Asian J Agric & Biol. xxxx(x).
DOI: 10.35495/ajab.2021.420

AJAB

Original Article

Influence of dietary neutral detergent fiber on feed intake and nutrient digestibility of crossbred Black Angus cattle

Nguyen Binh Truong[1,2*], Tran Trung Tuan[1,2]
[1]An Giang University, An Giang, Vietnam
[2]Vietnam National University, Ho Chi Minh City, Vietnam

Received:
December 31, 2021
Accepted:
August 31, 2022
Published Online:
November 12, 2022

Abstract

The objective of this experiment was to evaluate different neutral detergent fiber (NDF) levels affected on the feed intake and nutrient digestibility of crossbred beef cattle. Four male F_1 (Black Angus x Zebu cross) cattle at 20.5±1.21 (Mean±SD) months of age with average body weight of 299±12.1 kg were used in a 4x4 Latin square design (fourteen days per each period). The treatments were 47% (NDF47), 51% (NDF51), 55% (NDF55), and 59% (NDF59) NDF in diets. The results showed that the dry matter (DM), organic matter (OM), and crude protein (CP) intake were not different (P>0.05) among treatments. However, both NDF and acid detergent fiber (ADF) consumption were lower for NDF 47 than NDF59 treatments (P<0.05), while metabolizable energy was highest for NDF47 compare with NDF59 treatment (P<0.05). The DM digestibility was higher (P<0.05) for the NDF47 (65.3%) compared with NDF59 (57.5%), while NDF47 was similar (P>0.05) to NDF51 (62.4%), and NDF55 (59.4%) treatments. The data for CP, NDF, and ADF digestibility were similar (P>0.05) among treatments. However, there was tended to be lower in NDF59 than NDF47 treatments. The daily weight gain was 866, 821, 786, and 686 g/animal/day for treatments of NDF47, NDF51, NDF55, and NDF59, respectively. While, feed conversion ratio was lower for NDF47 and higher for NDF59 treatments (P>0.05). The conclusion in the present study was 55% NDF in diet could be properly recommended for farmers' practice in terms of feed utilization.

Keywords: Neutral detergent fiber, Rumen digestibility, Crossbred beef cattle

How to cite this:

Truong NB and Tuan TT. Influence of dietary neutral detergent fiber on feed intake and nutrient digestibility of crossbred Black Angus cattle. Asian J. Agric. Biol. xxxx(x): 2021420. DOI: https://doi.org/10.35495/ajab.2021.420

Corresponding author email:
nbtruong@agu.edu.vn

Introduction

Crossbred beef cattle were produced by artificial insemination between Zebu crossbred with sire breeds such as Angus, Charolais, Wagyu, etc. (Vu et al., 2021); and the crossbred cattle had higher growth performance than Zebu crossbred (Truong, 2021). However, ruminant animals can use locally available forage, as rumen microorganisms can break fibrous materials into simple chemical compounds which are either used by microbes or absorbed into the body (Dong and Thu, 2020). However, crossbred beef cattle fed traditionally by the local people would not be suitable for high-produced beef cattle. Forage contained with a high level of the cell wall or neutral detergent fiber were digested slowly and promoted low voluntary feed intake reported by Tham and Udén (2013). According to Rahman et al. (2009), the digestibility of NDF in diet improved and as result, live weight gain was increased. In Vietnam, studies on NDF levels in the diets of crossbred beef cattle are still limited. In a previous *in vitro* study, Truong and Thu (2020) reported that there was a negative relationship between increasing the levels of dietary NDF from 35 to 65% and digestibility of OM and NDF; and the level from 47 to 59% NDF content in diets could reasonably be tested for the upcoming study of *in vivo* and growth performance. However, the nutrient requirements of beef cattle were different for each period of the age. This is the reason that the experiment was conducted to test the hypothesis. The aims of the experiment were to determine the daily feed intake and apparent digestibility of nutrients of different levels of NDF on Black Angus crossbred from 21 to 23 months old.

Material and Methods

Location and time

The study was conducted in Viet Nam at Sau Duc cattle farm, which was located in Tri Ton district of An Giang province (10°29'33.6"N 104°49'05.4"E), and samples were analyzed at the laboratory E205 of the Department of Animal Science, College of Agriculture, Can Tho University from May to August 2021.

Experimental design

Four crossbred male F1 (Black Angus x Zebu crossbred) cattle at 20.5±1.21 months of old (Mean±SD) with average body weight of 299±12.1 kg. The experiment followed a Latin Square design with four treatments (NDF levels) and elaborate four periods (14 days/period). The different levels of NDF in the diet including 47, 51, 55, and 59% corresponding to NDF47, NDF51, NDF55, and NDF59 treatments based on the study results of Truong and Thu (2020). The dietary CP content was calculated by the suggestion of Thu and Dong (2015) and the nutrient requirements of ruminants in developing countries by Kearl (1982). The composition of feeds used in the present study showed in Table 1; ingredient proportion and chemical composition of the experimental diets presented in Table 2.

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

Item	DM	OM	CP	NDF	ADF	Ash
Elephant grass	16.5	90.0	9.02	64.9	40.7	10.0
O. turpethum vines	13.4	89.6	13.9	37.1	31.2	10.4
Rice straw	84.2	88.5	5.18	69.5	40.9	11.6
Soybean meal	84.7	93.6	42.5	18.5	14.4	6.40
Concentrate	88.1	90.0	15.7	19.1	12.9	10.0
Rice bran	88.7	88.9	9.47	26.4	18.2	11.1
Broken rice	88.8	99.7	8.03	6.65	1.84	0.35
Urea	99.4	-	286	-	-	-

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

Table -2. Ingredient and chemical composition (%DM) of the experimental diets.

Item	Treatments			
	NDF47	NDF51	NDF55	NDF59
Ingredient composition, DM%				
Elephant grass	10.0	10.0	9.93	9.89
O. turpethum vines	38.0	25.1	12.4	-
Rice straw	33.0	45.7	58.2	70.9
Soybean meal	-	2.00	2.98	5.96
Concentrate	19.0	17.0	15.9	12.5
Urea	-	0.230	0.537	0.686
Total	100	100	100	100
Chemical compositions, DM%				
DM	24.7	30.5	39.7	56.2
OM	92.1	92.3	92.4	92.7
CP	11.4	11.4	11.4	11.4
NDF	47.1	51.0	54.9	58.9
ADF	31.0	32.5	34.0	35.5

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% (DM basis).

Feed ingredients used for diets formulation were elephant grass was planted in the cattle farm, rice straw and *O. turpethum* vines were bought in the farmers' surrounding the farm. While the concentrate was formulated (% in DM basis) from rice bran (51.7), broken rice (20.8), soybean meal (24.7), dicalcium phosphate (1.14), salt (1.14), premix vitamins, and minerals (0.57). Urea and extra soybean meal were used to fix the dietary CP content of 11.4 %. The fixed quantities of feed supplements were daily offered to the animals two times at 7:00 am and 1:00 pm. Elephant grass and *O. turpethum* vines were supplied at a level in diets at 8:00 am and 2:00 pm, *ad libitum* rice straw. The crossbred beef cattle were individually penned, and water was available at all times. Before the start of this study, each animal was treated for external and internal parasites (Ivermectin and given Albendazole, respectively).

Measurements taken

Feeds, nutrient and energy intakes

Samples of feed, refusal, and feces were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), and ash following the standard method of AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed following the methods of Van Soest et al. (1991). Determination of metabolizable energy (ME) in the diets was calculated by the method of Bruinenberg et al. (2002), in which ME (MJ/head/day) = 15.1*DOM (with DOM/DCP>7.0; where: 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 collected and weighed daily according to McDonald et al. (2010). In this study, each experiment period was 14 days. The first seven days were for adaptation to the experimental diets and the last seven days were for collecting and dissecting samples.

Daily weight gains (DWG) and feed conversion ratio (FCR)

Cattle were weighed for 3 consecutive days in the early morning before feedings at the beginning and the end of each experimental period by an electronic scale (Model TPSDH, YAOHUA, Taiwan).

The feed conversion ratio was calculated by dividing the average DM intake by the DWG of each crossbred cattle.

Statistical analysis

The data were analyzed by analysis of variance using the ANOVA of General Linear Model (GLM) of Minitab Reference Manual Release 16.0 (Minitab, 2010). The statistical equation for this model was $Y_{ijk} = \mu + N_i + A_j + P_k + e_{ijk}$; where: Y_{ijk}: observation from crossbred beef cattle, N_i: effect of NDF levels (i = 1, 2, 3, 4), A_j: the effect of cattle (j = 1, 2, 3, 4); P_k: the effect of period (k = 1, 2, 3, 4), and e_{ijk}: residual effect. Then, the paired comparison of two treatments, Tukey test of the Minitab was used (α=0.05).

Results and Discussion

Feed, nutrient, and ME intakes of experimental beef cattle.

Feeds, nutrients and metabolizable energy intakes of crossbred beef cattle in different treatments are shown in Table 3.

Table-3. Total nutrient intake of crossbred cattle by different treatments

Items	Treatments				P	SEM
	NDF 47	NDF 51	NDF 55	NDF 59		
Dry matter intake of feed, kg/day						
O. turpethum vines	2.39	1.60	0.79	-	0.000	0.019
Elephant grass	0.77	0.78	0.78	0.79	0.622	0.006
Rice straw	2.13	2.91	3.69	4.36	0.000	0.059
Concentrate	1.25	1.13	1.06	0.87	0.000	0.008
Soybean meal	-	0.130	0.196	0.394	0.000	0.004
Urea	-	0.014	0.034	0.042	0.000	0.001
Nutrient intake, kgDM/animal/day						
DM	6.55	6.56	6.57	6.45	0.620	0.071
OM	5.85	5.85	5.83	5.71	0.419	0.063
CP	0.710	0.719	0.720	0.723	0.597	0.007
NDF	3.11[c]	3.37[b]	3.62[a]	3.80[a]	0.000	0.043
ADF	2.09[b]	2.17[ab]	2.25[a]	2.28[a]	0.010	0.026
DM/BW, %	2.06	2.06	2.05	2.01	0.153	0.015
CP/100 kg BW	0.224	0.225	0.225	0.225	0.573	0.001
NDF/100 kg BW	0.98[d]	1.06[c]	1.13[b]	1.18[a]	0.000	0.009
ME, MJ	58.0[a]	55.1[ab]	52.7[ab]	49.7[b]	0.045	1.575

Note: DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ME: metabolizable energy (MJ/kg DM), BW: body weight. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter. [a, b, c] Means within rows with different letters were differ (P<0.05).

The results in Table 3 showed that the nutrient intake was not different (P>0.05) among treatments but NDF, ADF and ME were different (P<0.05) between NDF groups.

The DM intake was not different (P>0.05) among treatments and ranged 6.45-6.57 kg/animal/day. It was similar to the results on crossbred beef cattle of Kearl (1982) which reported that 6.0-7.0 kg DM for 0.50-

0.75 kg average weight gain. The CP intake of crossbred beef in this experiment was similar (P>0.05) among NDF groups and ranged from 0.710 to 0.723 kg/animal/day. Peng et al. (2018) reported that the CP was intermediate for genotype expression and muscle formation for the breed, it is necessary to respond to enough protein in the diet to improve growth performance. The CP in this study was similar to the results of Kearl (1982) who reported 0.705-0.780 kg for 0.50-0.75 kg daily weight gain.

The NDF consumption (kg/animal/day) was higher (P<0.05) for NDF59 treatment (3.80 kg) than NDF47 treatment (3.11 kg). Similarly, the ADF intake was different (P<0.05) among treatments, the highest value for NDF59 treatment (2.28 kg) and the lowest value for NDF47 treatment (2.09 kg). The NDF intake in this study was similar to the findings of Porsch et al. (2018) who reported that the daily NDF consumption of crossbred cattle (312 kg) was about 2.92 to 3.38 kg. The ME intake in this study was different (P<0.05) among treatments. It was 58.0, 55.1, 52.7 and 49.7 MJ/animal/day corresponding to NDF47, NDF51, NDF55 and NDF59 treatments, respectively. While, NDF47 and NDF55 were not different (P>0.05) in this study. The ME in this present study was lower than the result of ME intake which ranged from 56.1 to 62.6 MJ/crossbred cattle/day reported by Kearl (1982). However, It was similar to the finding of Kongphitee et al. (2018), who reported that ME consumption was decreased by increasing levels of NDF in the diets from 45.2 to 63.2%.

Although, increasing the level of NDF from 47 to 59% in diets did not affect CP intake per 100 kg body weight (0.224-0.225 kg) but the proportion of DM intake per 100 kg body weight tended to be higher (P>0.05) in NDF47 than in NDF59 treatments (2.06 and 2.01%, respectively). When the NDF content of diets increases and feed intake was reduced. The result of this study suggests that the main factor of feed intake regulation was NDF (Tham and Udén, 2013). Moreover, Brandao and Faciola (2019) reported that highly productive animals maybe require less than 58% NDF in diets.

In short, Table 3 showed that the NDF intake of NDF59 treatment was higher than NDF47 treatment (P<0.05). Moreover, the increasing NDF levels have not a better ME intake of beef cattle and DM/BW.

Nutrient digestibility and digestible nutrient of experimental cattle

The nutrient digestibility and digestible nutrients of experimental crossbred beef cattle are shown in Table 4.

Table-4. Nutrient digestibility and digestible nutrient of experimental beef cattle

Items	Treatments				P	SEM
	NDF47	NDF51	NDF55	NDF59		
Nutrient digestibility, %						
DM	65.3[a]	62.4[ab]	59.4[ab]	57.5[b]	0.020	1.277
OM	65.6[a]	62.5[ab]	59.6[ab]	57.6[b]	0.023	1.340
CP	68.5	66.7	66.3	65.3	0.652	1.782
NDF	63.6	61.1	60.5	57.4	0.220	1.823
ADF	56.0	51.5	50.0	49.6	0.210	2.054
Digestible nutrient, kg/animal/day						
DM	4.28	4.09	3.92	3.71	0.057	0.115
OM	3.84[a]	3.65[ab]	3.49[ab]	3.29[b]	0.045	0.104
CP	0.487	0.480	0.478	0.472	0.934	0.016
NDF	1.97	2.06	2.19	2.18	0.172	0.069
ADF	1.17	1.11	1.13	1.13	0.895	0.053

Note: DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter [a, b, c] Means within rows with different letters were differ (P<0.05).

Both digestibility and digestible value (DM and OM) were different (P<0.05) among treatments but no difference (P>0.05) was observed for NDF, ADF, and CP.

The DM digestibility of NDF47 treatment (65.3%) was higher than NDF59 (57.5%), but it was not different compared with NDF51 (62.4%) and NDF55 treatments (59.4%). Konka et al. (2015) observed that increasing NDF from 55.4 to 66.2% in the diets, reduced DM digestibility from 57.8% to 55.5%. Besides, the OM digestibility was different (P<0.05) among treatments. It was 65.6, 62.5, 59.6 and 57.6 % corresponding to NDF47, NDF51, NDF55 and NDF59 treatments. In this study, OM digestion was a major component to reflect on nutrient digestibility of diets, which is in agreement with Truong and Thu (2020) who demonstrated that NDF levels in diets are the main limit for OM digestibility from NDF different sources. Although digestibility of DM and OM decreased with decreasing levels of *O. turpethum* vines. However, no differences were found in NDF47, NDF51, and NDF55 treatments during the experimental period.

The CP digestibility was not affected (P>0.05) by the treatments and ranged from 65.3 to 68.5%. An increasing level of NDF in the diets from 47 to 59% did not affect (P>0.05) NDF and ADF digestibility. However, both NDF and ADF digestibility tended to be lower in NDF59 (57.4 & 49.6%) than NDF47 treatments (63.6 & 56.0%, respectively). In another study by Konka et al. (2015), due to increasing levels of NDF in the diets from 55.4% to 66.2% and as a result, NDF digestibility (%) was decreased from 54.2 to 53.2%.

In the current study, the DM digestible value (kg/animal/day) tended to be lower (P=0.057) in NDF59 (3.71 kg) treatment than NDF47 (4.28 kg) treatments, however, there were not different (P>0.05) among NDF47, NDF51 (4.09 kg) and NDF55 (3.92 kg) treatments. The digestible OM of treatment (kg/animal/day) decreased from the NDF47 (3.84 kg) to NDF59 (3.29 kg) and were significantly different (P<0.05) among the treatments but NDF47, NDF51 (3.65 kg), and NDF55 (3.49 kg) were not different in this study. The above results explained that NDF47 had higher ME consumption than NDF59 treatment from a calculator by Bruinenberg et al. (2002). Based on rumen fermentation characteristics, the digestibility of treatments was decreased by increasing NDF levels in the diets. Increasing NDF levels in the cattle diets led to reducing DM and OM digestibility (P<0.05); however, NDF55 treatment was not different (P>0.05) with NDF47 and NDF51 treatments.

Daily weight gain and feed conversion ratio

The daily weight gain and feed conversion ratio of NDF levels are presented in Table 5.

Table-5. Daily weight gain and feed conversion ratio of cattle in different treatments

Items	Treatments				P	SEM
	NDF47	NDF51	NDF55	NDF59		
Body weight, kg/animal						
Initial	312	314	315	316	0.673	2.571
Final	324	325	326	326	0.931	2.363
DWG, g/animal/day	866	821	786	686	0.669	103.7
Feed conversion ratio, kg						
DM	7.92	10.3	10.2	10.8	0.682	1.772
CP	0.86	1.13	1.12	1.21	0.635	0.195
NDF	3.76	5.29	5.60	6.37	0.327	0.920

Note: DM: dry matter, CP: crude protein, NDF: neutral detergent fiber, DWG: daily weight gain. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter.

Daily weight gain (DWG) of crossbred beef cattle in this study was similar (P>0.05) among treatments. However, the DWG (g/animal/day) decreased slightly from the NDF47 (866 g) to NDF51 (821 g), NDF55 (786 g), and NDF59 treatments (686 g). Subepang et al. (2019) reported that the DWG of male crossbred beef cattle was 0.80 kg/animal/day in the 51.9% NDF diet.

The DM conversion ratio of NDF47 treatment (7.92 kg) was lower than (P>0.05) NDF51 (10.3 kg), NDF55 (10.2 kg) and NDF59 treatments (10.8 kg). In another study, Truong and Preston (2021) reported that the feed conversion ratio of crossbred beef cattle was around 7.98-13.6 kgDM. The NDF conversion ratio was similar (P>0.05) among treatments. It was 3.76, 5.29, 5.60, and 6.37 kg NDF/kg DWG corresponding to NDF47, NDF51, NDF55, and NDF59 treatments. In short, daily weight gain was reduced from NDF47 to NDF51, NDF55, and NDF59 treatments. The feed conversion ratio at NDF59 treatments was higher than NDF47 treatment.

Overall, the DM/BW (%) of the NDF59 treatment was lower than other treatments. The daily ME of NDF47 treatment was higher than NDF59 treatment but NDF47, NDF51 and NDF55 treatments were not different in this study. The difference NDF in the diets affected nutrient digestibility and digestible value in crossbred Black Angus cattle. In detail, DM and OM digestibility decreased (P<0.05) from NDF47 to NDF59 treatments. Nutritionally, highly productive animals probably needed diets containing NDF lower than 58% (Brandao and Faciola, 2019). According to Harper and McNeill (2015), the higher NDF content in the diet can be considered a more feasible target in the tropical cattle system. In tropical developing countries, the high fiber diets are usually applied for cattle due to the utilization of locally available forages with low feed costs.

Conclusion

An increase in dietary NDF from 47% to 59% reduced intake, ruminal digestibility of DM and OM. The dietary NDF level of 55% was recommended for crossbred Black Angus cattle from 21 to 23 months of old.

Acknowledgement

The Author thanks private SD cattle farm, the Department of Animal Sciences of the College of Agriculture, Can Tho University for facilitating the equipment and laboratory work of the experiment.

Disclaimer: None.
Conflict of Interest: None.
Source of Funding: This research was funded by An Giang University, Vietnam.

References

AOAC, 1990. Official methods of analysis (15th edition). Washington. DC. Volume 1: 69-90

Brandao VL and Faciola AP, 2019. Unveiling the relationships between diet composition and fermentation parameters response in dual-flow continuous culture system: a meta-analytical approach. Transl. Anim. Sci. 3(3): 1064-1075. DOI: 10.1093/tas/txz019.

Bruinenberg MH, Valk H, Korevaar H and Struik PC, 2002. Factors affecting digestibility of temperate forages from semi-natural grasslands. Grass and Forage Science. 57(3): 292-301. DOI: https://doi.org/10.1046/j.1365-2494.2002.00327.x.

Dong NTK and Thu NV, 2020. Effects of dietary protein sources on feed and nutrient intake, digestibility and rumen parameters of growing Bach Thao goats. NIAS, 108: 43-49. Link: https://vcn.org.vn/xuat-ban/tap-chi-khoa-hoc-cong-nghe-chan-nuoi-so-108-thang-02-2020-journal-of-animal-science-and-technology-vol-108-february-2020

Harper KJ and McNeill DM, 2015. The Role iNDF in the Regulation of Feed Intake and the Importance of Its Assessment in Subtropical Ruminant Systems (the Role of iNDF in the Regulation of Forage Intake) – Review. Agriculture 2015. 5: 778-790. DOI: 10.3390/agriculture5030778.

Kearl LC, 1982. Nutrient requirements of ruminants in development countries, International feedstuffs institute Utah Agricultural experiment station. Utah State University. Loga, Utah, USA. Google Scholar ; CAB Direct.

Kongphitee K, Sommart K, Phonbumrung T, Gunha T and Suzuki T, 2018. Feed intake, digestibility and energy partitioning in beef cattle fed diets with cassava pulp instead of rice straw. Asian-Australasian J. Anim. Sci. 31(9): 1431-1441. Link: https://doi.org/10.5713/ajas.17.0759.

Konka RK, Dhulipalla SK, Jampala VR and Arunachalam R, 2015. Evaluation of crop residue based complete rations through *in vitro* digestibility. J. Adv. Vet. Anim. Res. 2(1): 64-68. DOI: 10.5455/javar.2015.b50.

McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA and Wilkinson RG, 2010. Animal Nutrition (7th edition). Longman Scientific and Technical. N. Y. USA.

Minitab, 2010. Minitab Reference Manual. Release 16 for Windows, Minitab Inc, USA.

Peng HQ, Khan AN, Xue B, Yan HT and Wang SZ, 2018. Effect of different levels of protein concentrates supplementation on the growth performance, plasma amino acids profile and mTOR cascade genes expression in early-weaned yak calves. Asian-Australasian J. Anim. Sci. 31(2): 218-224. DOI: https://doi.org/10.5713/ajas.16.0999.

Porsch RV, Machado DS, Brondani IL, Cocco JM, Filho DCA and Oliveira LMD, 2018. Nitrogen sources associated with different physical forms of corn grain in the diet for steers in feedlot. Acta Sci., Anim. Sci. 40: 1-8. DOI: 10.4025/actascianimsci.v40i1.42541

Rahman MM, Akbar MA, Islam KMS, Khaleduzzaman ABM and Bostami ABMR, 2009. Nutrient digestibility and growth rate of bull calves fed rice straw treated with wood ash extract. Bang. J. Anim. Sci. 38(1&2): 42-52.

Subepang S, Suzuki T, Phonbumrung T and Sommart K, 2019. Enteric methane emissions, energy partitioning, and energetic efficiency of zebu beef cattle fed total mixed ration silage. Asian-Australasian J. Anim. Sci. 32(4): 548-555. DOI: https://doi.org/10.5713/ajas.18.0433.

Tham HT and Udén P, 2013. Effect of water hyacinth (*Eichhornia crassipes*) silage on intake and nutrient digestibility in cattle fed rice straw and cottonseed cake. Asian-Australasian J. Anim. Sci. 26(5): 646-653. Link: http://dx.doi.org/10.5713/ajas.2012.12498.

Thu NV and Dong NTK, 2015. Effect of dietary crude protein levels supplemented by multi-nutrient cakes on feed intake, rumen parameters and nitrogen retention of Lai Sind cattle. CTUJSJ. 37(1): 11-17. Link: https://sj.ctu.edu.vn/ql/docgia/tacgia-1137/baibao-8121/doi-ctu.jvn.2015.077.html.

Truong NB and Preston TR, 2021. Soybean meal as source of rumen scape protein for fattening crossbred beef cattle. LRRD. 33 (10) 2021. Link: http://www.lrrd.org/lrrd33/10/33126nbtru.html

Truong NB and Thu NV, 2020. Effect of dietary levels of neutral detergent fiber (NDF) on in vitro organic matter and NDF digestibility with rumen fluid of beef cattle as an inoculum source. NIAS. 116(10.20): 34-41. Link: https://vcn.org.vn/xuat-ban/journal-of-animal-science-and-technology-vol-116-october-2020-tap-chi-khoa-hoc-cong-nghe-chan-nuoi-so-116-thang-10-2020.

Truong NB, 2021. Effects of dietary concentration levels on feed intake and nutrients digestibility in crossbred beef cattle. Online J. Anim. Feed Res. 11(6): 224-231. DOI: https://dx.doi.org/10.51227/ojafr.2021.33.

Van Soest PJ, Robertson JB and Lewis BA, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3598. DOI: https://doi.org/10.3168/jds.S0022-0302(91)78551-2

Vu DD, Quyen PV, Ngan HT, Hai DV, Van NT and Tho NTB, 2021. Appearance and growth performance of F1 crossbreds between Red Angus, BBB and Black Wagyu bulls with Zebu crossbred cows at Ho Chi Minh city. NIAS, 125: 13-21. Link: https://vcn.org.vn/xuat-ban/tap-chi-khoa-hoc-cong-nghe-chan-nuoi-so-125-thang-7-2021.

Contribution of Authors

Truong NB: Conceived and designed the field trials, analyzed the data and wrote manuscript
Tuan TT: Reviewed literature and wrote manuscript