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EFFECT OF DIETARY CRUDE PROTEIN LEVELS ON FEED INTAKE AND NUTRIENT DIGESTIBILITY OF WAGYU CROSSBRED CATTLE

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ABSTRACT: The objective of the experiment was to determine the suitable crude protein level on feed intake and digestible nutrient value of Wagyu crossbred cattle from 13 to 20 months of age. The research included 2 experiments. Experiment 1: five male Wagyu x Zebu crossbred cattle (12.2±0.56 months of age and average live weight of 179±24.2 kg, Mean±SD). Experiment 2: five male Wagyu x Zebu crossbred cattle (16.7±1.05 month's old and live weight of 276±22.0 kg). Two experiments were Latin square design (5x5) with 5 treatments and 5 periods (21 days per period). The treatments were different crude protein levels at 210, 245, 280, 315, and 350 g per 100 kg live weight (LW) corresponding to CP210, CP245, CP280, CP315, and CP350 treatments, respectively. The basal diet was commercial concentrate (1.2 kg/day), fresh Elephant grass (5.0 kg/day) and *ad libitum* rice straw. While soybean meal was used to adjust the dietary CP level per 100 kg LW in diets. The result showed that increasing nutrient consumption and metabolism energy ($P<0.05$) but reduced fiber intakes ($P>0.05$) by increasing crude protein levels. Experiment 1: the CP digestibility was highest ($P<0.05$) of CP350 (72.8%) treatment compare to CP210 (58.8%) treatments, while the CP280 (67.2%) treatment was not significant ($P>0.05$) with CP245 (62.9%) and CP315 (71.7%) treatments. Experiment 2: the highest CP digestibility ($P<0.05$) of CP350 treatment as compared to CP315, CP280, CP245, and CP210 treatments (80.2, 77.4, 73.1, 70.5, and 65.0%, respectively). As a result, increasing CP levels per 100 kg BW could rise nutrients digestibility and digestible value for Wagyu crossbred cattle. The level of 245 g CP per 100kg live weight in Wagyu crossbred cattle diet from 13 to 20 months of age could be recommended for application.

Keywords: Beef production, Crude protein, Digestion, Rumen escape protein, Ruminants.

Abbreviations: CP210, CP245, CP280, CP315 and CP350: crude protein at 210, 245, 280, 315 and 350 g/100kgLW.

INTRODUCTION

A survey of nutrients intake of Zebu cross cattle showed that the crude protein (CP) intake (g/100 kg body live weight) consume of cattle at 6, 12, 18, 24, 30 and 36 months of age were 219, 196, 194, 192, 172 and 153, respectively (Truong and Thu, 2019). In previous studies, Nha et al. (2008) reported that the crude protein level of local growing cattle diet was 210 g CP/100 kg body weight/day. Similarly, Thu and Dong (2015) concluded that supplementing CP in diets by using multi-nutrient cake improved nutrient intake and digestibility. Further studies should increase the CP contained in diets more than 230 g/100 kg body weight. In Vietnam, the Wagyu crossbred beef cattle is produced from the artificial insemination between Zebu cattle groups and frozen semen of Wagyu (Pham-Thanh et al., 2020; Vu et al., 2021). The crossbred cattle have better beef performance compared to the local breeds, nevertheless, they require higher-quality diets (Favero et al., 2019; Mwangi et al., 2019). However, research on crude protein demands of crossbred beef cattle by each of the age periods is limited. Nutritionally, protein in the diet plays an essential role in the nutrition of ruminants. Preston et al. (2021) have proposed that the key factor in the design of diets or growing cattle is the supply of rumen escape protein. Soybean meal is used as the main protein source for beef cattle as it is richer in valuable rumen undegradable protein than most other protein sources (Keller et al., 2021). In addition, research from Truong and Preston (2021) proves that soybean meal is a source of rumen scape protein for fattening crossbred beef cattle. The combination of both local feed sources and scientific results for further studies to respond to the nutrient requirements of growth performance cattle is necessary. We hypothesized that the level of CP could act collectively on the intake and digestibility of crossbred beef cattle.

In this study, the objective was to evaluate the effects of different crude protein levels in the diets on feed intake and nutrient digestibility of Wagyu crossbred cattle from 13 to 20 months of age for applications.

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MATERIALS AND METHODS

Materials

This study was conducted from May 2020 to December 2020 at Sau Duc cattle farm, Vinh Gia commune, Tri Ton district of An Giang province and the Laboratory E205 of the Department of Animal Science, College of Agriculture of Can Tho University. All experimental procedure was under ethical regulations (animal welfare and animal care rules) of Can Tho University.

Experimental design

Five male Wagyu x Zebu crossbred cattle at 12.2±0.56 months of age (Mean±SD) with an average body weight of 179±24.2 kg were used in the first experiment. Five male cattle of Wagyu crossbred (50% Wagyu and 50% Zebu crossbred) at 16.7±1.05 months of age and 276±22.0 kg body weight were used in the second experiment. The experimental design was a Latin square with five treatments and five beef cattle in five periods (21 days/period). The five dietary was different crude protein levels including 210, 245, 280, 315, and 350 g/100 kg body weight for CP210, CP245, CP280, CP315, and CP350 treatments. The basal diet was commercial concentrate (1.2 kg/d), fresh Elephant grass (5 kg/d), *ad libitum* rice straw, and soybean meal was used to adjust CP levels in different treatments.

The commercial concentrate and soybean meal were bought from a Feed Company. The Elephant grass was planted on the farm. Rice straw was purchased from local farmers. The fixed quantities of commercial concentrate (1.2 kg/animal/day) and soybean meal were daily offered to the animals 2 times at 7:00 am and 1:00 pm. Elephant grass was supplied at a level of 5 kg/animal/day (in the fresh matter) at 7:30 am and 1:30 pm followed by the rice straw offered *ad libitum* at 8:00 am, 11:00 am 2:00 pm, 6:00 pm and the remainder given at 10:00 pm. Clean and fresh water were offered *ad libitum* during the whole experiment. Before the start of this study, each animal was treated for external and internal parasites (Ivemectin and given Albendazole, respectively).

Measurements taken

- *Feed, nutrient and energy intakes:* Feeds and refusals were daily measured for analyses of dry matter (DM), organic matter (OM), crude protein (CP) and ash following the procedure of AOAC (1990), acid detergent fiber (ADF) and neutral detergent fiber (NDF) according to Van Soest et al. (1991). The metabolic energy (ME) was determined according to Bruinenberg et al. (2002), in which ME (MJ/animal/day) = 14.2*DOM + 5.9*DCP (DOM/DCP<7.0); ME (MJ/animal/day) = 15.1 x DOM (with DOM/DCP>7.0, DOM is digestible organic matter and DCP is digestible crude protein).

- *Apparent nutrient digestibility:* Apparent DM, OM, CP NDF and ADF digestibility were employed with the animal feces that were daily collected and weighed according to McDonald et al. (2010). In present study has five periods. One experimental period was three weeks, including two weeks for dietary adaptation and another week for the sampling.

- *Daily weight gains (DWG):* Experimental cattle were weighed by an electronic scale (Model TPSDH, YAOHUA, Taiwan) and calculated by using cattle live weights, which were weighed for 3 consecutive days in the early morning before feedings at the beginning and at the end of each experimental period.

Statistical analysis

The data were analyzed by analysis of variance using the ANOVA of General Linear Model (GLM) of Minitab Reference Manual Release 16.1 (Minitab, 2010). The statistical equation for this model was $y_{ijk} = \mu + T_i + A_j + P_k + e_{ijk}$; where y_{ijk}: = the dependent variable, μ: the overall mean, T_i = the effect of treatment (i = 1 to 5), A_j: the effect of animal (j = 1 to 5), P_k= the effect of period (j = 1 to 5), and e_{ijk} = the random error. Then for the paired comparison of two treatments, Tukey test of the Minitab was used (P = 0.05).

RESULTS AND DISCUSSION

Feed characteristics of experimental diet is presented in Table 1. The results presented in Table 1 indicated that the CP content was higher in soybean meal (42.5-45.0%) than in concentrate (15.3-15.9%), elephant grass (8.13-8.76%) and dry rice straw (5.11-5.41%). The chemical composition of feeds in the present study agreement with the result of some previous studies. Don et al. (2020) reported that rice straw's CP, NDF, and ADF were about 2.0-6.6% CP, 66.3-73.2% NDF and 36.3-42.6% ADF. The nutrient of elephant grass was 7.20-12.1%, 57.4-75.4% and 30.6-51.7% corresponding to CP, NDF, and ADF (Rusdy, 2016). The CP, NDF, and ADF of soybean extraction meal in the present study agreed with that presented by Dong and Thu (2020) being 43.2% CP, 18.4% NDF and 11.3% ADF. However, the highest protein from soybean meal in the present study.

Experiment 1: Wagyu crossbred cattle from 13 to 16 months of age

Feed, nutrient and ME intakes of experimental cattle

Results presented in Table 2 indicated that the DM intake (kg/animal/day) was significantly different (P<0.05) among treatments, with the highest value for CP350 (5.51 kg) and the lowest value for CP210 treatment (5.02 kg). While the CP280 treatment (5.17 kg) was not different (P>0.05) compared to CP245 (5.09 kg) and CP315 treatments (5.33 kg).

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The DM intake of the experiment was higher than the result reported by Dung and Ngoan (2016) in crossbred beef cattle from 13 to 15 months of age was 4.98-5.58 kgDM/animal/day. The crude protein intake increased (P<0.05) by increasing soybean meal supplement levels in diets. It was 0.448, 0.520, 0.590, 0.670 and 0.743 kg corresponding to CP210, CP245, CP280, CP315 and CP350. According to Thu and Dong (2015), supplementing CP in diets by using multi-nutrient cake improved nutrient intake and further studies should increase the CP containing in diets more than 230 g/100 kg. Because the transformation of feed protein into body protein is an important process of nutrition and metabolism. While protein is needed to meet for cell repair and synthetic processes in the body (Dong and Thu, 2020). The CP intake of cattle in this experiment was similar to those reported by Kearl (1982) studied growing crossbred beef cattle (225 kg) being of 0.502-0.784 kg/day for daily weight gain 0.25-1.10 kg/animal/day.

The NDF consumption per day was not different (P>0.05) among treatments. It ranged from 2.96 to 3.00 kg/animal/day, which was similar to those reported by Quang et al. (2015) being 2.38-3.01 kg/animal/day. Similarly, the ADF intake ranged from 1.80-1.84 kg/animal/day (P>0.05). Metabolizable energy intake was different (P<0.05) with the highest value for CP350 (45.0 MJ) and the lowest value for CP210 (37.8 MJ). However, the CP280 treatment was not different (P>0.05) compared to CP245 and CP315 treatments (41.4, 39.8 and 43.9 MJ, respectively). The ME intake obtained in this experiment was consistent with the results of Kearl (1982) being 36.9-64.9 MJ/animal/day but lower than that reported by Dung and Ngoan (2016) being 45.3-49.7 MJ/animal/day. Theoretically, the cell wall is the main source of roughages in the diet because their rumen microbes can effectively digest fibrous feeds into energy sources. Thus, elephant grass and rice straw are often used for cattle feeding. In our study, we found that ME consumption was significantly affected by supplementation with soybean extraction meal. The DM intake per 100 kg LW was different (P<0.05) between treatments, the highest value for CP350 (2.59%) and the lowest value for CP210 (2.36%). The result in the experiments was similar to reported by Pimpa et al. (2019) in Wagyu crossbred cattle in Thailand about 2.41-2.64%. In general, improved nutrient intakes are found by increasing the CP in the diets.

Table 1 - Chemical composition of feeds (% DM basis) used in the experiment.

Feed	DM %	% in DM				
		OM	CP	NDF	ADF	Ash
Experiment 1						
Elephant grass	14.8	89.0	8.76	62.5	40.2	11.0
Rice straw	85.2	89.2	5.11	67.6	44.0	10.8
Concentrate	89.3	90.6	15.3	40.0	15.6	9.43
Soybean meal	83.3	93.5	45.0	14.2	10.9	6.50
Experiment 2						
Elephant grass	14.0	88.1	8.13	62.5	-	11.9
Rice straw	84.3	87.8	5.41	69.0	-	12.2
Concentrate	86.1	90.9	15.9	36.4	-	9.13
Soybean meal	86.2	93.5	42.5	19.3	-	6.52

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber

Table 2 - Effect of protein levels on feed, nutrient and metabolizable energy intakes of Wagyu crossbred cattle in the experiment 1.

Item \ Treatments	CP210	CP245	CP280	CP315	CP350	P	SEM
Feed intake, kg DM/animal/day							
Elephant grass	0.741	0.741	0.741	0.741	0.741	-	-
Rice straw	3.07	2.96	2.89	2.86	2.88	0.116	0.058
Concentrate	1.07	1.07	1.07	1.07	1.07	-	-
Soybean meal	0.137[e]	0.311[d]	0.474[c]	0.655[b]	0.815[a]	0.001	0.022
Total nutrient intake, kg/animal/day							
DM	5.02[c]	5.09[bc]	5.17[bc]	5.33[ab]	5.51[a]	0.001	0.055
OM	4.50[c]	4.56[c]	4.65[bc]	4.79[ab]	4.96[a]	0.001	0.049
CP	0.448[e]	0.520[d]	0.590[c]	0.670[b]	0.743[a]	0.001	0.009
NDF	3.00	2.95	2.92	2.92	2.96	0.616	0.039
ADF	1.84	1.82	1.80	1.80	1.83	0.674	0.025
ME, MJ	37.8[d]	39.8[cd]	41.4[bc]	43.9[ab]	45.0[a]	0.001	0.662
DM/LW, %	2.36[c]	2.39[bc]	2.43[bc]	2.50[ab]	2.59[a]	0.001	0.025

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ME: metabolizable energy, LW: live weight. CP210, CP245, CP280, CP315 and CP350: crude protein at 210, 245, 280, 315 and 350 g/100kgLW. [a, b, c] values with different superscript letters within one row are significantly different at the level of 5%.

Apparent nutrient digestibility and daily weight gain

The result of Table 3 showed that the CP350 treatment (57.7%) was higher DM digestibility (P<0.05) than CP210 treatment (52.9%) but it was not different (P>0.05) compared to CP315, CP280 and CP245 treatments (58.1, 56.3 and 55.0%, respectively).

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The DM digestibility in the present study was lower than reported by Pimpa et al. (2019), who found that DM digestibility of Wagyu crossbred cattle in Thai Lan being 58.5-62.7%. In our study, the NDF and ADF digestibility were not (P>0.05) among treatments and they were about 55.6-58.3% and 48.8-51.9%, respectively. Seankamsorn and Cherdthong (2020) reported that NDF digestibility of Wagyu crossbred cattle in Thailand was about 53.0-56.4%. However, the rumen digestibility converts rice straw and elephant grass protein of roughage into the microbial protein of high biological value (Liu et al., 2019). The CP digestibility was different (P<0.05) among treatments. It was 58.8, 62.9, 67.2, 71.7 and 72.8% for CP210, CP245, CP280, CP315 and CP350 treatments. However, CP280 treatment was not significantly different (P>0.05) compare to CP245, CP315 and CP350 treatments. Although nitrogen available for rumen microbes for their growth and cell activities is equally vital, by-pass protein is advantageous for the host ruminant to receive good quality protein directly from the diet (Ngu et al., 2019). Because a high percentage of rumen undegradable protein sources can improve host protein utilization. Moreover, Sari et al. (2018) reported that higher digestibility of CP means the total amount of CP content that can be digested in the digestive tract. The CP digestibility (%) was increased as the offer level of protein was increased. A result digestible CP (kg/animal/day) was significantly different (P<0.05) among treatments. It was 0.226, 0.332, 0.397, 0.483 and 0.541 kg corresponding to CP210, CP245, CP280, CP315 and CP350 treatments. To our knowledge, the CP of soybean extraction meal is by-pass protein, which is advantageous for the host ruminant to receive good quality protein directly from the diet. Because protein will escape from fermentative processes increasing the total amino acid supply (from dietary sources and microbial cells) for more efficient digestion by mammalian enzymes in the small intestine (Preston and Leng, 2021). Besides providing a more protein diet, the daily weight gain was increased (P<0.05) among treatments. It was 579, 607, 645, 742, and 888 g/animal/day corresponding to CP210, CP245, CP280, CP315, and CP350 treatments. In another study, Vu (2019) found that daily weight gain of Wagyu crossbred cattle from 13 to 18 months of age being 411-577 g/animal/day.

Thus, increasing CP intake per 100 kg body weight from 210 to 350 g was improved nutrient intake, digestibility and daily weight gain. The CP intake was 245 g/100 kg BW which was potentially promising for applied studies in diets of crossbred beef cattle from 13 to 16 months of age.

Table 3 - Apparent nutrient digestibility and daily weight gain of cattle in different treatments in the experiment 1.

Item \ Treatments	CP210	CP245	CP280	CP315	CP350	P	SEM
Nutrient digestibility, %							
DM	52.9[b]	55.0[ab]	56.3[ab]	58.1[ab]	57.7[a]	0.029	1.076
OM	55.7[b]	57.6[ab]	58.9[ab]	60.8[a]	60.0[a]	0.020	0.957
CP	58.8[d]	62.9[cd]	67.2[bc]	71.7[ab]	72.8[a]	0.001	1.193
NDF	55.6	55.9	57.0	58.6	58.3	0.057	0.764
ADF	51.4	50.3	50.2	51.9	48.8	0.265	0.984
Body weight, kg							
Initial	209	208	207	207	206	0.618	1.582
Final	220	221	220	222	224	0.160	1.028
Daily weight gain, g	579[b]	607[ab]	645[ab]	742[ab]	888[a]	0.033	64.58

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, LW: live weight. CP210, CP245, CP280, CP315 and CP350: crude protein at 210, 245, 280, 315 and 350 g/100kgLW. [a, b, c] values with different superscript letters within one row are significantly different at the level of 5%.

Experiment 02: wagyu crossbred cattle from 17 to 20 months old

Feeds and feeding in the present study

The result in Table 4 showed that DM intake was not significantly different (P>0.05) among treatments. It was 6.57, 6.88, 6.70, 6.83 and 7.14 kg/animal/day for CP210, CP245, CP280, CP315 and CP350 treatments, respectively.

It was similar to that of 325 kg crossbred beef cattle reported by Filho et al. (2016) in Brazil being 6.10-7.57 kg DM with a daily weight gain of 0.5-1.0 kg/day. In a previous report, Thu (2010) recorded variation in DM intake of local cattle when the cattle received supplements having different levels of protein 150, 180, 210 and 240 g/100 kg BW. The DM intake per body weight ratio gradually increased from CP210 (2.11%) to CP350 (2.29%) and was not significantly different (P = 0.071) among the treatments. The results of the present study were similar to those of Mirattanaphra and Suksomba (2020), who report that DM/LW (%) was about 2.14-2.15% in Wagyu crossbred cattle. The daily CP intake was significantly different (P<0.05) among the treatments and increased for CP210, CP245, CP280, CP315, and CP230 treatments corresponding to 0.662, 0.758, 0.873, 0.983, and 1.094 kg/animal/day. The result in the experiments was higher than reported by Dung and Ngoan (2016) being 0.667-0.762 kg for crossbred beef cattle from 17 to 20 months of age. The ME consumption (MJ/animal/day) was significantly different (P<0.05) among treatments with the highest value for the CP350 treatment (63.7 MJ) and the lowest value for the CP210 treatment (51.0 MJ). While the CP245 treatment was not significantly different (P>0.05) with CP280 and CP315 (54.3, 57.7 and 59.6 MJ, respectively). The ME intake in our study was in agreement with that presented by Filho et al. (2016) (53.6-72.0 MJ/animal/day).

Our study confirmed that the increasing level of CP from 210 to 350 g/100 kg BW affects feed consumption and tended to improve protein and estimated dietary metabolism energy.

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Table 4 - Feed and nutrient intake of experimental crossbred beef cattle in the experiment 2.							
Item / Treatments	CP210	CP245	CP280	CP315	CP350	P	SEM
Feed intake, kg DM/animal/day							
Elephant grass	0.70	0.70	0.70	0.70	0.70	-	-
Rice straw	4.34	4.44	3.93	3.78	3.83	0.054	0.128
Concentrate	1.03	1.03	1.03	1.03	1.03	-	-
Soybean meal	0.49[e]	0.71[d]	1.04[c]	1.32[b]	1.57[a]	0.000	0.032
Intake, kg DM/animal/day							
DM	6.57	6.88	6.70	6.83	7.14	0.070	0.116
OM	5.84[b]	6.13[ab]	5.99[ab]	6.12[ab]	6.40[a]	0.039	0.101
CP	0.662[e]	0.758[d]	0.873[c]	0.983[b]	1.094[a]	0.001	0.012
NDF	4.00	4.13	3.83	3.79	3.88	0.308	0.083
ME, MJ	51.0[c]	54.3[bc]	57.7[ab]	59.6[ab]	63.7[a]	0.001	1.231
DM/LW, %	2.11	2.23	2.16	2.19	2.29	0.071	0.037

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ME: metabolizable energy, LW: live weight. CP210, CP245, CP280, CP315 and CP350: crude protein at 210, 245, 280, 315 and 350 g/100kgLW; [a, b, c] values with different superscript letters within one row are significantly different at the level of 5%.

Digestibility measurements and daily weight gain

The analysis statistics result of Table 5 showed that the difference (P<0.05) was found in the digestibility of DM, OM, and CP but NDF was not significantly different (P>0.05) among treatments.

The DM digestibility was significantly different (P<0.05) among treatments with the highest value at 62.5% (CP350 treatment) and the lowest value at 56.7% (CP210 treatment). However, no difference was found that from CP245 to CP350 treatments (56.9, 61.5 and 61.2%, respectively). The digestibility of OM was a different increase (P<0.05) from CP210 to CP350 treatment. It was 58.5, 58.7, 63.4, 63.3, and 64.4 % corresponding to CP210, CP245, CP280, CP315, and CP350 treatments. The highest CP digestibility of CP350 treatment (P<0.05) as compared to CP315, CP280, CP245, and CP210 treatments (80.2, 77.4, 73.1, 70.5, and 65.0%, respectively). However, there were no significant differences (P<0.05) between CP245, CP280 and CP315 treatments. In another study, Thu and Dong (2015) recorded variation in CP digestibility of Sind crossbred cattle (52.3% to 70.5%) when the cattle received having different levels of protein from 140, 170, 200, and 230 g per 100 kg live weight. According to Dong and Thu (2020), the transformation of feed protein into body protein is an important process of nutrition and metabolism. Moreover, Sari et al. (2018) reported that higher digestibility of CP means the total amount of CP content that can be digested in the digestive tract. The NDF digestibility was not significantly different (P>0.05) among treatments and it was about 56.9-61.4%. However, the rumen digestibility converts rice straw and elephant grass protein of roughage into microbial protein of high biological value (Liu et al., 2019). In the second study, increasing CP levels per 100 kg live weight could rise daily weight gain for Wagyu crossbred cattle. It was 597, 713, 730, 862, and 876 g/animal/day corresponding to CP210, CP245, CP280, CP315, and CP350, respectively. However, no difference was found from 245 to 315 g CP/100 kg body weight.

Table 4 - Apparent nutrient digestibility (%) and daily weight gain of crossbred beef cattle in the experiment 2.							
Item / Treatments	CP210	CP245	CP280	CP315	CP350	P	SEM
Digestibility, %							
DM	56.7[b]	56.9[ab]	61.5[a]	61.2[a]	62.5[a]	0.008	0.881
OM	58.5[b]	58.7[ab]	63.4[a]	63.3[a]	64.4[a]	0.008	1.040
CP	65.0[c]	70.5[bc]	73.1[b]	77.4[ab]	80.2[a]	0.000	1.371
NDF	56.9	58.9	60.9	60.1	61.4	0.114	1.170
Body weight, kg							
LW Initial	306	304	304	304	304	0.783	1.551
LW Final	319	319	319	322	323	0.512	1.735
Daily weigh gain, g	597[b]	713[ab]	730[ab]	862[a]	876[a]	0.016	48.50

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, LW: live weight. CP210, CP245, CP280, CP315 and CP350: crude protein at 210, 245, 280, 315 and 350 g/100kgLW. [a, b, c] values with different superscript letters within one row are significantly different at the level of 5%.

CONCLUSION

Increasing CP intake per 100 kg body weight from 210 to 350 g was gradually improved nutrient intake, digestibility and daily weight gain. The CP intake was 245 g per 100 kg BW of Wagyu crossbred cattle from 13 to 20 months of age could be recommended for farmers' application.

DECLARATIONS

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Authors' contribution

Nguyen Binh Truong contributes on data analysis and the write up of the manuscript. Truong N.B and Trung TT conceived and designed the experiments; Truong N.B performed the experiments; Truong N.B analyzed the data; Truong N.B and Trung TT wrote the paper.

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Competing interests

Authors declared no conflict of interest.

Consent to publish

All authors reviewed and approved the final manuscript.

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