Jurnal Sain Peternakan Indonesia
Available at https://ejournal.unib.ac.id/index.php/jspi/index
DOI: https://doi.org/10.31186/jspi.id.19.1.21-29
P-ISSN 1978-3000
E-ISSN 2528-7109
Volume 19 Issue 1 January-March 2024

Different Dietary Fiber Stimulates Eating Behavior and Rumination Activity in Brahman Crossbred Calves

Nurmeiliasari [1*], A. H. K. Amrullah [1], Y. R. Ramadhan [1], J. Firison[2], and H. Kusnadi[2)]

[1]Animal Husbandry Study Program, Faculty of Agriculture Bengkulu University
Jl. WR Supratman Kandang Limun Bengkulu 38112, Indonesia
[2] Research Center for Animal Husbandry, National Research and Innovation Agency,
Bogor 16911, Indonesia
**Corresponding Author*: sari_nurmeiliasari@unib.ac.id
Revised: 2023-03-20, Accepted: 2024-03-26, Publish: 2024-03-30

ABSTRACT

Alteration in diet during a weaning period is often associated with changes in eating behaviour. This research evaluated the effect of providing different fibre sources on Brahman crossbred calves' eating behaviour and rumination activity. Ten Brahman crossbred calves aged eight weeks were randomly distributed into two dietary fibre treatments: COP = concentrate 40% + *Pennisetum purpureum* cv. Taiwan 60%; COM = concentrate 40% + *Pennisetum purpureum* cv. Taiwan 30% + *Gliricidia sepium* 30%). Feeding different dietary fibre changed the duration, percentage of eating time, and eating frequency ($P<0.05$). Of the 9 hours of observation, 45.62% of the time was allocated for eating *Pennisetum purpureum* cv. Taiwan. Less time was spent eating a combination of dietary fibres (44.31%). More frequent eating was observed in the COP group (20.88 times) than in the COM group (20.02 times). The treatments did not affect the drinking time ($P>0.05$). Providing a higher fibre diet in the COP group increased rumination frequency ($P<0.05$). However, it did not affect the duration and percentage of time of rumination during diurnal observation ($P>0.05$). In conclusion, feeding *Pennisetum purpureum* cv Taiwan as a dietary fibre during the weaning transition improves calves' eating behaviour and rumination activity.

Keywords: grass, legume, young calves, eating behaviour, rumination

INTRODUCTION

The dietary transition from liquid to solid can be stressful for a calf, which may lead to adverse effects on feed intake, health, and growth. Monitoring eating behaviour can help identify any issues due to dietary changes in young calves (Muhammad et al.,2015). During the transition from pre-ruminant to ruminant, calves exhibited significant changes in their feeding behaviour, which affects growth and development (Wang et al., 2022).

Dietary fibre plays a crucial role in ruminants' nutrition and overall health. Castells et al. (2015) reported that offering forage to a four-week calf succeeds in the weaning process and improves growth. For young calves, forage supplementation increases total dry matter intake, ruminal pH, and ruminating time. Thus, dietary fibre influences nutrient absorption and gut health, affecting their eating and rumination activity. Selecting and manipulating fibre sources in calf diets can enhance their growth, feed efficiency, and overall well-being.

The eating behaviour of calves, including feeding time, frequency of meals, and intake rate, is essential in understanding their nutrient requirements and optimizing feed management strategies. Similarly, rumination, the process of regurgitating and re-chewing feed, contributes to the breakdown of fibrous materials, microbial fermentation, and nutrient utilization (Hosseini et al.,2016). By studying the impacts of various fibre sources on these aspects, valuable insights can be gained to improve young calves' management and feeding practices.

Understanding the relationship between dietary fibre and eating behaviour and rumination activity in calves is vital for formulating appropriate diets and optimizing growth performance. Furthermore, these findings may contribute to developing sustainable and efficient feeding practices, ultimately benefiting the livestock industry and promoting animal welfare. In addition, the type and quality of feed offered to calves during this transition period significantly impacted their feeding behaviour and growth (Kargar et al., 2021). Calves fed high-quality hay and concentrate feed showed a more gradual transition to solid feed and had better growth rates than those fed lower-quality feed (Terler et al., 2022). Moreover, Forage inclusion in the diet increased total dry matter

intake, ruminal pH, and rumination time (Ali et al., 2016). This research evaluated the effect of providing different fibre sources on Brahman crossbred calves' eating behaviour and rumination activity during the weaning transition.

MATERIALS AND METHODS

Animals and Diets

Animal Ethics Committee, University Bengkulu (protocol number: 47/KEH/2021) approved the methods and protocol used in this study. This experiment used ten Brahman crossbred calves aged eight weeks old. The calves were with the cows in the barn, and then the calves were removed to 1,2 x2,4 m individual stalls. During adaptation, a four-litre milk replacer was given twice daily, then gradually removed to introduce a fibre diet. On day 7th of adaptation, milk was no longer given. The dietary treatments were COP-without *Gliridia sepium* (concentrate 40% + *Pennisetum purpureum* cv. Taiwan 60%) and COM-a combination of *Pennisetum purpureum* and *Gliricidia sepium* (concentrate 40% + *Pennisetum purpureum* cv. Taiwan 30% + *Gliricidia sepium* 30%).

The calves were equipped with identification (an ear tag) and weighed before the experiment. The concentrate and forage were given 3% body weight DM twice daily at 8 am and 4 pm. The composition of the ratio is presented in Table 1. The chemical composition of the research rations is presented in Table 3. Feed adaptation was carried out seven days before the study. Calves were weaned on week 10th and remained in the trials until week 19th.

Table 1. The composition of the research ration ingredients

Feed ingredients	COP ration composition (%)	COM ration composition (%)
Dried cassava waste	1	1
Palm Kernel Cake	1	18
Corn meal	1	1
Pollard	15	1
Soybean meal	20	12
Coffee husk	1	6
Mineral	0.5	0.5
Salt	0.5	0.5
Pennisetum purpureum	60	30
Gliricidia sepium	0	30
Total	100	100
Nutrient composition	COP ration composition (%)	COM ration composition (%)
Dry matter	45.84	45.27
Crude protein	17.88	17.26
Crude fiber	22.33	18.42
TDN	59.06	59.92

Data Collection and Analysis

In this final week, the researchers observed a direct diurnal behavioural activity. The parameters were the duration of eating, drinking, ruminating, standing, and resting during 9 hours of observation, starting from 08.00 am to 5.00 pm for seven consecutive days. The observation was carried out using the focal method, time sampling or instantaneous focal animal sampling, a mixture of scan and focal animal sampling methods. The percentage of the duration of eating, drinking, standing, rest duration, rumination duration, and remastication duration was calculated using the following formula.

$$\%\ \text{behavior} = \frac{\text{behaviour (minute)}}{\text{Total observation (minute)}} \text{x } 100\%$$

The frequency of the behaviour is the number of times a particular eating behaviour occurs within 9 hours of observation. Observation of behaviour to determine the frequency of a parameter of eating behaviour is carried out using the method of *one zero time record* (Altmann 1974). Animals that show eating behaviour according to the observation target are given a score of 1 and 0 if the cattle do not show this behaviour within 15 minutes. Data analysis was done using an independent sample T-test.

RESULTS AND DISCUSSION

Eating Time

A two-treatment t-test was applied to the hypothesis that changing from liquid to solid feed by introducing different dietary sources may initiate rumen development, eating behaviour, and the ruminating activity of Brahman crossbred calves. The eating behaviour of BX calves given *Pennisetum purpureum* as dietary fibre (COP group) and a combination of *Pennisetum purpureum* and *Gliricidia sepium* (COM group) are presented in Table 2. below.

Table 2. Eating behaviour of Brahman crossbred calves

Parameters	Treatment	Mean±Stdev	Probability
Eating time (minutes)	COP	246.35 ± 3.62	0.03
	COM	239.31 ± 3.66	
Eating percentage (%)	COP	45.62 ± 0.67	0.03
	COM	44.31 ± 0.68	
Eating Frequency (times)	COP	20.88 ± 0.22	0.00
	COM	20.02 ± 0.07	

The analysis showed that in this study, the treatment significantly affected eating time, eating percentage, and eating frequency of Brahman crossbred calves ($P<0.05$). The average eating time, eating percentage, and eating frequency of the COP groups was greater than that of the COM group ($P<0.05$). Differences in eating time may be due to the coarse texture of the *Pennisetum purpureum*, so it takes longer for the calves to chew and swallow it.

A study on the eating behaviour of four-week Holstein calves found that eating time for calves fed maize stover was 11.4 minutes; on the other hand, calves fed a wheat straw diet spent 9.2 minutes. The coarse structure of dietary fibre leads to a different amount of time spent.The transition from liquid to solid feed leads to changes in eating behaviour. Miller-Chuson and DeVries (2016) mentioned that calves showed feeding preferences. Weaned calves aged 65 days selected long particles against small particles diets. On day 70, the calves preferred a fine-particle diet. It explains the longer duration of eating in the COP treatment group. It can be concluded that calves alter eating behaviour as they are affected by dietary fibre sources. This is due to the particle size and texture of the dietary fibre presented.

Similarly, the bulky properties of forage results in a longer process of mastication and digestion (Burn et al., 1997). Transitioning from milk to concentrate and *Pennisetum purpureum* increased eating time; in contrast, a combination of *Pennisetum purpureum* and *Gliricidia sepium* in an equal portion decreased eating time ($P<0.05$). Introducing forage in young calves induces changes in the rumen environment and the development of eating behaviour (Suarez et al.,2016). The average eating time is 239.31-246.35 minutes. Eating duration increases over time. As the young calves grow, their eating time increases. Miller-Chuson (2014) revealed that young calves aged 100 days spend 360 minutes eating per day. Moreover, forage supplementation decreases non-nutritive oral and feed-sorting behaviours, which can help maintain rumen fluid pH and increase the number of cellulolytic bacteria in the rumen (Terler et al.,2020).

Drinking Time

The drinking time of the Brahman crossbred calves, from 08:00 to 17:00 WIB, can be seen in the following table. The analysis showed no significant effect in this study on drinking time, drinking percentage, and drinking frequency of Brahman crossbred calves. The average drinking time, percentage, and frequency were 16.71-16.50 seconds, 3.05-3.09%, and 2.26-2.27 times, respectively. Some determinant factors influencing drinking behaviour are the availability of water sources, the type of food eaten, and the climate or environmental conditions.

Table 3. The drinking behaviour of Brahman crossbred calves

Parameter	Treatment	Mean±Stdev	Probability
Drinking Time (seconds)	COP	16.71 ± 0.57	0.53
	COM	16.50 ± 0.30	
Drinking Percentage (%)	COP	3.09 ± 0.10	0.51
	COM	3.05 ± 0.50	
Drinking Frequency (times)	COP	2.27 ± 0.11	0.93
	COM	2.26 ± 0.13	

According to Sumoprastowo (1989), water should be provided continuously in drinking containers to guarantee the need for drinking water. According to Soetarno (2003), the factors that influence water consumption for a cow are age, body weight, milk production, heat, humidity, and type of food ration.

Standing Time

The standing time observation revealed that COP calves stand more often than COM calves, as seen in the following table.

Table 4. Standing behaviour of Brahman crossbred calves

	Treatment	Mean±Stdev	Probability
Standing Time (minutes)	COP	427.20 ± 3.25	0.60
	COM	426.21 ± 1.67	
Standing percentage (%)	COP	79.11 ± 0.72	0.60
	COM	78.29 ± 0.31	
Standing Frequency (times)	COP	2.21 ± 0.04	0.50
	COM	2.15 ± 0.03	

The analysis showed that this study did not significantly affect standing time, standing percentage, and standing frequency in Brahman crossbred calves. The average standing time, percentage, and frequency were 426.21-427.20 minutes, 78.29-79.11%, and 2.15-2.21 times, respectively. The average standing time for COP was 427.20 minutes and for COM was 426.21 minutes; the average standing percentage for COP was 79.11% and for COM was 78.29%, for the average standing frequency for COP was 2.21 times and COM of 2.15 times/9 hours. According to research by Castells et al. (2012) giving different forages to Holstein calves aged four weeks for 8 hours, observations revealed that calves fed with hay straw spent 154.3 minutes standing time and maize stover was 192.4 minutes. The Brahman crossbred calves in our study spent longer for standing activity than in the previous study. It is worth noting that light intensity can affect standing and lying activities (Purnomoadi and Rianto, 2002).

Lying Behavior

The lying time of Brahman crossbred calves is shown in the following table. The analysis showed that this study had no significant effect on lying time, lying percentage, and lying frequency in Brahman crossbred calves. The average lying time, percentage, and frequency were 135.27-136.06 minutes, 24.23-25.01%, and 1.56-1.61 times/9 hours, respectively. Different dietary fibres may give different results. Castells et al. (2012) reported that at four weeks of age, Holstein calves fed wheat straw spent 255.3 minutes and 205.7 minutes in the maize stover treatment group. Tucker et al. (2019) mentioned that lying behaviour is affected by environmental and animal-based factors such as stall design, flooring type, stocking density, and social hierarchy among cows. In addition, Jongman et al. (2014) mentioned that lying time is associated with age of young calves. The duration of lying of 10-day-old calves is shorter than the 3-day-old calves.

Table 5. Lying behaviour of Brahman crossbred calves

Parameter	Treatment	Mean± Std Deviation	P
Lying time (minutes)	COP	135.27 ± 0.62	0.07
	COM	136.06 ± 0.91	
Lying percentage (%)	COP	24.23 ± 0.39	0.43
	COM	25.01 ± 0.38	
Lying Frequency (times)	COP	1.56 ± 0.09	0.54
	COM	1.61 ± 0.06	

Rumination Time

During a nine-hour observation, the rumination time for the Brahman crossbred calves showed that feeding *Pennisetum purpureum* cv Taiwan increased rumination. Data on the rumination of calves are displayed in Table 6. below. Calves fed *Pennisetum purpureum* showed similar rumination time and percentage with calves fed a combination of *Pennisetum purpureum* and *Gliricidia* sepium ($P>0.05$). Coon et al. (2018) mentioned that particle size contributes to a more significant fluctuation in rumination time.

However, rumination frequency is higher in the COP group than in the COM group calves. Forage supplementation in this research facilitates frequent rumination. Forage is one type of solid feed that can affect the development of rumination behaviour in calves. The provision of forage has been shown to affect solid feed intake and can promote the development of rumination behaviour (Khan et al., 2016).

The mean rumination time, rumination percentage, and rumination frequency in this study were respectively 56.88-57.83 minutes, 10.53-10.72 %, and 6.09-6.33 times for a nine-hour observation. The initiation of solid feed and the amount eaten are the primary factors in initiating rumen motility and, thereby, regurgitation in calves. Additionally, Porter et al. (2007) demonstrated that calves fed a texturized calf starter feed began ruminating by four weeks of age and spent 21% of their time ruminating. Castells et al. (2012) reported that an eight-hour diurnal observation showed a rumination time of four-week calves of 35 minutes for the wheat straw feeding group and 42 minutes for the maize stover silage group. This study revealed that higher crude fibre content in the *Pennisetum purpureum* treatment group led to more frequent rumination. Different sources of dietary fibre are proven to have different responses in rumination activity. A higher crude fibre diet initiates a higher rumination activity.

Table 6. Rumination behaviour of BX calves fed with different forages

Parameter	Treatment	Mean± Std Deviation	P
Rumination Time (minutes)	COP	57.83 ± 0.69	0.08
	COM	56.88 ± 0.61	
Rumination Percentage (%)	COP	10.72 ± 0.12	0.08
	COM	10.53 ± 0.11	
Rumination Frequency (times)	COP	6.33 ± 0.05	0.00
	COM	6.09 ± 0.06	

Remastication Time

The remastication time of the Brahman crossbred calves in a nine-hour observation is displayed in Table 7. The analysis showed that this study did not significantly affect remastication time, percentage, and frequency in Brahman crossbred calves. The average remastication time, percentage, and frequency were 31.06-32.26 minutes, 5.76-5.98 %, and 65.02-66.99 times/9 hours. The average time of COP1 is 32.26 minutes, and COM is 31.06 minutes, the percentage of COP is 5.98%, and COM is 5.76%, for P1 is 66.99 times/9 hours, and COM is 65.02 times/9 hours. From the statement above, it can be concluded that the average COP is higher than COM because the feed given to COP has more crude fibre.

Table 7. Remastication of BX calves given different forages

Parameter	Treatment	Mean± Std Deviation	P
Remastication Time (minutes)	COP	32.26 ± 1.27	0.20
	COM	31.06 ± 1.10	
Percentage of Remastication (%)	COP	5.98 ± 0.24	0.20
	COM	5.76 ± 0.21	
Remastication Frequency (times)	COP	66.99 ± 1.90	0.08
	COM	65.02 ± 0.28	

Remastication behaviour is the process of chewing livestock when rumination occurs, according to Frandson (1993). Remastication activity in cattle is when the cow expels the bolus formed after regurgitation, and mastication will be released to be remated. The regurgitated material usually consists of forages and liquid. One remastication usually lasts an average of one minute. Adams et al. (1992) stated that remastication is usually longer and less frequent than rumination, and in general, remastication is usually carried out when the animal is lying.

CONCLUSION

This study concludes that feeding elephant grass can increase feeding time, feeding percentage, and frequency and rumination frequency. However, it does not affect drinking time, percentage, drinking time, drinking frequency, standing time, standing percentage, standing frequency, resting time, lying percentage, resting frequency, rumination time, rumination percentage, remastication time, and remastication percentage.

REFERENCES

Adams, D. B., G. N. Hinch, and J. Lynch. 1992. The Behaviour Of Sheep. CAB. International and CSIRO Australia. New Zealand. 19-21.

Ahmad, F., M. A. Jabbar, I. Ahmad, M. Rafique and I. Ahmad. 2004. Comparative efficiency of calf starter and conventional rations in buffalo suckling. Pakistan Vet. J. 24(4): 169- 172.

Ali, A., M. Khorvash, G. Ghorbani, A. Mahdavi, M. Malekkhahi, M. Mirzaei, A. Pezeshki, and M. Ghaffari. 2016. Effects of forage offering method on performance, rumen fermentation, nutrient digestibility and nutritional behaviour in Holstein dairy calves. Journal of animal physiology and animal nutrition 100(5): 820-827.

Altmann, J. 1974. Observational study of behavior: sampling methods. Behavior, 49(3), 227–267. https://doi.org/10.1163/156853974x00534.

Anderson, K. L., T. G. Nagaraja, J. L. Morrill, T. B. Avery, S. J. Galitzer, and J. E. Boyer. 1987. Ruminal microbial development in conventionally or early-weaned calves. J. Anim. Sci. 64:1215–1226.

Brown, M. S., C. R. Krehbiel, M. L. Galyean, M. D. Remmenga, J. P. Peters, B. Hibbard, and W. M. Moseley. 2000. Evaluation of models of acute and subacute acidosis on dry matter intake, ruminal fermentation, blood chemistry, and endocrine profiles of beef steers. J. Anim. Sci. 78 (12): 3155–3168.

Baldwin, R. L. V. I., and K. R. McLeod. 2000. Effects Of Diet Forage:Concentrate Ratio To Age and Metabolizable Energy Intake On Isolated Rumen Epithelial Cell Metabolism In Vitro. J. Animal Science 78:771-173.

Baldwin, R. L. V.I. , K. R. McLeod, J. L. Klotz, and R. N. Heitmann. 2004. Rumen development, intestinal growth and hepatic metabolism in the pre- and post-weaning ruminant. J. Dairy Sci. 87(ESuppl.):E55–E65.

Bučková, K., R. Šárová, A. Moravcsíková, and M. Špinka. 2021. The effect of pair housing on dairy calf health, performance, and behavior. Journal of Dairy Science 104 (9): 10282–10290. https://doi.org/10.3168/jds.2020-19968

Burfeind, O., K. Schirmann, M. A. G. von Keyserlingk, D. M. Veira, D. M. Weary, and W. Heuwieser. 2011. Technical note:

Evaluation of a system for monitoring rumination in heifers and calves. J. Dairy Sci. 94:426–430.

Church, D. C. 1975. Digestive Physiology and Nutrition of Ruminant. Vol : 1 Second Edition. John Wiley and Sons. New York.

Coon, R.E., T. F. Duffield, and T. J. DeVries. 2018. Effect of straw particle size on the behavior, health, and production of early-lactation dairy cows. Journal of dairy science 101 (7): 6375-6387 .

Castells, LI., A. Bach, G. Araujo, C. Montoro, and M. Terre. 2012. Effect of different forage sources on performance and feeding behavior of Holstein calves. Department of Ruminant Production. Agro-Food Research and Technology Institute (IRTA). 08140 Caldes de Montbui. spain

Ebey, T.N.1983. The genetic pool of sheep and goats. In: Tropical Sheep ang Goat Production (Edited by Ebey. T. N). Australia University International Development Program. Canberra.

Elvith, C. R. and Francis. 2006. *Gliricide hedges (glyciridia)*. Available at:http://raskisimani.files.wordpress.com/2013/01/gliciridia-gliciridia.pdf.

Fikar, S. dan D. Ruhyadi. 2010. Beternak dan Bisnis Sapi Potong. AgroMedia Pustaka. Jakarta.

Frandson, R. D. 1993. Anatomy and Physiology of Livestock. Gajah Mada UniversityPress. Yogyakarta. Indonesia. 600-609.

Fraser, F. A. 1975. Farm Animal Behaviour. The Macmillan Publishing Company Inc. New York.

Ganong, W. F. 2002. Physiology of Medicine. EGC Medicine. Jakarta.

Ginnette, T. F., J. A. Dankosky, G. Deo, and M. W. Demment. 1999. Patch Depression in Grazers: the Roles of Biomass Distribution and Residual Stems. Functional Ecology 13:37-44.

Hafes, E. S. E. 1975. The Behaviour of Domestic Animal. 3rd Ed. The Wiliams and Wikind Co., Baltimore.

Hartadi, S. R., S. Prawirokusumo, A. D. Tillman and H. S. Lebdosoekojo. 1993. Feed Composition Table for Indonesia. Gajah Mada Press University. Yogyakarta.

Hill, T.M., Bateman, H.G., Aldrich, J.M., and R. Schlotterbeck. 2012. High-starch, coarse-grain, low-fiber diets maximize growth of weaned dairy calves less than 4 months of age. The Professional Animal Scientist 28: 325-331.

Hosseini, S. M., G.R. Ghorbani, P. Rezamand, and M. Khorvash. 2016. Determining optimum age of Holstein dairy calves when adding chopped alfalfa hay to meal starter diets based on measures of growth and performance. Animal 10 (4): 607-615, ISSN 1751-7311, https://doi.org/10.1017/S1751731115002499.

Hodgson, J. 1971. The development of solid food intake in calves. 1. The effect of previous experience of solid food, and the physical form of diets, on the development of food intake after weaning. Anim. Prod. 13:15–24.

Jongman E. and K. Butler. "The Effect of Age, Stocking Density and Flooring during Transport on Welfare of Young Dairy Calves in Australia." Animals : an Open Access Journal from MDPI. 2014. https://doi.org/10.3390/ani4020184.

Kamal, M., 1994. Nutrisi Ternak I. Fakultas Peternakan, Universitas Gajah Mada, Yogyakarta.

Kargar, S., M. Bahadori-Moghaddam, S.M. Ghoreishi, A. Akhlaghi, M. Kanani, A. Pazoki, and M.H. Ghaffari, 2021. Extended transition milk feeding for 3 weeks improves growth performance and reduces the susceptibility to diarrhea in newborn female Holstein calves, Animal 15(3):1-9, https://doi.org /10.1016/j.animal.2020.100151.

Khalifa, T. A. A. and B. E. El-Saidy. 2006. Pellet-freezing of Damascus goat semen in a chemically defined extender. Anim. Reprod.Sci. 93: 303–315.

Khan, M.A., A. Bach, D.M. Weary, and M.A.G. von Keyserlingk. 2016. Invited review: Transitioning from milk to solid feed in dairy heifers. Journal of Dairy Science 99: 885–902.

Kononoff, P. J., H. A. Lehman, and A. J. Heinrichs. 2002. Technical note: A comparison of methods used to measure eating and ruminating activity in confined dairy cattle. J. Dairy Sci. 85:1801–1803.

Lesmana. 2013. Paper on Animal Behavior. Success Revelation. Macassar.

Lindgren, H. C. 1969. An Introduction to Social Psychology. John wiley and Sons. Inc. New York.

Martin, C., L. Brossard, and M. Doreau. 2006. Mechanisms of appearance of ruminal acidosis and consequences on physiopathology and performances. Prod. Anim. 19:93–107.

Miller-Cushon, E. K., R. Bergeron, K. E. Leslie, and T. J. DeVries. 2013. Effect of milk feeding level on development of feeding behavior in dairy calves. J. Dairy Sci. 96:551–564. http:// dx .doi .org/ https://doi .org/ 10 .3168/ jds .2012 -5937.

Muhammad, A. U., C. Q. Xia, and B. H. Cao. 2016. Dietary forage concentration and particle size affect sorting, feeding behaviour, intake and growth of Chinese Holstein male calves. Journal of Animal Physiology and Animal Nutrition 100 (2): 217–223. https://doi.org/10.1111/jpn.12349

Noorgard, P. 1989. The Influence of Physical From of The Diets on Chewing Activity and Reticulo-Rumen Motility in Cows. Acta Vet. Scan. Suppl. 86:46-52.

Okaraonye, C. C., and J. C Ikewuchi. 2009. Nutritional and Antinutrional Componenst of *Crimson pennywort* Schumach. Pakistan Journal of Nutritional 8 (1):32-34.

Phillips, C. J. C. 2004. The effects of forage provision and group size on the behavior of calves. J. Dairy Sci. 87:1380–1388.

Del Porto, H., C. Pechak, D. Smith, and R. Reed-Jones. 2012. Biomechanial Effect of Obesity on Balance. International Journal of Exercise Science. 5(4). 301-320. Retrieved From .http:digitalcommons.wku.edu/cgi/viewcontent.cgi?article=1465&context=ij es

Purnomoadi, A. and E. Rianto. 2002. Feeding Behavior of Buffalo Heifers Fed Rice Straw Supplemented With Urea-Mollases. Proceedings of the National Seminar on Animal Husbandry and Veterinary Technology. Animal Husbandry Research and Development Center . Bogor. Matter. 79-81.

Purwanti, E. 2012. Midwifery Care for Postpartum Mothers. Yogyakarta: Horizon Science.

Quigley, J. 2001. Development of Rumen Epithelium. Avaliable From URL: http//www.calfnote.com tanggal akses 8 Januari 2022.

Russell, J. B. and J. L. Rychlik. 2001. Factors That Alter Rumen Microbial Ecology. Science. Vol. 292. No. 5519 pp. 1119-1122.

Sahoo, A., D. N. Damra, and N. N. Pathak. 2005. Pre- and postweaning attributes in faunated and ciliate-free calves fed calf starter with or without fish meal. J. Dairy Sci. 88:2027–2036.

Sajimin, I. P. Kompiang, Supriyati and N. P. Suratmini. 2001. Use of Biofertilizer to Increase Productivity of Elephant Grass Forage (*Crimson pennywort* cv Africa) on Marginal Land in Subang, West Java. Livestock Media. 24(2): 46-50.

Soetarno, T. 2003. Management of Dairy Cattle Cultivation. Yogyakarta . UGM Faculty of Animal Husbandry.

Sugeng, Y.B. 1998. Raising Beef Cattle. Independent Spreader, Jakarta.

Sumoprastowo, C. D. A., 1989. Successful Goat Breeding. Bratara. Media Commerce. Jakarta.

Supriatna. A. 2014. Fecal Conditions and Body Weight Gain of FH Dairy Calves Given Oral Corn Silage Juice Treatment. (Thesis). Bogor Agricultural Institute. Bogor.

Susilo, E. 2014. How To Successfully Start And Run A Goat Livestock Business. First edition. Yogyakarta. Trans Media Publishing.

Swanson, E. W. and J. D. Harris Jr. 1958. Development of rumination in the young calf. J. Dairy Sci. 41:1768–1776.

Terler, G., G. Poier, F. Klevenhusen, and Q. Zebeli. 2022. Replacing concentrates with

a high-quality hay in the starter feed in dairy calves: I. Effects on nutrient intake, growth performance, and blood metabolic profile. Journal of Dairy Science 105(3): 2326-2342.

Tomaszewska, M. W, I. K. Sutama, I. G. Putu, and T. D. Chaniago. 1991. Reproduction, Behavior and Livestock Production in Indonesia. Gramedia Pustaka Utama, Jakarta.

Wahiduddin, M. 2008. Animal Feed Science. (http://wah1d.wordpress.com/category/ilmu-pakan) access date January 6, 2022.

Wang, S., Q.Y. Diao, F.M. Hu, Y.L. Bi, M.Y. Piao, L.S. Jiang, F. Sun, H. Li, and Y. Tu, 2022. Development of ruminating behavior in Holstein calves between birth and 30 days of age. Journal of Dairy Science 105(1): 572-584.

Widyawati, N., P. Yudono, and I. Soemardi. 2009. Permeability and Germination of Sugar Palm Seeds (*Arenga pinnata* Wurmb Merr). Indonesian Journal of Agronomy 37 (2) : 152-1