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ORIGINAL ARTICLE

Feeding pineapple waste silage as roughage source improved the nutrient intakes, energy status and growth performances of growing Myanmar local cattle

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ABSTRACT

Objective: The aim of this experiment was to determine the effect of feeding pineapple waste silage (PWS) as the source of roughage replaced in Napier grass silage (NGS) on the nutrient intakes, energy status, and growth performances of growing Myanmar local cattle.
Materials and methods: Eight growing Myanmar local cattle were randomly allocated into two groups, which were adjusted for age, sex, and body weight. Treatments were control (70% NGS + 30% concentrate) and PWS (45% NGS + 25% PWS + 30% concentrate). This experiment lasted for 6 weeks, including adaptation, and feed intake, energy status, and body weight gain were measured.
Results: The higher ($p < 0.05$) intakes of dry matter, crude protein, non-fiber carbohydrate, neutral detergent fiber and energy, and energy balance were observed in the PSW group than in the control group. Although the initial and final body weights of both groups were not different ($p > 0.05$), the body weight gain and average daily gain were significantly higher ($p < 0.05$) in the PSW group than in the control group. Feeding PWS as a roughage source at 25% of diet improved the nutrient intake, energy balance, and body weight gain of growing Myanmar local cattle.
Conclusion: Thus, PWS could be used as the source of roughage replaced in NGS in Myanmar local cattle with the improvement of productive performances.

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Introduction

The fluctuation in nutritional quality and shortage of fodders in tropical and sub-tropical countries are the factors responsible for reducing ruminants' productivity. The provision of high-quality forages could improve the ruminants' productivity; however, high temperature and low rainfall in tropical and sub-tropical regions is the major constraint for the quantity and quality of forages. Accordingly, there is increased interest in using alternative feeds, which have the potential to use the livestock feeds. As the alternative feeds, the utilization of by-products from agro-industry as ruminant feed is the strategies to improve feed supply [1,2]. Otherwise, most of those by-products are problems for environmental waste management. Thus the interest in the application of agro-industrial by-products as livestock feed is growing.

Among the agro-industrial by-products, the practice of pineapple wastes as feed for ruminants is well recognized in tropical and sub-tropical countries. About 70%–75% of products from the pineapple industry are by-products, such as peel, crown, core, stem, and leaf [3], which are available in large amounts during a short period, the harvest season. If they are not used in that time, they will be wasted in the field and polluted to the environment. Thus the preservation is required to keep for more extended periods and use them as feed for animals. As the preservation, ensiling has been considered for more extended storage of those materials. Ensiling of pineapple waste has benefits for improving the economics of feeding as well as overcoming the disposal problem [4].

Pineapple waste silage (PWS) is promising for ruminants to use as the roughage source [5,6]. The inclusion of

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pineapple waste in the ensiling of elephant grass improved the rumen degradability parameters [7] and digestibility of silage [8]. Feeding pineapple peel ensiled with bagasse and vinasse increased nutrient intake and average daily gain (ADG) of fattening Thai steers compared with feeding sweet corn husks and cob ensiled with bagasse and vinasse [9]. Likewise, the replacement of PWS in Napier green fodder improved average daily milk yield and milk fat content without increasing nutrient intakes in Holstein Friesian dairy cows and no effect on nutrient intakes and growth performances in lambs [4]. Hattakum et al. [5] also reported that the replacement of PWS in Napier grass silage (NGS) increased the weight gain of Holstein steer without improving feed intake. As mentioned above, feeding PWS as the source of roughage enhanced the growth performances of ruminants; however, its impact on nutrient intake was varied based on type and breed of ruminants. Otherwise, Napier grass is one of the most popular grasses in the tropics and sub-tropics as well as in Myanmar. It has been the most promising and high yielding fodder with good adaptability that suppresses most tropical grasses. However, the report on feeding PWS as a roughage source replaced in NGS and its effects on performances of local cattle in Myanmar is also limited. Thus, this experiment was designated to determine the impact of feeding PWS as the source of roughage replaced in NGS on nutrient intakes, energy status, and growth performances of growing Myanmar local cattle.

Materials and Methods

Ethical approval

This experiment was carried out at the Livestock Demonstration Farm, University of Veterinary Science, and it was approved by the Committee of Animal Experiments of the University of Veterinary Science, Yezin, Myanmar, for the use of animals in the experiment.

Experimental animals, feeds, and managements

Eight growing Myanmar local cattle were randomly assigned into two groups [control (n = 4) and PWS; (n = 4)]. Each group contained two male and two female cattle. The average age and body weight of control and PWS groups before the start of the experiment were 17.50 ± 2.55 and 17.25 ± 2.93 months, and 255.00 ± 6.19 and 275.46 ± 31.42 kg, respectively.

NGS, PWS, palm kernel cake (PKC), and commercial concentrate (CC) were used as experimental feedstuffs. Before the experiment, Napier grass (approximately 60-day old of the third harvest) was harvested from the pasture of Livestock Demonstration Farm, University of Veterinary Science, and ensiled with a single batch to ensure the consistent nutritional quality. The pineapple waste was collected from the fruit processing factory, Myanmar Golden Produce Co., Ltd., Nay Pyi Taw, Myanmar, and ensiled with a single batch. Before the ensiling of pineapple waste, they were wilted under sunlight for 1 day to reduce the moisture content. After 14 days of the ensiling period, they were fed to experimental animals.

The ingredient and chemical compositions of feedstuffs and diets used in the experiment are shown in Table 1. Diets were calculated weekly for the growing beef cattle with 240 kg to allow 0.7 kg/day of ADG [10]. The experimental animals were fed *ad libitum* of their respective diet with 5%–10% refusal. The removal of refused feeds was completed at 08:00 h, and the offering of experimental diets was made twice daily at 09:00 h and 16:00 h throughout the experiment. The duration of the experiment was 6 weeks, whereas the first 2 weeks were assumed as the period for adaptation, and the next 4 weeks was considered as the period for feeding trial. Animals were kept in an individual tie-stall barn, and free assess of water was provided.

Measurements and sample collection

The daily feed offered and refusals were recorded and sampled to determine the individual nutrient intake. Body weight was measured weekly with digital balance (Centra, Mya Pan Wah Co. Ltd., Yangon, Myanmar) to estimate the body weight gain ADG. The samples of feeds offered and refusals were air-dried to obtain the constant weight. Then, all samples were kept for further analysis of proximal compositions.

For the estimation of energy status (NE_m) of experimental animals, the energy balance was estimated by model; energy balance = feed energy intake – energy requirements for maintenance and activity. The feed energy intake was calculated by multiplying dry matter intake (DMI) and feed energy content. The content of energy in feed was estimated by the model; NE_m (Mcal/kg DM) = $[(1.37 \times ME) - (0.138 \times ME^2) + (0.0105 \times ME^3)] - 1.12$ [10], whereas the ME was estimated by the model; ME (Mcal/kg DM) = 1.01 × DE (Mcal/kg) – 0.45 [11]. The DE was also estimated by the model; DE (Mcal/kg DM) = 0.04409 × TDN [11], whereas TDN was estimated as; TDN (% DM) = 87.84–(0.70 × ADF) [12]. The energy requirement for maintenance and activity was estimated by the model; NE_m (Mcal/kg DM) = $0.077 \times BW^{0.75}$ [10].

Laboratory analysis

Dry matter (DM), organic matter (OM), and ether extract of feed samples were analyzed by the method reported by Association of Official Analytical Chemists [13]. In contrast, neutral detergent fiber (NDF), and acid detergent fiber

Table 1. Ingredient and nutrient compositions of experimental feedstuffs and diets.

Items	Feedstuffs				Diets	
	NGS	PWS	PKC	CC	Control	PWS
Ingredient compositions, %						
NGS	–	–	–	–	70	45
PWS	–	–	–	–	0	25
PKC	–	–	–	–	17	17
CC	–	–	–	–	13	13
Nutrient composition, %						
DM	47.88	38.65	91.81	91.22	60.98	58.51
OM	89.58	92.26	96.48	90.59	90.88	91.55
CP	6.32	6.20	13.11	18.52	9.06	9.03
NDF	65.75	59.48	52.18	48.64	61.22	59.65
ADF	52.35	42.63	42.60	18.94	46.35	43.92
NFC[a]	15.01	24.09	28.68	20.92	18.11	20.37
TDN[b]	51.19	58.00	58.02	74.58	55.40	57.10
NE_m[c] (Mcal/kg DM)	0.99	1.28	1.28	1.92	1.16	1.23

NGS = Napier grass silage; PWS = pineapple waste silage; PKC = palm kernel cake; CC = commercial concentrate; NDF = neutral detergent fibre; ADF = acid detergent fibre.
[a]Non-fiber carbohydrate = 100 – (% NDF + % CP + % fat + % ash).[b]Total digestible nutrient (%) = 87.84–(0.70 × ADF) Schmid et al. [12].
[c]Net energy for maintenance, NE_m (Mcal/kg DM) = [(1.37 × ME)–(0.138 × ME^2) + (0.0105 × ME^3)]–1.12 NRC [10].

(ADF) were analyzed by the method described by Goering and Van Soest [14]. Crude protein (CP) was calculated as 6.25 × nitrogen (N) [13], whereas nitrogen was analyzed by the Kjeldahl method (Foss 2020 digester and Foss 2,100 Kjeltec distillation unit).

Statistical analysis

The data on average nutrient intakes, energy status, and body weight gains were analyzed with the independent *t*-test. The data on weekly nutrient intake and energy status were analyzed with the repeated measure analysis of variance. The model included the group and the time as fixed effects and its interactions, and the random effect of the experimental animals. When an interaction between groups and time was detected, these data were analyzed using Student's *t*-test for each sampling period to determine the simple effect of treatment on dependent variables. For all statistical procedures, SPSS (Statistical Package for the Social Sciences; Window version 16.0, 2007, Chicago, IL) was used with the consideration of significant differences at $p < 0 .05$.

Results and Discussion

The average DM, CP, NFC, and NDF intakes (kg/day and gm/kg $BW^{0.75}$) were significantly higher ($p < 0.05$) in the PWS group than in the control group (Table 2). No differences ($p > 0.05$) of weekly DM, NFC, and NDF intakes (kg/day) were detected at the first week of experiment because of a short period of adaptation used in this experiment; however, at the subsequent weeks, those intakes were higher ($p < 0.05$) in PWS group compared with the control group (Fig. 1a–c). Thus, it could be assumed that feeding PWS as a roughage source replaced in NGS improved the DMI and nutrient intakes of growing Myanmar local cattle. This finding is supported by Maneerat et al. [9]. They reported that feeding pineapple peel ensiled with bagasse and vinasse increased DMI of fattening Thai steers than feeding sweet corn husk and cob ensiled with bagasse and vinasse. Wattayakun et al. [15] also reported that diet, including a higher ratio of PWS, increased the DM digestibility of dairy heifer. This is likely due to the higher NFC, TDN, and energy contents of the PSW group compared to the control diet, which might provide the higher energy supply for microbial protein synthesis in the rumen, resulted increasing digestibility and feed intake. Gao and Oba [16] stated that the feed intake of the dairy cow was enhanced by a high NFC and TDN diet. Aung et al. [17] reported that dietary inclusion of *Albizia saman* pods improved the DMI and nutrient intake of lactating dairy cows because of its higher NFC and energy density.

Concerning the feed intake of cattle fed on PWS, Gowda et al. [4] reported that replacement of PWS in Napier green fodder showed no significant effect on nutrient intakes of Holstein Friesian dairy cows. Moreover, Hattakum et al. [5] also stated that the replacement of PWS in NGS decreased

Table 2. Nutrient intake, energy status, and body weight gain of growing Myanmar local cattle.

	Mean ± SEM		
	Control	**Treatment**	***p* values**
DM intake			
kg/day	6.47 ± 0.10	7.70 ± 0.42	0.030
gm/kg $BW^{0.75}$	98.70 ± 2.76	111.80 ± 3.65	0.029
CP intake			
kg/day	0.62 ± 0.01	0.73 ± 0.04	0.036
gm/kg $BW^{0.75}$	9.56 ± 0.17	10.46 ± 0.29	0.036
NFC intake			
kg/day	1.23 ± 0.01	1.57 ± 0.11	0.025
gm/kg $BW^{0.75}$	19.01 ± 0.61	22.67 ± 0.78	0.010
NDF intake			
kg/day	3.89 ± 0.07	4.57 ± 0.22	0.024
gm/kg $BW^{0.75}$	59.32 ± 1.83	66.21 ± 1.70	0.033
Energy status (NE_m Mcal/day)			
Energy intake[a]	7.73 ± 0.08	9.54 ± 0.60	0.025
Energy requirement[b]	5.06 ± 0.10	5.26 ± 0.44	0.668
Energy balance[c]	2.67 ± 0.14	4.27±0.39	0.008
Bodyweight gain (kg)			
Initial weight	255.00 ± 6.19	275.46 ± 31.42	0.547
Final weight	267.67 ± 6.51	290.46 ± 31.87	0.510
Weight gain	12.67 ± 0.59	15.01 ± 0.48	0.022
ADG	0.45 ± 0.02	0.54 ± 0.02	0.021

DM = dry matter; CP = crude protein; NFC = non-fibre carbohydrate; NDF = neutral detergent fibre; $BW^{0.75}$ = metabolic body weight; ADG = average daily gain.

[a]Energy intake = DM intake × energy content of feed. Energy content of feed, NE_m (Mcal/kg DM) = $[(1.37 \times ME) - (0.138 \times ME^2) + (0.0105 \times ME^3)] - 1.12$ NRC [10].[b]Energy requirement = requirement for maintenance + requirement for activity; requirement for maintenance, NE_m (Mcal/kg DM) = $0.077 \times BW^{0.75}$; requirements for activity, NE_L (Mcal/km) = 0.00045 NRC [10].

[c]Energy balance = feed energy intake – energy requirements for maintenance and activity NRC [10].

feed intake of Holstein steer. However, Maneerat et al. [9] reported that feeding pineapple peel silage instead of sweet corn husk and cob silage increased DMI of fattening Thai steers, which is consistent with our finding. Thus, the inconsistency of feed intake of cattle fed on PWS might be the differences in the breed of cattle used in experiments. In the experiments of Gowda et al. [4] and Hattakum et al. [5], Holstein dairy cows and steer were used as experimental animals, which are different in the breed of cattle used in our experiment and Maneerat et al. [9]. In contrast, Myanmar local cattle and fattening Thai steers, both are Zebu type (*Bos indicus*) [18,19], were used, respectively. Jardstedt et al. [20] reported that feed intake was influenced by the breed of cattle, whereas Charolais cattle have a higher feed intake than Hereford cattle.

The energy intake was higher ($p < 0.05$) in the PWS group than in the control group, whereas the energy requirements of both groups were not significantly different ($p > 0.05$). Consequently, the positive energy balance of the PSW group was higher ($p < 0.05$) than the control group (Table 2). As the weekly energy status, no differences ($p > 0.05$) of energy intake and balance were found in the first week of the experiment because of the short period of adaptation used in this experiment. Subsequently, those of the PSW group were greater ($p < 0.05$) than the control group. The energy requirements of both groups were not different ($p > 0.05$) throughout the experiment (Fig. 1d–f). Thus, feeding PWS as the roughage source replaced in NGS increased the energy intake and balance of growing Myanmar local cattle, which is consistent with Suksathit et al. [3], who stated that increasing the level of PWS in diets improved energy intake of Southern Thai native cattle. This is likely due to the different energy content of NGS and PWS (0.99 and 1.28 Mcal/kg DM), and control and PWS groups (1.16 and 1.23 Mcal/kg DM) in this experiment. Otherwise, the higher nutrient intake observed in the PWS group is also

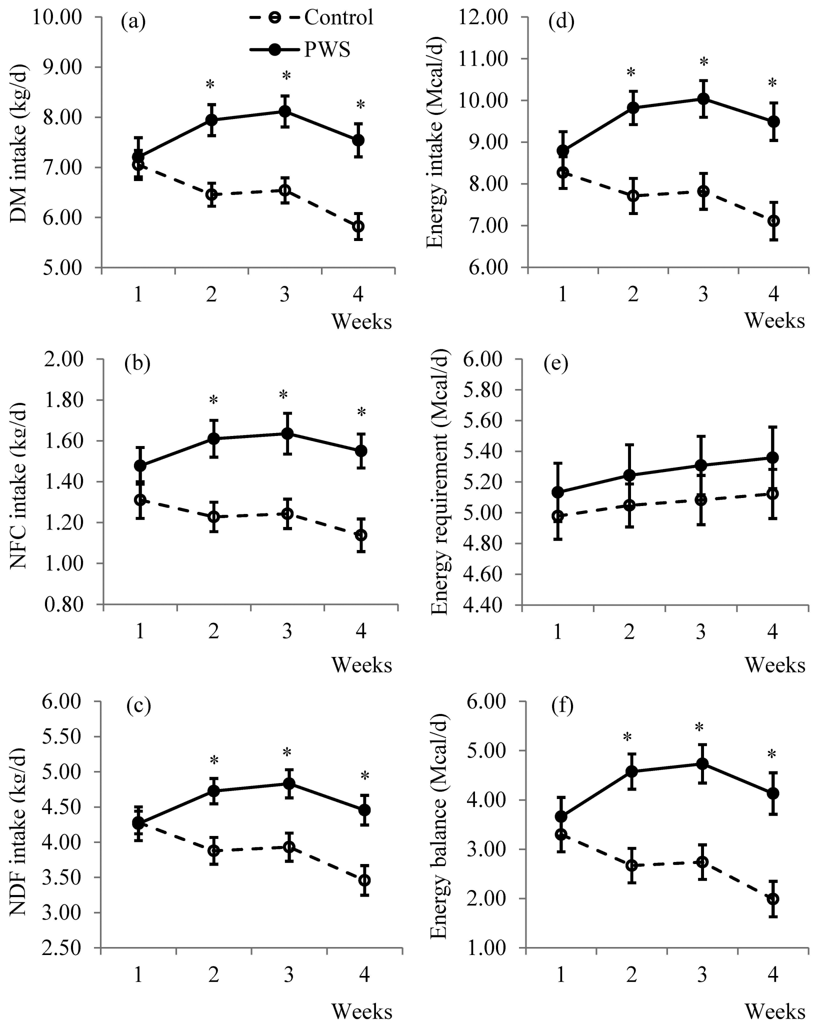

Figure 1. Nutrient intakes and energy status of growing Myanmar local cattle [(a) DM intake, (b). NFC intake, (c). NDF intake, (d). energy intake, (e). energy requirement, (f). energy balance]. Data are shown as the mean ± SEM [(control (dotted line with white circle) and PWS (black line with black circle)]. Asterisks (*) indicate significant differences ($p < 0.05$) between groups at the same time.

the reason for the increased energy intake of that group. The greater positive energy balance found in the PWS group is a result of the higher energy intake of that group. In contrast, the energy requirements of both groups were not different.

No differences ($p > 0.05$) of initial and final body weights were observed, whereas body weight gain and ADG of PSW group were higher ($p < 0.05$) than the control group (Table 2). This finding might be related to the higher nutrient intakes and energy supply of the PWS group compared to the control group. Thus, the growing Myanmar local cattle fed with the PWS diet received the greater nutrients for body utilization than cattle fed with the control diet, which had a positive effect on body weight gain and ADG of cattle [21]. Maneerat et al. [9] reported that feeding pineapple peel ensiled with bagasse and vinasse increased body weight gain and ADG of fattening Thai steers than feeding sweet corn husk and cob ensiled with bagasse and vinasse. Likewise, feeding PWS replacing in Napier green fodder to dairy cows improved average daily milk yield and milk fat content [4]. Hattakum et al. [5] also reported that the replacement of PWS in NGS increased the weight gain of Holstein steer.

Conclusion

Feeding PWS as a roughage source at 25% of diet improved the nutrient intake, energy balance, and body weight gain of growing Myanmar local cattle. Thus, PWS could be used as the source of roughage replaced in NGS in Myanmar domestic cattle with an improvement of productive performances. However, the research with a longer period would be suggested for further study to assess the growth performances of growing Myanmar local cattle.

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Conflict of interest

The authors declared no competing interests.

Authors' contribution

The conception and design of the study were contributed by all authors. YYK, KSW, and MA performed the material preparation, data collection, and analysis. YYK wrote the first draft of the manuscript and revision was completed by KSW, KSM, AA, and MA. All authors read and approved the final manuscript.

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