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Crude protein requirements of light-weight feedlot steers during a 35-d receiving period

J SALINAS-CHAVIRA[1], B C LATACK[2], A PLASCENCIA[3✉] and D R A ZINN[4]

Faculty of Veterinary Medicine and Zootechnics, Autonomous University of Sinaloa, Sinaloa 80260 Mexico

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ABSTRACT

The influence of dietary crude protein (CP) levels on growth performance, morbidity, and estimated dietary net energy (NE) of light-weight crossbreed feedlot calves during a 35-d receiving period was evaluated. For the above, 108 crossbred steers (196±13 kg) were used in 35-d receiving trial. Steers were randomly allocated to 18 pens (6 steers/pen, 6 replicas/treatment). Treatments consisted of a steam flaked corn-based receiving diet (72:28 concentrate to forage ratio) containing 12.5, 13.5 and 14.5% CP. Crude protein level in diet was manipulated by replacing steam flaked corn by canola meal. Steers were allowed *ad lib.* access to their experimental diets. Morbidity averaged 32%, and was not affected by treatments. Increasing the level of dietary CP improved average daily weight gain, gain efficiency and tended to increase the ratio of observed-to expected dietary NE. Furthermore, in CP range from 12.5 to 13.5%, these effects were evident, but were not apparent at 13.5 to 14.5% CP. It can be concluded that high-energy receiving diet formulations containing 13.5 to 14.5% CP will optimise initial growth performance of light-weight (~200 kg BW) feedlot calves. However, present effect may be more a function of achieving metabolisable amino acid rather than metabolisable protein requirements.

Keywords: Crude protein, Feedlot-calves, Light-weight, Receiving diets

Crude protein levels in diets become critical during the receiving phase, i.e. first 6-8 weeks of feedlot cattle (Fluharty and Loerch 1995). This is because dry matter intake (DMI) during initial period when cattle are adapting to the feedlot environment is characteristically low (Barajas *et al.* 2014). Therefore, a greater allowance of dietary CP is needed to achieve metabolisable protein requirements. It is well known that appropriate CP intake plays an important role at the initial stage of growing-finishing regarding expressing the maximum potential growth. Intake deficiency of protein may be reflected in both decreased microbial protein synthesis and bypass protein reaching the small intestine, affecting growth rate and dietary energy utilisation (Zinn *et al.* 2007). Optimising growth rate during the initial period can increase health and weight rate gain resulting in both short and long-term positive effects on productive performance (Harvey *et al.* 2021). For this reason, the importance of protein level in the receiving phase of feedlot has been investigated. However, receiving studies evaluating protein nutrition have been largely directed toward that of light-yearling crossbreed cattle (Galyean 1996), but studies evaluating protein supplementation of receiving diets for lighter-weight (<200 kg BW at receiving) feedlot calves are limited. In order to avoid problems with the metabolisable protein intake at receiving period, CP levels up to 16% have been recommended (McKinnon *et al.* 1993). However, a concern from livestock industry is the potential environmental contamination by over reaching protein levels in diets. In such a manner that the challenge is to find the optimal protein level in diets to maximal growth with a minimal contamination of soils and water by excessive N excretion (NRC 2015). For this reason, the objective of this study was to further evaluate the influence of dietary crude protein levels on morbidity rate, growth performance, and dietary energy of light-weight (<200 kg BW) feedlot crossbreed calves during a 35-d receiving period.

Present address: [1]Department of Animal Nutrition, Faculty of Veterinary Medicine and Zootechnics, Autonomous University of Tamaulipas, Mexico. [2]Cooperative Extension, University of California, USA. [3]Faculty of Veterinary Medicine and Zootechnics, Autonomous University of Sinaloa, Mexico. [4]Department of Animal Science, University of California, Davis, USA. ✉Corresponding author email: aplas_99@yahoo.com

MATERIALS AND METHODS

All procedures involving animal care and management were in accordance with and approved by the University of California, Davis, Animal Use and Care Committee (Protocol # 20548).

Experimental animals and managements: One hundred eight crossbred steers (approximately 25% Brahman breeding with the remainder represented by Hereford, Angus, Shorthorn, and Charolais breeds in various proportions with an average initial weight of 196±3 kg were used in 35-d receiving trial to evaluate the influence of crude protein intake on growth performance, morbidity, and estimated dietary net energy. Calves were received at the research center facilities and processing on arrival included branding, ear-tagging, castration, vaccination for IBR-PI3 (TSV-2, Zoetis Inc., Kalamazoo, MI) and for Clostridials/Haemophilus (Ultrabac, Zoetis Inc., Kalamazoo, MI), and were treated against internal and external parasites (Dectomax, Zoetis Inc., Kalamazoo, MI). All calves received an injection with 500,000 IU vitamin A and 75,000 IU vitamin D (Vita-jec A&D, Aspen Veterinary Resources, Liberty, MO). Calves were individually ear-implanted with 200 mg progesterone and 20 mg estradiol benzoate (Synovex-S®, Zoetis Inc., Kalamazoo, MI) and weighed. Calves were randomly allocated in 18 pens (6 calves/pen). Pens were 43 m^2 with 22 m^2 overhead shade, equipped with automatic waterers and fence-line feed bunks. Experimental treatments consisted of a steam flaked corn-based receiving diet (72:28 concentrate to forage ratio) containing 12.5, 13.5 and 14.5% CP. Crude protein level in diet was manipulated by replacing steam flaked corn by canola meal. The replacement of SFC with canola meal slightly reduced dietary NE_m from 1.99 to 1.94 Mcal/kg diet, but degradable intake protein (DIP) was maintained in all diets (~ 66% of total CP). Composition of experimental diets is shown in Table 1. Diets were prepared at weekly intervals and stored in plywood boxes located in front of each pen. Steers were allowed *ad lib.* access to water and to their experimental diets. Fresh feed was provided twice daily at 0700 and 1500 h.

Growth trial and measurement: The estimations of performance and dietary net energy were performed based on measures of initial off-truck shrunk weight and final live weight which was reduced 4% to account for digestive tract fill (SBW). Average daily gain (ADG) was computed by subtracting the initial SBW from the final SBW and dividing the result by the number of days on feed (35-d). The gain efficiency was computed by dividing ADG by the daily DMI. One approach for evaluation of the efficiency of dietary energy utisisation in growth-performance trials is the ratio of observed-to-expected dietary NE. Energy gain (EG, Mcal/d) was calculated by the equation: $EG = 0.0557W^{0.75} \times ADG^{1.097}$, Where EG, daily deposited energy, and W, body weight (NRC 1984). Maintenance energy (EM, Mcal/d) was calculated by the equation: $EM = 0.077W^{0.75}$. From the derived estimates of energy required for maintenance and gain, the NEm and NEg values of the diet were obtained using the quadratic formula:

$$x = (-b - \sqrt{b2-4ac})/2c$$

Where, a, −0.41EM; b, 0.877EM + 0.41DMI + EG; and c, −0.877DMI, and NEg, 0.877 NEm – 0.41 (Zinn *et al.* 2008).

The observed to expected dietary NE ratio was calculated by dividing the observed NE by the expected NE which is estimated through corresponding NE values based on the ingredient composition (NRC 2016) of the experimental diet (Table 1).

Table 1. Composition of experimental diets (DM basis)

Item	12.50	13.50	14.50
Ingredient composition, % DM			
Alfalfa hay	9.50	9.50	9.50
Sudangrass hay	18.50	18.50	18.50
Tallow	2.00	2.00	2.00
Molasses, cane	8.00	8.00	8.00
Steam flaked corn	56.00	52.75	49.75
Canola meal	3.75	7.00	10.00
Urea	0.50	0.50	0.50
TM salt[a]	0.40	0.40	0.40
Limestone	1.15	1.15	1.15
Magnesium oxide	0.20	0.20	0.20
Monensin, mg/kg	22	22	22
Dry matter content, %	87.52	87.67	87.83
Nutrient composition, DM basis b			
Crude protein, %[b]	12.48	13.50	14.45
Rumen DIP, %	66.08	66.78	67.34
Rumen UIP, %	33.91	33.21	32.66
Ether extract, %	5.13	5.10	5.08
Ash, %	6.85	7.02	7.17
Nonstructural CHO, %	52.17	50.26	48.50
NDF, %	22.00	22.60	23.14
Calcium, %	0.76	0.78	0.80
Phosphorus, %	0.31	0.33	0.36
Potassium, %	1.18	1.22	1.25
Magnesium, %	0.35	0.37	0.38
Sulfur, %	0.20	0.23	0.26
Net energy, Mcal/kg			
Net energy for maintenance	1.99	1.96	1.94
Net energy for gain	1.33	1.31	1.29

[a]Trace mineral salt contained, $CoSO_4$, 0.068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 0.75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%. [b]Based on the tabular values for individual feed ingredients (NRC, 2016) with the exception of DM and CP which were determined in our laboratory by analysing subsamples collected and composited throughout the experiment. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.

The morbidity rate was determined as described by Schunicht *et al.* (2003). Furthermore, each dietary treatment was sampled and was composited throughout the experiment to perform the following analysis: Dry matter (method 930.15) and Kjeldahl N (method 984.13) following the procedures published by AOAC (2000).

Statistical analyses: The experimental data were analyzed as a completely random design according to the following statistical model:

$$Yij = \mu + Ti + \varepsilon i$$

Where, μ, general mean; Tj, dietary treatment effect (df = 2); and εij, residual error (df = 15). Treatments effects were tested by means of orthogonal polynomials (Statistix-10, Analytical Software, Tallahassee, FL). Least squares mean and standard error are reported, and contrasts are considered significant when the P value ≤ 0.05, and tendencies are identified when the P value > 0.05 and ≤ 0.10.

RESULTS AND DISCUSSION

Treatment effects on feedlot growth performance are shown in Table 2. Morbidity averaged 32%, and was not affected (P ≥ 0.90) by treatments. During the past few years, little new information has been reported regarding protein's effects on newly received calves' health. The performance of newly received cattle is usually improved by feeding diets containing higher concentrations of concentrate, as are diets containing protein supplements; however, very limited data suggest that higher dietary CP concentrations are associated with an increased risk of respiratory disease morbidity (Duff and Galyean 2007). However, this effect is not plenty corroborated. In this sense, Galyean *et al.* (2022) proposed that further research is needed on how dietary protein level and source affect morbidity and health in newly received calves.

Increasing the level of dietary CP did not affect DMI. It is thought that protein supplements stimulate energy intake indirectly through improving diet acceptability, enhancing fermentation of organic matter, and modulating gastric emptying (Zinn and Shen 1998). However, the magnitude of the response to change on DMI intake by CP level can be affected by quantity of CP and by rumen undegradable intake protein (DIP) in the ration (Lee *et al.* 2020). In line with the current study, Jeong *et al.* (2010) studied the response to low- (12%) and high-CP (14%) diets with a similar total digestible nutrient (TDN) and DIP content, and found that the high-CP diet had no effect on DMI. On the contrary, increase on DMI was noted in Hereford calves when fed with 18% CP, but no differences were noted when compared to DMI of steers that received 12 vs 15% CP (Beretta *et al.* 2020). It seems that increase of DMI by CP level is not manifested when CP levels are below 15%.

Typically, the initial phase of growth period is when feed intake is relatively low and the rate of protein deposition is potentially high. Therefore, increasing CP concentration during this phase may increase the growth rate. Accordingly, increasing the level of dietary CP increased ADG (linear component, P = 0.03) and gain efficiency (linear component, P = 0.05) and tended to increase the ratio of observed-to expected dietary NE (P = 0.06). These effects were largely manifested in going from 12.5 to 13.5% CP, as differences in ADG, gain efficiency, and observed vs expected dietary NE going from 13.5 to 14.5% dietary CP was not appreciable (P > 0.10). The results of the current study are consistent with previous reports in which heavier calves were used. For example, in a preliminary report, Eck *et al.* (1988) observed greater ADG and DMI during a 28-d receiving period in steers with an initial BW of 236 kg and fed 12.5 vs 10.5% dietary CP. On the other hand, Fluharty and Loerch (1995) observed a quadratic effect of dietary CP level (12, 14, 16 and 18% CP) on ADG and gain efficiency in steers with initial BW of 246 kg during a 42-d receiving period, with growth performance being optimal with receiving diets containing 14% CP. Likewise, in a subsequent study (Fluharty and Loerch 1996) observed greater ADG and gain efficiency in steer calves (BW = 226 kg) fed a receiving diet containing 16.0 vs 12.5% CP during initial 28 days on feed.

In addition to dietary CP level, per se, the basis for improved growth performance is likely related to the nature of dietary protein sources that influence supply of limiting metabolisable amino acids (Eck *et al.* 1988, Fluharty *et al.* 1994, Fluharty and Loerch 1995). Zinn and Shen (1998) observed that changes in estimated dietary NE based on growth performance due to protein supplementation were a sensitive indicator of metabolisable amino acid adequacy for receiving crossbreed cattle. The importance of adequate consumption of metabolisable amino acids in the receiving

Table 2. Treatment on 35-d growth performance and estimated dietary net energy

Item	Crude protein, %			SEM	Contrast P-value	
	12.50	13.50	14.50		Linear	Quadratic
Days on test	35	35	35			
Pen replicates	6	6	6			
Live weight, kg[a]						
Initial	196	197	193	2.2	0.33	0.28
35-d	216	224	220	3.1	0.32	0.10
DMI, kg	3.79	3.97	4.02	0.14	0.21	0.69
ADG, kg	0.56	0.76	0.77	0.07	0.03	0.25
ADG/DMI	0.15	0.19	0.19	0.01	0.05	0.19
Dietary NE Mcal/kg						
Maintenance	1.77	1.94	1.90	0.06	0.15	0.18
Gain	1.14	1.29	1.26	0.06	0.15	0.18
Observed/Expected NE						
Maintenance	0.89	0.99	0.98	0.03	0.06	0.17
Gain	0.86	0.98	0.98	0.04	0.06	0.17
Morbidity, %	31.1	33.3	32.2	12.0	0.94	0.90

[a] Initial weight is off-truck arrival weight. Final 35-d weight reduced 4% to account for fill.

phase has been previously reported. Torrentera *et al.* (2017) observed enhanced gain efficiency and dietary energetics of growing Holstein calves when supplemented with rumen-protected methionine and lysine. Montaño *et al.* (2016) observed a linear increase in ADG, gain efficiency and estimated dietary NE in feedlot steers (229 kg) fed receiving diets containing 11.4, 12.2, 12.6 and 13.4% CP. Improved growth performance was closely associated with supply of metabolisable lysine, explaining 91% of the variation in observed vs expected dietary NE. In a subsequent study, Montaño *et al.* (2019) observed that even when metabolisable protein supply exceeded theoretical requirements, gain efficiency and dietary energetics were further enhanced when metabolisable amino acid requirements were likewise met.

Based on diet formulation and DMI, the estimated supply of metabolisable protein was 431, 457, and 468 g/d for diets containing 12.5, 13.5, and 14.5% dietary CP, respectively (NRC 2000). The metabolisable protein requirement for the maximal observed ADG (0.77 kg/d) was 437 g/d. Accordingly, estimated metabolisable supply, alone, does not explain observed treatment effects on ADG, gain efficiency and energetics. However, with increasing dietary CP, the estimated supply of metabolisable lysine averaged about 83, 90, and 93% for 12.5, 13.5 and 14.5% CP levels, respectively, according to the theoretical requirements informed by NRC 2000 (Level 1).

Therefore, it can be concluded that formulating high-energy receiving diets to contain 13.5 to 14.5% CP will optimise initial growth performance of light-weight feedlot calves. This effect may be more a function of achieving metabolisable amino acid rather than metabolisable protein requirements.

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