin and SCFP (Original XP). Although not statistically different, cattle fed a diet supplemented with SCFP that did not contain monensin had numerically more choice carcasses (30 and 55%, respectively) and fewer select carcasses (53 and 33%, respectively) when compared with cattle fed a diet with monensin and no SCFP. Cattle fed a diet containing both monensin and SCFP had similar choice (58%) and select (38%) carcasses to those fed SCFP alone. The results from the current study suggest that removing monensin and tylosin from finishing diets fed to heifers and replacing with PRT would yield similar carcass characteristics.

Liver Abscesses

The total prevalence of liver abscesses was similar ($P = 0.27$) between treatments (Table 5). However, heifers fed PRT had fewer total liver abscesses, specifically less

severe (i.e., A⁻) abscesses. Reinhardt and Hubbert (2015) found that the degree of grain processing and the subsequent increase in the rate of ruminal starch fermentation and potential risk of acidosis was not a primary factor in formation or reduction of liver abscesses. Roughage level and form had a much greater effect on liver abscesses than did grain source or degree of processing. Previous research summarized by Laudert and Vogel (2004) showed that tylosin reduced liver abscesses by 73% (7.48 vs. 27.90% for tylosin and no tylosin, respectively). Wagner et al. (2016) revealed that cattle supplemented with other SCFP products (Original YC, XP, and XPC) tended to have a lower liver abscess prevalence than those fed a conventional diet that contained tylosin.

IMPLICATIONS

Replacing monensin, tylosin, and bacterial (*Lactobacillus* and *Propionibacterium*) DFM in conventional feedlot diets with NaturSafe (PRT) resulted in similar growth performance, carcass characteristics, and liver abscess prevalence in yearling fed heifers. NaturSafe (PRT) is a potential fit in a natural yearling feedlot production system and may offset some of the growth performance losses normally observed when monensin and tylosin are removed from a conventional production system.

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