International Journal of Agriculture and Biosciences 2024 13(1): 34-38.
https://doi.org/10.47278/journal.ijab/2024.084

RESEARCH Article
eISSN: 2306-3599; pISSN: 2305-6622

The Difference of Neutral Detergent Fiber in the Diet of Charolais Crossbred Cattle on Feed Consumption and Nutrient Digestibility Over 13–16 Months

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ABSTRACT

This study was conducted to further establish the effects of neutral detergent fiber (NDF) levels in Charolais crossbred cattle from 13 to 16 months on feed intake and digestibility of nutrients. Four male Charolais crossbred cattle at 13 months old (227±36.5 kg) were bred in a 4x4 Latin square design (21 days for each period) to evaluate the effects of rations with increasing NDF levels 43, 47, 51, and 55% DM (NDF43, NDF47, NDF51, and NDF55 treatments, respectively). It was shown that crude protein intake (%DM) was unaffected by diets, but dry matter consumption was higher in NDF43 treatments (6.30 kg DM). NDF intake increased from NDF43 to NDF55 treatments. It was 2.74, 2.88, 2.86, 3.01 kg. Total metabolism energy was highest (P<0.05) on the NDF43 and lowest on the NDF55 treatments (58.7 and 44.6 MJ/cattle/day, respectively). Nutrient digestibility decreased from NDF43 to NDF55 treatments. As a result, the amount digestible of DM and OM (3.07 & 2.94 kg) was lower in NDF55 than in NDF51, NDF47 and NDF43 treatments (3.19 & 3.04, 4.12 & 3.83, and 4.21 & 3.88, respectively). An observation of daily weight gain (g/cattle/day) was not different between treatments. It was 774, 734, 730 and 679 g corresponding to NDF43, NDF47, NDF51 and NDF55 treatments. Therefore, the decrease in NDF levels from 55 to 43% in the diet improved feed consumption, digestive nutrients, and weight gain. A level of 51% NDF could be recommended for the Charolais crossbred cattle diet for 13 to 16 months.

Keywords: Forage quality, Digestion, Rumen, Ruminants, Vietnamese breeds.

Article History
Article # 23-547
Received: 12-Dec-2023
Revised: 29-Dec-2023
Accepted: 11-Jan-2024

INTRODUCTION

Forage accounts for a greater proportion of beef cattle's diet than feed supplements. Because locally available low-cost forages are usually applied to beef cattle in tropical developing countries (Ghedini and Moura, 2021), economically feasible forages are in practice.

Also, feeding a calf is very important, how much and when the calf consumes it, how much and when it affects its growth. Breeding calves produces red meat. A calf's average daily weight gain is about 1,000 to 1,800 grams, its meat protein percentage is 21%, and its fat content is lower than sheep's meat, so calf breeding is particularly important in providing society with protein. Feed and nutrition are the most important issues in breeding. When the animal has maximum production, its needs are met by energy, protein, and other nutrients. In meat cattle farming, more than 60% of the current costs are related to food, and 25% are consumed to purchase lean calves (Udeh, 2021).

Types of cows are born with a four-part stomach. Calves live on their mother's protein-rich fat and milk at birth, and their stomach function is almost the same as that of single-stomach animals. Although these cows begin feeding on fresh fodder and other fodder, the other three parts of their stomach continue to grow and change to become one of the most efficient tools for converting fodder into protein and fat (Rinehart, 2008). Cows absorb as much nutrients as they can from fodder. Ruminants have a special gastric chamber with microorganisms that break down grass, hay, and other plants. The cows' abdomen, or specific stomach, allows them to feed on plants that other single-stomach animals cannot digest (Saha et al. 2021).

Beef cows need specific nutrients and the best livestock feed to grow and improve meat quality. Most cattle feed programs consist of different proportions of hay, grains, and different minerals to help cows grow and develop (McAllister et al. 2020). For example, during the transfer of cattle from open farms to feed before slaughter, they are given peeled corn. The meat is "sweetened" and added fat to make cutting easier.

So, the better the calves are fed and healthier, the more profitable the breeding profession will be. Therefore, breeding cattle farmers are advised to read this section

Cite this Article as: Truong NB, Trung NB and Hạnh NTB, 2024. The difference of neutral detergent fiber in the diet of charolais crossbred cattle on feed consumption and nutrient digestibility over 13–16 months. International Journal of Agriculture and Biosciences 13(1): 34-38. https://doi.org/10.47278/journal.ijab/2024.084

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carefully and use it in their cattle farming to maximize profitability and avoid common mistakes that reduce breeding calves' productivity (Phillips, 2018).

The use of high-fiber feeds in the diet will affect fiber digestibility by the rumen. However, neutral detergent fiber (NDF) is identified as the fibrous component in the feed cell wall, comprising polysaccharides such as hemicellulose, cellulose and lignin. It is the key metric for evaluating ruminant feed quality (Mertens, 2002). The previous study showed that increasing NDF in the diet from 47.0 to 59.0 percent had a decreased tendency for nitrogen retention, nutrient digestibility, and weight gain in crossbred beef cattle (daily) over 17 months of age. Hue (2010) says calves stress after weaning and recover at 9-12 months. Therefore, 13 months of age is a good period for cattle performance. Beef production in the Mekong Delta is currently developed with Charolais crossbred cattle. Feed quality affects cattle's nutrient supplements and forage digestibility.

Therefore, this study hypothesizes that dietary NDF levels influence feed intake and nutrient digestibility in Charolais crossbred cattle from 13 to 16 months.

MATERIALS & METHODS

Material and Breeding Facilities

The experimental calves were experimented on from March 2023 to June 2023 at the cattle farm of Hanh Cuong in Chau Thanh district of “An Giang province” and Laboratory no. E205 of the Agriculture University of Can Tho University, and also under ethical regulations of the committee of “Can Tho University for Animal Experiments.”

Experimental Design

A total of 4 male Charolais cattle (crossbred) at 13 months (weight range: 227±36.5 kg) were used in the Latin square design (4x4) with different levels of neutral detergent fiber in the diet, including 43, 47, 51 and 55% (NDF43, NDF47, NDF51 and NDF55, respectively). The ratio of ingredients in diets is shown in Table 1.

Feeds, Feeding and Performance of Animals

Elephant grass was developed on the farm, but rice straw and O. turpethum vines were bought from local farmers. In this study, the cattle collected feces advantageously and fed individually. Feed intake was determined daily by weighing the number of feeds offered and refused. Fixed quantities and percentages of concentrate, urea, and soybean meal were offered daily to the animals at 7 am and 1 pm. Forages, including O. turpethum vines, elephant grass, and rice straw, were given at 8 am, 10 am, 3 pm, 6 pm and 10. Water was available continuously, ad libitum.

Measurements

The feed analysis and leftovers adhered to the AOAC (1990) procedure, encompassing dry matter, organic matter and crude protein (DM, OM, CP, respectively). However, ADF (acid detergent fiber) and NDF (neutral detergent fiber) were determined according to the procedure of Van Soest et al. (1991). Additionally, the feeds' metabolizable energy (ME) content was computed using the formula proposed by Bruinenberg et al. (2002).

The apparent digestibility of DM, OM, CP, NDF, and ADF was assessed using the methodology recommended by Richards et al. (2021). The present study has four periods. Three weeks was an experimental period, including two weeks of dietary adaptation and sampling for a week. Water intake was weighed before feeding in the morning of each day.

Daily Weight Gain (DWG)

In the early morning before feedings of each experimental period at the beginning and end. The cattle were weighed (2 consecutive days) using an electrical scale (Tru-Test Limited Auckland, New Zealand) and calculated live weights.

Statistical Analysis

The experiment data was subjected to analyses of variance using the ANOVA method (GLM) with Minitab software version 20.3 (Kenett & Zacks, 2021). The statistical equation for the 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 NDF levels (i = 1 to 4), A_j: the effect of Charolais crossbred cattle (j = 1 to 4), P_k= the effect of period (j = 1 to 4), and e_{ijk} = the random error. The Tukey test of the Minitab (α = 0.05) compared the treatment mean.

RESULTS AND DISCUSSION

Feed Specification and Composition of an Experimental Dietary Regimen for Cows

Table 2 showed that O. turpethum vines (13.1%) had a higher CP than elephant grass (7.26%) and rice straw (5.53%). However, rice straw NDF (69.1%) was higher and lower than *O. turpethum* vines (36.8%). In another study, Don et al. (2020) showed that rice straw had CP (2.0-6.6%), NDF (66.3-73.2%), and ADF (36.3-42.6%). Rusdy (2016) reported that elephant grass nutrients were CP, NDF, and ADF, corresponding to 7.20-12.1%, 57.4-75.4%, and 30.6-51.7%. In this study, the supplements from soybean meal, rice bran, and broken rice were similar to another study. Dong and Thu (2020) suggested that soybean meal was 43.2% CP, 18.4% NDF, and 11.3% ADF. Thus, the NDF of *O. turpethum* vines is important for calculating NDF levels in diets.

Feed, Nutrient and ME Intakes of Charolais Crossbred Cattle

The nutrient intake was different (P<0.05) at DM, CP, ME and DMI/BW but not different (p>0.05) from other items. The DM consumption (kg/cattle/day) of NDF43 treatment (6.30 kg) was higher than (P<0.05) NDF55 treatment (5.38 kg). However, the NDF47 (6.07 kg) and NDF51 treatments (5.53 kg) were not different (P>0.05) from the NDF43 treatment. In detail, the DMI/BW (%) was different (P<0.05) among treatments. It was 2.47, 2.32, 2.13, and 2.09% corresponding to NDF43, NDF47, NDF51 and NDF55 treatments. Remarkably, Tham and Udén (2013) concluded that the NDF was a primary component of feed-regulated intake. According to Rotta et al. (2023), the crossbred cattle (*Bos taurus x Bos Indicus*) about 270 kg with a daily weight gain of 0.80 kg/day must be 6.40 kg DM. Although CP intake (g/cattle/day) was different (P<0.05) between treatments, the opposite CP/DMI (%) was not different (P>0.05) in this study. It was 12.5, 12.8, 12.6, and 12.7% (NDF43, NDF47, NDF51 and NDF55 treatments, respectively). The CP consumption in this study agreed with Garg et al. (2013), who reported that crossbred beef cattle (225 kg) need 0.502-0.784 kg/day for a daily weight gain of 0.25-1.10 kg/animal/day. Daily NDF intakes of Charolais crossbred cattle gradually increased from NDF43 to NDF55 treatments. They were not different (P>0.05) among the treatments, while ME consumption values in the present study were significantly different (P<0.05) in four treatments. It was 58.7, 57.9, 46.0, and 44.6 MJ/cattle/day (Fig. 1). It was shown that the increase in NDF of diets affected ME intake. In another study,

Table 1: The ratio of ingredients in diets (% DM basis).

Ingredient, %	NDF43	NDF47	NDF51	NDF55
O. turpethum vines	53.4	40.1	26.8	13.7
Elephant grass	12.0	12.0	11.9	11.9
Rice straw	14.5	27.7	40.8	53.8
Soybean meal	1.00	2.99	4.97	6.94
Concentrate	19.0	16.9	14.9	12.9
Urea	0.10	0.34	0.57	0.80
Total	100	100	100	100

Table 2: Chemical composition of feeds (% DM ; dry matter basis).

Feeds	DM %	DM %			
		OM	CP	NDF	ADF
O. turpethum vines	13.5	86.9	13.1	36.8	33.0
Elephant grass	15.2	89.6	7.26	61.1	40.4
Rice straw	83.9	93.3	5.53	69.1	40.9
Soybean meal	85.2	93.6	44.9	24.1	16.9
Rice bran	87.9	88.9	9.80	24.9	14.2
Broken rice	86.0	99.6	7.99	6.98	1.82
Concentrate	87.1	89.7	17.8	20.3	11.9
Urea	99.4	-	286	-	-

Table 3: The ratio of ingredients in diets (% DM basis).

Items	NDF43	NDF47	NDF51	NDF55	SEM	P
Dry mater intake, kgDM/cattle						
O. turpethum vines	2.64^{a}	1.96^{b}	1.11^{c}	0.48^{d}	0.085	0.001
Elephant grass	0.585	0.609	0.569	0.558	0.028	0.615
Rice straw	1.77^{c}	2.26^{bc}	2.72^{cb}	3.27^{c}	0.149	0.002
Soybean meal	0.072^{d}	0.181^{c}	0.272^{b}	0.357^{a}	0.014	0.001
Concentrate	1.22^{a}	1.03^{b}	0.82^{c}	0.67^{c}	0.034	0.001
Urea	0.013^{d}	0.021^{c}	0.032^{b}	0.042^{a}	0.002	0.001
Nutrient intake, kgDM						
DM	6.30^{a}	6.07^{ab}	5.53^{ab}	5.38^{b}	0.188	0.039
OM	5.63	5.44	4.99	4.88	0.172	0.062
CP	0.79^{a}	0.76^{ab}	0.70^{ab}	0.69^{b}	0.021	0.043
ADF	1.94	1.95	1.85	1.87	0.071	0.643
NDF	2.74	2.88	2.86	3.01	0.114	0.477
ME*, MJ	58.7^{a}	57.9^{ab}	46.0^{ab}	44.6^{b}	3.190	0.036
DMI/BW, %	2.47^{a}	2.32^{ab}	2.13^{ab}	2.09^{b}	0.062	0.017
CP/DMI, %	12.5	12.6	12.8	12.7	0.250	0.887
Water, kg	12.08	13.76	20.9	19.2	2.360	0.105
Output, kgDM/cattle						
Feces	2.11	1.94	2.34	2.31	0.264	0.699

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ME: metabolizable energy (MJ/kgDM), **Bruinenberg et al. (2002), BW: body weight. NDF43, NDF47, NDF51 and NDF55 treatment contained neutral detergent fiber at 43, 47, 51 and 55% based on dry matter: a,b,c,d; within a same row with different superscripts differ significantly (P≤0.05).

Table 4: Daily weight gain of cattle in the present study

Items	NDF43	NDF47	NDF51	NDF55	SEM	P
Initial BW, kg	248	249	251	250	1.760	0.694
Final BW, kg	264	265	266	264	1.430	0.767
BW gain, g/cattle/day	774	734	730	679	88.20	0.895

BW: body weight.

Kongphitee et al. (2018) concluded that increasing levels of NDF (45.2 - 63.2%) in the diets by ME intake decreased.

In short (Table 3), CP intake per DMI was not different, and NDF consumption increased between treatments. As a result, both DMI/BW (%) and ME intake were decreased in this study.

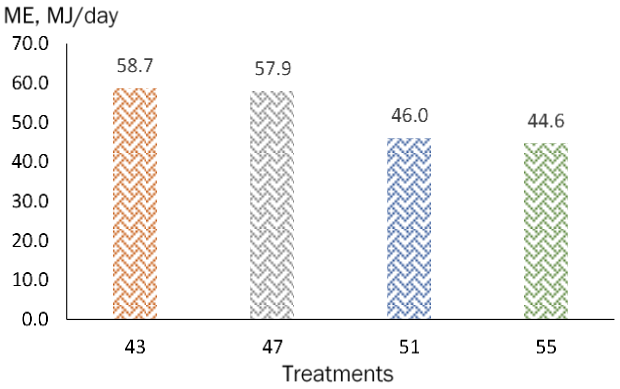

Fig. 1: ME consumption in present experiment.

Apparent Nutrient Digestibility of Charolais Crossbred Cattle

The nutrient digestibility did not vary (P>0.05) with different levels of NDF, but the opposition digestive nutrient was different (P<0.05) in the experiment goats.

The DM digestibility decreased from NDF43 to NDF47, NDF51, and NDF55 treatments (66.8, 67.9, 58.6 and 56.9%, respectively). Similarly, no significant difference (P>0.05) was observed for OM, CP, ADF, and NDF digestibility among diets. However, the nutrient digestibility of the NDF55 treatment was lower than the NDF51, NDF47 and NDF41 treatments. In another study, Konka et al. (2015) concluded that DM digestibility decreased from 57.8% to 55.5%, with the NDF in the diets from 55.4% to 66.2%. This study found that digestible nutrient is affected by the NDF levels. In detail, DM and OM of digestible were significantly (P<0.05) lower when fed on an NDF55 diet than on NDF51, NDF47, and NDF43 diets. The NDF55 treatments have higher fiber content than other treatments, which increases forage retention in the rumen. Moreover, the DMI/BW (%) in Table 3 of the NDF55 treatment is the lowest in the present study. NDF55 treatment had lower digestive CP than NDF51, NDF47, and NDF43 treatments (0.473, 0.490, 0.596, and 0.598 kg, respectively).

Table 5 determined that nutrient digestibility (%) was gradually reduced from NDF43 to NDF55 treatment (P<0.05). However, they differed significantly (P<0.05) among treatments with digestible nutrients; the NDF55 treatment was the lowest.

Daily Weight Gain (DWG) of Charolais Crossbred Cattle

The DWG of Charolais crossbred cattle gradually decreased from NDF43 to NDF55 and was not different (P>0.05) among the treatments (Table 4). At the same time, CP values for nutrient intake and digestive nutrients were similar (P>0.05) in different treatments. It was 774, 734, 730 and 679 g/cattle/day (NDF43, NDF47, NDF51, and NDF55, respectively), with 80% forage and 20% feed supplements in the diet. Moreover, the DWG in this study agreed with Subepang et al. (2019), who concluded that the 51.9% NDF diet of male crossbred beef cattle had a weight gain of 0.80 kg/day.

Overall, the DMI/BW (%) of the NDF55 treatment was lower than other treatments. The NDF43 treatment's ME intake is higher than the NDF55 treatment but not different from the NDF47 and NDF51 treatments. Feed intake and digestible value in Charolais crossbred cattle are affected by NDF diet differences. The cattle were highly productive and probably needed diets containing NDF lower than the 58% reported by Brandao and Faciola (2019). Moreover, the tropical cattle system can be considered a more feasible target with higher NDF content in the diet (Harper and McNeill, 2015).

Table 5: Nutrient digestibility (%) of cattle in present study

Items	NDF43	NDF47	NDF51	NDF55	SEM	P
Digestibility, %						
DM	66.8	67.9	58.6	56.9	3.700	0.180
OM	69.0	70.3	61.7	60.1	3.400	0.185
CP	75.6	78.4	71.0	68.3	4.000	0.359
ADF	58.5	59.2	51.4	51.6	4.330	0.466
NDF	65.6	65.2	58.6	60.3	4.090	0.568
Digestive nutrients, kg DM						
DM	4.21^{a}	4.12^{ab}	3.19^{ab}	3.07^{b}	0.249	0.032
OM	3.88^{a}	3.83^{ab}	3.04^{ab}	2.94^{b}	0.212	0.036
CP	0.596	0.598	0.490	0.473	0.033	0.067
ADF	1.143	1.163	0.931	0.956	0.105	0.345
NDF	1.80	1.88	1.66	1.81	0.139	0.714

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

Conclusion

Increasing NDF in the diet from 43.0 to 55.0% had a decreased tendency for feed intake, nutrient digestibility, digestive nutrients, and everyday weight gain of Charolais crossbred cattle from 13 to 16 months of age. This study shows that the 51% NDF in the diet was higher in forage utilization, nutrient digestibility, and promising application. The likely benefit will be increased fibrous roughage utilization and daily weight gain.

Authors' Contribution

Truong N.B conceived, designed and performed the experiments; Truong N.B analyzed the data; Truong N.B, Trung N.B and Hanh N.T.B wrote the paper; all authors reviewed and approved the final manuscript.

Conflict of interests

Authors declared no conflict of interest.

Acknowledgements

This research is funded by Vietnam National University HoChiMinh City (VNU-HCM) under grant number C2023-16-03. The Author thanks the private Hanh Cuong cattle farm, An Giang University (AGU) and Vietnam National University HoChiMinh City (VNU-HCM).

REFERENCES

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

Brandao, V. L., & Faciola, A. P. (2019). Unveiling the relationships between diet composition and fermentation parameters response in dual-flow continuous culture system: A meta-analytical approach. *Translational Animal Science*, *3*(3), 1064-1075.

Bruinenberg, M. H., Valk, H., Korevaar, H., & Struik, P. C. (2002). Factors affecting digestibility of temperate forages from seminatural grasslands: a review. *Grass and forage science*, *57*(3), 292-301.

Nguyen, D. V., Vu, C. C., & Nguyen, T. V. (2020). The current utilisation and possible treatments of rice straw as ruminant feed in Vietnam: A review. *Pakistan Journal of Nutrition*, *19*(3), 91-104.

Dong, N. T. K., & Thu, N. V. (2020). Effects of dietary protein sources on feed and nutrient intake, digestibility and rumen parameters of growing Bach Thao goats. *Journal of Animal Science and Technology*, *108*, 43-49.

Garg, M. R., Sherasia, P. L., Bhanderi, B. M., Phondba, B. T., Shelke, S. K., & Makkar, H. P. S. (2013). Effects of feeding nutritionally balanced rations on animal productivity, feed conversion efficiency, feed nitrogen use efficiency, rumen microbial protein supply, parasitic load, immunity and enteric methane emissions of milking animals under field conditions. *Animal Feed Science and Technology*, *179*(1-4), 24-35.

Harper, K. J., & McNeill, D. M. (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). *Agriculture*, *5*(3), 778-790

Hue, P.T. (2010). Performance and meat production of Lai Sind, F1 (Brahman x Lai Sind) and F_1 (Charolais x Lai Sind) cattle in Dak Lak. PhD thesis specialized in Agriculture, Faculty of Agriculture & Applied Biology, Hanoi University of Agriculture, Hanoi. Link: https://tailieumienphi.vn/doc/luan-an-tien-si-nong-nghiep-kha-nang-sinh-truong-san-xuat-thit-cua-bo-lai-sind-f-2tb8tq.html

Kongphitee, K., Sommart, K., Phonbumrung, T., Gunha, T., & Suzuki, T. (2018). Feed intake, digestibility and energy partitioning in beef cattle fed diets with cassava pulp instead of rice straw. *Asian-Australasian Journal of Animal Sciences*, *31*(9), 1431.

Konka, R. K., Dhulipalla, S. K., Jampala, V. R., Arunachalam, R., Pagadala, E. P., & Elineni, R. R. (2015). Evaluation of crop residue based complete rations through in vitro digestibility. *Journal of Advanced Veterinary and Animal Research*, *2*(1), 64-68.

McAllister, McAllister, T. A., Stanford, K., Chaves, A. V., Evans, P. R., de Souza Figueiredo, E. E., & Ribeiro, G. (2020). Nutrition, feeding and management of beef cattle in intensive and extensive production systems. In *Animal Agriculture* (pp. 75-98). Academic Press.

Richards, N., Nielsen, B. D., & Finno, C. J. (2021). Nutritional and non-nutritional aspects of forage. *Veterinary Clinics: Equine Practice*, *37*(1), 43-61.

Mertens, D. R. (2002, April). Measuring fiber and its effectiveness in ruminant diets. In *Proc. Plains Nutr. Cncl. Spring Conf. San Antonio, TX* (pp. 40-66).

Kenett, R. S., & Zacks, S. (2021). *Modern industrial statistics: With applications in R, MINITAB, and JMP*. John Wiley & Sons.

Ghedini, C. P., & de MOURA, D. C. (2021). Flaxseed meal feeding to dairy cows as a strategy to improve milk enterolactone concentration: a literature review. *Nativa*, *9*(4), 373-381.

Phillips, C. J. (2018). Principles of cattle production. CABI. https://www.cabdirect.org/cabdirect/abstract/20183281393

Rinehart, L. (2008). Ruminant nutrition for graziers. National Sustainable Agriculture Information Service (ATTRA). https://www.nrcs.usda.gov/wps/cmis_proxy/https/ecm.nrcs.usda.gov%3A443/fncmis/resources/WEBP/ContentStream/idd_F0999877-0000-C91F-A64D-559F64DA07CB/0/Ruminant+Nutrition+for+Graziers.pdf

Rotta, A. C. B. M., Prados, L. F., Marcondes, M. I., & de Campos, S. (2023). Protein and amino acids requirements for beef cattle. *BR-CORTE*, 201.

Rusdy, M. (2016). Elephant grass as forage for ruminant animals. *Livestock Research for Rural Development*, *28*(4), 1-6.

Saha, S. K., Pathak, N. N., Saha, S. K., & Pathak, N. N. (2021). Digestion, Absorption and Metabolism of Nutrients. *Fundamentals of Animal Nutrition*, 219-246.

Tham, H. T., & 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 journal of animal sciences*, *26*(5), 646.

Udeh, F. U. (2021). Beef and Dairy Cattle Production. *Agricultural Technology for Colleges*, 316.

Van Soest, P. V., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of dairy science*, *74*(10), 3583-3597.

Subepang, S., Suzuki, T., Phonbumrung, T., & Sommart, K. (2019). Enteric methane emissions, energy partitioning, and energetic efficiency of zebu beef cattle fed total mixed ration silage. *Asian-Australasian Journal of Animal Sciences*, *32*(4), 548. Link: https://doi.org/10.5713/ajas.18.0433