Applied Animal Science 38:279–284
https://doi.org/10.15232/aas.2022-02274

NUTRITION: *Original Research*

Effects of backgrounding-phase rate of gain on performance and carcass characteristics of feedlot steers

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ABSTRACT

Objective: The objective was to evaluate effects of varying backgrounding-phase growth rates (BGR) on subsequent finishing-phase performance and carcass characteristics of feedlot cattle.

Materials and Methods: Steers (n = 144) were randomly assigned to 1 of 3 BGR treatments from study initiation to 409 kg of BW. Treatments consisted of 0.91 kg/d (0.91ADG), 1.13 kg/d (1.13ADG), or 1.36 kg/d (1.36ADG). Net energy equations were used to prescribe sufficient DM to achieve desired BGR for each group. When each treatment reached the target BW of 408 kg at the end of the backgrounding phase, steers were transitioned to a finishing diet. From this point on, treatments were managed similarly. Steers within each treatment were slaughtered independently at a common 12th-rib fat endpoint.

Results and Discussion: Backgrounding-phase ADG linearly increased ($P < 0.01$). The backgrounding phase lasted 76, 61, and 54 d for 0.91ADG, 1.13ADG, and 1.36ADG, respectively. Finishing-phase ADG and DMI linearly decreased ($P \leq 0.02$) as BGR increased, with no difference in G:F ($P \geq 0.16$). Cumulative ADG linearly increased with greater BGR ($P = 0.02$), and G:F also increased ($P = 0.07$). Restricting BGR linearly increased hot carcass weight ($P = 0.04$). Marbling score tended to respond quadratically to increasing BGR as it increased from 0.91ADG to 1.13ADG and then decreased between 1.13ADG and 1.36ADG ($P = 0.05$). Marbling scores responded quadratically ($P = 0.05$).

Implications and Applications: Using a low BGR can result in improved finishing-phase performance and greater final BW; however, a greater number of days on feed is required. Increases in hot carcass weight also can be achieved with lesser BGR, although greatest carcass quality may be realized with only modest restriction in BGR.

Key words: backgrounding phase, growing cattle, growth rate, feedlot performance

INTRODUCTION

Backgrounding calves after weaning and before entry into the feedlot is a common practice in the cattle feeding industry. Backgrounding programs aim to achieve a less-than-maximal growth, ultimately suppressing lipid deposition and promoting maturation of lean tissue and bone (Block et al., 2001). Goals of the backgrounding phase include allowing smaller-framed cattle to reach a greater (more desirable) BW at a similar body fat endpoint (Byers, 1982), to increase mature size (Owens et al., 1993), meet a targeted gain ADG, offer a market outlet for forages (Sip and Pritchard, 1991), and shift the timing and quantity of cattle entering the feedlot (Peel, 2003). Limiting backgrounding growth rate (**BGR**) is accomplished by reducing the energy content of the diet through the inclusion of roughages or by limit feeding a high-concentrate diet. Using net energy equations to determine the quantities of feed required to meet a specified BGR may allow for more precise management of cattle before the finishing phase. The objective of this research was to determine the effect of differing programmed rates of gain during the backgrounding phase on subsequent finishing-phase growth performance and carcass characteristics.

MATERIALS AND METHODS

The experimental protocol was approved by the South Dakota State University Institutional Animal Care and Use Committee (approval # 13-088E) and was conducted at the South Dakota State University Ruminant Nutrition Center.

Angus and Angus-based crossbred steer calves (n = 144) from 2 western South Dakota ranches were used for this experiment. Steers were housed in outdoor pens that were concrete surfaced with straw bedding and measured 7.6 × 7.6 m, with a 7.6-m fence-line feed bunk. Water tanks were

The authors have not declared any conflicts of interest.
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located between adjacent pens, and steers had *ad libitum* access to fresh water at all times.

Steers were blocked by ranch of origin, stratified by BW, and randomly assigned to 1 of 3 BGR treatments (8 steers per pen; 6 pen replicates per treatment) from study initiation to 408 kg of BW. Treatments consisted of 3 different BGR: 0.91 (**0.91ADG**), 1.13 (**1.13ADG**), or 1.36 kg/d (**1.36ADG**), which were achieved using prescribed offerings of a common corn silage–based diet (Table 1). The experiment started on December 6, 2017 (d 0). Steers were vaccinated with clostridium perfringens type A toxoid (Elanco) and implanted with 100 mg of progesterone and 10 mg of estradiol benzoate (Synovex C; Zoetis) on d 0. On d 43, steers were treated for internal and external parasites (Cydectin; Bayer), and on d 71 steers were treated for external parasites (CyLence; Bayer). Health status was monitored daily. Throughout the duration of the study 1, steer was treated for a corneal ulcer and 3 steers were treated for foot rot.

Treatments were applied on d 0 of the study until each treatment reached a 408-kg-of-BW goal (end of backgrounding phase). Prescribed DM offerings were calculated using net energy equations (NASEM, 1984). Nutrient concentration and ionophore inclusion (Rumensin 90; Elanco) of the supplement was adjusted for each treatment to ensure similar intakes based on total daily intake. Feed deliveries were programmed to achieve the caloric intake necessary to support the BGR of each treatment. Feed ingredients were conveyed to the nearest 0.45 kg into a 25.6-m^3 mixer (Roto-Mix LLC) and mixed for 4 min. Cattle were fed twice daily (0800 and 1500 h) in equal amounts to the nearest 0.45 kg (as-is basis) at each delivery. Steers were weighed individually in the morning before feed delivery every 21 d, and prescribed feed offerings were adjusted to ensure steers were achieving targeted BGR.

Following the backgrounding phase, cattle were transitioned for 7 d to a final finishing diet (Table 1). After 14 d on the finishing diet, steers were reimplanted with 120 mg of trenbolone acetate and 24 mg of estradiol (Revalor-S; Merck Animal Health).

Steers were slaughtered by treatment, at a commercial abattoir (Tyson Fresh Meats; transit of 234 km), when the average backfat of the treatment was visually appraised to be 1.4 cm. Individual identity was tracked throughout the slaughter and grading process. Hot carcass weight was measured on the day of slaughter. Dressing percentage was calculated using shrunk (4%) final BW. Carcass data necessary to determine USDA YG and QG were obtained from the video image analysis system in the packing plant the following day. Longissimus muscle area, 12th-rib backfat, marbling score, and percent KPH from each side of the carcass were averaged for each carcass. Yield grade was calculated by using the USDA regression equation (USDA, 2016). Empty body fat and weight at 28% empty body fat were estimated using equations from Guiroy et al. (2001).

Table 1. Composition of backgrounding, transition, and finishing diets as derived from weekly assays and batching formulas[1]

Item, %	Backgrounding	Transition	Finishing
Corn silage	63.67	24.95	—
Oat hay	15.23	8.98	—
Grass hay	—	—	7.86
Dry-rolled corn	—	26.58	35.67
High-moisture corn	—	20.78	35.16
Dried distillers grains	14.96	13.65	16.23
Pelleted supplement[2]	6.14	—	—
Liquid supplement[3]	—	5.06	5.08
DM	45.52	61.15	78.54
CP	12.81	12.80	13.45
NDF	34.95	21.86	16.18
ADF	19.06	10.51	6.36
Ash	6.20	5.86	5.20
NE_g,[4] Mcal/kg	1.06	1.25	1.38

[1]All values except DM are reported on a DM basis.

[2]Supplement for the 1.36ADG treatment was formulated to provide 28 mg/kg monensin, 2,200 IU/kg vitamin A, 26 IU/kg vitamin E, 55 mg/kg Zn, and 15 mg/kg Cu. Nutrient concentration and ionophore inclusion of the supplement was adjusted for the 1.13ADG and 0.91ADG treatments to ensure similar intakes based on total daily feed intake. Treatments targeted backgrounding-phase ADG of 0.91 (0.91ADG), 1.13 (1.13ADG), or 1.36 kg/d (1.36ADG).

[3]The liquid supplement contained 39% CP as NPN and 33 mg/kg monensin.

[4]Predicted from tabular values (Preston, 2016).

Laboratory Analyses

Feed samples were collected weekly. Feed batching records and weekly ingredient assay values were used to calculate actual diet formulation and composition values. Feed samples were dried in a forced-air oven at 60°C until a constant weight was maintained to determine DM and then ground through a 1-mm screen (Thomas-Wiley Laboratory Mill Model 4, Thomas Scientific USA). Ground samples were analyzed for DM (method no. 935.29; AOAC International, 2012), CP (Kjeldahl procedure; method no. 951.01; AOAC International, 2012), NDF, ADF, (Goering and Van Soest, 1970), and ash content (method no. 942.05; AOAC International, 2012).

Statistical Analyses

Data from one steer were removed from analyses for reasons unrelated to treatment. Data were analyzed using the General Linear Model procedure of SAS (SAS Institute Inc.). Treatment effects were tested with treatment and source block in the model, and pen was the experimental unit. All BW were shrunk 4% except for initial BW. Carcass-adjusted final BW was calculated by dividing hot carcass weight by a common DP of 62.5%. Linear and quadratic effects of BGR were tested using unequally spaced, polynomial orthogonal contrasts generated using PROC IML of SAS. Effects were considered significant at a P-value of $\leq$0.05, with tendencies declared at P-values between 0.05 and 0.10.

RESULTS AND DISCUSSION

Backgrounding end BW were approximately the targeted BW of 408 kg. The BGR for all 3 treatment groups was greater than targeted values. The BGR was 11% greater than targeted for the 0.91ADG group, 12% greater than targeted for 1.13ADG, and 4% greater than targeted for 1.36ADG. The percentage difference for the 0.91ADG and 1.13ADG treatments was expected. Decreased DMI can decrease rate of passage, increase ruminal retention time, and thereby increase digestibility (Church, 1988). The 1.36ADG group may have been nearing *ad libitum* intake, explaining why the percentage difference from the target was less than that for 0.91ADG or 1.13ADG. Animal growth performance data are presented in Table 2. Initial BW did not differ among treatments ($P \geq 0.75$). Backgrounding-phase end BW did not differ by design ($P \geq 0.53$). Furthermore, by design, backgrounding-phase DMI linearly increased with BGR ($P < 0.01$), as steers were offered prescribed amounts of DM to achieve the BGR of each treatment. Gain:feed increased linearly with increasing BGR ($P < 0.01$). A greater BGR resulted in a 17% increase (1.36ADG vs. 0.91ADG) in G:F in the backgrounding phase.

The finishing phase in this experiment lasted 112 to 113 d among treatments. Final BW linearly decreased with increasing BGR ($P = 0.02$). Similarly, ADG ($P = 0.02$) and DMI ($P = 0.01$) linearly decreased during the finishing phase with increasing BGR, thus resulting in no difference in finishing phase G:F ($P \geq 0.16$). Although backgrounding cattle at a slow rate of gain has mixed results on G:F during this phase, greater efficiency is often observed during the subsequent finishing period. Sainz et al. (1995) backgrounded steers from 237 to 327 kg on a high-concentrate diet for either *ad libitum* or limited intake. Cattle fed for *ad libitum* intake had improved G:F during the growing period compared with limit-fed cattle. Conversely, cattle limit fed during backgrounding were more efficient during the finishing phase compared with cattle backgrounded at *ad libitum* intakes. Cumulatively, no difference in G:F was observed; however, it took almost 50 additional days for cattle backgrounded at slower rates to reach a similar final weight (Sainz et al., 1995). Loerch and Fluharty (1998) backgrounded cattle at similar rates of gain to those used in the current study and reported no difference in G:F during the backgrounding phase. Additionally, no difference in finishing or cumulative ADG or G:F was observed when cattle were slaughtered at similar final weights (Loerch and Fluharty, 1998). Felix et al. (2011) limit fed cattle to gain either 0.9 or 1.4 kg/d during the backgrounding phase during which no difference in G:F was observed. During the finishing phase, cattle grown more slowly during backgrounding compensated to grow more rapidly and more efficiently during the finishing phase. When slaughtered at a common end BW, cattle grown at 1.4 kg/d consumed more DM and had a tendency for improved ADG, with no overall difference in G:F (Felix et al., 2011).

Others have used diets with less dietary energy to restrict BGR. Ridenour et al. (1982) backgrounded cattle using diets with either 50 or 85% concentrate and observed greater finishing-phase ADG for cattle grown on the 50% concentrate diet, with no difference in G:F. Cumulatively, cattle grown on the high-concentrate diet had a small advantage in ADG but no difference in G:F when slaughtered at a common 12th-rib fat thickness (Ridenour et al., 1982). Similarly, finishing-phase ADG and G:F were improved for cattle backgrounded on a high-concentrate diet compared with cattle backgrounded at a lower rate on *ad libitum* forage intake (Sainz et al., 1995). Conversely, Loken et al. (2009) varied backgrounding diet energy content to alter BGR but noted no differences in finishing-phase ADG, DMI, or G:F. However, the lack of observed differences by these authors may be because differences in BGR (1.40 vs. 1.67 kg/d) were not sufficient to elicit a detectable response during the finishing phase. The 1.13ADG and 1.36ADG steers required 14 and 21 fewer days on feed, respectively, compared with 0.91ADG steers.

In the present study, increasing BGR yielded linear increases in cumulative ADG ($P = 0.02$). Nonetheless, DMI responded quadratically ($P = 0.03$), as DMI increased from the 0.91ADG to 1.13ADG treatment, where it reached a plateau. Furthermore, there was a tendency for a linear increase in G:F with greater BGR ($P = 0.07$). Carcass-

Table 2. Backgrounding, finishing, and cumulative performance of steers grown at varying ADG during the backgrounding phase[1]

	Backgrounding ADG target[2]					
Item	0.91ADG	1.13ADG	1.36ADG	SEM[3]	Linear	Quadratic
Backgrounding						
Initial BW, kg	333	332	333	0.9	0.95	0.75
End BW, kg	411	411	409	1.4	0.53	0.72
ADG, kg	1.03	1.28	1.42	0.022	<0.01	0.05
DMI, kg	7.40	8.28	8.52	0.050	<0.01	<0.01
G:F	0.139	0.155	0.167	0.0021	<0.01	0.39
Days	76	61	54	—	—	—
Finishing						
Final BW, kg	628	619	612	4.7	0.02	0.93
ADG, kg	1.94	1.85	1.80	0.038	0.02	0.69
DMI, kg	12.04	11.81	11.44	0.119	0.01	0.56
G:F	0.161	0.156	0.157	0.0020	0.16	0.33
Days	112	113	113	—	—	—
Cumulative						
Live basis						
ADG, kg	1.57	1.65	1.67	0.028	0.02	0.43
DMI, kg	10.16	10.57	10.50	0.080	0.01	0.03
G:F	0.154	0.156	0.159	0.0018	0.07	0.68
Days	188	174	167	—	—	—
Carcass-adjusted basis[4]						
Final BW, kg	639	620	623	4.9	0.04	0.09
ADG, kg	1.63	1.65	1.74	0.029	0.03	0.37
G:F	0.161	0.156	0.166	0.0023	0.14	0.05

[1]All BW are shrunk 4%.

[2]Treatments targeted backgrounding-phase ADG of 0.91 (0.91ADG), 1.13 (1.13ADG), or 1.36 kg/d (1.36ADG).

[3]Pooled SE of LSM (n = 6 pen replicates per mean).

[4]Carcass-adjusted final BW = hot carcass weight divided by 0.625.

adjusted final BW linearly decreased with greater BGR ($P = 0.04$), whereas carcass-adjusted ADG linearly increased ($P = 0.03$). Carcass-adjusted G:F responded quadratically ($P = 0.05$), where it decreased from 0.91ADG to 1.13ADG and increased from 1.13ADG to 1.36ADG. It appears that restricting BGR can result in improvements in finishing-phase performance, especially in ADG. Although the prescribed BGR increased linearly from 0.91 to 1.36 kg/d, not all production responses followed the same trend, as noted for carcass-adjusted final BW and carcass-adjusted G:F.

Lancaster et al. (2014) used regression models to evaluate the effect of BGR on finishing-phase performance and reported that both ADG and G:F during the finishing phase were negatively correlated with BGR. The effect of varying BGR on cumulative growth performance is much less conclusive and is often dependent on the endpoint criteria selected for the finishing phase, whether it be days on feed or 12th-rib fat thickness.

In the present study, greater BGR resulted in linear decreases in hot carcass weight ($P = 0.04$; Table 3). According to Lancaster et al. (2014), when using compiled available data, hot carcass weight (**HCW**) was positively correlated with BGR, contrary to the results of the current study. Likewise, when backgrounding ADG was limited with a high-forage diet, Sainz et al. (1995) reported decreased HCW compared with cattle fed a high-concentrate diet throughout. However, when these authors decreased BGR to a similar degree by limit feeding a high-concentrate diet, HCW did not differ from cattle fed a high-concentrate diet ad libitum. Block et al. (2001) backgrounded cattle at a lower BGR for either 70 or 126 d and reported increases in both final BW and HCW when cattle were grown for 126 d.

When cattle backgrounded at different rates of gain are slaughtered at a common BW endpoint, little difference in HCW is typically observed. Ridenour et al. (1982) observed no difference in HCW when cattle were backgrounded at different rates of gain. When cattle were grown at similar BGR to the ones used in the current study, Loerch and Fluharty (1998) reported no HCW differences. Similarly, Loken et al. (2009) observed no difference in HCW; however, cattle with greater BGR displayed an 11-kg numeri-

Table 3. Carcass characteristics of steers grown at varying rates of ADG during the backgrounding phase

	Backgrounding ADG target[2]					
Item[1]	0.91ADG	1.13ADG	1.36ADG	SEM[3]	Linear	Quadratic
HCW, kg	400	387	390	3.1	0.04	0.08
DP, %	63.7	62.5	63.6	0.39	0.91	0.04
LM area, cm[2]	85.4	89.2	88.6	0.97	0.07	0.14
12th-rib fat, cm	1.59	1.47	1.52	0.051	0.32	0.22
KPH, %	1.87	1.89	1.89	0.015	0.50	0.51
Marbling score[4]	592	642	598	18.2	0.83	0.05
YG	3.55	3.15	3.24	0.085	<0.01	0.02
EBF, %	32.1	31.4	31.3	0.354	0.18	0.53
AFBW, kg	561	554	558	5.3	0.66	0.37

[1]HCW = hot carcass weight; EBF = estimated empty body fat predicted from carcass measurements (Guiroy et al., 2001); AFBW = adjusted final BW adjusted to 28% empty body fat (Guiroy et al., 2001).

[2]Treatments targeted backgrounding-phase ADG of 0.91 (0.91ADG), 1.13 (1.13ADG), or 1.36 kg/d (1.36ADG).

[3]Pooled SE of LSM (n = 6 pen replicates per mean).

[4]Small^{00} = 500.

cal increase in HCW from a relatively small increase (0.27 kg/d) in BGR. It appears that slaughter point selection can largely influence whether differences in HCW are elicited from differences in BGR.

In the present study, a quadratic response was observed for DP, where it decreased from the 0.91ADG to 1.13ADG treatment and then increased again from 1.13ADG to 1.36ADG ($P = 0.04$). Longissimus muscle area tended to increase ($P = 0.07$) with greater BGR, which contrasts with the findings of Felix et al. (2011), who reported an increase in LM area as BGR decreased. Similar to HCW, greater BGR has been shown to be positively correlated with LM area (Lancaster et al., 2014). Each treatment was targeted with a 12th-rib fat endpoint of 1.4 cm. Actual 12th-rib fat measures were slightly greater than targeted values (1.53 ± 0.032 cm); however, 12th-rib fat was not different among treatments ($P \geq 0.22$). No difference in KPH fat was observed ($P \geq 0.50$).

Marbling score is not typically correlated with differences in BGR (Reuter and Beck, 2013; Lancaster et al., 2014). Indeed, Loerch and Fluharty (1998) noted no differences in quality grade when cattle were backgrounded at rates similar to those used in the current study and slaughtered at a common final BW. However, when marbling scores were adjusted for 12th-rib fat thickness, marbling scores were positively correlated with BGR (Lancaster et al., 2014). Indeed, in the present study, we observed a quadratic response in marbling score ($P = 0.05$) to increasing BGR as evidenced by the intermediate BGR group yielding the greatest marbling score. Perhaps restricting BGR to 0.91ADG sufficiently reduced caloric intake to the point where intramuscular fat deposition was suppressed compared with 1.13ADG. If this did occur, the tissue may not be capable of compensatory accretion during the finishing phase as demonstrated by Bruns et al. (2005). Furthermore, it is possible that greater total days (7 d) on feed for 1.13ADG compared with 1.36ADG allowed enough time for 1.13ADG cattle to deposit greater amounts of intramuscular fat. Alternatively, there may be an upper limit for the relative accretion rate of intramuscular fat deposited at lower BGR than what occurs for s.c. adipose accretion. If so, the more rapid growth of cattle in 1.36ADG during backgrounding may have caused the 1.36ADG cattle to be fatter but at a comparable i.m. fat to 1.13ADG as they entered the finishing phase. When slaughtered at a common BW endpoint, the 1.36ADG group had a decreased s.c.-to-i.m. fat ratio compared with the 1.13ADG group. Therefore, a quadratic response suggests that optimal marbling score may be realized with less-than-maximal BGR.

Yield grade responded quadratically ($P = 0.02$), where it decreased from 0.91ADG to 1.13ADG and then plateaued. No differences were observed for estimated empty body fat ($P \geq 0.18$) or BW adjusted to 28% empty body fat ($P \geq 0.37$). Variations in carcass characteristics resulted in decreasing YG with greater BGR. Similarly, others have reported no change in YG with differences in BGR (Ridenour et al., 1982; Sainz et al., 1995; Loerch and Fluharty, 1998). The change in YG is attributable to the smaller LM area of the 0.91ADG group. The smaller LM area is likely a result of the BGR being so low lean growth potential was not achieved, fewer days on the terminal implant, or a combination of both. Felix et al. (2011) reported decreased BGR decreased YG when cattle were finished at a common final BW. Studying the effect of growth rate on carcass composition is not new. Fox et al. (1972) and Rompala et al. (1985) reported that empty body composition of steers was not altered because of growth restriction; nonetheless, both experiments report a transitory increase in leanness early during the growth restriction. Conversely, Alderson et al. (1993) noted the proportion of carcass weight gained as fat was decreased after discontinuous growth in heifers.

APPLICATIONS

In conclusion, a lower rate of gain during the backgrounding phase can improve finishing phase growth rate and gain efficiency. Furthermore, the compensation of growth during the finishing period offset the lower ADG during the backgrounding period such that there was little overall effect on ADG or G:F. It should be noted that the optimal rate of gain is likely different for different types and classes of cattle, and the results of this study are likely attributed to the rate of gain relative to mature size, rather than the absolute rates of gain. More research is warranted to better understand how to manage cattle during the backgrounding phase to optimize finishing-phase performance and carcass characteristics.

ACKNOWLEDGMENTS

This work was funded by the South Dakota Agriculture Experiment Station and the Beef Nutrition Program.

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