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Evaluation of Maintenance Requirements and Dietary Energetics in Jersey Steers Feeding under Feedlot System

Research Article

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ABSTRACT

Two trials were conducted to evaluate maintenance energy requirements and feedlot growth performance of calf-fed Jersey steers. In trial 1, 30 Jersey calves (49.7±6.8 kg) were fed during the 524 d growing-finishing period to derive the maintenance coefficient (MQ). Overall, average daily gain (ADG, kg), dry matter intake (DMI, kg), and gain-to-feed ratio (GF) were 0.76, 5.09, and 0.150, respectively. The derived MQ based on observed energy intake and ADG was 0.114, this value is 35% greater than 0.084 specified to Holstein steers. To validate the applicability of the MQ coefficient derived in Trial 1, we used 80 Jersey calves (101.5±4.1 kg), which were randomly assigned to diets containing 12 or 24% forage. Overall, steer performance measures for the 12 and 24% forage diets were ADG (0.96 *vs.* 0.99 kg, P=0.12), DMI (5.95 *vs.* 6.15 kg, P=0.04), and GF (0.166 *vs.* 0.156, P<0.01). Thus, the high-forage diet increased DMI and decreased GF. Applying the MQ of 0.114 derived in Trial 1, the estimated dietary net energy (NE) for Trial 2 was in close agreement with the expected, averaging 1.02 and 1.00 for steers receiving the 12 and 24% forage levels, respectively. It is concluded that the MQ of calf-fed Jersey steers is 35% greater than Holstein steers. Increasing dietary forage level to 24% decreased gain efficiency but did not appreciably affect daily weight gain.

KEY WORDS energetics, feedlot system, Jersey steers, maintenance coefficient, performance.

INTRODUCTION

As milk production potential increases in cattle breeds, the energy requirements for maintenance (MQ) increase (Mulliniks *et al.* 2020). These increases in MQ may be attributed to differences in visceral energy expenditure between dairy and beef cattle (Ferrell and Jenkins, 1985). In this sense, a coefficient of net energy for maintenance of 0.84 Mcal/kg of shrunk body weight (SBW)$^{0.75}$ has been determined in Holstein steers (NASEM, 2016). This represents almost 10% more than the MQ determined for feedlot cattle (0.77 Mcal/kg SBW$^{0.75}$, NASEM, 2016). The higher MQ is responsible, in a great measure, for dairy steers typically have lower feed efficiency in the feedlot compared to beef steers. Nonetheless, the demand for dairy cattle for the feedlots grows every year. According to the last National Beef Quality Audit, dairy-type cattle represented approximately 16.3% of United States of America fed cattle (Boykin *et al.* 2017). Since Jersey cows represent 12.2% of the United States dairy herd (Guinan *et al.* 2019), bull calves might contribute appreciably to the beef supply. Currently, however, Jersey bull calves have limited commercial value (Bechtel, 2018) due to slower rate of gain and gain efficiency and prolonged feeding periods to attain desirable carcass weight compared with Holstein and crossbred steers (Cole *et al*. 1964; Lehmkuhler and Ramos, 2008; Berry *et al*. 2018; Jaborek *et al*. 2019). The lower gain efficiency of calf-fed Jersey calves may reflect, in part, a potentially greater maintenance energy requirement than Holstein calves.

In this sense, Solis *et al*. (1988) observed that the net energy for the maintenance requirement of mature Jersey cows, as a function of shrunk metabolic body weight ($SBW^{0.75}$, kg), was close to 30% greater than that of mature Holstein cows. However, the MQ may differ for growing-finishing steers vs cows in the lactation stage (NRC, 2001; NASEM, 2016). In addition, lactation cows are fed with greater levels of forage than finishing steers, and dietary forage levels may influence the efficiency of energy utilization (Shi *et al*. 2018; Hales, 2019).

To our knowledge, energy requirements of calf-fed Jersey steers have not been reported at the time of preparation of this manuscript. For this reason, the objectives of the present study are: 1) assess the maintenance energy coefficient (MQ) of calf-fed Jersey steers receiving a conventional steam-flaked corn-based growing-finishing, and 2) validate the MQ obtained in trial 1 through a second feeding trial with calf-fed Jersey steers receiving a steam flaked corn-based diet containing different forage levels (12% *vs*. 24% forage, DM basis) during 350 d growing-finishing period. The design of this study allows us to elucidate empirically the MQ requirement in Jersey steers fattening under a feedlot system.

MATERIALS AND METHODS

This study was conducted at the University of California Desert Research and Extension Center from UC Davis, located in El Centro, CA (32°47′31″N and 115°33′47″W). El Centro is about 12 m below sea level and has a desert climate. All animal care and management procedures were in accordance with and approved by the University of California, Davis, Animal Use and Care Committee (Protocol #22271).

Trial 1. Determining the coefficient of requirement for maintenance (ME)

Animals, diets, and sample analyses

For this experiment, all steers were subjected to the same feeding program and health management. Based on their performance, the MQ was determined using the following protocol: Thirty Jersey steer calves (initial live weight, 49.7±7.2 kg) were used in a 504-d study to derive the maintenance coefficient (MQ) based on growth-performance measures. Upon arrival, calves were vaccinated against infectious bovine rhinotracheitis (IBR-PI3; TSV-2, Zoetis Animal Health, Florham Park, NJ), Clostridials/Haemophilus (Ultrabac 7/Somubac®, Zoetis Animal Health, Florham Park, NJ), Pasteurella (One Shot, Zoetis Animal Health, Florham Park, NJ), treated against internal and external parasites ((Dectomax Injectable, Zoetis, New York, NY), subcutaneously injected with 1500 IU vitamin E (as d-alpha-tocopherol) 500000 IU vitamin A (as retinyl-palmitate) and 50000 IU vitamin D3 (Vital E-A+D3, Stuart Products, Bedford, TX), and 2.4 g oxytetracy-cline (LA-200, Zoetis, New York, NY), branded, and ear-tagged. On d 224, 308, and 392 of the study calves were implanted with 28 mg of estradiol benzoate and 200 mg of trenbolone acetate (Synovex® Plus, Zoetis Animal Health, Florham Park, NJ) and injected subcutaneously with 1500 IU vitamin E (as d-alpha-tocopherol) 500000 IU vitamin A (as retinyl-palmitate) and 50000 IU vitamin D3 (Vital E-A+D3, Stuart Products, Bedford, TX). Steers were blocked by initial shrunk (off truck) arrival weight (SIW) and randomly assigned within weight groups to 6 pens (5 steers/pen). Pens were 50 m^2 with 26.7 m^2 overhead shade, equipped with automatic drinkers, and 4.3 m fence-line feed bunks. All steers were fed with a growing diet during the first 224 days of the experiment. The composition of the diets fed during each phase is shown in Table 1. Diets were prepared weekly and stored in plywood boxes in front of each pen. Calves were provided *ad libitum* access to the diet (approximately 105% of consumption). Fresh feed was added to the feed bunk twice daily (08:00 and 14:00 h). Samples of feed and orts were collected daily for DM analysis (AOAC, 2000). Steers were individually weighed (off truck) at the start of the experiment and subsequently on days 120, 224, 308, 392, 457, and prior to harvest (day 524).

Hot carcass weights (HCW) were obtained from all steers immediately after slaughter. After carcasses were chilled (-2 to 2 °C) for 24 h, the following measurements were obtained: Longissimus muscle (LM) area by direct grid reading of the muscle at the 12^{th} rib; subcutaneous fat over the LM at the 12^{th} rib taken at a location 3/4 the lateral length from the chine bone end (adjusted for unusual fat distribution); kidney, pelvic, and heart fat (KPH) as a percentage of HCW; and marbling score (using 3.0 as minimum slight, 4.0 as minimum small, 5.0 as minimum modest, 6.0 as minimum moderate, etc., USDA, 1997).

Calculation of dietary NE and estimation of MQ of steers

Estimations of expected dry matter intake (DMI) and dietary net energy value were performed on the basis of measures of initial off-truck shrunk body weight (SBW) and intermediate SBW, assuming that intermediate SBW is 96% of full weight (NASEM, 2016). Average daily gain (ADG) was computed by subtracting the initial SBW from the final fasted weight and dividing the result by the number of days on feed in each phase. Gain efficiency was computed by dividing ADG by the daily DMI. The estimation of expected DMI was performed on the basis of the observed ADG and SBW according to the following equation: expected DMI, kg/day= (EM/NE_m) + (EG/NE_g), where EM (energy required for maintenance, Mcal/day)= $0.084SBW^{0.75}$ (Plascencia and Zinn, 2021), EG (energy required for gain, Mcal/day)= $ADG^{1.097} \times 0.0557SBW^{0.75}$ (NRC, 1984), and divisors NE_m (diet energy for maintenance) and gain NE_g (diet energy for gain) derived from tabular values based on the ingredient composition of the diet (NASEM, 2016). Estimation of dietary NEm was performed by means of the following quadratic formula:

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

Where:
x: NE_m, Mcal/kg.
a: -0.41EM.
b: 0.877EM + 0.41DMI + EG.
c: -0.877DMI (Zinn and Shen, 1998).

The observed dietary NE_g was derived from observed dietary NE_m using the equation NE_g= 0.877NEm - 0.41 (Zinn *et al.* 2008).

The estimated EM coefficient (MQ) was derived by applying the conventional equation (NASEM, 2016):

DMI= ((MQ× $SBW^{0.75}$)/dietary NE_m) + ((0.557×(478/454)$SBW^{0.75}$×$ADG^{1.097}$)/dietary NE_g), and solving for MQ based on minimum sums of squares for the difference between observed and predicted DMI for each weight registered during through the experiment using the Excel Solver function (Microsoft, Redmond, WA).

Statistical design and analysis

Growth performance data (gain, gain efficiency and dietary energetics) were analyzed as a randomized complete block design (using an initial weight as block criterion), with the pen as the experimental unit. Carcass data were analyzed using the MIXED procedure (SAS, 2007), with treatment and pen as fixed effects and interaction treatment × pen and individual carcasses within pen by treatment subclasses as random effect. All the data were tested for normality using the Shapiro-Wilk test. Treatment means were separated using the "honestly significant difference test" (Tukey's HSD test). Treatment effects were considered significant at $P < 0.05$ and were identified as trends at $p > 0.05$ $P \leq 0.10$.

Trial 2. Validation of the applicability of the MQ coefficient obtained in trial 1

Animals, sampling, and treatments

Eighty Jersey steer calves (initial live weight 101±19 kg) were used to validate the applicability of the MQ coefficient derived in Trial 1. Cattle were processed as described in Trial 1, with the exception of the anabolic implant. Steers were implanted with 200 mg progesterone and 20 mg estradiol benzoate per implant (Synovex®-S Zoetis Animal Health, Florham Park, NJ) on day 56 and reimplanted with 28 mg of estradiol benzoate and 200 mg of trenbolone acetate (Synovex® Plus, Zoetis Animal Health, Florham Park, NJ) on days 168 and 252 d of the feeding trial. The steers were blocked by initial shrunk (off-truck) weights and assigned within weight grouping to 16 pens (5 steers/pen). Pens were 50 m^2 (26.7 m^2 overhead shade), equipped with automatic drinkers, and 4.3 m fence-line feed bunks. Dietary treatments consisted of a steam-flaked corn-based growing-finishing diet containing 12 *vs.* 24% forage (DM basis). The composition of experimental diets is shown in Table 2. Diets were prepared weekly and stored in plywood boxes in front of each pen. Calves were provided ad libitum access to the diet. Fresh feed was added to the feed bunk twice daily (08:00 and 14:00 h). Samples of feed and orts were collected daily for DM analysis (AOAC, 2000). Steers were individually weighed (off-truck) at the start of the experiment and, subsequently, were individually weighed starting at 0600 h on days 140 and upon completion of the study (day 350).

Calculation of dietary NE

Dietary net energy was determined as in Trial 1. However, the coefficient determined in Trail 1 for EM (EM=0.114Wkg0.75) was used instead of the coefficient of 0.084 proposed for Holstein steers by NASEM (2016).

Statistical design and analysis

Growth performance (ADG, DMI, and feed efficiency) and estimated dietary NE were analyzed as a randomized complete block design (initial weight as block criterion) using the MIXED procedure of SAS software (SAS, 2007), where initial weight was the blocking criterion and pen as the experimental unit according to the following statistical model:

$$Y_{ijk} = \mu + G_i + T_j + \varepsilon_{ijk}$$

Where:
μ: common experimental effect.
G_i: initial weight grouping (block) effect.
T_j: dietary energy density effect.
ε_{ijk}: residual error.

Table 1 Composition of experimental diets fed to calf-fed Jersey steers (Trial 1)

Item	Growing diet	Finishing diet
	1-224 d	224-524 d
Ingredient composition, % dry matter basis		
Steam-flaked corn	68.4	78.0
Alfalfa hay	4.00	0.000
Sudangrass hay	8.00	12.0
Yellow grease	3.50	3.50
Molasses	4.00	6.00
Fish meal	2.50	0.000
Canola meal	6.00	0.000
Urea	1.00	1.40
Limestone	1.60	1.60
Magnesium oxide	0.200	0.200
Trace mineral salt[1]	0.400	0.400
Monensin, mg/kg	23.0	23.0
Nutrient composition[2], dry matter basis		
Net energy for maintenance, Mcal/kg	2.22	2.27
Net energy for gain, Mcal/kg	1.55	1.60
Crude protein, %	15.3	12.50
Ether extract, %	7.60	7.00
Potassium, %	0.770	0.680
Magnesium, %	0.290	0.290
Calcium, %	0.900	0.700
Phosphorus, %	0.400	0.290
Sulfur, %	0.220	0.140

[1] Trace mineral salt contained: $CoSO_4$: 0.68%; $CuSO_4$: 1.04%; $FeSO_4$: 3.57%; ZnO: 0.240%; $MnSO_4$: 1.07%; KI: 0.052%; and NaCl: 92.96%.
[2] Based on tabular values for individual feed ingredients published by NASEM (2016).

Table 2 Composition of experimental diets fed to calf-fed Jersey steers (Trial 2)

Item	Low-forage (12%)		High-forage (24%)	
	Growing[1]	Finishing[2]	Growing	Finishing
Ingredient composition, % dry matter basis				
Steam-flaked corn	57.2	63.2	46.1	51.2
Sudangrass hay	6.00	6.00	12.0	12.0
Alfalfa hay	6.00	6.00	12.0	12.0
Canola meal	3.50	0.00	2.60	0.00
Fish meal	3.00	0.00	3.00	0.00
Dry distillers grains with solubles	15.0	15.0	15.0	15.0
Tallow	2.00	2.50	2.00	2.50
Molasses	5.00	5.00	5.00	5.00
Limestone	1.30	1.30	1.30	1.30
Urea	0.500	0.500	0.500	0.500
Magnesium oxide	0.100	0.200	0.100	0.100
Trace mineral salt[3]	0.400	0.400	0.400	0.400
Monensin, mg/kg	28.0	28.0	28.0	28.0
Nutrient composition[4], dry matter basis				
Net energy for maintenance, Mcal/kg	2.15	2.21	2.02	2.08
Net energy for gain, Mcal/kg	1.49	1.54	1.37	1.42
Crude protein, %	17.0	14.1	17.6	14.9
Calcium, %	0.880	0.690	0.980	0.800
Phosphorus, %	0.480	0.360	0.460	0.350
Potassium, %	0.900	0.850	1.13	1.09
Magnesium, %	0.280	0.300	0.310	0.300
Sulfur, %	0.240	0.190	0.240	0.200

[1] Growing diet offered during 1 to 140 d.
[2] Finishing diet offered during 141 to 383 d.
[3] Trace mineral salt contained: $CoSO_4$: 0.68%; $CuSO_4$: 1.04%; $FeSO_4$: 3.57%; ZnO: 0.24%; $MnSO_4$: 1.07%; KI: 0.052%; and NaCl: 92.96%.
[4] Based on tabular values for individual feed ingredients published by NASEM (2016).

All the data were tested for normality using the Shapiro-Wilk test. Treatment means were separated using the "honestly significant difference test" (Tukey's HSD test). Treatment effects were considered significant at P < 0.05 and were identified as trends at P > 0.05 P ≤ 0.10.

RESULTS AND DISCUSSION

The number of pen replicates and animals within treatments for Trial 1 were 6 and 30, respectively, and 20 for Trial 2 are enough to determine statistical differences in cattle growth performance, and carcass variables of feedlot cattle. Based on power analysis and SD for measure, we had a power >0.94 for detecting a 5% difference.

There was no death loss, and morbidity was 27%. The growth performance of calf-fed Jersey steers during the 524-d feedlot growing-finishing period is summarized in Table 3. Overall, average daily gain (ADG) and gain efficiency were 0.76 kg/d and 0.150, respectively. In prior feedlot growth performance studies, carcass-adjusted ADG of Jersey steers ranged from 0.85 to 1.02 kg/d (Lehmkuhler and Ramos, 2008; Jaborek *et al*. 2019), greater values than reported in the current experiment. The lower ADG observed in the present study compared to previous research is a direct reflection of the lighter initial live weight; 49.7 kg for the present study *vs*. 118 kg (Lehmkuhler and Ramos, 2008) and 222 kg (Jaborek *et al*. 2019). Tschida (2013) evaluated the impact of the initial weight of Jersey calves on performance in feedlots. They observed that an increase in initial weight of 19 kg (77.2 *vs*. 96.5 kg) resulted in an 8.9% increase in overall ADG (0.89 *vs*. 0.97 kg/d). Differences in the rate of weight gain mediated by initial weight in dairy (Flores *et al*. 2022) and beef cattle (Zinn *et al*. 2008) have been previously reported. This effect is mainly explained by the differences in the composition of gain (protein:fat accretion ratio; Norman *et al*. 2024).

Table 3 Feedlot growth performance of calf-fed Jersey steers (Trial 1)

Item	Pens	Mean	SD	Minimum	Maximum
Live Weight, kg [1]					
Initial	6	49.8	2.32	47.5	53.5
120 d	6	142	17.5	122	161
224 d	6	234	20.6	205	259
308 d	6	311	24.3	279	346
392 d	6	359	19.9	332	389
457 d	6	395	31.8	355	438
524 d	6	446	33.2	401	484
Dry matter intake, kg/d					
1-120 d	6	3.00	0.111	2.85	3.14
120-224 d	6	4.53	0.064	4.43	4.60
224-308 d	6	5.77	0.333	5.36	6.26
308-392 d	6	5.37	0.262	5.01	5.77
392-457 d	6	6.44	0.500	5.58	7.00
457-524 d	6	7.16	0.312	6.79	7.54
1-524 d	6	5.09	0.153	4.86	5.25
Average daily gain, kg/d					
1-120 d	6	0.762	0.141	0.60	0.93
120-224 d	6	0.891	0.060	0.80	0.97
224-308 d	6	0.914	0.122	0.71	1.04
308-392 d	6	0.572	0.064	0.49	0.64
392-457 d	6	0.563	0.271	0.05	0.77
457-524 d	6	0.764	0.082	0.69	0.89
1-524 d	6	0.760	0.065	0.67	0.83
Gain to feed ratio					
1-120 d	6	0.263	0.053	0.207	0.323
120-224 d	6	0.201	0.027	0.176	0.211
224-308 d	6	0.162	0.011	0.132	0.172
308-392 d	6	0.112	0.014	0.098	0.121
392-457 d	6	0.082	0.041	0.011	0.114
457-524 d	6	0.114	0.013	0.097	0.119
1-524 d	6	0.150	0.015	0.143	0.162

[1] Interim and final weight reduced by 4% to account for fill.
SD: standard deviation.

Maximal ADG (0.90 kg/d) was observed during the period of 120 to 308 d on feed (Table 3). During the subsequent 149-d period, daily gain averaged 0.57 kg/d. The observed decrease in ADG corresponds with decreased DMI as a proportion of live weight during the very hot summer months (June through October; Figure 1) in the Southwestern desert region of the United States in which the study was conducted (Figure 2).

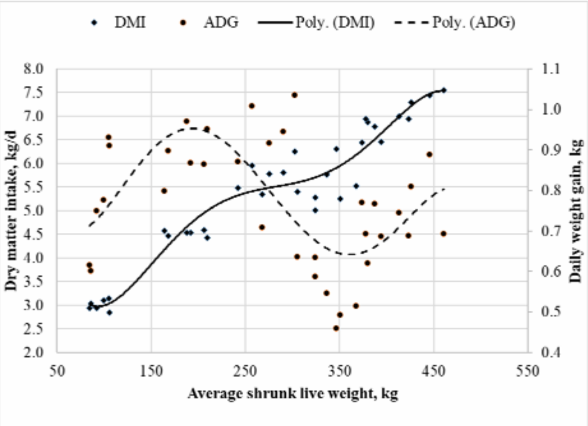

Figure 1 Relationship between average shrunk live weight and daily weight gain and dry matter intake of calf-fed Jersey steers (Trial 1)

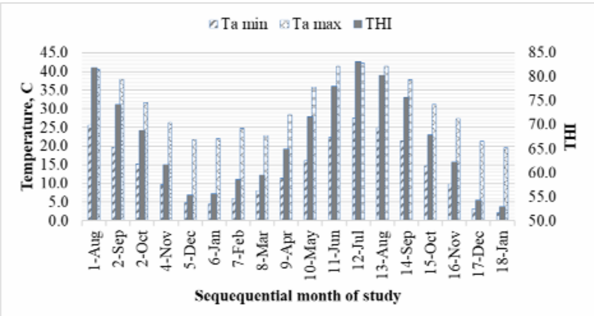

Figure 1 Sequential monthly average minimum and maximum air temperature (Ta) and temperature humidity index (THI) during the course of the 524-d study (Trial 1)

The average temperature humidity index (THI) for June through August exceeded 78, reflecting a "Danger" category of heat exposure (Brown-Brandl, 2018). Previous research has reported that cattle adapt to increased ambient temperature by reducing feed intake, thereby reducing their heat load (Hahn, 1999; Mitlöhner *et al.* 2002; Barajas *et al.* 2013), which was the case in the current study.

When THI decreased, returning to more favorable weather conditions during the final period of the experiment (d 457 to 524), DMI, ADG, and feed efficiency increased by 11.2%, 35.7%, and 37.5%, respectively. This behavior is consistent with what was observed with long-term experiments (>300 d) carried out at this Research Center involving Holstein steers, where DMI and ADG decreased during intermediate periods of high ambient heat load, followed by compensatory improvements in growth performance during subsequent favorable environmental conditions (Torrentera *et al.* 2017; Carvalho *et al.* 2023).

Overall, Jersey steers gain efficiency was poor, averaging 0.150 (Table 3). The poor feed efficiency observed in the current study was, in part, expected due to the small overall ADG (0.76 kg/d). However, it reflects a potential greater maintenance energy requirement of calf-fed Jersey steers as well. This is the first study to address the productive performance of Jersey steers in the feedlot from an energetic perspective. Considering that the total of 65–70% of the energy required for meat production goes toward maintenance (Ferrell and Jenkins, 1985); therefore, to maximize the efficiency of dietary energy utilization for gain, the energy requirement for maintenance must be accurately determined. Because information about of estimation of the MQ requirement of Jersey steers in feedlot is not available, some of our results are compared, with the proper proportion of the case, with available reports with Jersey cows. Solis *et al.* (1988) observed that the EM requirement of Jersey mature cows, as a function of metabolic weight ($BW^{0.75}$, kg), was close to 30% greater than Holsteins mature cows. As explained previously, the EM coefficient (MQ) for the present study can be derived applying the conventional equation (NASEM, 2016): DMI= $((MQ \times SBW^{0.75})/\text{dietary } NE_m) + ((0.557 \times (478/454)SBW^{0.75} \times ADG^{1.097})/\text{dietary } NE_g)$, and solving for MQ based on minimum sums of squares for the difference between observed and predicted DMI for each registered weight. Applying the equation, the derived MQ resulted is 0.114 Mcal EM/$SBW^{0.75}$ (ratio of observed *vs.* predicted DMI=1.006±0.034; r^2=0.99). Accordingly, the estimated EM requirement of Jersey steers as a function of metabolic size was 35% greater than that of Holsteins steers (0.084 Mcal EM/ $SBW^{0.75}$) as specified by Garrett (1971). This derived MQ for feedlot Jersey steers is in close agreement with the relative value of ~28% reported for mature Jersey cows (Solis *et al.* 1988; Morris and Kononoff, 2020). The reason why the Jersey breed has a greater MQ requirement than Holstein has not been deeply investigated. Although several factors can affect the MQ in cattle (Cabezas-Garcia *et al.* 2021), the main factor has to do with the gastrointestinal mass (GIT).

Around 20% of the cost of energy expenditure for maintenance is by GIT (Caton *et al.* 2000). Jersey cattle had a proportionally greater GIT weight than Holstein cattle (Beecher *et al.* 2014), so this may be one of the reasons for the higher MQ requirement. However, Kempster (1981) noted that the site of fat storage in the body has a substantial impact on the maintenance requirements of cattle.

Table 4 Carcass characteristics of calf-fed Jersey steers (Trial 1)

Item	Pens	Mean	SD	Minimum	Maximum
How carcass weight, kg	6	275	23.9	247	303
Dressing percentage	6	61.5	1.20	59.5	62.5
KPH, %	6	2.62	0.210	2.38	2.90
Fat thickness, cm	6	0.380	0.090	0.280	0.510
Ribeye area, cm^2	6	83.8	7.43	72.8	95.2
Marbling score	6	3.97	0.550	3.13	4.60

KPH: kidney, pelvic, and heart fat.
SD: standard deviation.

Table 5 Feedlot growth performance of Jersey steers fed with 12 or 24% of forage level (Trial 2)

Item	Forage level		SEM	P-value
	12%	24%		
Live weight[1], kg				
Initial	101	102	0.401	0.691
Final	446	437	5.940	0.122
Average daily gain, kg/d				
1-140 d	1.090	1.100	0.011	0.293
141-350 d	0.924	0.862	0.027	0.051
1-350 d	0.992	0.960	0.024	0.124
Dry matter intake (DMI), kg/d				
1-140 d	4.74	5.22	0.053	<0.01
141-350 d	6.76	6.77	0.110	0.922
1-350 d	5.95	6.15	0.081	0.042
Predicted DMI[2], kg/d				
1-140 d	4.66	5.09	0.072	<0.01
141-350 d	6.97	7.20	0.138	0.101
1-350 d	6.04	6.32	0.100	0.021
Gain to feed ratio				
1-140 d	0.230	0.212	0.003	<0.01
141-350 d	0.136	0.127	0.004	0.050
1-350 d	0.166	0.156	0.003	<0.01
Dietary NE[3], Mcal/Kg				
1-140 d				
Maintenance	2.22	2.11	0.032	0.012
Gain	1.54	1.44	0.033	0.014
Observed/expected	0.98	0.97	0.017	0.463
141-350 d				
Maintenance	2.27	2.20	0.044	0.13
Gain	1.58	1.52	0.049	0.13
Observed/expected	1.03	1.06	0.023	0.19
1-350 d				
Maintenance	2.22	2.11	0.033	0.012
Gain	1.54	1.44	0.037	0.016
Observed/expected	1.02	1.00	0.022	0.548

[1] Interim and final weight reduced by 4% to account for fill.
[2] Predicted DMI: DMI= $((MQ \times W^{0.75})/\text{dietary } NE_m) + ((0.557*(478/454)W^{0.75} \times ADG^{1.097})/\text{dietary } NE_g)$.
[3] Calculated based energy equations using the NASEM (2016) with a derived coefficient for maintenance energy (EM) estimation ($EM=0.114SBWkg^{0.75}$).
SEM: standard error of the means.

Cattle that deposit greater amounts of internal fat require more energy for maintenance, and Jersey cattle have greater relative proportions of internal fat than Holsteins and beef breeds (Kempster, 1981). The increase in energy maintenance requirements in cattle that have greater visceral fat is not fully understood yet. However, both the energy cost of tissue and certain hormonal regulations associated with visceral fat depots can be implicated (Heins *et al*. 2008).

Further research is needed in order to elucidate the physiological mechanisms involved in why Jersey cattle have such a high MQ and thus be able to develop strategies to improve their efficiency in the feedlot. In addition, to confirm the results obtained in the current experiment, a validation involving a greater number of Jersey steers under different feedlot environments is desirable.

Carcass characteristics are reported in Table 4. Reports regarding carcass yield in Jersey steers finished in feedlot are scarce (Berry *et al.* 2018). Nevertheless, based on a previous report, it was noted that the target endpoint for the Jersey steers would need to be equal to or greater than 450 kg BW (Lehmkuhler and Ramos, 2008). In the present study, the average harvest weight was in close agreement with the targeted (445.7 kg). The average HCW was 274.7 ± 23.9 kg, resulting in a dressing percentage (DP) of 61.5 ± 1.2%. The DP observed in the current experiment is in close agreement with the 61.2% reported by Jaborek *et al.* (2019), but greater than the 58.6% observed by Lehmkuhler and Ramos (2008). Discounting genetic factors, dressing percentage is affected by the energy density (and composition) of diet and days on feed, among other factors (Coyne *et al.* 2019). The values recorded for the LM area observed in the current experiment were greater, while the percentage of kidney-pelvic-heart fat and marbling score were lower than those reported previously (Lehmkuhler and Ramos, 2008; Jaborek *et al.* 2019). As indicated above, factors such as diet energy density, initial weight, weight at slaughter, and days on feed affect the rate of gain and gain composition affecting carcass characteristics. In this sense, these factors were quite different between the current experiment and the experiments performed by Lehmkuhler and Ramos (2008) and Jaborek *et al.* (2019).

There was no death loss, and morbidity was 6.7%. Effects of dietary energy density on feedlot growth performance of calf-fed Jersey steer are shown in Table 5. Increasing dietary forage level from 12 to 24% (DM basis) decreased (P=0.02) overall ADG by 4 % and tended (P=0.07) to increase DMI by 3%. Therefore, a 5% decrease (P=0.02) gain to feed efficiency was observed in cattle eating 12% forage in the diet. Differences in DMI during the study were consistent (r^2=0.92) with predicted, based on the derived intake equation from Trial 1 and tabular dietary NE values (Table 2). The predicted overall DMI was 6.02 and 6.32 kg/d for the 12 and 24% forage diets, respectively, corresponding closely with the observed DMI of 6.04 and 6.32 kg/d, respectively, validating derived MQ (0.114) for Jersey steers obtained in Trial 1.

During the initial 140 d growing phase, the forage level of the diet did not affect ADG (P=0.29; Table 5). However, Jersey steers receiving the 24% forage in the diet had 10% greater (P<0.01) DMI and 9% less (P<0.01) gain to feed efficiency. During the subsequent 210-d growing-finishing phase, increasing dietary forage level from 12 to 24% decreased (P≤0.05) ADG by 6.5% and gain to feed efficiency by 6.6%. Increasing dietary forage level did not appreciably affect overall ADG (P=0.12), but as expected, decreased (P<0.01) gain efficiency by 6.0%.

The increased DMI and decreased gain efficiency with the increased forage level are consistent with the associated decrease in dietary energy density (Table 2) but without affecting the efficiency of dietary energy utilization. Indeed, observed dietary NEm and NEg were in good agreement (observed-to-expected=1.01) with expected based on diet formulation (Table 2). This confirms that the MQ of Jersey steers was not affected by the levels of forage tested in the current experiment. Lehmkuhler and Ramos (2008) also fed 2 different roughage levels (a continuous level of 10% roughage vs. phase-feeding protocol with decreasing levels of roughage from 30 to 10% roughage) to calf-fed Jersey steers. Similar to the current study, these authors reported that Jersey steers continuously fed the 10% forage diet had a greater overall ADG than Jersey steers that received greater forage levels. Forage is included in feedlot diets largely for functional purposes, reducing the risk of digestive dysfunctions (Cole *et al.* 1976). Prior research from our group, under similar climate and feeding conditions, has demonstrated that 12% forage is sufficient for the maintenance of ruminal health (<10% incidence of liver abscess with no digestive death) of calf-fed Holstein steers fed steam-flaked corn-based growing-finishing diets (Latack *et al.* 2021; Latack *et al.* 2022; Carvalho *et al.* 2023; Latack *et al.* 2024). Although liver abscess was not reported in the current study, the results of the present study are supportive that this is likewise the case for calf-fed Jersey steers since no digestive abnormalities were reported in the current study.

CONCLUSION

The derived maintenance coefficient for calf-fed Jersey steers was 0.114, which is 35% greater than that of calf-fed Holstein steers (0.084). Thus, the lower gain efficiency of Jersey steers is not only impacted by their comparatively low rate of daily weight gain, but also by the marked increase in maintenance energy requirements. An increase in forage level from 12 to 24% did not affect dietary net energy utilization in Jersey steers. As expected, increasing dietary forage level from 12 to 24% decreased gain efficiency but did not appreciably affect daily weight gain. The MQ value generated and validated in the present study can be a tool to predict more accurately the growth performance of Jersey steers during the fattening process. Further research is needed in order to elucidate the physiological mechanisms involved in why Jersey cattle have such a high MQ and thus be able to develop strategies to improve their efficiency in the feedlot.

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