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Supplementing a yeast-derived product to enhance productive and health responses of feeder steers

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ABSTRACT: This experiment evaluated the impacts of supplementing a yeast-derived product (Celmanax; Church & Dwight Co., Inc.; Princeton, NJ) on productive and health responses of feeder steers, and was divided into a preconditioning (d 4 to 30) and feedlot receiving phase (d 31 to 69). Eighty-four Angus × Hereford steers were weaned at approximately 7 mo of age (d -4), and maintained in a single group from d -4 to 3. On d 4, steers were allocated according to weaning BW and age to a 21-pen drylot (5 steers/pen). Pens were randomly assigned to receive: 1) no Celmanax supplementation during the experiment (n = 7), 2) supplementation with Celmanax (14 g/steer daily; as-fed) from d 14 to 69 (n = 7), or 3) supplementation with Celmanax (14 g/steer daily; as-fed) from d 31 to 69 (n = 7). Steers had free-choice access to grass-alfalfa hay and received a corn-based concentrate beginning on d 14. Celmanax was mixed daily with the concentrate. On d 30, steers were road-transported for 1,500 km (24 h). On d 31, steers returned to their original pen assignment for a 38-d feedlot receiving. Shrunk BW was recorded on d 4, 31, and 70. Feed DMI was evaluated from each pen daily (d 14 to 69). Steers were observed daily (d 4 to 69) for bovine respiratory disease (BRD) signs. Preconditioning results were analyzed by comparing pens that received (CELM) or not (CON) Celmanax during the preconditioning phase. Feedlot receiving results were analyzed by comparing pens that received Celmanax from d 14 to 69 (CELPREC), d 31 to 69 (CELRECV), or no Celmanax supplementation (CON). During preconditioning, incidence of BRD was less (P = 0.03) in CELM compared with CON steers. During feedlot receiving, ADG tended (P = 0.07) to be greater in CELPREC and CELRECV vs. CON steers. No treatment differences were detected ($P \geq 0.29$) for DMI parameters; hence, G:F also tended (P = 0.08) to be greater in CELPREC and CELRECV vs. CON steers. No further treatment differences were detected ($P \geq 0.20$) for performance, health, and blood variables during the experimental period. In summary, Celmanax supplementation reduced BRD incidence during a 30-d preconditioning. Moreover, Celmanax improved ADG and G:F during a 38-d feedlot receiving, independently if supplementation began during preconditioning or upon feedlot entry. Hence, Celmanax supplementation appears to be a nutritional strategy to enhance health parameters and receiving performance of feeder cattle.

Key words: cattle, growth, health, supplementation, yeast

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INTRODUCTION

Transport and feedlot entry are two of the most stressful events experienced by feeder cattle (Swanson and Morrow-Tesch, 2001). Upon long transportation periods and during the initial 30 d at the feedlot, cattle experience inflammatory and acute-phase responses (Cooke, 2017) known to impair their productivity and health, including susceptibility to respiratory diseases (Berry et al., 2004; Araujo et al., 2010). These inflammatory and acute-phase responses are elicited by several stress-related stimuli (Cooke, 2017) including endotoxemia caused by 1) death of rumen microbes upon feed/water deprivation during transport and 2) major dietary changes during feedlot receiving (Marques et al., 2012). Consequently, nutritional efforts to enhance gut and overall health upon transport and feedlot entry are

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warranted to optimize productivity and welfare of feeder cattle (Duff and Galyean, 2007).

One strategy to enhance gut and overall immune function during feedlot receiving is to supplement cattle with yeast-derived products, such as cultures and extracts (Cole et al., 1992; Brown and Nagaraja, 2009). Accordingly, Ponce et al. (2012) supplemented beef heifers during a 35-d receiving period with Celmanax (Church & Dwight Co., Inc.; Princeton, NJ), a commercial product containing yeast culture and enzymatically hydrolyzed yeast product. These authors reported that heifers receiving Celmanax had greater growth rates, feed intake, and reduced morbidity caused by respiratory diseases compared with non-supplemented heifers. However, Ponce et al. (2012) did not evaluate immunological and physiological responses to elucidate the biological benefits of Celmanax supplementation on cattle health and performance traits. In addition, Ponce et al. (2012) began supplementing Celmanax to heifers 1 d after feedlot arrival, which is after the critical period of stress and microbial death caused by feed/water deprivation during road transport (Marques et al., 2012).

Based on this latter rationale, we hypothesized that beginning Celmanax supplementation to feeder cattle prior to transport and feedlot entry, such as during a 30-d preconditioning period (Pritchard and Mendez, 1990), will further increase its health and performance benefits during feedlot receiving. Therefore, this experiment evaluated the impacts of Celmanax supplementation beginning at preconditioning or upon feedlot entry on performance, health and physiological variables of beef steers during preconditioning followed by a 38-d feedlot receiving.

MATERIALS AND METHODS

All animals were cared for in accordance with acceptable practices and experimental protocols reviewed and approved by the Oregon State University, Institutional Animal Care and Use Committee (#4862). This experiment was divided into a preconditioning (d 4 to 30) and feedlot receiving phase (d 31 to 69).

Cattle Diets and Management

Eighty-four Angus × Hereford steers were weaned at 7 mo of age (d -4), and maintained in a single meadow foxtail pasture for 7 d (d -4 to 3). On d 4, steers were allocated according to weaning BW and age to a 21-pen drylot (7 × 15 m; 5 steers/pen). Pens were randomly assigned to receive 1 of 3 treatments: 1) no Celmanax supplementation during the experiment (n = 7), 2) supplementation with Celmanax (14 g/steer daily) from d 14 to 69 (n = 7), or 3) supplementation with Celmanax (14 g/steer daily) from d 31 to 69 (n = 7).

TABLE 1. Ingredient composition (as-fed basis; kg/d) of concentrate offered during preconditioning (d 4 to 30) and feedlot receiving (d 31 to 69) phases 1

Item	Whole corn	Soybean meal	Mineral[2]
Preconditioning	0.64	0.23	0.05
Feedlot receiving			
A	0.91	0.36	0.05
B	2.27	0.36	0.05
C	4.10	0.55	0.05

[1]Preconditioning concentrate was offered from d 14 to 30. During feedlot receiving, A = d 31 to 36; B = d 37 to 44; and C = d 45 to 69. Steers had free-choice access to grass-alfalfa hay throughout the experimental period (d 4 to 69). Hay and concentrate were offered separately, in different sections of the feed bunk.

[2] Cattleman's Choice (Performix Nutrition Systems, Nampa, ID) containing 14% Ca, 10% P, 16% NaCl, 1.5% Mg, 3,200 mg/kg of Cu, 65 mg/kg of I, 900 mg/kg of Mn, 140 mg/kg of Se, 6,000 mg/kg of Zn, 136,000 IU/kg of vitamin A, 13,000 IU/kg of vitamin D3, and 50 IU/kg of vitamin E.

During the preconditioning phase (d 4 to 30), steers had free-choice access to grass-alfalfa hay and received a corn-based concentrate (Table 1) beginning on d 14. Celmanax was mixed daily with the concentrate. Within each pen, hay and concentrate were offered separately in different sections of the feed bunk. On d -4 and d 18, steers were vaccinated against *Clostridium* (One Shot Ultra 7; Zoetis, Florham Park, NJ), parainfluenza virus (TSV-2; Zoetis), infectious bovine rhinotracheitis virus, bovine viral diarrhea virus Types 1 and 2, and *Mannheimia haemolytica* (Bovi-Shield Gold One Shot; Zoetis).

On d 30, all steers were commingled and transported at the same time and in the same double-deck commercial livestock trailer (Legend 50' cattle liner; Barrett LLC., Purcell, OK) for 1,500 km (24 h) to simulate the stress of a long-haul (Marques et al., 2012). On d 31, steers returned to their original pen assignment for a 38-d feedlot receiving phase. During feedlot receiving, steers had free-choice access to grass-alfalfa hay and received a corn-based concentrate (Table 1), with Celmanax also mixed daily with the concentrate. Within each pen, hay and concentrate were offered separately in different sections of the feed bunk.

Sampling

Steer shrunk BW (after 16 h of water and feed withdrawal) was recorded on d 4 and 70, and on d 31 (after transport) for ADG calculation. Feed DMI was evaluated daily from d 14 to 69 by weighing and collecting samples of the offered and non-consumed feed from each pen. All samples were dried for 96 h

at 50°C in forced-air ovens for DM calculation. Feed efficiency during the feedlot receiving phase was calculated according to total DMI and BW gain of each pen. Steers were observed daily (d 4 to 69) for sickness, particularly bloat (Meyer and Bartley, 1972) and bovine respiratory disease (**BRD**; Berry et al., 2004). Cattle received (i.m.) 0.1 mL/kg of BW of Hexasol LA Solution (Norbrook® Inc. USA; Overland Park, KS) when BRD signs were observed, or 60 mL (oral drench, mixed with 500 ml of water) of Therabloat (Zoetis) when bloat was detected.

Blood samples were collected on d 14, 30, 31, 33, 35, 40, 45, 54, and 69. Samples were collected via jugular venipuncture into commercial blood collection tubes (Vacutainer, 10 mL; Becton Dickinson, Franklin Lakes, NJ) containing no additive or containing 158 USP units of freeze-dried sodium heparin for serum and plasma collection, respectively. After collection, all blood samples were placed immediately on ice, centrifuged (2,500 × *g* for 30 min; 4°C) for plasma or serum harvest, and stored at -80°C on the same day of collection. Serum samples collected from d 14 to 54 were analyzed for NEFA concentrations (colorimetric kit HR Series NEFA – 2; Wako Pure Chemical Industries Ltd. USA, Richmond, VA). Plasma samples collected from d 14 to 54 were analyzed for cortisol (Immulite 1000; Siemens Medical Solutions Diagnostics, Los Angeles, CA) and haptoglobin (Cooke and Arthington, 2013) concentrations. Plasma samples collected on d 14, 30, 54, and 69 were analyzed for IGF-I concentrations (Immulite 1000; Siemens Medical Solutions Diagnostics). The intra- and interassay CV were, respectively, 1.7 and 6.8% for NEFA, and 3.0 and 4.5% for haptoglobin. Plasma IGF-I and cortisol were analyzed within single assays, and the intra-assay CV were, respectively, 2.7, and 1.4%.

Statistical analysis

Pen was considered the experimental unit. Results from the preconditioning phase were analyzed by comparing pens that received (**CELM**) or not (**CON**) Celmanax during preconditioning. Results from the feedlot receiving phase were analyzed by comparing pens that received Celmanax from d 14 to 69 (**CELPREC**), d 31 to 69 (**CELRECV**), or no Celmanax supplementation during the experiment (**CON**). In addition, treatment effects during feedlot receiving were compared using pre-planned single-df orthogonal contrasts (CELPREC and CELRECV vs. CON; CELPREC vs. CELRECV).

Quantitative data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC), binary data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc.), and Satterthwaite approximation to determine the denominator df for tests of fixed effects. All data were analyzed using pen(treatment) and steer(pen) as random variables, but for DMI and G:F that used pen(treatment) as random variable. Model statement for BW, ADG, G:F, and morbidity and mortality rates within each phase contained the effects of treatment. Model statement for DMI, cumulative BRD incidence, and blood variables contained the effects of treatment, day, and the resultant interaction, in addition to results from d 14 as independent covariate for blood variables only. The specified term for the repeated statements was day, with pen(treatment) as subject for DMI and steer(pen) as subject for blood variables and cumulative BRD incidence. The covariance structure used was first-order autoregressive, which provided the smallest Akaike information criterion and hence the best fit for all variables analyzed. All results are reported as least square means, but for blood variables that are reported as covariately adjusted least square means. Significance was set at $P \leq 0.05$ and tendencies were determined if $P > 0.05$ and ≤ 0.10. Results are reported according to main effects if no interactions were significant, or according to the highest-order interaction detected.

RESULTS AND DISCUSSION

During the preconditioning phase, no treatment differences were detected ($P \geq 0.20$) for BW, ADG, and intake parameters (Table 2). However, incidence of respiratory disease was less ($P = 0.03$) in CELM steers compared with CON steers (Table 2). It is important to note that all cases of BRD signs during the preconditioning phase were observed from d 16 to 30 (treatment × day interaction, $P < 0.01$; Fig. 1); hence, after treatments began to be administered. These results indicate that supplementing Celmanax during preconditioning did not enhance steers performance traits, but eliminated the incidence of BRD typically observed in recently-weaned cattle (Taylor et al., 2010). Although the effects of yeast products on cattle immunity is not clearly established, yeast components such as β-glucan are positively associated with proliferation and responsiveness of T-cells to antigens or cytokines (Nocek et al., 2011). Accordingly, others have reported similar outcomes in cattle supplemented with Celmanax during feedlot receiving (Ponce et al., 2012) or upon bovine rhinotracheitis virus challenge (Cole et al., 1992).

During the feedlot receiving phase, ADG tended ($P = 0.07$) to be greater in CELPREC and CELRECV vs. CON steers, and was similar ($P = 0.89$) between CELPREC and CELRECV steers (Table 3). No treat-

TABLE 2. Performance and health parameters during the preconditioning phase (d 4 to 30) in steers receiving a concentrate containing (CELM; n = 7) or not (CON; n = 14) 14 g/steer daily of Celmanax (Church & Dwight Co., Inc.; Princeton, NJ) from d 14 to 30

Item	CON	CELM	SEM	*P* =
Growth parameters[1]				
Initial BW, kg	230	232	3	0.60
Post-transport BW, kg	242	245	3	0.52
ADG, kg/d	0.46	0.52	0.05	0.41
DMI parameters[2]				
Hay, kg/d	5.27	5.41	0.10	0.27
Concentrate, kg/d	0.44	0.50	0.04	0.26
Total, kg/d	5.55	5.77	0.11	0.20
Health parameters[3]				
Morbidity, %	16.0	0.0	4.9	0.03
Bloat, %	0.0	0.0	-	-
Respiratory, %	16.0	0.0	4.9	0.03
Mortality, %	0.0	0.0	-	-

[1]Steer shrunk BW was recorded after 16 h of water and feed withdrawal on d 4 (initial BW), and after road transport (1,500 km for 24 h) on d 31.

[2]Feed intake was recorded daily from d 14 to 30 by measuring offer and refusals from each pen.

[3]Steers were observed daily (d 4 to 69) for sickness, particularly bloat (Meyer and Bartley, 1972) and respiratory disease (Berry et al., 2004).

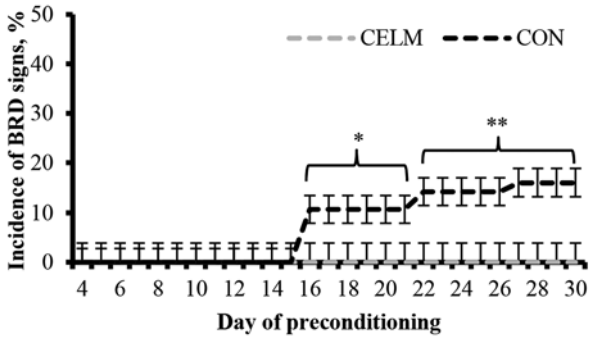

Figure 1. Incidence of bovine respiratory disease (BRD) signs, according to Berry et al. (2004), during the preconditioning phase (d 4 to 30) in steers receiving a concentrate containing (CELM; n = 7) or not (CON; n = 14) 14 g/steer daily of Celmanax (Church & Dwight Co., Inc.; Princeton, NJ) from d 14 to 30. A treatment × day interaction was detected ($P < 0.01$). Within day; * $P = 0.03$, ** $P < 0.01$.

ment differences were detected ($P \geq 0.29$) for DMI parameters (Table 3). Hence, G:F also tended ($P = 0.08$) to be greater in CELPREC and CELRECV vs. CON steers, and was similar ($P = 0.54$) between CELPREC and CELRECV steers (Table 3). However, treatment differences detected for ADG were not sufficient to impact ($P \geq 0.44$) steer final receiving BW (Table 3), and no treatment differences were detected ($P \geq 0.22$) for morbidity and mortality parameters (Table 3).

No treatment differences were detected ($P \geq 0.27$) for concentrations of plasma cortisol, plasma haptoglobin, plasma IGF-I, and serum NEFA (Table 4). As expected based on experimental design, day effects were detected for all blood variables (Fig. 2). Plasma cortisol and haptoglobin concentrations transiently increased ($P \leq 0.05$) across all treatments after transport, demonstrating that steers experienced a neuroendocrine and subsequent acute-phase protein response elicited by transport and feedlot entry (Marques et al., 2012; Cooke, 2017). Serum NEFA concentrations also transiently increased across all treatments after transport, which can be associated to water and nutrient deprivation during transport and the cortisol-induced lipolysis (Marques et al., 2012). Plasma IGF-I concentrations increased across all treatments during feedlot receiving, mainly due to increased nutrient intake (Table 1) and growth (Table 3) during this phase (Elsasser et al., 1989).

Supporting our hypothesis and results from Ponce et al. (2012), Celmanax supplementation improved feedlot receiving ADG and G:F. These outcomes were independent if Celmanax supplementation began during preconditioning or upon feedlot entry. Hence, beginning Celmanax supplementation during preconditioning, to allow cattle to consume and adapt to the product prior to the stress of road transport and feedlot entry, failed to further increase receiving performance and health despite eliminating BRD incidence during preconditioning. Moreover, Celmanax supplementation did not influence circulating concentrations of variables associated with stress, inflammation, and nutritional status in feeder cattle (Cooke, 2017). Perhaps Celmanax supplementation improves performance and health of feeder cattle, as reported herein and by Ponce et al. (2012), without modulating systemic physiological responses; although further research is warranted to support this rationale.

It is important to note, however, that BRD incidence during the feedlot receiving phase was not as prevalent compared with values from research conducted at commercial receiving yards (Snowder et al., 2006; Marques et al., 2016). This outcome can be associated with the fact that while steers were subjected to the stress of road transportation (Cooke, 2017), they returned to the same facility with the same pen members, and were not exposed to cattle from other sources in a novel environment (Step et al., 2008). Hence, research with cattle exposed to a high-stress commercial feedlot scenario is also warranted to further investigate the physiological, immune, and performance effects of Celmanax supplementation, starting either during preconditioning or upon feedlot entry.

TABLE 3. Performance and health parameters during a 38-d feedlot receiving period (d 31 to 69) in steers receiving 14 g/d of Celmanax (Church & Dwight Co., Inc.; Princeton, NJ) during preconditioning and feedlot receiving (d 14 to 69; CELPREC; n = 7), during feedlot receiving only (d 31 to 69; CELRECV; n = 7), or not receiving Celmanax during the experiment (d 4 to 69; CON; n = 7)

					Single df contrasts[1]	
Item	CON	CELPREC	CELRECV	SEM	1	2
Growth parameters[2]						
Final BW, kg	302	309	304	4	0.47	0.44
ADG, kg/d	1.51	1.61	1.62	0.048	0.07	0.89
DMI parameters[3]						
Hay, kg/d	4.13	4.30	4.26	0.14	0.41	0.85
Concentrate, kg/d	2.94	3.00	2.93	0.09	0.83	0.60
Total, kg/d	7.07	7.29	7.19	0.13	0.29	0.57
G:F,[4] g of BW/kg DMI	219	227	231	4	0.08	0.54
Health parameters[5]						
Morbidity	10.7	14.2	17.8	7.3	0.56	0.73
Bloat, %	10.7	10.7	17.8	7.3	0.69	0.50
Respiratory, %	0.0	3.5	0.0	2.0	0.48	0.22
Mortality, %	3.5	3.5	0.0	2.9	0.62	0.39

[1]Single-df orthogonal contrasts: 1 = CON vs. CELPREC and CELRECV, and 2 = CELPREC vs. CELRECV.

[2]Steer shrunk BW was recorded after road transport (1,500 km for 24 h) on d 31, and after 16 h of water and feed withdrawal on d 70 (final BW).

[3]Feed intake was recorded daily from d 31 to 69 by measuring offer and refusals from each pen.

[4]Calculated according to total DMI and BW gain of each pen

[5]Steers were observed daily (d 4 to 69) for sickness, particularly bloat (Meyer and Bartley, 1972) and bovine respiratory disease (Berry et al., 2004).

TABLE 4. Concentrations of plasma cortisol, plasma haptoglobin, plasma IGF-I, and serum NEFA in steers receiving 14 g/d of Celmanax (Church & Dwight Co., Inc.; Princeton, NJ) during preconditioning and feedlot receiving (d 14 to 69; CELPREC; n = 7), during feedlot receiving only (d 31 to 69; CELRECV; n = 7), or not receiving Celmanax during the experiment (d 4 to 69; CON; n = 7)[1]

					Single df contrasts[2]	
Item	CON	CELPREC	CELRECV	SEM	1	2
Plasma cortisol, ng/mL	30.3	28.0	31.4	2.1	0.82	0.27
Plasma haptoglobin, mg/mL	0.258	0.233	0.221	0.034	0.46	0.82
Plasma IGF-I, ng/mL	198	203	207	7	0.41	0.73
Serum NEFA, μEq/L	0.288	0.283	0.283	0.009	0.65	0.94

[1]Blood samples were collected on d 14, 30, 31, 33, 35, 40, 45, 54, and 69. Serum samples collected from d 14 to 54 were analyzed for NEFA concentrations. Plasma samples collected from d 30 to 54 were analyzed for cortisol and haptoglobin concentrations. Plasma samples collected on d 14, 30, 54, and 69 were analyzed for IGF-I concentrations. Results from d 14 were used as independent covariate for each respective analysis; hence, values reported are covariately-adjusted least square means.

[2] Single-df orthogonal contrasts: 1 = CON vs. CELPREC and CELRECV, and 2 = CELPREC vs. CELRECV.

IMPLICATIONS

Celmanax supplementation reduced incidence of respiratory disease but did not enhance performance of recently-weaned steers during a 30-d preconditioning. Moreover, Celmanax supplementation improved growth and feed efficiency during a 38-d feedlot receiving, independently if Celmanax supplementation began during preconditioning or upon feedlot entry. Hence, Celmanax supplementation appears to be a nutritional strategy to enhance health parameters and receiving performance of feeder cattle.

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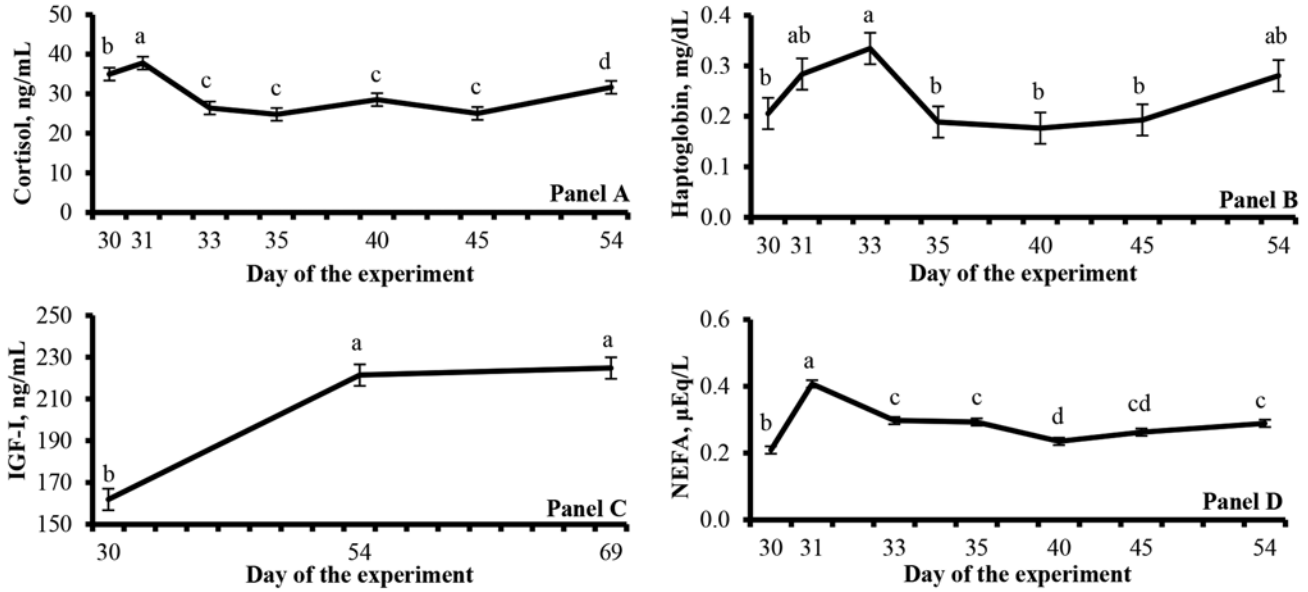

Figure 2. Concentrations of plasma cortisol (Panel A), plasma haptoglobin (Panel B), plasma IGF-I (Panel C), and serum NEFA (Panel D) during the experiment, On d 30, steers were loaded into a livestock trailer and transported for 1,500 km (24 h), and assigned to a 38-d feedlot receiving (d 31 to 69). Day effects were detected for all variables ($P < 0.01$). Within variable, days with different letters (a-d) differ ($P < 0.05$).

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