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Evaluation of a phytogenic blend with essential oils and plant extracts on initial receiving period growth performance of auction-derived beef steers

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Abstract
The receiving period is a critical point in a calf's life as they are introduced to new stressors which can increase their susceptibility to disease. The use of essential oil and phyto-molecule compounds may help improve immune function decreasing the incidence of disease and improving the performance of newly received calves. Ten replicate pens per treatment were used in a randomized complete block design. Each pen contained 8 steers (İnitial BW = 305±30.4 kg; n = 80 steers/treatment). The objective was to determine if a phytogenic feed additive (PFA) with essential oils and plant extracts (PHYTOsolvan 200; DOSTOFARM, Westerstede, Germany) influences measures of growth or growth efficiency during the feedlot receiving phase in auction-derived beef steers. No steers were removed from the study; one steer from the control treatment was treated for respiratory disease (0.63%), and no mortality was noted. No appreciable differences were noted for BW, ADG, DMI, or feed conversion efficiency from d 1 to 29, 29 to 53, or during the cumulative receiving period ($p \geq 0.12$). Performance-based NEm and NEg were not influenced by dietary treatment ($p \geq 0.79$). The ratio of observed-to-expected dietary net energy was not impacted by dietary treatment ($p \geq 0.71$). Steers performed met growth performance expectations based upon dietary net energy and dry matter intake (the ratio of observed-to-expected NEm = 1.00), hence, it is not surprising that the phytogenic compound did not influence growth or health outcomes under the conditions of this experiment.

Keywords: Beef, essential oil, newly arrived, receiving

1. Introduction
Arrival to the feedlot from various marketing channels is a critical time in a beef animal's life. Arguably, it is the most stressful event of a beef calf's life as they are transported, deprived of feed and water, and introduced to an unfamiliar feed source [1]. This period of reduced feed intake and transit stress can lead to respiratory distress such as the bovine respiratory disease complex (BRD). GH Loneragan, DA Dargatz, PS Morley and MA Smith [2] identified BRD as the largest cause of death in feedlots and is responsible for approximately 75% of feedlot morbidity. Respiratory disease accounted for 68% of all deaths in a 30 feedlot analysis including nearly 1 million head of cattle [3]. Furthermore, it was noted that approximately 10% of all lungs evaluated during the 2011 and 2016 National Cattleman's Beef Association - Beef Quality Audit had lung lesions associated with pneumonia [4]. It is likely that many of these cattle were not treated for BRD, based on results observed in lung evaluations and treatment records for nearly 6,000 feedlot cattle fed in Iowa [5]. Also, antimicrobial resistance is a large concern to animal producers. Improper use of antimicrobials results in more pools of antimicrobial-resistant genes among bacteria. All medically important antimicrobials to human medicine that are used to combat disease in livestock are listed in the Veterinary Feed Directive (VFD). The VFD requires veterinarian oversight and the prescription of feed-based antimicrobials from a veterinarian that has a working patient-client relationship with the producer. Essential oils (EOs) and phytomolecule (PM) compounds have been shown to reduce inflammation and modulate immune function. Botanicals, EOs, encompass secondary metabolites synthesized by plants, which have protective effects and defense mechanisms for the host plant. Various EOs have been studied for their potential to influence the ruminal environment due to antimicrobial properties at higher dosages [6]. These botanicals may either promote or inhibit specific microbial populations, as noted by [6].

Subsequent research has highlighted their antimicrobial and anti-inflammatory effects, which could enhance feed efficiency and health status by modulating both ruminal and host metabolism [7]. There is potential that the use of these products in combination with commonly employed therapeutic strategies (i.e., antimicrobial treatment) might aid in controlling systemic inflammation that in turn might reduce the need to use in feed antimicrobials to control disease or repeated antimicrobial use after unsatisfactory initial antimicrobial treatment. Although many phytogenic compounds have been investigated as antimicrobial replacements in many livestock species, results have been variable due to differences in the composition and source of phytogenic compounds, diet type fed, stage of production (i.e., growing and fattening or lactation), and the degree of stress challenge [8]. The objective of this research was to determine if a phytogenic feed additive (PFA) with essential oils and plant extracts containing no more than 5.0% thymol, 2.5% anise oil, 2.5% p-cymene, 2.5% p-mentha-1,4-diene, and 0.5% carvacrol (PHYTOsolvan 200; DOSTOFARM, Westerstede, Germany) influences measures of growth or growth efficiency during the feedlot receiving phase.

Materials and Methods

Animal use approval

Procedures involving the use of animals were all approved by the Institutional Animal Care and Use Committee at South Dakota State University (Animal Use Protocol Approval # 2209-055A) and the study was conducted between January and March of 2023 at the Ruminant Nutrition Center located 2.4 km north of Brookings, SD, USA (44°18′08″ N, 96°47′10″ W).

Dietary treatments and diet

The dietary treatments included:

1. Fed no PFA (Control).
2. Fed PFA at a rate of 0.25 g/45.4 kg of BW (PHYTOsolvan 200; DOSTOFARM, Westerstede, Germany, PFA).

Supplements for dietary treatment inclusion were manufactured at the SDSU feed mill in Brookings, SD using dried distillers grains plus solubles (DDGS) as a carrier. The PFA carrier was formulated to contain 4.0 g in every 0.454 kg of DDGS.

A total of 10 replicate pens per treatment (n = 20 pens total) were used in a randomized complete block design and each pen contained 8 steers (n=80 steers/treatment). No tylosin phosphate was fed during this experiment, nor was a steroidal implant administered, but monensin sodium (Rumensin-90, Elanco Animal Health, Indianapolis, IN, USA) was fed at 25 g/907 kg (DM basis). The basal diet was formulated to include (DM basis): corn silage (65%), dried distillers grains plus solubles (20%), and a suspended supplement (5%) that was fortified with vitamins and minerals to exceed nutrient requirements for growing and finishing beef steers [9]. Actual diet formulation (Table 1) was based on weekly DM determination and tabular ingredient nutrient values [10].

Table 1: Actual diet formulation and tabular nutrient values based on weekly feed batching records [1]

Item	Basal Diet
Corn Silage, %	73.84
Dried Distillers Grains Plus Solubles, %	20.91
Suspended Supplement[2], %	5.25
Diet DM, %	50.34
Crude Protein, %	12.83
Neutral Detergent Fiber, %	42.12
Acid Detergent Fiber, %	24.96
Ash, %	7.89
Organic Matter, %	92.11
Ether Extract, %	3.79
Net Energy for Maintenance (NEm), Mcal/kg	1.77
Net Energy for Gain (NEg), Mcal/kg	1.15

[1] All values except diet DM on a DM basis.

[2] The suspended supplement contained: 36.47% CP, 28.00% NPN, 1.54 Mcal/kg NEm, 0.99 Mcal/kg NEg, 0.78% fat, 4.62% Ca, 0.38% P, 2.62% K, 0.73% Mg, 5% NaCl, 0.48% S, 4 ppm Co, 200 ppm Cu, 400 ppm Mn, 1,800 ppm Zn, 44,092 IU/kg vitamin A, 441 IU/kg vitamin E, and 500 g/907 kg monensin sodium.

Cattle and feeding management

One-hundred and sixty, single source, newly received, Charolais × Angus crossbred steers (initial BW = 305±30.4 kg) were used in the 53 d receiving phase experiment. The steers were acquired from a Western South Dakota auction facility and transported 285 km (3.5 hours transit) to the Ruminant Nutrition Center (RNC) in Brookings, SD on January 7, 2023. Upon arrival, steers were group housed (10 steers/pen) in 7.62 × 7.62 m concrete surfaced pens and offered long-stem grass hay and *ad libitum* access to water.

The morning following arrival to the research feedlot, all steers were subjected to an individual BW measurement, captured on a scale (scale sensitivity = 0.454 kg) mounted on a hydraulic restraining chute, that was used for allotment purposes, given a unique identification ear tag, then vaccinated against: infectious bovine rhinotracheitis virus, bovine viral diarrhea Types 1a, 1b, and 2 viruses, parainfluenza 3 virus, and bovine respiratory syncytial virus (Bovishield Gold 5, Zoetis, Florham Park, NJ) and clostridial species (Ultrabac 7/Somubac, Zoetis), and administered pour-on anthelmintic.

(Cydectin, Elanco Animal Health) according to label directions.

The morning following the initial processing day, steers (n = 160) selected from the larger population based upon:

1. Temperament.
2. Health.
3. Uniformity of body weight were allotted to treatment pens (n = 10 pens/treatment; 20 pens total).

Throughout the entire study, steers were delivered 50% of their prescribed feed call twice daily (0800 and 1400 h). During the initial 14 d on feed, intakes were closely managed to accommodate steer adaptation to the receiving diet. For the remainder of the experiment (d 15 to 53) bunks were managed such that bunks were managed to be devoid of feed by 0800 h most mornings. Bunks were evaluated daily at 0700 h for residual feed and a bunk score of 0 to 1 was targeted for all pens. Feed was manufactured twice daily in two batches for each treatment in a stationary mixer. Feed was weighed and loaded into a feed delivery wagon that was not mounted on load cells and then delivered to each pen. The batching sequence was: (Control), (PFA), (Control), and finally (PFA). Following each batch of feed, long-stem grass hay (~1.8 kg) was added to the mixer and used to flush out all residual feed remaining in the mixer.

Growth performance calculations

Steers were individually weighed on d 1, 29, and 53. Growth performance was calculated for each interim period (d 1 to 29 and d 30 to 53) and the cumulative receiving period (d 1 to 53). All BW measures that were used for growth performance calculations were shrunk by 4% to account for digestive tract fill. Average daily gain (ADG) was determined as the difference in body weight divided by days for that respective period. Dry matter intake (DMI) was determined at weekly intervals and summarized by interim period. The feed conversion ratio (G: F) was calculated by dividing ADG by DMI.

Observed growth performance was also used to calculate performance-based dietary NE to determine the efficiency of dietary NE capture. Performance-based dietary NE was calculated from daily energy gain (EG; Mcal/d): $EG = ADG^{1.097} \times 0.0557W^{0.75}$, where W is the mean equivalent shrunk BW [kg; [9]] from median feeding shrunk BW and final BW at 28% estimated empty body fatness (601 kg) was calculated as [median feeding shrunk BW × (478/601), kg; [9].

Maintenance energy (EM) was calculated by the equation: $EM = 0.077 \times \text{median feeding shrunk BW}^{0.75}$.

Since dry matter intake is related to energy requirements and dietary NEm (Mcal/kg) according to the following equation: $DMI = EG/(0.877NEm - 0.41)$, and can be resolved for estimation of dietary NEm by means of the quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2c},$$

Where $a = -0.41EM$, $b = 0.877EM + 0.41DMI + EG$, and $c = -0.877DMI$ [11]. Dietary NEg was derived from NEm using the following equation: $NEg = 0.877NEm - 0.41$ [12].

Statistical analysis

Data were analyzed using a model appropriate for a randomized complete block design with pen serving as the experimental unit according to the following model: $Y_{ij} = \mu + \beta_i + T_j + \varepsilon_{ij}$, where μ is the common experimental effect, β_i represents the location in the feed yard (df = 9), T_j represents dietary treatment (df = 1), and ε_{ij} represents the residual error (df = 9). Least squares means were generated and treatment effects were evaluated by the use of pairwise comparisons. An alpha of 0.05 was used to determine significance and tendencies were discussed from an alpha of 0.06 to 0.10.

Results and Discussion

No steers were removed from the study, morbidity was minimal (0.63%) and no mortality was noted in the present experiment. No appreciable differences were noted for body weight, ADG, DMI, or G: F from d 1 to 29, 29 to 53, or during the cumulative receiving period ($p \geq 0.12$, Table 2). These findings are in contrast to what was observed in lambs fed a similar energy concentration diet as the present study, where supplementation with a blend of encapsulated carvacrol, thymol, and cinnamaldehyde increased weight gain [13]. When a blend of eugenol, thymol, and vanillin was fed to finishing Nelore heifers, dry matter intake was increased by 13.8%; however, the daily gain was not appreciably increased nor was feed conversion efficiency [14]. Alternatively, when a blend of limonene and thymol was fed to finishing beef steers, no increase in growth performance was noted [15].

Performance-based NEm and NEg were not influenced by dietary treatment in the present study ($p \geq 0.79$). The ratio of observed-to-expected dietary net energy was not impacted by dietary treatment ($p \geq 0.71$), hence, it was not anticipated that the phytogenic compound would appreciably influence growth or health outcomes under the conditions of this experiment. While many phytogenic compounds have been investigated as antimicrobial replacements in ruminant species, results have been variable because of differences in composition and source of phytogenic compounds, diet type fed (i.e. forage versus concentrate), stage of production (i.e. growing and fattening versus lactation), and the degree of stress challenge imposed to the animal (i.e. auction-derived versus not auction-derived) [8]. The fact that the steers in the current experiment already had been weaned before arrival and had not been commingled with other cattle at any point limited the degree of stress imposed, and consequently, those factors limited the ability of cattle to respond to any beneficial aspects of PFA supplementation.

Table 2: Growth performance responses in auction-derived steers fed a phytogenic feed additive (PFA) Treatments included: fed no PFA (Control) or fed PFA at a rate of 0.25 g/45.4 kg of BW (PFA; PHYTOsolvan 200; DOSTOFARM, Westerstede, Germany)

Treatment				
Item	**Control**	**PFA**	**SEM**	***P* - value**
Steers, n	80	80	-	-
Pens, n	10	10	-	-
Initial BW[1], kg	303	303	-	-
Initial to d 29				
d 29 BW[2], kg	346	342	2.3	0.13
ADG, kg	1.46	1.36	0.081	0.22
DMI, kg	7.71	7.64	0.054	0.28
G:F	0.189	0.177	0.0094	0.22
d 30 to d 53				
d 53 BW[2], kg	384	381	2.4	0.25
ADG, kg	1.62	1.66	0.059	0.53
DMI, kg	9.94	9.68	0.158	0.14
G:F	0.163	0.171	0.0047	0.14
Initial to d 53				
ADG, kg	1.53	1.49	0.045	0.40
DMI, kg	8.72	8.57	0.088	0.12
G:F	0.176	0.174	0.0041	0.68
Diet net energy, Mcal/kg[3]				
Maintenance	1.77	1.76	0.023	0.79
Gain	1.14	1.14	0.020	0.79
Observed-to-expected dietary net energy				
Maintenance	1.00	1.00	0.013	0.89
Gain	0.99	0.98	0.014	0.71

[1] No shrink was applied to the initial BW.
[2] A 4% shrink was applied to account for digestive tract fill.
[3] Calculated assuming a mature BW of 601 kg.

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Conflict of Interest Statement

The author declares no conflict of interest except for the fact that DOSTOFARM, provided partial funding to complete this research.

Author Contributions

Conceptualization: JJD, WCR, and ZKS; Data Curation: JJD, WCR, and ZKS; Formal analysis: JJD, WCR, and ZKS; Methodology: JJD, WCR, and ZKS; Investigation: JJD, WCR, and ZKS; Writing - Original Draft: JJD, WCR, and ZKS; Writing - Review & Editing: JJD, WCR, ZKS.

Data Availability Statement

Data can be made available with a reasonable request to ZKS.

Animal use approval

All procedures involving the use of animals were approved by the Institutional Animal Care and Use Committee at South Dakota State University (Approval # 2209-055A) and the study was conducted between January and March of 2023.

Informed consent

All procedures involving the use of animals were approved by the Institutional Animal Care and Use Committee at South Dakota State University (Approval # 2209-055A) and the study was conducted between January and March of 2023.

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