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Research Article
Performance of Kacang Goats Fed with Complete Wafered Forage Based on Palm Plantation Waste

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Abstract
Background and Objective: Palm oil plantations have great potential for supporting the development of the animal industry in South Kalimantan through supplying feeds for ruminants. This research was aimed at utilizing palm oil plantation byproducts to improve the production performance of Kacang goats in South Kalimantan using complete wafered roughages (CWR) based on palm oil plantation byproducts. **Materials and Methods:** Twelve month old male Kacang goats weighing 12±1.2 kg were allocated four different feed formulations with four replications: (1) Control feed consisting of 60% pasture grass +40% legume (PTA), (2) 50% CWR +50% PTA (PT1) (3) 75% CWR +25% PTA (PT2) (4) 100% CWR (PT3). The experimental measurements were dry matter intake (DMI), dry matter digestibility (DMD), live weight gain (LWG) and feed efficiency. The data were statistically analyzed using one-way ANOVA. **Results:** Compared to those fed with other dietary treatments, Kacang goats offered 75% CWR (PT2) feed treatment had higher DMI (521.7 g day^{-1}, $p<0.05$), crude protein (CP) consumption (68.4 g day^{-1}, $p<0.05$), DMD (64.7%, $p<0.05$) and protein digestibility (72.4%;, $p<0.05$). As a result, the PT2 feed formulation significantly increased LWG of Kacang goats by 95.5 g day^{-1} ($p<0.05$) and improved feed efficiency by 0.12 P. **Conclusion:** Complete wafered roughage can be used as a feed for Kacang goats at a ratio of 75% of the total diet.

Key words: Complete wafered roughages, Kacang goats, oil palm fronds, production performance, protein digestibility

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The rapid expansion of palm oil plantations has resulted a large amount of waste products either from the plantation area or the palm oil mill. The main byproducts of the palm oil industry are empty fruit bunches (EFB), oil palm fronds (OPF), oil palm trunks (OPT), palm kernel cake (PKC), palm press fiber (PPF), palm oil mill effluent (POME) and shell[1] In South Kalimantan, however, these byproducts have not been utilized optimally for animal feeds due to technical issues such as limited access to obtain the byproducts and lack of technology to treat them as feeds for livestock.

Palm kernel cake is the material with the most potential to be used as a feed for ruminants owing to the high crude protein (CP) content of PKC compared to other byproducts ranging from 16-17%[2]. Because the content of crude fiber is 16%, the use of PKC in the feed of ruminants should be accompanied by other feed supplements. Moreover, PKC can be added into the feed ration by up to 30% without hindering the performance of ruminants[3]. Following this, OPF, which consists of leaves, midribs and stems (petioles), could also be utilized as a potential source of energy for ruminants because it generates a huge amount of biomass, approximately 82.5 kg tree^{-1} annually[4]. After being segregated from OPF, Biyatmoko[5] reported that a palm oil tree yielded ~3.3 kg of fresh leaves with 35% dry matter (DM) content. Apart from its abundant availability, Rusli *et al.*[6] reported that palm leaves contain 11.2% CP, 46% cellulose, 26.3% lignin, 69.3% NDF and < 50% *in vitro* digestibility. Therefore, pretreatments to palm oil byproducts are necessary prior to offering these products to ruminants to improve digestibility and palatability.

Complete wafered roughage (CWR) products have two main benefits viz, they are easily stored and nonperishable[7]. Moreover, Retnani *et al.*[8] emphasized that the nutrient content of wafered roughages is more complete than those without any treatment. Moreover, the compact form of wafered roughages results in the efficient use of storage space. The main objective of this study was to scrutinize the effectiveness of utilizing oil palm byproducts to improve the performance of Kacang goats using complete wafered roughages (CWR) derived from oil palm plantation products.

MATERIALS AND METHODS

The experiment was conducted at the animal house of the Islamic University of Kalimantan (UNISKA), Animal Nutrition Laboratory, the Lambung Mangkurat University (ULM), Feed Technology Laboratory, the Bogor Agricultural University (IPB), Biotechnology Laboratory IPB and the BALITNAK Ciawi Laboratory Bogor. Palm oil fronds were sourced from the oil palm plantation, Gunung Kupang, South Kalimantan.

Animals and diets: Twelve month old male Kacang goats weighing 12±1.2 kg were housed in individual metabolic pens for 40 days and subjected to four replications of experimentation. The goats were given four different feed treatments: (1) control feed consisting of 60% pasture grass+40% legume (PTA), (2) 25% pasture grass +25% legume + 50% complete wafered forage (PT1), (3) 12.5% pasture grass +12.5% legume +75% complete wafered forage (PT2) and (4) 100% complete wafered forage (PT3). Prior to the experiment, the goats had been treated with a dose of 0.01% LW Kalbazenat and vitamins at a dose of 250 mg head^{-1}. Treated feeds were fed to goats twice a day at 08.00 and 15.00. The nutrient composition of each treatment is described in Table 1 and 2.

Procedure of complete wafered roughage production: After being separated from oil palm fronds, stems were peeled and chopped using a chopper until a smooth fiber-like consistency was achieved. Following this, the chopped stems were dried under sunlight or a drier for 5-8 h until the moisture content was 15-17%. Palm kernel cake, rice bran, cassava meal,

Table 1: Nutrient composition of grass, legume and complete wafered forage

Nutrient content (%)	Grass (G)	Legume (L)	Complete wafered roughage (CWR)
Dry matter	20.12	27.86	86.54
Crude protein	9.21	18.43	12.64
Crude fibre	25.12	23.20	24.67
Ether Extract	2.85	0.12	3.14
Nitrogen free extractives	54.86	42.65	44.03
TDN	51.86	52.72	61.42
NDF	63.00	58.93	43.99
ADF	45.25	38.28	37.23
Ca	0.54	0.32	1.32
P	0.72	0.64	0.86

TDN: Total digestible nutrients, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, Ca: calcium, P: Phosphorus

Table 2: Nutrient analysis and feed composition of experimental diets offered to Kacang goat

	Ration formulation			
Nutrient content (%)	PTA (60%G+40%L)	PT1 (C25%G+25%L+50%C)	PT2 (12.5%G+12.5%L+75%C)	PT3 (100%C)
Dry matter	70.68	71.53	70.26	86.54
Crude protein	12.24	13.12	13.62	12.64
Ether extract	3.00	3.88	4.98	3.14
Crude fiber	25.76	23.82	24.74	24.67
TDN	58.21	59.87	60.12	61.42
NDF	57.85	54.32	56.62	43.99
ADF	39.54	32.75	42.76	37.23
Ca	1.05	1.39	1.45	1.32
P	0.68	0.72	0.78	0.86

PTA: Control feed consisting of 60% pasture grass +40% legume, PT1: 25% pasture grass +25% legume +50% complete wafered forage, PT2: 12.5% pasture grass +12.5% legume +75% complete wafered forage and PT3: 100% complete wafered forage, TDN: Total digestible nutrient, NDF: Neutral detergent fiber, ADF: Acid detergent fiber

Table 3: Feed intake of Kacang goat across feed treatments

	Treatments				
Intake	PTA	PT1	PT2	PT3	SEM
Dry matter (g day^{-1})	474.63^a	497.36^b	521.74^b	486.42^a	20.08
Crude protein (g day^{-1})	62.21^a	64.41^b	68.45^b	62.78^a	2.820
Crude fibre (g day^{-1})	113.50	126.86	120.76	112.64	6.690
Ether extract (g day^{-1})	33.62	48.54	50.14	35.65	8.560
N Free extractives (g day^{-1})	246.54	252.98	264.12	240.76	10.01
TDN (g day^{-1})	282.74	324.24	345.85	298.13	27.94
NDF (g day^{-1})	250.52	274.65	308.75	283.76	24.06
ADF (g day^{-1})	172.34	184.60	245.84	215.25	32.94

PTA: Control feed consisting of 60% pasture grass +40% legume, PT1: 25% pasture grass +25% legume +50% complete wafered forage, PT2: 12.5% pasture grass +12.5% legume +75% complete wafered forage and PT3: 100% complete wafered forage, TDN: Total digestible Nutrient, NDF: Neutral detergent fiber,. ADF: Acid detergent fiber, Means within a row with no common superscript differ significantly ($p<0.05$)

molasses and urea were further mixed with the dry chopped stem. To generate complete wafered roughage, the mixed feedstuff was inserted into a wafering machine to be pressed, heated and formed at a temperature of 100°C for 10 min. Finally, the wafered roughages were cooled down at room temperature. The dimensions of the CWR was 20×20×1.5 cm and the average weight was approximately 400 g.

Data collection and fecal analysis: Fecal and urine collections were conducted daily within seven days after all treatments and other measurements had been undertaken completely. Fecal samples and refuse were collected every morning before the feed was given. Approximately 10% of the samples were composited a plastic bag and refrigerated before being analyzed in the laboratory.

Experimental design: The completely randomized design was used with four treatments and four replications. Goat performance [DMI, digestibility, live weight gain (LWG) and feed efficiency] was statistically assessed by one-way ANOVA using IBM® SPSS version 22. The difference between means was analyzed using Duncan's multiple-range test to compare means within the fixed factors. The significance level was set at $p<0.05$.

RESULTS

Feed intake: Kacang goats given the control feed (60% grass +40% legume) ingested the least fodder compared to those that were treated with 50 and 75% CWR. Inclusion of CWR by up to 75% in the diet increased DMI of goats significantly ($p<0.05$). However, providing 100% CWR to the goats decreased DMI by 35.3 g day^{-1} ($p<0.05$) (Table 3). Moreover, an inclusion of CWR in the diet at either 50 or 75% did not have a significant impact on the DMI of the Kacang goats ($p>0.05$).

On a dry matter basis, the average CP intake (CPI) of Kacang goats was 64.5 g day^{-1}. There was a significant increase ($p<0.01$) in the CPI of goats with the increase in the level of CWR in the ration by up to 75%. However, the CPI markedly declined by 8.3% when CWR was offered as the only feed for Kacang goats ($p<0.05$). The CPI of Kacang goats is presented in Table 3.

Table 4: Feed digestibility of Kacang goat fed complete forage wafered

	Treatments				
Digestibility	PTA	PT1	PT2	PT3	SEM
Dry matter (%)	62.11[a]	63.94[a]	64.72[b]	62.23[a]	1.47
Crude protein (%)	68.02[a]	69.98[a]	72.45[b]	69.24[a]	1.87
Crude fiber(%)	61.45	60.32	62.89	61.45	1.05
Ether extract (%)	34.12[a]	45.41[a]	66.54[b]	65.75[b]	15.92
Free N extractives (%)	65.64	66.34	67.52	65.54	0.91
NDF (%)	39.54[a]	50.42[b]	48.48[b]	56.73[c]	7.10
ADF (%)	42.78[a]	49.46[b]	46.18[a]	53.62[b]	4.63

PTA: Control feed consisting of 60% pasture grass +40% legume, PT1: 25% pasture grass +25% legume +50% complete wafered forage, PT2: 12.5% pasture grass +12.5% legume +75% complete wafered forage and PT3: 100% complete wafered forage, TDN: Total digestible nutrient, NDF: Neutral detergent fiber, ADF: Acid detergent fiber

Table 5: The effects of complete wafered roughages on live weight gain (LWG) and feed efficiency of Kacang goat

	Treatments				
Variables	PTA	PT1	PT2	PT3	SEM
Initial body weight (kg)	12.50	13.00	12.90	13.00	0.26
Final body weight (kg)	15.00	16.10	16.50	16.30	0.67
Live weight gain (total) (kg)	2.50[a]	3.10[a]	3.90[b]	3.30[b]	0.58
Live weight gain (average) (g day^{-1})	62.50[a]	77.50[a]	92.50[b]	82.50[b]	9.63
Feed efficiency	0.08	0.09	0.12	0.09	0.02

PTA: Control feed consisting of 60% pasture grass +40% legume, PT1: 25% pasture grass +25% legume +50% complete wafered forage, PT2: 12.5% pasture grass +12.5% legume +75% complete wafered forage and PT3: 100% complete wafered forage. Means within a row with superscript differ significantly (p<0.05)

Feed digestibility: Dry matter digestibility (DMD) of feed was significantly influenced by the presence of CWR in the rations of Kacang goats. An enhancement level of CWR in the rations from 0-75% significantly altered DMD by 2.6% (p<0.05). However, there was a 2.5% decrease in DMD of feed (p<0.05) when 100% CWR was used as a feed for the goats (Table 4). The DMD of feed did not differ by the inclusion of CWR at a level of 0, 50 and 100% (Table 4).

Live weight gain and feed efficiency: During the 40 days of this study, the LW of Kacang goats increased from 12.85-15.98 kg. On average, the LWG of Kacang goats in this experiment was 78.75 g day^{-1}. Addition of CWR to feed rations at the levels of 75 and 100% successfully enhanced LWG significantly (p<0.05). However, both treatments did not differ significantly in altering the LWG of goats. Accordingly, there was no significant impact of adding 50% CWR on the LWG of Kacang goats (p>0.05) (Table 5). Furthermore, the inclusion of 75% CWR was the most efficient feed treatment utilized by Kacang goats.

DISCUSSION

The dietary intake of goats in this experiment fulfilled the standard requirement for the basal metabolic rate (BMR), which was between 2.6 and 3.5% LW. According to the NRC[9] the BMR of goats requires 2.4-2.8% LW of DMI. In this trial, inclusion of CWR at a level of 75% resulted in the highest DMI (521.7 g day^{-1}) and at 100% CWR feed consumed by goats was the least (474.6 g day^{-1}). This results was likely due to increasing levels of fine particles in the rations of goats. Poppi *et al.*[10] reported that particles greater than 1.18 mm have difficulty in flowing from rumen to abomasum. Rostini *et al.*[11] stated that wafering dried forages shriveled the particle size, which leads to an increase in voluntary feed intake (VFI) of beef cattle. Likewise, Kawamoto *et al.*[12] noted that a decrease in the particle size of oil palm fronds enhances the amount of particles flowing from the rumen and hence increases VFI.

Utilizing complete wafered roughage as a sole feed for goats reduced DMI significantly. According to Eriksson *et al.*[13], a ratio of entirely wafered roughages could potentially reduce the motility of the reticulo-rumen and cause a loss of appetite. Therefore, 100% CWR in this experiment decreased DMI and DMD. Wilkins *et al.*[14] stated that finer particle size accelerates the passage rate in the alimentary tract and hence diminishes DMD. Hence, it can be inferred that the 75% wafered oil palm leaf treatment in this trial creates the optimum particle size to be digested by the rumen microbiota of Kacang goats. Dahlan *et al.*[15] reported that 80 and 63% OPF in the rations of goats significantly improves digestible DMI. Reduced DMI and DMD observed in the 100% CWR treatment was likely due to an insufficient amount of CP and energy. Therefore, it is critical to provide concentrates and other supplementary feeds along with CWR in the rations of goats for fulfilling protein and energy requirements.

Significant effects of high levels of CWR (75 and 100%) on LWG of goats occurred because both treatments had higher nutrient content, particularly CP and TDN, than did other feed formulations. This is because CWR contains palm kernel cake, rice bran, molasses, cassava meal and urea. McDonald *et al.*[16] explained that those feedstuffs are the major sources of carbohydrates, protein and nitrogen. In this trial, Kacang goats fed 75% CWR were also the most efficient feed utilizers. Reynolds *et al.*[17] stated that a high dependency of ruminants on forages as the main sources of energy has reduced feed efficiency. Thus, a low forage proportion in the rations can be associated with high feed efficiency.

CONCLUSION

The utilization of complete wafered roughage based on palm oil leaves as a feed for Kacang goats has potential to improve DMI, DMD, LWG and feed efficiency. However, the use of CWR in the rations of Kacang goats should be used along with forages and other supplementary feeds to fulfil protein and energy requirements. Hence, it can be suggested that 75% is the optimum level of CWR in the rations of Kacang goats.

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