Agriculture and Natural Resources 51 (2017) 57–61

Contents lists available at ScienceDirect

Agriculture and Natural Resources

journal homepage: http://www.journals.elsevier.com/agriculture-and-natural-resources/

Original Article

Effects of protein levels and energy sources in total mixed ration on feedlot performance and carcass quality of Kamphaeng Saen steers

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ARTICLE INFO

Article history:
Received 5 June 2015
Accepted 4 August 2016
Available online 22 February 2017

Keywords:
Carcass quality
Energy
Kamphaeng Saen beef
Performance
Protein

ABSTRACT

The effects of dietary protein and energy sources of a total mixed ration (TMR) were evaluated based on the performance, carcass quality and production cost of feedlot Kamphaeng Saen steers. Twenty-four Kamphaeng Saen steers were assigned according to a 2 × 2 factorial in a randomized complete block design with two factors: 1) energy sources comprised of cassava chip (cTMR) and cassava chip plus ground corn (ccTMR); and 2) crude protein (CP) levels (12%CP and 14%CP). The steers were slaughtered after being fed for 120 d. The carcass characterization and meat quality were determined at day 7 of aging. The results indicated that the average daily gain, final weight ($p < 0.05$), carcass weight ($p = 0.06$) and the profit of the steers fed the cTMR were greater compared to the ccTMR without effects on carcass characteristic and meat quality. The different levels of CP in the diet had no effects ($p > 0.05$) on feedlot performance, carcass characteristic and meat quality but steers fed 12%CP cTMR provided a profit. Cassava chip provided good potential to be used as an energy source in a TMR for feedlot cattle.

Introduction

Cattle production in developing countries is dependent on pasture, crop residue and low quality forage (Devendra and Thomas, 2002; Food and Agriculture Organization, 2007; Steinfeld et al., 2006). Rearing indigenous beef cattle breeds on natural pasture without dietary supplementation in communal areas is a common feature in developing countries. Nowadays, new technologies, mechanization and modernization are changing agricultural production systems from traditional to mechanical systems, which have reduced cattle production in rural areas. With the increasing population in Southeast Asian countries and decreasing cattle production, the beef market demand continues to rise daily while beef cattle production based on existing indigenous beef cattle breeds and natural pasture is insufficient to satisfy demand (Jones, 2013; Thornton, 2010; United Nations Industrial Development Organization, 2013).

Sawanon (2013) summarized developments with Kamphaeng Saen beef cattle, the first beef cattle breed of Thailand. This cross breed between *Bos taurus* (50% Charolais) and *Bos indicus* (25% Brahman and 25% Thai native) provides high quality beef but is yet to show high growth rates and performance. Accordingly, it is important to provide the cattle with adequate amounts of digestible nutrients for their optimal performance. Otherwise, the predominant use of low nutritive value forage will usually result in poor performance and reduced average daily gain of 450 g/d (Sawanon, 2013).

Therefore, additional protein and energy supplement will be often required for cattle fed on forage-based diets as such forage is low in quality during the winter season or under a poor management regime (Horrocks and Vallentine, 1999). Wanapat (2009) reported that energy and protein are the most important sources of nutrients for beef cattle as the nutrients stimulate rumen microorganisms for their growth and rumen fermentation and enhance the productive functions of the animals. In the rumen, simultaneous carbohydrate fermentation is essential for microbial protein synthesis. He found that ammonia nitrogen and carbon sources from corn or cassava chip were superior to other local feed energy sources. Using cassava chip plus ground corn provided more synchronous carbohydrate and protein degradation in the rumen

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http://dx.doi.org/10.1016/j.anres.2017.02.003

when combined with urea as a non-protein nitrogen (NPN) source and soybean meal as a nitrogen source because soybean meal and ground corn have similar rumen degradation rates, while urea and cassava chip are highly degradable in the rumen (Sawanon, 2008). The objective of the current study was to evaluate the effects of total mixed ration (TMR) feeding using cassava chip or ground corn plus cassava chip as energy sources with different crude protein levels on the feedlot performance and carcass quality of Kamphaeng Saen steers.

Materials and methods

Animal arrangement and management

Twenty-four Kamphaeng Saen steers were grouped into six blocks over the period of the study with four animals per block after each animal had reached a body weight (BW) of 350 kg when they were castrated and administered a preventive treatment of Albendazole (5 mL per 100 kg BW) and Ivermectin (2 mL per 100 kg BW). The four TMR diets were assigned randomly to the four animals in each block. The steers were weighed again at the end of the adaptation period (14 d) when their feed intake was stable. The animals were kept in individual pens (2.5 m × 6 m) each with a roof and concrete floor and TMR was fed *ad libitum*. The feeds were offered twice per day (at 0700 h and at 1700 h). The feeding trial lasted for 120 d until the animals had reached the local market weight (500–550 kg). During the experimental period, each animal had free access to clean, fresh drinking water.

Experimental diets

The four finishing TMR diet treatment combinations were: T1) cassava chip (c) and 12% crude protein (CP)-based TMR; T2) cassava chip and 14% CP-based TMR; T3) cassava chip plus ground corn (cc) and 12% CP-based TMR; and T4) cassava chip plus ground corn and 14% CP-based TMR. The ingredients and chemical compositions of the experimental diets are shown in Table 1. The representative feed samples were collected at least five times from each batch and all these samples from the same batch were sampled again to make a single sample and the samples were analyzed to evaluate the nutrient composition of the TMR. Samples of feeds and refusals were analyzed for dry matter (DM), ash, crude protein (CP), ether extract (EE), calcium and phosphorus using standard methods (Association of Official Agricultural Chemists, 1990). Neutral detergent fiber (NDF), and acid detergent fiber (ADF) were analyzed according to the procedure of Van Soest et al. (1991).

Table 1
Experimental feed ingredients and chemical analysis (dry matter basis) for two different crude protein (CP) levels using cassava chip (cTMR) or cassava chip plus ground corn (ccTMR) as the energy sources in the total mixed ration (TMR).

	Treatment diet			
	cTMR		ccTMR	
	12%CP	14%CP	12%CP	14%CP
Ingredient composition (%)				
Cassava chip	36.00	36.00	18.00	18.00
Ground corn	–	–	18.00	18.00
Soybean meal	5.00	10.00	1.50	7.00
Palm kernel meal (solvent extracted)	17.05	11.85	20.55	14.85
Palm kernel meal (expeller pressed)	20.00	20.00	20.00	20.00
Luecaena	10.00	10.00	10.00	10.00
Molasses	10.00	10.00	10.00	10.00
Urea	0.80	1.00	0.80	1.00
Sulfur	0.05	0.05	0.05	0.05
Salt	0.50	0.50	0.50	0.50
Di-calcium phosphate	0.10	0.10	0.10	0.10
Premix[a]	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Chemical composition (% dry matter)				
Moisture	12.23	12.20	12.16	12.38
Crude protein	11.78	13.95	11.81	13.95
Ether extract	2.60	2.28	3.24	3.35
Crude fiber	10.77	10.44	12.49	12.89
Neutral detergent fiber	29.47	33.62	32.85	32.78
Acid detergent fiber	20.22	21.73	21.74	21.46
Ash	5.30	5.55	5.52	5.65
Calcium	0.65	0.68	0.74	0.71
Phosphorus	0.31	0.35	0.32	0.35
Gross energy (MJ/kg dry matter)	17.80	17.96	17.85	17.94
TDN (%)[b]	72.03	73.15	70.17	71.40
NE (MJ/kg dry matter)[c]	6.61	6.69	6.61	6.74

[a] Agromix beef No. 46: vitamin A = 2,160,000 IU, vitamin B3 = 100,000 IU, vitamin E = 5000 IU, Mn = 8.5 g, Zn = 6.4 g, Cu = 1.6 g, Mg = 16 g, Co = 320 mg, I = 800 mg, Se = 32 mg.
[b] Total digestible nutrients by calculation.
[c] Net energy by calculation.

Performance data collection

Dry matter intake (DMI), average daily gain (ADG) and the feed conversion ratio (FCR) were measured to obtain animal performance data. DMI was measured by the difference between the weight before feeding and the residual feed removed from each feed trough. Daily feed consumption was recorded and refusals were collected from individual animals in the morning of the next day. Steers were weighed at the start of the study and then every 30 d (successive periods) during the experiment. The means of the initial, final and successive period body weights for each treatment combination were recorded throughout the trial at the same interval to determine the ADG and FCR.

Carcass characteristics and meat quality data collection

At the end point of the experiment (a BW of 500 ± 36 kg), each steer was weighed and then deprived of feed, but allowed free access to water before being stunned and humanely slaughtered after a fasting period of approximately 12 h. The weight of the head, hide, intestinal tract, internal organs and kidneys, pelvic and heart fat (KPH fat) were recorded at the time of slaughtering. The warm carcass weight (WCW) was taken shortly after slaughtering. The dressing percentage was determined as the carcass weight divided by the live animal weight (Yimmongkol et al., 2009). Carcasses were chilled at 4 °C for 7 d. The chilled carcass weight (CCW) of each carcass was recorded and the chilling loss was determined after chilling for 7 d. The carcass temperature and pH level were measured at 1 h and 24 h post-mortem from the muscle of the lumbar region (between the 4th and 5th lumbar vertebrae) using a portable meter with a penetrating electrode probe (TESTO205 pH/Temperature meter; Testo Pty Ltd., Croydon South, VIC, Australia). Two measurements were made for each carcass according to the technique of Orellana et al. (2009).

Back fat thickness was measured using a caliper over the *longissimus dorsi* muscle (LD) between the 12th and 13th ribs at three-quarters of the length of the loin eye muscle from the chine (backbone) according to Orellana et al. (2009). The area of the loin eye was measured by tracing the outline onto tracing paper and determined using an LI-3100 CArea Meter (LI-3100, Li-COR Biosciences, Lincoln, NE, USA) according to Cacere et al. (2014). Marbling was evaluated by estimating the amount of intramuscular fat visible on the cut surface of the rib eye muscle between the 12th and 13th ribs using photographic standard scales of five values: 1 = devoid, 2 = slight, 3 = small, 4 = moderate and 5 = abundant) after chilling for 7 d according to the Thai Agricultural Commodity and Food Standard (National Bureau of Agriculture Commodity and

Food Standards, 2004). Meat color was assessed using the L*, a*, b* system (Commission Internationale de L'Elairage, 1978) using a color meter (HunterLab Mini Scan EZ, 4500L, Reston, VA, USA) to determine the colorimetric index of chromaticity. Color was measured on the LD muscle between 12th and 13th ribs after cutting a slice and blooming for 15 min. A meat sample from the LD at the surface between the 12th and 13th ribs was taken to determine drip loss according to Christensen (2003). Additionally, for n the LD sample, grilling loss and tenderness were determined. Samples were sliced 2.5 cm thick. Each sample was weighed and grilled in an electric oven at 150 °C until the internal temperature reached 70 °C (using thermocouples to monitor the core temperature). The grilled meat was weighed again and grilling loss was expressed as the percentage loss related to the initial weight after cooling down to room temperature (Jaturasitha et al., 2009).

Then, core samples were used to determine tenderness using the Warner–Bratzler shear force (WBS). The sample was punched parallel to the muscle fibers using a steel hollow-core device with a diameter of 1.27 cm to obtain six pieces from each muscle sample. The shear force test was performed using a Warner–Bratzler Shear device (Challion; GH Electronics Co.; San Francisco, CA, USA). The samples were sheared across the fiber axis using a V-shaped cutting blade with a shearing velocity of 20 cm/min. The shear force value from each steak was recorded and the average value was used for evaluation (Jaturasitha et al., 2009).

Production cost and economic return

The production was determined using the cattle cost, feed cost and total cost for each beast, which were calculated using Equations (1)–(3), respectively:

$$\text{Cattle cost} = \text{Initial live weight} \times \text{Price of live animal} \quad (1)$$

$$\text{Feed cost} = \text{Feed intake} \times \text{Price of feed} \quad (2)$$

$$\text{Total cost} = \text{Cattle cost} + \text{Feed cost} + \text{Management cost} \quad (3)$$

where the management cost includes capital investment expenditures (depreciation price of land, building and utensils) and current expenses (wages, medicine, water, electricity, fuel, materials and interest amounts).

Income was determined using the local market pricing method of the Kasetsart University Beef Cattle Cooperative Company Limited as shown in Equation (4):

$$\text{Profit} = \text{Total income} - \text{Total cost} \quad (4)$$

Statistical analysis

The data were analyzed as a randomized complete block design with a 2 × 2 factorial arrangement. The blocks were arranged by the periods with four animals having the same BW. The effect of TMR feeding with different energy sources and different crude protein levels on the performances and carcass quality were analyzed statistically using analysis of variance and a general linear model procedure: $y_{ijkl} = \mu + \gamma_k + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijkl}$, where μ is the overall mean, γ_k is blocking effect (k = 1, …,6), ε_{ijkl} is the random error term, α_i (i = 1, 2), β (j = 1, 2) and $\alpha\beta_{ij}$ are the effects of energy treatment, protein treatment and their interaction, respectively. The significant effects were determined at $p \leq 0.05$. Differences of $p < 0.1$ were discussed as trends. The treatment means were used to compare the different results using Duncan's new multiple range test. The production and economic returns were not analyzed statistically.

Results and discussion

Feedlot performance

The energy sources and crude protein levels of the different diets fed to the steers produced no significant interaction on the feedlot performance and carcass characteristics of steers. The steers fed cTMR had significantly increased final body weight and tended to have increased weight gain and ADG ($p = 0.06$) compared to steers fed ccTMR.

Furthermore, protein levels and energy sources had no effect on FCR and feed intake (Table 2). However, when the protein levels in cTMR were considered, there was a numerical difference (16 kg) in the initial body weight (12%CP at 376 kg versus 14%CP at 392 kg). There was a significant difference (14 kg) between the body weights (12%CP at 507 kg versus 14%CP at 521 kg). Although the difference in the CP levels tended to be higher ($p = 0.092$) in initial body weight and might have been the cause of the difference in final body weight, when the weight gain was considered, there was no difference ($p = 0.200$) even though in ccTMR there was a numerical difference (27 kg) in weight gain (12%CP at 98.17 kg versus 14%CP at 125.17 kg). Nevertheless, in ccTMR, the steers fed the TMR diet containing 14%CP had significantly higher final body weights compared to the 12%CP TMR diet but when weight gain was considered, there was no difference.

Huuskonen and Huhtanen (2015) concluded that the body weight gain of growing cattle increased with increasing ME intake ($ME/BW^{0.75}$) and showed only marginal effects for the protein supply on body weight gain, consistent with Huuskonen et al. (2014) who reported that the body weight gain and ADG response of cattle fed a control diet were not related to the CP concentration in the diet and increased protein supplementation was negatively related to the DMI and ME intake. Although in the current study there was a similar energy composition among the treatments (Table 1), cTMR that contained cassava chip would provide a greater rumen soluble energy source compared to ccTMR that replaced 18% DM of main energy sources in the formula by ground corn. Chanjula et al. (2003) concluded that cassava chip had the greatest values at all times. The results of the current study indicated that steers fed highly rumen degradable energy sources such as cassava chip (Chanjula et al., 2003; Wanapat, 2003; Wanapat and Khampa, 2007) would give better feedlot performance for Kamphaeng Saen steers. The finishing performance results in this study differed slightly with the results described in Zinn and DePeters (1991) and Holzer et al. (1997), where the inclusion of cassava addition in the diet increased the feed intake and ADG; however, the results indicated that cassava chip had good potential to be used as an energy source in feedlot rations.

Carcass characteristics

The carcass characteristics of steers fed different energy sources and crude protein levels are shown in Table 3. The dressing, KPH fat percentage, back fat thickness, loin eye area and marbling score were not significantly different between the two energy sources. On the other hand, the empty body weight of cattle fed cTMR was significantly higher whilst WCW and CCW and entrails weight tended to be higher ($p = 0.064$, 0.069 and 0.055, respectively) than in the other group. It was clear that these carcass traits were higher in cTMR compared to ccTMR according to the higher final body weight as well. Furthermore, in entrails weight, Sawanon and Chaiyahan (2011) reported that cattle fed high energy diet had higher visceral fat as fat would accumulate in visceral organs, subcutaneously.

The steers fed 14%CP TMR diet had greater ($p < 0.05$) WCW and CCW than the steers fed the 12%CP TMR diet, although other carcass

Table 2
Feed intake and feedlot performance of Kamphaeng Saen steers fed two different crude protein (CP) levels using cassava chip (cTMR) or cassava chip and ground corn (ccTMR) as the energy sources in the total mixed ration (TMR).

Item[a]	cTMR		ccTMR		SEM	p-Value		
	12%CP	14%CP	12%CP	14%CP		TMR	CP	TMR × CP
Initial body weight (kg)	376.00	391.83	381.50	382.67	3.70	0.703	0.092	0.141
Final body weight (kg)	507.33	520.67	479.66	507.83	7.27	0.034	0.030	0.405
Weight gain (kg)	131.33	128.83	98.17	125.17	6.09	0.062	0.200	0.127
ADG (kg/d)	1.11	1.09	0.83	1.06	0.05	0.063	0.193	0.120
FCR	8.81	8.44	10.75	8.80	3.70	0.102	0.328	0.207
DM intake								
(kg/d)	8.76	8.91	8.56	8.54	0.04	0.251	0.781	0.748
(%BW)	1.98	1.95	1.98	1.92	1.94	0.749	0.369	0.676
(g/kg $BW^{0.75}$)	90.72	90.24	90.35	88.03	0.51	0.576	0.544	0.689

[a] ADG = average daily gain, FCR = feed conversion ratio, DM = dry matter, BW = body weight.

Table 3
Effects of energy sources and crude protein levels in total mixed ration (TMR) diets on carcass characteristics of Kamphaeng Saen steers fed two different crude protein (CP) levels using cassava chip (cTMR) or cassava chip and ground corn (ccTMR) as the energy sources in the TMR.

Item[a]	cTMR		ccTMR		SEM	p-Value		
	12%CP	14%CP	12%CP	14%CP		TMR	CP	TMR × CP
Empty body weight (kg)	491.17	499.67	465.67	486.00	7.31	0.032	0.103	0.487
WCW (kg)	287.83	297.67	275.75	288.92	4.04	0.064	0.043	0.750
CCW (kg)	284.54	296.18	271.90	286.40	4.07	0.069	0.038	0.807
Entrails weight (kg)	92.10	87.72	79.60	87.12	2.42	0.055	0.627	0.079
Dressing (%)	58.72	59.23	59.64	59.45	0.37	0.795	0.363	0.574
KPH fat (%)	5.60	5.36	6.61	5.30	0.22	0.269	0.076	0.210
Back fat thickness (cm)	1.32	1.17	1.65	1.28	2.28	0.288	0.223	0.600
Loin eye area (cm^2)	86.05	84.15	77.75	89.58	0.15	0.779	0.338	0.192
Marbling score	2.00	1.83	2.17	2.17	0.34	0.449	0.799	0.799

[a] WCW = warm carcass weight, CCW = chilled carcass weight, KPH = kidneys, pelvic and heart.

compositions showed no significant differences. KPH fat tended to increase ($p = 0.076$) with 12%CP due to the effect of increasing HCW and CCW without any difference in the empty body weight. Conversely, the current study diverged with the results reported by Huuskonen et al. (2014) and Huuskonen and Huhtanen (2015) that the CP concentration had no effect on the carcass weight, dressing proportion and carcass conformation score.

Carcass quality

The carcass quality of steers fed different energy sources and crude protein levels are shown in Table 4. The changes in the pH level and carcass temperature at 1 h and 24 h post-mortem were found to be regular and there were no significant differences between feeding with different energy sources (cTMR and ccTMR) and crude protein levels (12%CP and 14%CP). There were no significant differences in chilling loss, drip loss and grilling loss among the treatment groups. These results indicated that the water holding capacity of the carcasses of the animals was not affected by feeding with different energy sources and crude protein levels. Meat color values (L*, a*, b*) and shear force showed no significant effects between the two different TMRs even with the different energy sources. The carcass quality of the current study agreed with other studies on different energy sources by Yimmongkol et al. (2009) and Laorodphan et al. (2012) which also reported no significant effects on meat quality.

Production cost and economics return

The carcass income from steers fed different energy sources and crude protein levels are shown in Table 5. The results showed that steers fed 12%CP cTMR had a greater total production cost (USD

Table 4
Effects of energy sources and crude protein levels in total mixed ration (TMR) diets on carcass quality of Kamphaeng Saen steers fed two different crude protein (CP) levels using cassava chip (cTMR) or cassava chip and ground corn (ccTMR) as the energy sources in the TMR.

Item[a]	cTMR		ccTMR		SEM	p-Value		
	12%CP	14%CP	12%CP	14%CP		TMR	CP	TMR × CP
pH at 1 h	6.80	6.65	6.52	6.65	0.05	0.162	0.886	0.172
Temperature at 1 h (°C)	38.48	38.63	39.35	39.38	0.30	0.163	0.870	0.917
pH at 24 h	5.44	5.51	5.41	5.55	0.43	0.928	0.198	0.652
Temperature at 24 h (°C)	6.82	7.86	7.44	6.56	0.67	0.691	0.925	0.273
L*	46.95	47.48	47.86	44.26	0.95	0.395	0.260	0.138
a*	16.84	16.96	16.26	6.16	0.43	0.425	0.992	0.898
b*	17.36	17.81	17.10	16.13	0.40	0.161	0.699	0.298
Chilling loss (%)	1.15	1.40	0.50	0.81	0.20	0.164	0.518	0.930
Drip loss (%)	3.55	3.74	3.98	3.81	0.38	0.575	0.983	0.691
Grilling loss (%)	31.59	32.08	30.35	28.80	0.97	0.104	0.688	0.446
WBS (kg)	1.72	1.50	2.13	1.65	0.09	0.255	0.166	0.605

[a] L*, a* and b* values are used to describe meat color (CIE, 1978), WBS = Warner–Bratzler shear force.

Table 5
Effects of energy sources and crude protein levels in total mixed ration (TMR) diets on production cost and economic return of Kamphaeng Saen steers fed two different crude protein (CP) levels using cassava chip (cTMR) or cassava chip and ground corn (ccTMR) as the energy sources in the TMR.

Item	cTMR		ccTMR	
	12%CP	14%CP	12%CP	14%CP
Total production cost (USD)[a]	1333.92	1397.76	1348.12	1365.55
Feed price (USD)	0.24	0.25	0.24	0.26
Total feed cost (USD)	283.53	305.57	283.21	297.56
Feed cost per day (USD/d)	2.39	2.57	2.38	2.51
Feed cost per gain (USD/kg)	2.23	2.44	2.99	2.58
Production cost per gain (USD)	10.61	11.19	14.38	11.78
Carcass price (USD)	1516.59	1583.03	1404.55	1507.50
Net profit/head (USD)	182.68	185.27	80.90	163.95
Profit (%)	14.04	13.56	6.03	12.37

[a] Exchange rate = USD 1 to THB 30.

1333.92 versus USD 1397.76), total feed cost (USD 283.53 versus USD 305.57), feed cost per day (USD 2.39 versus USD 2.57), feed cost per gain (USD 2.23 versus USD 2.44), production cost per gain (USD 10.61 versus USD 11.19) and profit (14.04% versus 13.56%) compared to steers fed 14%CP cTMR. This group had the highest profit (%) among all treatment groups. The steers fed 12%CP cTMR had a greater feed cost per gain (USD 2.23 versus USD 2.99), production cost per gain (USD 10.61 versus USD 14.38) and profit (14.04% versus 6.03%) compared to steers fed 12%CP ccTMR. The steers fed 14%CP cTMR had a greater feed cost per gain (USD 2.44 versus USD 2.58), production cost per gain (USD 11.19 versus USD 11.78) and profit (13.56% versus 12.37%) compared to steers fed 14% CP ccTMR. However, the steers fed ccTMR, whose diet contained 14%CP, had greater feed cost per gain (USD 2.58 versus USD 2.99), production cost per gain (USD 11.78 versus USD 14.38) and profit (12.38% versus 6.03%) compared to 12%CP. The diet containing higher CP had a higher feed price or feed cost per day; nevertheless, when considered in terms of feed cost per gain or production cost per gain, the steers fed lower CP provided greater profit compared to higher CP, except in the steers fed 12%CP ccTMR because this group had the lowest growth performance (ADG and body weight gain). This resulted from the inclusion of ground corn in ccTMR because during the experiment, the price of ground corn was higher than for cassava chip (USD 0.35/kg and USD 0.29/kg, respectively). Greater income was dependent on the carcass price and chilled carcass weight, because carcass income was calculated by multiplying CCW by carcass price. The results revealed that the steers fed a TMR diet using only cassava chip as the energy source provided higher profit than the other group. Even though the total production cost and total feed cost were higher than in the other group, cassava chip still had enough potential to be used as a cheap energy source of TMR diet in feedlot rations.

Using cassava chip in the TMR produced a better finishing performance, higher income, and cheaper cost than a TMR diet with cassava chip plus ground corn without affecting the meat quality. Cassava chip has potential to be used as an energy source in TMR for feedlot cattle because of its cheaper price and market availability. The different levels of CP in the diet had no effect on feedlot performance, carcass characteristics and carcass quality although the final body weight, WCW and CCW were greater in steers fed 14%CP. The diet containing 12%CP cTMR provided the highest profit (%).

Conflict of interest

There is no conflict of interest.

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