

Influence of Yeast Culture on Feeder Calves and Lambs^{1,2,3}

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ABSTRACT: Four experiments were conducted to determine the influence of yeast culture on 1) the health and performance of feeder calves, 2) the response of calves to an infectious bovine rhinotracheitis virus (IBRV) infection, and 3) nutrient utilization in lambs fasted for 3 d. In Exp. 1, 108 feeder calves were transported from Tennessee to Texas (1,600 km) and fed receiving diets containing 0 or .75% yeast culture and .35 or .69% P in a 2 x 2 factorial arrangement of treatments. In Exp. 2, 101 calves were transported 950 km from Austin, TX to Bushland, TX and fed receiving diets containing 0, .75, 1.125, or 1.5% yeast culture. Yeast culture did not significantly affect the health or performance of calves in either experiment, although morbid calves fed yeast culture required fewer ($P < .05$) days of antibiotic therapy in Exp. 2. In Exp. 3,

feeder steers were fed diets containing 0 or .75% yeast culture and challenged intranasally with IBRV. Calves fed yeast culture tended to maintain heavier weights and higher DMI during IBRV infection than did steers fed the control diet. In Exp. 4, feeder lambs were fasted for 3 d and re-fed diets containing 0, .75, 1.125, or 1.5% yeast culture during a N and mineral balance trial. Lambs fed yeast culture had greater ($P < .08$) N balance and tended to have greater Zn and Fe balance than control lambs. Results of these studies are interpreted to suggest that supplementation of morbid calves with yeast culture can have beneficial effects (fewer sick days, higher feed intakes) and that these effects may be mediated by improved N, Zn, and Fe metabolism.

Key Words: Calves, Lambs, Yeast Culture, Stress, Diets, Metabolism

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Introduction

Feeder calves encounter numerous stressors during movement from the farm or origin to commercial feedyards. Studies have indicated that modifications of the receiving diet of stressed feeder calves can improve animal health, performance, and DMI (Cole, 1982; Hutcheson, 1988; Lofgreen, 1988).

Yeast culture has been shown to have several effects in ruminants. Harrison et al., (1988) noted altered ruminal fermentation, Adams et al. (1981) noted an increased ruminal turnover rate, and Peterson et al. (1987) noted an increased retention of K, Cu, and Zn in ruminants fed diets supplemented with yeast culture.

Phillips and VonTungeln (1985) and J. E. Williams (personal communication) reported that the addition of yeast culture to the receiving diet of feeder calves increased DMI and daily gain. Williams et al. (1987) noted an improvement in performance of heat-stressed lambs when yeast culture was added to the diet.

These studies were conducted to determine the effects of yeast culture on 1) the health and performance of stressed feeder calves, 2) DMI and weight loss of calves challenged with infectious bovine rhinotracheitis virus (IBRV), and 3) nutrient digestibility and retention of fasted lambs. In addition, the effects of additional P in the receiv-

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ing diet on stressed calf health and performance were determined.

Materials and Methods

Four experiments were conducted. The research proposal for each experiment was reviewed and approved by the local animal care committee as outlined in the publication *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (Consortium, 1988). In Exp. 1 and 2 the effects of yeast culture on the health and performance of stressed feeder calves were determined. In Exp. 1 the effects of added P on health and performance were also determined. In Exp. 3, the effects of yeast culture on DMI, febrile response, and weight loss of calves challenged with IBRV were evaluated. In Exp. 4 the effects of yeast culture on nutrient repletion of lambs after a 3-d feed and water deprivation period were determined.

Yeast culture ("XP" Yeast Culture, Diamond V. Mills, Cedar Rapids, IA) used in each experiment was composed of live *Saccharomyces cerevisiae* grown on a medium of ground corn, hominy feed, corn gluten feed, wheat middlings, rye middlings, diastatic malt, corn syrup, and cane molasses and dried to preserve the fermenting activity of the yeast.

Experiment 1. One hundred sixteen steer calves of predominantly British breeding averaging 194 kg were purchased by a Tennessee orderbuyer in February 1988. Calves were purchased from eight auction markets in the southeast and assembled at the orderbuyer facility over a 4-d period. While in the orderbuyer facility, calves were given ad libitum access to fescue hay and water. Calves were then transported for 28 h by a standard double-deck trailer 1,600 km to the USDA-TAES research feedlot in Bushland, TX.

Upon arrival at Bushland calves were individually identified with ear tags and rectal temperature, breed, and body weight of each calf was recorded. Calves were allowed to rest overnight and were given ad libitum access to alfalfa hay and a 66% concentrate receiving diet (Table 1). Eight calves with rectal temperatures $> 41^{\circ}\text{C}$ at arrival were not used in the study.

On the day after arrival calves were weighed, blood-sampled by jugular venipuncture, vaccinated with a four-way Clostridial vaccine (Blacklego, Cutter Animal Health, Bayvet Div., Miles Lab, Shawnee, KS), treated for internal and external parasites (Ivomec, MSD AGVET, Div. of Merck & Co., Rahway, NJ), and injected with vitamins A, D, and E. Calves were randomly assigned to one of four dietary treatments in a 2 x 2 factorial arrangement of treatments (Table 1). Main treat-

ments consisted of two dietary concentrations of P (.35% or .69% of DM) and two concentrations of yeast culture (0 or .75% of DM). Calves were held in 12 open-lot pens with fenceline feedbunks (nine calves per pen; three pens per treatment) and fed their assigned diet daily to allow ad libitum consumption. Orts were obtained and weighed at weekly intervals.

Calves were observed between 0700 and 0800 each morning for clinical signs of respiratory disease. Calves determined to be morbid based on ocular discharge, nasal discharge, anorexia, and(or) depression were removed from their assigned pens, and their rectal temperatures were measured. Calves with more than three morbidity points based on one point for ocular or nasal discharge and two points for anorexia, depression, or a rectal temperature $> 40^{\circ}\text{C}$ were treated with antibiotics for a minimum of 3 d. During antibiotic therapy calves were held in "hospital" pens (one pen per treatment) and fed their assigned diets. Calves that died were transported to the Texas A&M Veterinary Medical Diagnostic Laboratory in Amarillo for necropsy and histopathological and microbiological examination to determine the cause of death.

Calves were weighed with no shrink period between 0800 and 1200 on d 7, 14, 28, 56, and 57 after arrival at the feedlot. Blood samples were obtained and rectal temperatures were measured at each weighing. Weights on d 56 and 57 were averaged for the final weight.

Blood samples were allowed to clot and centrifuged for 30 min at 3,000 x g, and the serum was decanted. Serum was stored at -4°C until it was analyzed for urea N (Marsh et al., 1965), Ca (Gindler and King, 1972), inorganic P (Daly and Ertingshausen, 1972), alkaline phosphatase (SSCC, 1974), and free fatty acids (FFA: Smith, 1975) by colorimetric procedures.

Performance data were statistically analyzed by ANOVA as a 2 x 2 factorial arrangement of treatments using the GLM procedure (SAS, 1985) with pens as the experimental units. The model included effects for yeast culture, P, and their interaction. Blood data were statistically analyzed by ANOVA as a split plot in time with the main plot as a 2 x 2 factorial arrangement of treatments using the GLM procedure (SAS, 1985). Animal(treatment) was the error term for main-plot effects. Morbidity and mortality data were analyzed by chi-square analysis.

Experiment 2. One hundred one steer calves of British breeding averaging 206 kg were purchased from an orderbuyer in Austin, TX in November 1988. Calves originated from six auction markets and were held in the orderbuyer facilities for 4 d. Calves were transported 950 km (18 h) to Bushland, TX by commercial double-deck trailer.

Table 1. Composition of diets used in each experiment (DM basis)

| Item | Experiment 1 ^a | | | | Experiments 2, 3, and 4 ^b | | | |
|--------------------------------|---------------------------|------|-------|-------|--------------------------------------|-------|--------|------|
| | 1 | 2 | 3 | 4 | 0 | .75 | 1.125 | 1.5 |
| Cottseed hulls | 29.0 | 28.6 | 28.25 | 27.85 | 29.0 | 28.25 | 27.875 | 27.5 |
| Corn ^c | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 |
| Alfalfa | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Cottonseed meal | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 | 14.0 |
| Molasses | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Salt | .25 | .25 | .25 | .25 | .25 | .25 | .25 | .25 |
| Trace mineral mix ^d | .05 | .05 | .05 | .05 | .05 | .05 | .05 | .05 |
| Limestone | 1.2 | .4 | 1.2 | .4 | 1.2 | 1.2 | 1.2 | 1.2 |
| Dicalcium phosphate | — | 1.2 | — | 1.2 | — | — | — | — |
| KCl | .5 | .5 | .5 | .5 | .5 | .5 | .5 | .5 |
| Yeast culture | — | — | .75 | .75 | — | .75 | 1.125 | 1.5 |

^aDiet 1 = low P, no yeast culture; Diet 2 = high P, no yeast culture; Diet 3 = low P + .75% yeast culture; Diet 4 = high P + .75% yeast culture. Diets 1 and 3 contained .35% P; Diets 2 and 4 contained .69% P. All four diets contained 5,000 IU/kg of vitamin A and 100 IU/kg of vitamin E.

^bPercentage of yeast culture in diet. All diets were formulated to contain 13.1% CP, .68% Ca, 1.15% K, .24% Mg, .35% P, 1.7 Mcal NE_m/kg, and .96 Mcal NE_g/kg. All diets contained 5,000 IU/kg of vitamin A and 100 IU/kg of vitamin E.

^cDry-rolled.

^dTrace mineral package contained 7.45% Mn, 17.6% Zn, 14.5% Fe, 3.72% Cu, .23% I, .23% Co, and 16.5% S in steer studies. Copper was omitted from the trace mineral package in the sheep study.

Upon arrival calves were processed as in Exp. 1 and randomly assigned to one of four treatments. Treatments (Table 1) consisted of 0, .75, 1.125, or 1.5% yeast culture in the receiving diet. Calves were fed in 12 pens (three pens per treatment; eight to nine calves per pen). After the 2-wk receiving period, all calves on the yeast culture treatments were fed a diet containing .375% yeast culture until the conclusion of the experiment (d 57). Control calves remained on the control diet until completion of the experiment. As in Exp. 1, calves were weighed on d 7, 14, 28, 56 and 57 after arrival. Rectal temperatures were measured at each weighing and blood samples were obtained on d 7, 14, 28, and 56. All other procedures were the same as in Exp. 1.

Performance data were statistically analyzed as a completely randomized design by the GLM procedure with pens as the experimental units. Treatment effects were tested by predetermined orthogonal contrasts; linear and quadratic effects of yeast culture and yeast culture vs control effects were tested. Blood data were statistically analyzed by ANOVA as a split plot in time using the GLM procedure (SAS, 1985). Morbidity and mortality data were analyzed by chi-square analysis.

Experiment 3. Thirty crossbred steers averaging 264 kg with no detectable serum antibody to IBRV were randomly assigned to one of two dietary treatments (0 or .75% yeast culture; Table 1) with 15 steers per treatment. Steers were housed in pens equipped with Pinpointers (Pinpointer 4000B, UIS Corp., Cookeville, TN) to obtain daily individual feed intakes. After a 2-wk pen and diet

adjustment period, calves were challenged by intranasal aerosol with 2.7×10^5 plaque forming units of the Cooper strain of IBRV (USDA-ARS, National Animal Disease Center, Ames, IA) in each nostril (Cole et al., 1986a). Individual steer weights, rectal temperatures, and feed intakes were recorded daily between 0800 and 0900 for the subsequent 14 d.

Data were statistically analyzed using the GLM procedure as a completely randomized design with animal as the experimental unit. The initial model included effects of yeast culture and sample day. Because of significant diet x day interactions, the data were subsequently analyzed within day with effects for dietary treatment.

Experiment 4. Four Suffolk lambs averaging 38 kg were used in a metabolism trial. All lambs were fed a control diet containing no yeast culture for 2 wk and were then deprived of feed and water for 3 d. The 3-d fasting period was used to stimulate a 24-h fasting-transport period (Cole et al., 1986b). Lambs were fed realimentation diets containing 0, .75, 1.125, or 1.5% yeast culture (Table 1) in a 4 x 4 Latin square design. Individual feed intakes were limited to near-maintenance energy intakes (730 g of DMI/d) during the prefast and realimentation phases of the study. This feed intake was used for two reasons: 1) stressed feeder calves normally consume near-maintenance amounts of energy (Cole, 1982; Hutcheson, 1988) and 2) it reduced the amount of orts obtained during the realimentation phase.

Lambs were confined in stainless steel metabolism stalls and total feces and urine excretion were collected, weighed, and subsampled daily for 14 d.

Table 2. Cumulative health and performance of calves in Exp. 1

| Item | % of Yeast culture | | % of Phosphorus | | SEM |
|---------------------------|--------------------|------|-----------------|------|-----|
| | 0 | .75 | .35 | .69 | |
| No. of calves | 54 | 54 | 54 | 54 | — |
| Morbidity, % | 63 | 60 | 63 | 60 | — |
| Mortality, % | 11.1 | 7.4 | 7.4 | 11.1 | — |
| Days treated ^a | 6.10 | 5.72 | 5.76 | 6.07 | .66 |
| Daily gain, kg | | | | | |
| Day 7 | 1.60 | 2.02 | 1.74 | 1.88 | .16 |
| Day 14 | 1.32 | 1.34 | 1.36 | 1.31 | .11 |
| Day 28 | 1.11 | 1.01 | 1.15 | .97 | .07 |
| Day 56 | 1.34 | 1.27 | 1.36 | 1.26 | .05 |
| Dry matter intake, kg/d | | | | | |
| Day 7 | 2.78 | 2.93 | 2.98 | 2.73 | .18 |
| Day 14 | 3.87 | 4.14 | 3.95 | 4.06 | .14 |
| Day 28 | 4.83 | 4.61 | 4.68 | 4.77 | .21 |
| Day 56 | 6.72 | 6.43 | 6.68 | 6.47 | .22 |
| Gain/feed ratio, g/kg | | | | | |
| Day 7 | 571 | 685 | 556 | 694 | 24 |
| Day 14 | 338 | 326 | 342 | 320 | 29 |
| Day 28 | 221 | 215 | 244 | 196 | 25 |
| Day 56 | 199 | 197 | 202 | 193 | 26 |

^aMean days of antibiotic treatment required by sick calves.

Subsamples were composited for the following intervals: 1) 4 d before fast, 2) 3 d of fast, and 3) 7 d of realimentation. Feed samples were collected three times per week and composited for each period of the Latin square. Feed and feces were analyzed for DM by drying to a constant weight at 60°C. Feed, feces, and urine were analyzed for N and P by digesting samples in a block digester and determining N and P by automated analysis (Technicon, 1977). Calcium, Na, K, Cu, Zn, Mg, and Fe were determined by atomic absorption spectroscopy.

Data were statistically analyzed using the GLM procedure as a 4 x 4 Latin square design. Treatment effects were tested by linear and quadratic effects of yeast culture and yeast culture vs control orthogonal contrasts.

Results

Experiment 1. Dietary yeast culture and P concentration did not significantly affect calf morbidity, mortality, or performance in Exp. 1. (Table 2). Ninety-three percent of morbidity and mortality occurred during the first 14 d after arrival at the feedyard.

Ten calves died of respiratory disease. This high mortality rate was probably due to several factors: 1) several extremes in weather occurred during the first 2 wk, with temperatures ranging from -20 to 20°C, 2) in vitro tests indicated that the *Pasteurella haemolytica* organisms isolated from the lungs of dead calves were highly resistant to the antibiotics used for treatment (erythromycin, oxytetracycline,

and tylosin), and 3) the *Pasteurella* infection was apparently complicated by infection with bovine viral diarrhea virus (a potential immunosuppressive organism) because it was isolated from 6 of 10 dead calves.

Serum metabolite concentrations (data not shown) were not significantly affected by dietary yeast culture or P. Serum urea N concentrations declined ($P < .05$) between arrival ($10.34 \pm .29$ mg/100 mL) and d 7 in the feedlot ($5.04 \pm .36$ mg/100 mL) then remained relatively constant during the 56-d feeding period. Serum Ca concentrations were relatively low upon arrival at the feedlot ($8.89 \pm .10$ mg/100 mL) but increased ($P < .05$) by d 7 ($10.03 \pm .09$ mg/100 mL). In contrast, serum P concentrations declined ($P < .05$) between arrival ($7.04 \pm .12$ mg/100 mL) and d 7 ($5.62 \pm .13$ mg/100 mL) then gradually increased ($8.62 \pm .11$ mg/100 mL) by d 56 of the feeding period. Alkaline phosphatase activity followed a pattern similar to that of serum P concentrations. Serum FFA concentrations were elevated at arrival (680 ± 35 μ mol/L), declined ($P < .05$) at d 7 (213 ± 12 μ mol/L), and remained relatively constant during the remainder of the feeding period.

Experiment 2. Yeast culture supplementation did not significantly affect morbidity, mortality, or calf performance in Exp. 2 (Table 3). Morbid calves fed diets containing yeast culture required fewer ($P < .05$) days of antibiotic therapy than did morbid calves fed the control diet.

Yeast culture had a quadratic effect on serum urea N concentrations on d 7 ($P < .05$) and 28 ($P < .10$) (Table 4). Serum urea N concentrations increased as yeast culture concentration increased

Table 3. Cumulative health and performance of calves in Exp. 2.

| Item | % of Yeast culture in receiving diet | | | | SEM |
|---------------------------|--------------------------------------|------------------|------------------|-------------------|-----|
| | 0 | .75 | 1.125 | 1.5 | |
| No. of calves | 25 | 26 | 25 | 25 | — |
| Morbidity, % | 52.0 | 84.6 | 92.0 | 80.0 ^a | — |
| Days treated ^b | 6.1 ^c | 4.5 ^d | 4.6 ^d | 4.4 ^d | .22 |
| Daily gain, kg | | | | | |
| Day 7 | 1.10 | 1.68 | 1.04 | 1.52 | .14 |
| Day 14 | 1.26 | 1.47 | 1.11 | 1.41 | .08 |
| Day 28 | 1.02 | 1.13 | .96 | 1.14 | .05 |
| Day 56 | 1.26 | 1.25 | 1.22 | 1.23 | .04 |
| Dry matter intake, kg/d | | | | | |
| Day 7 | 3.71 | 3.44 | 3.47 | 3.50 | .10 |
| Day 14 | 3.97 | 3.90 | 3.74 | 3.92 | .07 |
| Day 28 | 5.28 | 5.31 | 5.11 | 5.28 | .06 |
| Day 56 | 6.30 | 6.31 | 6.32 | 6.15 | .11 |
| Gain/feed ratio, g/kg | | | | | |
| Day 7 | 293 | 486 | 294 | 432 | 24 |
| Day 14 | 317 | 378 | 296 | 359 | 27 |
| Day 28 | 194 | 213 | 188 | 215 | 21 |
| Day 56 | 200 | 198 | 192 | 200 | 11 |

^aOne calf died of peritonitis unrelated to dietary treatments.

^bMean days of antibiotic treatment required by sick calves.

^{c,d}Means in same row without a common letter in their superscript differ ($P < .05$).

Table 4. Influence of yeast culture on serum metabolites and minerals of stressed feeder calves in Exp. 2.

| Item | % of Yeast culture in receiving diet | | | | SEM | PC ^a |
|--------------------------------|--------------------------------------|-------|-------|-------|------|-----------------|
| | 0 | .75 | 1.125 | 1.5 | | |
| Urea N, mg/100 mL | | | | | | |
| Day 7 | 3.62 | 3.83 | 5.15 | 3.25 | .24 | Q* |
| Day 14 | 3.77 | 4.12 | 4.83 | 3.92 | .34 | — |
| Day 28 | 5.26 | 6.42 | 5.97 | 4.92 | .29 | Q† |
| Day 56 | 4.91 | 7.65 | 5.02 | 7.66 | .53 | YC† |
| Free fatty acids, μmol/L | | | | | | |
| Day 7 | 125 | 155 | 294 | 140 | 25.0 | Q* |
| Day 14 | 118 | 94 | 91 | 105 | 9.4 | — |
| Day 28 | 138 | 112 | 162 | 116 | 9.6 | — |
| Day 56 | 118 | 87 | 111 | 98 | 4.8 | YC† |
| Calcium, mg/100 mL | | | | | | |
| Day 7 | 9.47 | 9.43 | 8.96 | 9.16 | .13 | — |
| Day 14 | 9.94 | 9.84 | 9.32 | 12.57 | .33 | L*,Q* |
| Day 28 | 9.64 | 9.46 | 9.98 | 9.48 | .15 | — |
| Day 56 | 9.48 | 10.71 | 10.12 | 8.88 | .16 | L*,Q* |
| Phosphorus, mg/100 mL | | | | | | |
| Day 7 | 6.36 | 7.12 | 6.63 | 7.37 | .22 | — |
| Day 14 | 7.59 | 7.75 | 8.03 | 8.51 | .23 | — |
| Day 28 | 8.38 | 8.71 | 8.13 | 9.62 | .22 | L† |
| Day 56 | 8.29 | 9.02 | 9.08 | 8.94 | .21 | YC* |
| Magnesium, mg/100 mL | | | | | | |
| Day 7 | 1.64 | 1.62 | 1.67 | 1.75 | .03 | — |
| Day 14 | 1.78 | 1.88 | 1.79 | 2.00 | .04 | L† |
| Day 28 | 1.57 | 1.67 | 1.66 | 1.84 | .03 | YC* |
| Day 56 | 1.86 | 1.82 | 1.93 | 1.99 | .04 | — |
| Alkaline phosphatase, units/mL | | | | | | |
| Day 7 | 35.3 | 32.5 | 41.9 | 54.0 | 2.65 | L** |
| Day 14 | 59.1 | 49.6 | 51.2 | 91.3 | 6.41 | L†,Q* |
| Day 28 | 103.5 | 77.2 | 76.9 | 119.4 | 7.26 | Q* |
| Day 56 | 102.7 | 83.6 | 126.7 | 135.1 | 8.55 | L† |

^aPolynomial contrasts. L = linear, Q = quadratic, YC = yeast culture effect, † $P < .10$, * $P < .05$, ** $P < .01$.

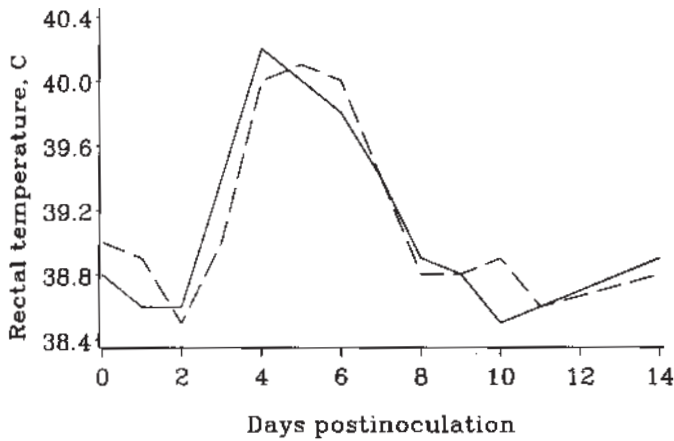


Figure 1. Rectal temperatures of calves inoculated with infectious bovine rhinotracheitis virus on d 0 and fed diets containing 0% (solid line) or .75% (dashed line) yeast culture. The pooled SEM was .08.

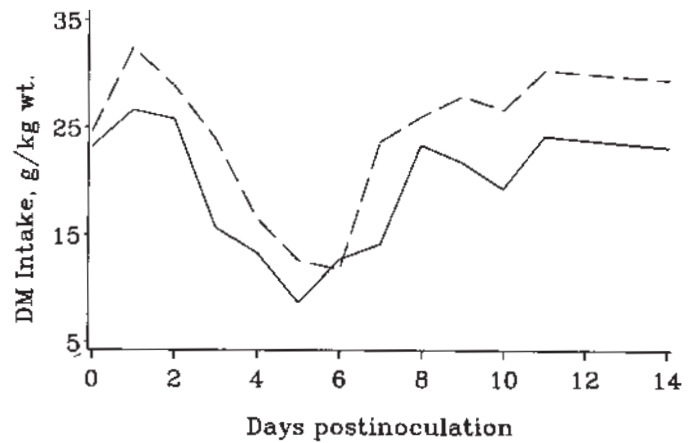


Figure 2. Daily feed dry matter intakes of calves inoculated with infectious bovine rhinotracheitis virus on d 0 and fed diets containing 0% (solid line) or .75% (dashed line) yeast culture. The pooled SEM was 1.58.

from 0 to 1.125% of the diet than decreased at 1.5% of the diet. Yeast culture had a quadratic effect ($P < .05$) on serum FFA concentrations on d 7, and on d 56 calves fed yeast culture had lower ($P < .10$) FFA concentrations than did controls.

Yeast culture had significant effects on serum Ca concentrations on d 14 and 56; however, these effects seemed to be the result of abnormal values in calves fed the diet containing 1.5% yeast culture. Yeast culture supplementation tended to increase serum inorganic P concentrations; the differences were significant on d 28 and 56. Yeast culture supplementation increased serum Mg concentrations on d 14 ($P < .10$) and 28 ($P < .05$); however, as with serum Ca, these effects were primarily due to changes occurring in calves fed the diet containing 1.5% yeast culture.

Serum alkaline phosphatase was significantly affected by yeast culture supplementation, although the trends varied among sample day. Most of this effect seemed to be due to elevated alkaline phosphatase activities in calves fed the diet containing 1.5% yeast culture. Calves fed the .75% yeast culture diet tended to have lower alkaline phosphatase activities than did calves on the remaining treatments.

Experiment 3. Yeast culture supplementation did not significantly affect calf rectal temperature after the IBRV challenge (Figure 1). Calves fed yeast culture had higher DMI than controls on d 3 ($P < .03$), 7 ($P < .09$), 9 ($P < .10$), 10 ($P < .02$), 11 ($P < .08$), 13 ($P < .05$), and 14 ($P < .10$) postinoculation (Figure 2). Calves fed yeast culture had a marked increase in DMI on d 1 postinoculation. It is not clear whether this was an anomaly or was due to the addition of yeast culture to the diet. However, DMI for d -4 to -1 were similar to both treatments,

suggesting that this increase in DMI was due to the addition of yeast culture. Because of the higher DMI, calves fed yeast culture tended to lose less weight after IBRV inoculation than did controls (Figure 3).

Experiment 4. Prefast daily nutrient retention, nutrient losses during the 3-d feed and water deprivation period, and average daily nutrient intake during the 7-d realimentation period are presented in Table 5. Values were not significantly affected by yeast culture supplementation. Except for Zn, mean nutrient retentions were positive during the prefast period.

Lambs fed yeast culture had higher apparent DM and N digestibility ($P < .04$), N retention ($P < .08$), and Na absorption ($P < .08$) than lambs fed

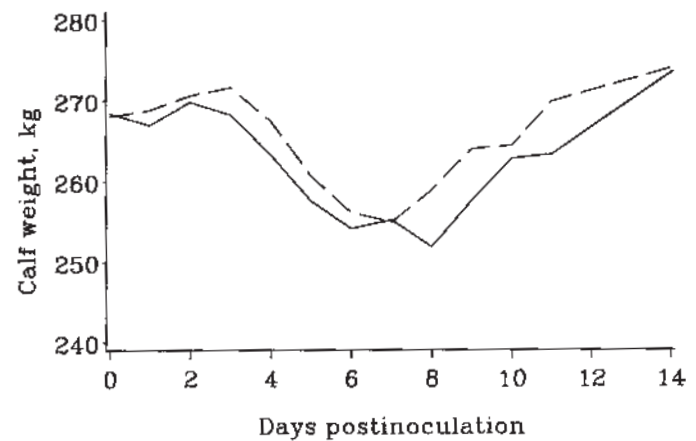


Figure 3. Weights of calves inoculated with infectious bovine rhinotracheitis virus on d 0 and fed diets containing 0% (solid line) or .75% (dashed line) yeast culture. The pooled SEM was 3.81.

Table 5. Prefast daily nutrient retention, nutrient losses during a 3-day feed and water deprivation period, and average realimentation nutrient intake in lambs (means \pm SEM)

| Nutrient | Prefast retention | | Deprivation losses | | Realimentation intake | |
|---------------|-------------------|------------|--------------------|------------|-----------------------|-----------|
| Nitrogen, g | 1.77 | \pm .32 | -25.30 | \pm .53 | 16.4 | \pm .03 |
| Phosphorus, g | .60 | \pm .12 | -2.12 | \pm .22 | 3.74 | \pm .01 |
| Calcium, g | .58 | \pm .31 | -6.64 | \pm .33 | 8.40 | \pm .02 |
| Sodium, g | .14 | \pm .15 | -.63 | \pm .08 | 2.54 | \pm .11 |
| Potassium, g | 3.61 | \pm .24 | -6.55 | \pm .29 | 13.01 | \pm .24 |
| Magnesium, g | .28 | \pm .07 | -1.48 | \pm .01 | 2.03 | \pm .07 |
| Copper, mg | 10.36 | \pm 1.14 | -19.46 | \pm 1.05 | 32.4 | \pm .06 |
| Zinc, mg | -1.54 | \pm 4.97 | -97.60 | \pm 4.66 | 114.6 | \pm .21 |
| Iron, mg | 67.60 | \pm 10.4 | -398.70 | \pm 18.3 | 522.2 | \pm .97 |

the control diet (Table 6). Lambs fed yeast culture tended ($P < .12$) to have greater Na, Cu, Zn, and Fe retention than did control lambs. Yeast culture tended ($P < .13$) to have an effect on Ca retention that was dose-related. Supplementation with .75%

yeast culture increased Ca retention 28%, but at the 1.5% concentration, Ca retention was reduced 60%. In addition, yeast culture increased urinary P ($P < .04$) and Fe ($P < .08$) excretion. These results suggest that some component(s) of yeast culture

Table 6. Influence of yeast culture on apparent nutrient absorption and retention and urinary excretion after a 3-day feed and water deprivation in lambs

| Item | % of Yeast culture in realimentation diet | | | | SEM | PC ^a |
|---|---|-------|-------|-------|------|-----------------|
| | 0 | .75 | 1.125 | 1.5 | | |
| Realimentation apparent absorption, % of intake | | | | | | |
| Dry matter | 62.9 | 65.6 | 67.1 | 65.6 | .67 | L*,YC* |
| Nitrogen | 49.3 | 55.1 | 54.7 | 53.2 | 1.28 | YC* |
| Phosphorus | 37.4 | 34.6 | 54.2 | 40.8 | 5.28 | — |
| Calcium | 15.0 | 19.0 | 13.5 | 6.4 | 2.47 | — |
| Sodium | 83.2 | 89.3 | 86.5 | 87.7 | 1.21 | YC [†] |
| Potassium | 90.0 | 90.5 | 92.0 | 90.5 | .73 | — |
| Magnesium | 39.2 | 41.2 | 42.4 | 39.4 | 1.86 | Q [†] |
| Copper | 30.8 | 37.3 | 39.8 | 38.9 | 3.50 | — |
| Zinc | 8.5 | 16.8 | 16.9 | 15.5 | 4.33 | — |
| Iron | 21.3 | 28.8 | 27.0 | 27.5 | 2.11 | — |
| Realimentation retention | | | | | | |
| Nitrogen, g/d | 3.02 | 4.07 | 3.97 | 3.81 | .19 | YC [†] |
| Phosphorus, g/d | .40 | .21 | .67 | .44 | .15 | — |
| Calcium, g/d | 1.20 | 1.54 | 1.07 | .48 | .21 | — |
| Sodium, g/d | .33 | .49 | .40 | .40 | .12 | — |
| Potassium, g/d | 4.13 | 4.30 | 4.40 | 4.13 | .20 | — |
| Magnesium, g/d | .47 | .52 | .53 | .48 | .07 | — |
| Copper, mg/d | 9.9 | 12.0 | 12.6 | 12.5 | 1.01 | — |
| Zinc, mg/d | 9.2 | 19.1 | 18.8 | 17.4 | 2.39 | — |
| Iron, mg/d | 110.4 | 149.9 | 139.2 | 142.8 | 11.4 | — |
| Realimentation urine losses | | | | | | |
| Nitrogen, g/d | 5.08 | 4.98 | 4.96 | 4.90 | .12 | — |
| Phosphorus, g/d | .99 | 1.07 | 1.32 | 1.08 | .15 | YC* |
| Calcium, g/d | .06 | .06 | .06 | .05 | .01 | — |
| Sodium, g/d | 1.82 | 1.79 | 1.79 | 1.84 | .06 | — |
| Potassium, g/d | 7.62 | 7.52 | 7.52 | 7.65 | .16 | — |
| Magnesium, g/d | .34 | .33 | .34 | .34 | .01 | — |
| Copper, mg/d | .10 | .10 | .20 | .10 | .02 | — |
| Zinc, mg/d | .50 | .20 | .40 | .40 | .07 | — |
| Iron, mg/d | 1.07 | 1.08 | 1.32 | 1.41 | .14 | L [†] |

^aPolynomial and orthogonal contrasts. YC = yeast culture effect. L = linear. Q = quadratic effect.

[†] $P < .10$, * $P < .05$.

may affect absorption of some minerals from the digestive tract. However, this effect may be dose-related, and excessive levels of yeast culture may cause reduced absorption of some minerals.

Discussion

Phillips and VonTungeln (1985) reported that yeast culture increased DMI and daily gain of stressed calves in two trials but had no effect on animal performance in two other trials. The reason for the variable results was not apparent. At Missouri, J. E. Williams (personal communication) noted a 5% increase in DMI and a 30% increase in daily gain of stressed yearlings fed yeast culture. In the present studies (Exp. 1 and 2) yeast culture supplementation did not significantly affect calf performance. Phillips and VonTungeln (1985) used a simulated marketing/transit stress in their study. Similarly, Williams used a 12-h transport period to simulate marketing/transport stress. In the present studies calves went through normal marketing/transport channels and were in transit for 18 to 28 h. There were also considerable differences in diets between those fed in the present studies and those fed by Phillips and VonTungeln (1985) and Williams. The diets fed by Williams contained approximately 17% corn silage, which would be expected to contain a considerable amount of natural yeast (Harrison et al., 1988). The diets of Phillips and VonTungeln (1985) contained no supplemental Na or trace minerals. These data are interpreted to suggest that yeast culture can have a beneficial effect on performance of stressed calves under some circumstances; however, there seems to be considerable unexplained variability in response.

Data from Exp. 2 indicated that morbid calves fed yeast culture responded more favorably to antibiotic therapy and spent fewer days in the hospital pen than did control calves. Data from the IBRV challenge experiment, in turn, indicated that morbid calves fed yeast culture had higher feed intakes than calves that did not receive yeast culture. Williams et al. (1987) reported that supplementation with yeast culture improved acid/base balance and performance of lambs subjected to heat stress. This suggests that any beneficial effects of yeast culture may be more pronounced when the animal is subjected to heat stress, either via elevated ambient temperatures or fever.

Peterson et al. (1987) reported increased K, Cu, and Zn retention in lambs fed yeast-culture-supplemented, 90% beet pulp diets. In the present study only N retention was significantly affected by yeast culture supplementation, although Cu, Fe, and Zn retention were numerically greater in

lambs fed yeast culture. Adams et al. (1981) reported that yeast culture did not significantly affect N retention in lambs; however, in their study, lambs fed the yeast culture diet had N intakes 20% lower than those of control lambs but had similar N retentions. Peterson et al. (1987) reported a significant increase in K retention of lambs fed yeast culture; however, no effect on K retention was noted in the present study. Potassium intake in the present study was about 2.5 g/d greater than in the study of Peterson et al. (1987). In addition, lambs in the study of Peterson et al. (1987) were not fasted before feeding the experimental diets. The biological reason(s) for these effects of yeast culture on mineral metabolism are not apparent. Studies have reported various effects of yeast culture on ruminal fermentation (Adams et al., 1981; Harrison et al., 1988), and Harrison et al. (1988) noted that ruminal fermentation was more stable in cows fed yeast culture supplements than in cows not given yeast culture supplements. An altered or more stable ruminal fermentation could possibly affect mineral solubility and absorption.

Daily retention of N, Ca, Na, K, Mg, Zn, and Fe was greater and retention of P was lower during the 7-d realimentation period than during the prefast period. Previous investigators (Cole and Hutcheson, 1988) have also noted that after a fasting period lambs remained in a negative P balance for 3 to 14 d.

Results of experiments using yeast culture in diets of stressed calves are highly variable, as are results using nonstressed animals. Under some circumstances yeast culture seems to have beneficial effects on the health and performance of stressed calves. However, the proper circumstances (environment, diet mineral concentrations, normal yeast in diet, animal nutrient status, etc.) remain to be determined.

Implications

Yeast culture additions to the receiving diet of stressed feeder calves did not significantly affect calf performance. Yeast culture additions to diets of morbid calves reduced the number of antibiotic treatment days and increased feed intake. These effects may have been partly due to beneficial effects on N and mineral metabolism.

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