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Nutrient Digestibility of Prewaning Pasundan Calves Fed Flushing Diets under Extensive Grazing

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Abstract | In an extensive rearing system, immediately after birth, the calf follows the mother to graze on pasture. This condition certainly affects nutrient digestibility because the digestive system is not yet fully developed. The study aims to reveal nutrient digestibility of preweaning calves fed flushing diets under extensive grazing. The study used a completely randomized factorial design with two factors and five replicates. The first factor is gender and the second one is diet treatment. The total number of calves used in this study was 30, consisting of 15 males and 15 female preweaning Pasundan calves. The dietary treatment included: (1) calves are allowed to graze without feeding flushing diet, (2) calves are allowed to graze and fed a flushing diet without urea-impregnated zeolite (flushing-1), (3) calves are allowed to graze and fed a flushing diets with urea-impregnated zeolite inclusion (flushing-2). The measured variables consisted of feed intake and apparent digestibility of nutrients. The collected data were analyzed by a general linear model univariate analysis. The results showed that compared to the control diet, supplementation of flushing diets increased ($P < 0.05$) dry matter digestibility up to 29.01% ($53.89 \pm 4.85\%$ in grazing calves vs. $80.94 \pm 1.65\%$ in flushing-1 calves or $82.90 \pm 1.47\%$ in flushing-2 calves), crude protein digestibility up to 5.71% ($86.17 \pm 2.91\%$ in grazing calves vs. $90.61 \pm 1.65\%$ in flushing-1 calves or $91.88 \pm 0.79\%$ in flushing-2 calves), ether extract digestibility up to 12.12% ($80.06 \pm 7.39\%$ in grazing calves vs. $92.18 \pm 1.57\%$ in flushing-1 calves or $90.09 \pm 1.20\%$ in flushing-2 calves), neutral detergent fiber up to 28.81% ($54.58 \pm 4.01\%$ in grazing calves vs. $81.13 \pm 3.41\%$ in flushing-1 calves or $83.39 \pm 1.75\%$ in flushing-2 calves), acid detergent fiber by up to 24.27% ($54.23 \pm 4.69\%$ in grazing calves vs. $72.41 \pm 6.78\%$ in flushing-1 calves or $78.50 \pm 3.49\%$ in flushing-2 calves), and cellulose by up to 22.79% ($61.01 \pm 5.15\%$ in grazing calves vs. $82.03 \pm 6.04\%$ in flushing-1 calves or $83.80 \pm 1.92\%$ in flushing-2 calves). In conclusion, supplementing flushing diet to preweaning Pasundan calves under extensive grazing improved most nutrient digestibility parameters (dry matter, crude protein, ether extract, and fiber).

Keywords | Cellulose, Crude protein, Calves, Flushing, Urea-impregnated zeolite

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INTRODUCTION

Currently, the development pattern of beef cattle breeding in Indonesia is still oriented to the pattern of community or family farms where the livestock raising system is carried out extensively or semi-intensively. Extensive maintenance is carried out by leaving the cattle in the pasture all day and night for a certain period without being shed. Semi-intensive maintenance is carried out by herding livestock to a place where there is a lot of grass, then fastening it with a long rope with a radius of 20-30 m

from morning to evening. Towards evening, around 05.30 PM, the farmer then drives his cattle back to a certain place, a kind of paddock, which is surrounded by a bamboo fence to ensure that his cattle keep inside the bamboo fence. Cattle control activities in semi-intensive care are carried out throughout the day because the livestock are grazed by one or two herders, depending on the number of the cattle.

Neither the extensive nor semi-intensive rearing systems are supportive of the development of the pre weaned new

born calves. The preweaning growth is a critical period because for the first time a calf enters an open environment where everything is out of control. The low quality of field grass in tropical areas worsen the livestock performances grazed extensively. However, in the extensive grazing systems, the utilization of low-quality feed, mainly from crop residues as well as agricultural by-products and other nonconventional feedstuffs is a common practice (Agus and Widi, 2018).

In a cow-calf raising system that is grazed extensively, the preweaning calf only gets solid feed from the forage available in grazing areas, such as field grass, rice straw, or other agricultural wastes. All those feeds are almost undigested by the pre-weaned calves because of their rumen system not well developed yet. Maskalová and Vajda (2015) described that fibrous feed had lower fiber digestibility because its lignin encrusted the fiber. Labussiere et al. (2009) described fibrous feed decreased dry matter digestibility. de Assis Lage et al. (2019) who fed the preweaning heifers with total solid diets (92% concentrates and 8% hay) resulted in higher digestibility of organic matter, crude protein, and fat. To improve the nutrient digestibility of low-quality feed is to reduce the particle size of the feed as recommended by (Ghassemi Nejad et al., 2012) that the small particle size of feed increased the surface area for microbial enzyme to access the feed particles, thus improved the nutrient digestibility.

However, due to the low quality of forage in the tropics (Agus and Widi, 2018), reducing the particle size alone will not be sufficient to meet the nutrient needs of pre-weaned calves during the transition period. The average crude protein content of field grass obtained from grasslands in the coastal areas of West Java is 9.74%. In fact, rumen microbial life requires feed containing at least 1.28% nitrogen or equivalent to 8% crude protein (Van Soest, 1994) and needs greater than 11% crude protein to support the optimal growth (Pathak, 2008). Thus, the crude protein content of field grass is only sufficient to meet the needs of rumen microbes. Therefore, to improve digestibility and fulfil nutrient requirements in pre-weaned calves that are herded extensively with their cows, a concentrate supplement is needed. Supplementation of the small particle size of concentrate as a flushing diet is expected to improve digestibility and fulfil nutrients requirement in the preweaning calves grazed extensively. The study aims to explore the nutrient digestibility of preweaning calves fed flushing diets under extensive grazing.

MATERIALS AND METHODS

ANIMALS AND EXPERIMENTAL DESIGN

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

The study used 30 preweaning Pasundan calves of 3 months consisting of 15 males and 15 females that were extensively grazed. The initial average body weight was 39.44 ± 13.57 kg for male calves and 37.167 ± 7.78 kg for female calves. The study used a completely randomized factorial design with two factors and five replicates. The first factor is gender and the second one is diet treatment. Five of each male or female calf was randomly selected and allocated to the following three treatments: (1) calves are allowed to graze without feeding flushing diet, (2) calves are allowed to graze and fed a flushing diet without urea-impregnated zeolite (flushing-1), (3) calves are allowed to graze and fed a flushing diets with urea impregnated zeolite inclusion (flushing-2). The measured variables consisted of feed intake and apparent digestibility of nutrients.

Flushing diets and drinking water were provided before and after the calves were grazed. Both flushing diets had similar protein and energy contents (Table 1). The urea-impregnated zeolite was formulated based on (Kardaya et al., 2018). Either flushing-1 or flushing-2 diet was provided in a coarse mash form. The adaptation period for flushing diet was carried out for 7 days and the feeding trial period was carried out for 7 days. Flushing diet was fed twice a day, i.e. in the morning at 0600–0800h as much as 500 grams before the calves were grazed and in the afternoon at 1700–1900h as much as 500 grams after the calves were driven back into the shed without rooftop from the grazing land. Every morning at 0800 h, the calves were driven out of the shed without rooftop and then led to pasture or areas overgrown with natural grass for grazing. Drinking water for the calves during grazing was available in the ponds around grazing areas. In the afternoon, the calves were driven back into the shed without a rooftop.

MEASUREMENTS AND DATA COLLECTION

The measured variables consist of feed intake and apparent nutrient digestibility. Flushing diet intake was calculated by subtracting the refusals from the offered. Apparent nutrient digestibility was determined by internal (lignin) indicator and calculated based on the formula of Zewdie (2019) as follows:

$$\text{Digestion coefficient of nutrient} = 100 - 100 \times \left(\frac{\% \text{ Indicator in feed} \times \% \text{ Nutrient in feces}}{\% \text{ Indicator in feces} \times \% \text{ Nutrient in feed}} \right)^{-1}$$

The refusals of flushing diets from each calf were weighed after the feeding time, put in a polyethylene bag, and air-dried on the next day. Field grass samples were collected randomly from 30 points (Cayley and Bird, 1996) where 30 calves grazed on pasture. The grass sample was taken as much as 100 grams from each point where the grass was taken so that the total sample of natural grass collected was 3 kg and air-dried. Fecal samples from each calf

were collected from the pasture every day between 1100 and 1600 h. Daily fecal samples that had been collected were put into polyethylene bags that had been numbered according to the number of each calf and then air-dried on the next day. The dried offer and refusal flushing diets, field grass, and fecal samples were then ground to pass a 1 mm screen mill for proximate analysis. The proximate analysis was carried out according to (AOAC, 2016) procedures. Neutral detergent fiber (NDF), Acid detergent fiber (ADF), cellulose, and lignin contents were analyzed according to (Van Soest et al. 1991). Hemicellulose was calculated by subtracting ADF from NDF.

Table 1: Nutrient composition of flushing diets.

Compositions	Diets (DM basis, %)		
	Native grass	Flushing 1	Flushing 2
Ingredients, % DM basis			
Rice bran		36	33
Cassava meal		-	12
Palm kernel meal		23	28
Coconut meal		30	23
Soybean meal		8	-
Urea-impregnated zeolite		-	1
Mineral mix [†]		3	3
Total		100	100
Nutrient composition, % DM basis			
DM ^{††}	33.02	89.84	89.41
Crude protein	9.74	17.71	17.69
Ether extract	1.43	5	3.15
Crude fiber	21.76	13.33	12.48
Nitrogen free extract	56.46	53.2	56.16
Ash	10.61	10.76	10.52
NDF ^{††}	64.96	66.49	66.16
ADF ^{††}	49.69	35.06	37.42
Cellulose	24.13	20.55	21.32
Hemicellulose	15.27	31.43	28.74
Lignin	10.98	10.82	11.48

[†]Composition (per kg): Vitamin A 3,300 IU, Vitamin D 360 IU, Vitamin E 100 IU, Mg 100 mg, Co 100 mg, P 340 mg, Ca 720 mg, K 650 mg, Na 90 mg, Zn 20 mg, Fe 7 mg, Mn 5 mg, Zn 4 mg, Cu 1 mg, I 60 mcg, Se 40 mcg, organic chromium 0.3 mg. ^{††}DM, Dry Matter; NDF, Neutral Detergent Fiber; ADF, Acid Detergent Fiber.

STATISTICAL ANALYSIS

All variables (dry matter intake of the flushing diets, apparent digestibility of nutrients,) were analyzed by General Linear Model Univariate Analysis (IBM SPSS Statistics 24, 2018). All dietary treatments and calf gender (male and female) were considered as fixed factors. All dietary treatments and gender main effects were subject to

the least significant difference (LSD) test option. The result of each variable analysis was considered as statistically significant if $P \leq 0.05$. The statistical model applied for analyses was:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk}$$

Where, Y_{ijk} is dependent variable; μ is the overall mean; α_i is the effect of gender; β_j is the effect of dietary treatment; $(\alpha\beta)_{ij}$ is the effect of the interaction between gender and dietary treatment; ϵ_{ijk} is the overall error term.

RESULTS AND DISCUSSION

FEED INTAKE

Average flushing concentrates intake (dry matter basis) of the preweaning calves for 60 days ranged within $0.50 \pm 0.03 - 0.58 \pm 0.07$ kg/d (Table 2). Average flushing concentrates intake in the recent study reached 1.44 % and 1.40 % BW of male and female, respectively. There was no significant difference in the concentrate intake between flushing-1 and flushing-2 diets in male and female Pasundan calves reared in a cow-calf system under extensive grazing.

Table 2: Concentrate intake (DM basis) in the grazing-preweaning calves fed the flushing concentrates.

Variables	Treatments	Male	Female	Total
Intake, (Mean ± SD, kg):				
Intake, 60 days (kg)	Flushing-1	37.41±4.49	32.18±2.07	34.80±4.29
	Flushing-2	36.33±0.60	34.39±1.78	35.36±1.62
	Average	36.87±3.07	33.29±2.16	35.08±3.17
Daily intake (kg)	Flushing-1	0.58±0.07	0.50±0.03	0.54±0.06
	Flushing-2	0.57±0.01	0.54±0.02	0.55±0.02
	Average	0.57±0.04	0.52±0.03	0.55±0.04

Various intakes of preweaning calves had been recorded by many researchers. The daily flushing concentrates intake in this study was comparable with Göncü et al. (2010) who fed a total mixed ration, i.e. 499.60±81.69 g/d, Chapman et al. (2017) for preweaning calves fed a calf starter (20% CP), i.e. 537 g/d, or with Wickramasinghe et al. (2019) who reported a calf starter intake 0.66 – 0.60 kg/d. However, either Casper et al. (2017) who fed calf starter containing 40% digestible corn or Li et al. (2019) who compared reconstituted and acidified milk resulted in lower intake (0.36–0.38 kg/d and 0.40–0.43 kg/d, respectively) than the daily flushing concentrate intake recorded in the recent study. The similarity intake between flushing-1 and flushing-2 concentrate related to its similar nutrient contents and its similar forms of both flushing concentrates as proposed by Ghassemi Nejad et al. (2012) that different forms of starter calf affected ($P < 0.05$) dry matter intake (DMI).

APPARENT NUTRIENT DIGESTIBILITY

Feeding treatment affected ($P < 0.05$) apparent dry matter digestibility (DMD). Grazing calves showed lower DMD than flushing-1 calves or flushing-2 calves (Table 3). The flushing-1 calves and flushing-2 calves showed similar DMD. Gender did not affect DMD significantly. There was no significant difference in organic matter digestibility (OMD) among feeding treatment or between gender. Feeding treatment affected ($P < 0.05$) crude protein digestibility (CPD). Grazing calves showed lower CPD ($P < 0.05$) than flushing-1 calves or flushing-2 calves. Either flushing-1 calves or flushing-2 calves showed similar CPD. Gender did not affect the CPD significantly. Feeding treatment affected ($P < 0.05$) fat or ether extract digestibility (EED). Grazing calves had lower EED ($P < 0.05$) than flushing-1 calves or flushing-2 calves. Gender affected ($P < 0.05$) the EED, in this case, males showed lower EED ($P < 0.05$) than the female calves. Feeding treatment affected ($P < 0.05$) neutral detergent fiber digestibility (NDFD), acid detergent fiber digestibility (ADFD), or cellulose digestibility (CELD). Grazing calves showed lower ($P < 0.05$) NDFD, ADFD, or CELD than flushing-1 calves or flushing-2 calves. Both flushing-1 calves and flushing-2 calves had similar NDFD, ADFD, or CELD.

Lower DMD in grazing calves was in relation to the low quality of native grass in the grazing area as generally found in tropical pasture regions. This is supported by Labussiere et al. (2009) who described fibrous feed decreased DM digestibility. In addition, preweaning calves have a low capacity to digest fiber, because its rumen development is not yet complete. Lower fiber digestibility (NDFD, ADFD, CELD) in grazing calves as shown in Table 3 confirmed the explanation above. Higher DMD in flushing-1 and flushing-2 calves reflect a higher degradability of nutrients contained in both flushing concentrates. DMD in flushing calves was comparable to the DMD reported by Casper et al. (2017), Chapman et al. (2017), or de Assis Lage et al. (2019), i.e. 86.2%, 78,9%, or 85.8 – 89.2% respectively.

The OMD similarity between grazing calves and flushing calves is still not well explained. This was unexpected because it was previously predicted that the grazing calves would have lower OMD than the flushing calves. Presumably, the grazing calves have adapted well to the condition of the grass in the grazing area so that the grazing calves are able to digest the OM as well as the flushing calves. Even if the OM content in native grass is the same as the OM in flushing concentrates, it does not warrant that the grazing calves would have similar OMD to the flushing calves because the OM compositions in native grass differ with the OM compositions in the flushing concentrates. Ghassemi Nejad et al. (2012) reported that differences in form of calf starter affected nutrients digestibility; calves fed mashed starter indicated lower OMD (78.6%) than the

OMD of calves fed pelleted starter (85.0%) or texturized starter (86.6%). The OMD in this study was slightly higher than the OMD (79.80%) obtained by Chapman et al. (2017) who fed a calf starter (20% CP) but it was comparable with the OMD (88% – 91.1%) reported by de Assis Lage et al. (2019).

Table 3: Nutrient apparent digestibility (% Mean ± SD) in grazing-preweaning calves.

Variables†	Diets	Male	Female	Average
DMD	Control (grass)	53.30±3.26	54.49±6.87	53.89±4.85 ^a
	Flushing-1	82.31±0.78	79.56±0.75	80.94±1.65 ^b
	Flushing-2	82.55±1.96	83.25±1.09	82.90±1.47 ^b
	Average	72.72±14.69	72.43±13.99	
OMD	Control (grass)	86.72±1.29	88.22±1.08	87.47±1.34
	Flushing-1	86.42±1.14	84.92±0.81	85.67±1.20
	Flushing-2	86.95±1.00	87.30±0.57	87.13±0.75
	Average	86.70±1.02	86.81±1.64	
CPD	Control (grass)	85.03±3.51	87.31±2.21	86.17±2.91 ^a
	Flushing-1	91.90±1.20	89.31±0.59	90.61±1.65 ^b
	Flushing-2	91.75±0.40	92.01±1.16	91.88±0.79 ^b
	Average	89.56±3.88	89.54±2.41	
EED	Control (grass)	74.02±4.78	86.10±2.12	80.06±7.39 ^a
	Flushing-1	91.47±0.64	92.89±2.07	92.18±1.57 ^b
	Flushing-2	89.71±1.16	90.47±1.36	90.09±1.20 ^b
	Average	85.07±8.68 ^a	89.82±3.39 ^b	
NDFD	Control (grass)	54.71±4.27	54.46±4.69	54.58±4.01 ^a
	Flushing-1	83.32±1.77	78.94±3.40	81.13±3.41 ^b
	Flushing-2	82.75±2.46	84.02±0.65	83.39±1.75 ^b
	Average	73.60±14.40	74.47±13.99	
ADFD	Control (grass)	53.13±4.15	55.32±5.84	54.23±4.69 ^a
	Flushing-1	77.37±4.15	67.45±6.23	72.41±6.78 ^b
	Flushing-2	76.48±2.97	80.53±3.05	78.50±3.49 ^b
	Average	68.99±12.19	67.77±11.82	
CELD	Control (grass)	62.04±5.75	59.98±5.49	61.01±5.15 ^a
	Flushing-1	86.01±1.11	78.05±6.53	82.03±6.04 ^b
	Flushing-2	82.68±2.33	84.92±0.27	83.80±1.92 ^b
	Average	76.91±11.68	74.32±11.94	

Different superscripts in the same row or column, significantly different ($P < 0.05$). †DMD, Dry Matter Digestibility; OMD, Organic Matter Digestibility; CPD, Crude Protein Digestibility; EED, Ether Extract Digestibility; NDFD, Neutral Detergent Fiber Digestibility, ADFD, Acid Detergent Fiber Digestibility; CELD, Cellulose Digestibility.

Similar CPD between flushing-1 calves and flushing-2 calves indicate that CP contents in flushing-1 and flushing-2 concentrates have the same degradability. Lower CPD in grazing calves indicate lower crude protein

availability in native grass. Crude protein digestibility in the recent study was higher than CPD (68.1– 72.6%) reported by Ghassemi Nejad et al. (2012) but lower than the crude protein digestibility reported by Casper et al. (2017), Chapman et al. (2017), or de Assis Lage et al. (2019), i.e. 85.2%, 75.0%, or 87.8 – 91.8% respectively.

Higher fat digestibility in female calves suggests that the female calves have the better fat utilization capacity than male calves. This suggestion is supported by Schäff et al. (2016) that female calves had greater capacity in fat deposition than male calves. Meanwhile, higher fat digestibility in flushing-1 calves or flushing-2 calves indicate that the fat contained in the flushing-1 diet or flushing-2 diet more digestible than fat contained in native grass. Fat digestibility in the recent study was lower than the fat digestibility (93.9 – 96.1%) reported by Chapman et al. (2017) who fed milk replacer or fat digestibility (93.1.0 – 96.4%) obtained by de Assis Lage et al. (2019) who fed total solid diets (92% concentrates and 8% hay).

Lower fiber (NDF, ADF, cellulose) digestibility in the grazing calves indicates that the fiber less availability for microbial fermentation. One explanation for this occurrence is in relation with lignin content as proposed by Maskalová and Vajda (2015) who described that lignin encrusting the fiber, complexing with other nutrients, and resulted in lower fiber digestibility. Supplementing flushing-1 or flushing-2 concentrates improve the fiber digestibility. This improvement may associate with a greater surface area of the small particle size of the flushing concentrates. This explanation is in accordance to Ghassemi Nejad et al. (2012) who explained that the small particle size of feed increased the surface area for microbial enzyme to access the feed particles. Apparently, feed grinding not only increases the surface area of feed particle, but also may destroy lignocellulose complex that increases microbial access to digest the fiber contained in the fibrous feeds, thus increases the fiber digestibility. The NDF digestibility in both flushing calves was comparable with the in vitro NDF digestibility (83.5%) obtained by Marumo et al. (2018) who used a commercial pelleted calf meal, but it was higher than the NDF digestibility (40.5 – 68.7%) obtained by some authors (Hill et al., 2016; Casper et al., 2017; Chapman et al., 2017; de Assis Lage et al., 2019) who fed the calves with milk replacer or calf starter.

CONCLUSIONS AND RECOMMENDATIONS

Supplementing flushing diet to preweaning Pasundan calves under extensive grazing improved most nutrient digestibility parameters (dry matter, crude protein, ether extract, and fiber). It is recommended that preweaning

calves under extensive grazing should be provided flushing diets to improve the nutrient digestibility.

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AUTHOR'S CONTRIBUTIONS

Dede Kardaya designed the study, executed the project, and analyzed data. Elis Dihansih assisted in the design of the study and data analyses. Deden Sudrajat designed the study and edited the draft version of the manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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