Research Article

The Impact of Replacement of Concentrates with Fermented Tithonia (*Tithonia diversifolia*) and Avocado Waste (*Persea americana miller*) in Fermented Sugarcane Shoots (*Saccharum Officinarum*) Based Rations on Consumption, Digestibility, and Production Performance of Kacang Goat

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Abstract | Fermented sugarcane shoots are used as energy sources, and fermented tithonia *(Tithonia diversifolia)* as a forage protein source in Kacang goat rations. Avocado waste to optimize rumen bioprocessing. This research aimed to obtain good performance from Kacang goats through appropriate ration formulation based on fermented forage (sugarcane shoots and tithonia) with avocado waste. This formulation is expected to minimize the use of concentrate in the ration. This study used 16 male Kacang goats aged one year, which consisted of four groups based on body weight. The concentrate consists of rice bran, corn, palm kernel cake, salt, and minerals. The treatments were as follows: T0= 35% fermented sugarcane shoots (FSS) + 5% fermented tithonia (FT) + 0% avocado waste (AW) + 60% concentrate, T1= 35% FSS + 9.5% FT + 0.5% AW + 55% concentrate, T2= 35% FSS + 14 % FT + 1% AW + 50% concentrate, T3= 35% FSS + 18.5% FT + 1.5% AW + 45% concentrate. The parameters measured included feed consumption (dry matter, organic matter, and crude protein), nutrient digestibility (dry matter, organic matter, and crude protein), and production performance (body weight gain and feed efficiency). The result showed that the difference in ration composition had a significant effect ($P<0.05$) on feed consumption, nutrient digestibility, and production performance. This study concluded that the combination of 35% fermented sugarcane shoots +14% fermented tithonia + 1% avocado waste (AW) +50% concentrate resulted in the best feed consumption, nutrient digestibility, and production performance of Kacang goat.

Keywords | Avocado waste, Daily gain, Kacang goat, Sugarcane shoots, *Tithonia diversifolia*

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INTRODUCTION

Many Indonesian people cultivate beef goats. The population of goats in Indonesia in 2021 is 19,229,067 heads, while in West Sumatra, there are 254,503 heads, or 1.322 percent of the total national population (BPS, 2021). Many people in West Sumatra keep meat goats with the Kacang goat type. The Kacang goat is a local Indonesian goat breed with the characteristics; of a relatively small body, straightforward maintenance, high adaptability, and reproduction (Udo et al. 2011).

Forage is the main feed in goat rations. Forage functions as bulk and plays a vital role in fiber sources as a fermentation material for microorganisms in the rumen. The problem that often occurs is that forage feeds have low productivity in the dry season, and the price of protein-source feed ingredients is high. The limitation of feed can interfere with livestock production and reproduction because its adequacy and quality are related to livestock performance. One solution to overcome this is looking for productive alternative forages based on continuity, quality, and quantity aspects.

Sugarcane shoots are a by-product of the sugarcane plant. Sugarcane shoots are a component of waste, with a proportion of 14% of the total weight of sugarcane remaining after harvest. The sugarcane plantation area in Indonesia covers an area of 419 thousand hectares, consisting of community plantations covering an area of 237.85 thousand hectares, large state plantations covering an area of 56.68 thousand hectares, and large private plantations covering an area of 124.46 thousand hectares (BPS, 2020). Sugarcane shoots can be used as a forage energy source because of their high crude fiber content. Sugarcane shoots contain 91.57% organic matter, 5.58% crude protein, 57.13% neutral detergent fiber (NDF), and 15.95% lignin (Pazla et al., 2021a). The lignin content in sugarcane shoots is relatively high. Lignin is a wood substance that binds cellulose and hemicellulose. This bond is so strong that it is difficult for rumen microbes to degrade fiber (Pazla et al., 2020). The lignocellulose bonds can be broken using the ligninase enzyme (Febrina et al., 2017; Jamarun et al., 2017a). *Pleurotus ostreatus* is a white rot fungus capable of degrading lignin. This mold produces extracellular oxide enzymes to degrade lignin, such as lignin peroxidase (LiP) and manganese peroxidase (MnP) (Yanti et al., 2021).

Ruminants also need feed ingredients to meet their protein needs. The tithonia plant is a forage that contains high level of protein. Tithonia is an herbaceous plant with a sunflower-like appearance. Tithonia can be found on roadsides, lakes, and abandoned lands. Jamarun et al. (2019) reported the nutritional content of Tithonia, namely dry matter at 22.57%, organic matter at 84.01%, crude protein at 22.98%, crude fiber at 18.17%, and lignin at 4.57%. Tithonia contains antinutritional substances such as flavonoids, tannins, alkaloids, phytic acid, saponins, and oxalate (Aye, 2016). Phytic acid is an antinutrient with the highest amount, 79.2 mg/100 g, and can reduce the palatability of livestock (Oluwasola and Dairo, 2016; Pazla et al., 2021b). One of the processing methods that can reduce phytic acid in Tithonia is fermentation. Pazla et al. (2021c) stated that the fungus *Aspergillus ficuum* was able to produce phytase enzymes. Phytase enzymes can break the bonds of phytic acid so that phosphorus minerals become more widely available (Pazla et al., 2021d).

Adding avocado waste in the form of skins and seeds into goat rations is expected to optimize the rumen bioprocess in Kacang goats. Avocado seeds have nutritional content and are beneficial for health. Avocado seeds are efficacious in reducing blood sugar levels (Hariana, 2004). Uchenna et al. (2017) reported that the chemical composition of avocado seeds was as follows: crude protein (9.6%), lipid (1.4%), ash (4.9%), and moisture content (8.5%). Justina et al. (2016) reported the following vitamin contents of avocado seeds: A (207.02 g/100g), C (14.63 g/100g), and E (0.65 g/100g). Avocado seeds also contain several high mineral elements such as calcium, magnesium, phosphorus, potassium, zinc, iron, copper, and sodium 14.15, 26.16, 31.33, 100.83, 0.09, 0.31, 0.98, and 0.30 mg/100g, respectively (Arukwe et al., 2012). Minerals Ca, P, Mg, K, and Zn are essential in optimizing the rumen bioprocess (Grace et al., 1977; Suyitman et al., 2021). Avocado seeds contain metabolic energy of 3370 kcal/kg, but their use must be limited because they contain antinutritional substances or tannins of 1.02% (Djulardi, 2004). Sagaf et al. (2022) reported that using avocado skins and seeds as much as 0.5% in concentrate feed, increases body weight gain, feed efficiency, body temperature, red blood cell count, hemoglobin level, and hematocrit value in Kacang goat. This study aimed to determine the feed consumption, nutrient digestibility, and production performance of Kacang goats fed sugarcane shoots with different proportions of Tithonia, avocado waste (skin and seeds), and concentrate.

MATERIALS AND METHODS

Animal ethics

Animal experiments were conducted following the republic of Indonesia Law No. 18 of 2009 (section 66), which addressed animal keeping, raising, killing, and proper treatment and care.

Research place

This research was conducted in one of the experimental goat pens at the Faculty of Animal Husbandry, Andalas University. The process of fermenting sugarcane shoots and tithonia was conducted at the Laboratory of Feed Technology and Industry, Faculty of Animal Husbandry, Andalas University. Proximate and van Soest analyze feed ingredients that make up rations and feces in the Ruminant Nutrition Laboratory, Faculty of Animal Husbandry, Andalas University.

Research material

The livestock used in this study were 16 male Kacang goats aged one year. Goats are grouped based on body weight: Group I: 12.26±0.43 (CV= 3.50%), II: 10.47±0.30 (CV= 2.82%), III: 9.22±0.54(CV= 5.82%), IV: 8.34±0.21 (CV= 2.47%). The individual cage was made of an iron frame measuring 1X0.75X1 m and equipped with a place to eat and drink.

The materials used in this study were sugarcane shoots, tithonia, *Pleurotus ostreatus* mold, *Aspergillus ficuum*, Potato Dextrose Agar media, aquades, avocado waste (skin and seeds), concentrates consisting of corn, palm kernel cake, minerals, salt, and rice bran. Materials for chemical composition analysis. The equipment used in this research is a set of tools for mold rejuvenation, beaker glass, autoclaves, beakers, cotton, aluminum foil, test tubes, analytical scales, plastic, ropes, and bench containers.

Sugarcane shoots fermentation process

The production of fermented sugarcane shoots follows the procedure of Pazla et al. (2021a). This fermentation uses *Pleurotus ostreatus*. The sugarcane shoots were collected from the Puncak Lawang sugarcane plantation area, Agam Regency, West Sumatra. Sugarcane shoots were separated from the stems, air-dried, and then put in the chopper. After that, the sugarcane shoots were spread evenly on the tarpaulin, then mixed evenly with 10% for *Pleurotus ostreatus*. After that, it was put into plastic, compacted under facultative anaerobic conditions, tied, and incubated for 21 days. Sugarcane shoots are air-dried before being fed to livestock.

Tithonia fermentation process

The fermentation tithonia procedure in this study followed that of Pazla et al. (2021c). The tithonia were fermented using Aspergillus *ficuum* mold. The tithonia plants were collected from the Puncak Lawang area, Agam Regency, West Sumatra. The tithonia substrate was cut, dried and, crushed. The tithonia was spread evenly on a tarp and given 10% *Aspergillus ficuum*. Tithonia was put into plastic, compacted in a facultative aerobic condition, and tied. Tithonia was harvested after seven days of incubation. It should be air-dried before being fed to livestock.

The avocado waste

The avocado waste used in this study had seeds and skin. Avocado waste was collected around the town of Padang, West Sumatra. It was dried, ground to a powder, and then mixed into the concentrate according to the treatment.

Trial ration

The ration used in this study consisted of forage, concentrate, minerals, and salt. The forages used were fermented sugarcane shoots, tithonia, and avocado waste, while the concentrates used were rice bran, palm kernel cake, and corn. The ration was given at 3.5% of body weight in dry matter conversion (Kearl, 1982). The proximate compositions were determined as described by AOAC (2007). The fibers fraction (NDF, ADF, cellulose, and lignin) were determined according to the method of Van Soest et al. (1991). TDN is calculated based on Moran (2005). The chemical composition of the ingredients for the ration is presented in Table 1. The composition of the ration and the nutritional content of the treatment ration are presented in Tables 2 and 3.

Table 1: Content of feed ingredients for ration.

Chemical composition (%)	Feed ingredients					
	Fermented tithonia	Fermented sugar-cane shoots	Avocado waste	Rice bran	Palm kernel cake	Corn
Dry matter	80.79	60.62	85.33	85.87	85.91	85.55
Organic matter	85.49	87.81	96.42	88.99	96.13	95.87
Crude protein	25.85	8.53	7.56	8.94	22.29	13.87
Crude Fat	2.61	1.64	10.67	8.76	10.99	3.09
NFE	37.21	38.92	69.89	55.67	32.89	69.31
ADF	36.81	51.21	38.13	23.08	50.33	34.66
NDF	54.17	81.98	65,70	48.11	72.59	58.62
Cellulose	23.12	29.08	14.29	11.05	29.10	19.70
Hemicellulose	17.35	30.77	27.57	25.03	22.26	23.96
Crude Fiber	19.82	38.72	8.90	15.62	29.96	9.61
TDN	59.53	57.30	90.67	77.70	68.64	82.82

TDN= 5.31+ (0.412*CP) +(0.249*Crude Fiber) + (1,444*Crude Fat) + (0.937*NFE). CP= crude protein, NFE= nitrogen free extract, ADF= acid detergent fiber, NDF= neutral detergent fiber. TDN= total digestible nutrient.

Table 2: Treatment ration composition (%).

Feed ingredients	Treatment			
	T0	T1	T2	T3
FT	5.0	9.5	14	18.5
FSS	35.0%	35%	35%	35%
Avocado Waste	0.0%	0.5%	1%	1.5%
Rice Bran	22.0%	18.0%	18.0%	14.0%
Palm kernel cake	27.0%	17.0%	17.0%	13.0%
Corn	10.0%	19.0%	14.0%	17.0%
Salt	0.5%	0.5%	0.5%	0.50%
Mineral	0.5%	0.5%	0.5%	0.50%
Amount	100%	100%	100%	100%

FSS= Fermented Sugarcane Shoots, FT= Fermented Tithonia

Table 3: Nutrient content of each treatment (% Dry Matter).

Nutritional content	Treatment			
	T0	T1	T2	T3
Dry matter	76.90	76.74	76.62	76.48
Organic matter	90.13	89.80	89.43	89.21
Crude protein	13.65	13.60	14.19	14.65
Crude fat	5.11	4.91	4.93	4.40
Crude fiber	27.03	25,12	25,48	24.78
NFE	43.54	46.28	44.83	45.38
ADF	41.90	40.84	40.88	40.76
NDF	67.45	66.17	65.86	65.42
Cellulose	23.59	23.09	23.19	23.26
Hemicellulose	25.55	25.33	24.98	24.66
Lignin	13.83	12.92	12.94	12.64
TDN	66.94	67.57	66.57	66.34

NFE= nitrogen free extract, ADF= acid detergent fiber, NDF= neutral detergent fiber. TDN= total digestible nutrient.

Research period

This research is divided into three periods: the adaptation period, the introductory period, and the collection period. The adaptation period lasts 25 days. This period aims to familiarize the goats with the treatment rations and the experimental environment. The preliminary period lasts for ten days to eliminate the influence of the previous ration and see the effect of the ration on the growth of goats. The collection period lasts five days. Feed consumption, body weight, and feces collection were calculated during this period. Stool collection is done by weighing the total feces for 24 hours, then 10% of fresh feces is taken as a sample. Stool samples were dried and mashed to be analyzed for their chemical composition.

Research design

The design used in this study was a randomized block design using four treatments and four replications. The treatments used in the study are as follows:

T0= 35% FSS + 5% F + 0% AW + 60% concentrate
T1= 35% FSS + 9.5% FT + 0.5% AW + 55% concentrate
T2= 35% FSS + 14 % FT + 1% AW + 50% concentrate
T3= 35% FSS + 18.5% FT + 1.5% AW + 45% concentrate

Where: FSS: fermented sugarcane shoots; FT: fermented tithonia; AW: avocado waste.

Mathematical model of the design using (Steel and Torrie, 2002).

$$Yij = \mu + \tau i + \beta j + \Sigma ij$$

Information: Yij= the results of the observation of the i-th treatment and the j-th replication; μ =general mean; τi = the effect of treatment i; Σij = random error; i = treatments (T0, T1, T2, T3); βj = the effect of treatment j; j = repetition (1, 2, 3, and 4).

The parameters measured were feed consumption (dry matter, organic matter, crude protein), nutrient digestibility (dry matter, organic matter, crude protein), and production performance (body weight gain and feed efficiency).

Consumption of rations (fresh) (Kg/day) = number of rations given – number of rations left
Dry matter consumption (Kg/day) = Fresh ration consumption * Dry matter ration
Consumption of organic matter (Kg/day) = DM ration consumption * Organic matter ration
Consumption of crude protein (Kg/day) = DM ration consumption * Crude protein ration
Dry matter digestibility (Kg/day) = (DMC- Feces)/ DMC * 100%)
Digestibility of organic matter (%) = (OMC- Feces)/ OMC * 100%)
Crude Protein Digestibility (%) = (CPC- Feces)/ CPC * 100%)
Body weight gain Kg/day) = (Final weight -Initial weight)/ Research Time
Feed Efficiency (%) = Body weight gain/ DMC * 100%

Where: DM= Dry matter; DMC= Dry matter consumption; OMC= Organic matter consumption; CPC= Crude protein consumption.

Statistical analysis

Data analysis used Analysis of Variances with Software Statistical Package for the Social Sciences (IBM SPSS Statistics, USA) Version 21.0. Further test using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Feed consumption of treatment ration

Table 4 shows that each treatment had a significant effect (P<0.05) on the consumption of dry matter, organic matter, and crude protein. The T2 treatment provided the highest dry matter consumption of organic matter and crude protein. After the further test of DMRT, T2 was significantly different (P<0.05) from T1, T3, and T0. T1 was not significantly different (P>0.05) from T3 but significantly different (P<0.05) from T0. T3 was significantly different (P<0.05) from T0. T0 indicates the lowest dry matter, organic matter, and crude protein consumption. An increase in tithonia from 5% (T0) to 14% (T2), an increase in avocado waste dose from 0% (T1) to 1% (T2), and a decrease in the amount of concentrate in the ration from 60% (T1) to 50% (T2) indicated an increasing trend of feed consumption (dry matter, organic matter, and crude protein). However, feed intake (dry matter, organic matter, and crude protein) decreased at T3.

Table 4: Consumption of Kacang goat ration treatment.

Consumption (g/e/day)	Treatment			
	T0	T1	T2	T3
Dry Matter	239.89[c]	260.74[b]	303.87[a]	258.15[b]
Organic Matter	281.15[c]	305.47[b]	354.65[a]	301.14[b]
Crude Protein	32.74[c]	35.46[b]	43.13[a]	37.81[b]

Description: T0= 35% FSS + 5% F + 0% AW + 60% concentrate, T1= 35% FSS + 9.5% FT + 0.5% AW + 55% concentrate, T2= 35% FSS + 14 % FT + 1% AW + 50% concentrate, T3= 35% FSS + 18.5% FT + 1.5% AW + 45% concentrate. Different superscripts on the same line showed significant differences (P<0.05).

The palatability of a feed ingredient determines feed consumption. High ration consumption indicates that the ration is palatable for livestock. T0 is the lowest value for ration consumption. The T0 ration contained 35% sugarcane shoots and 5% tithonia as the dominant forage. The dominant sugarcane shoots as forage become less favored by goats.

Meanwhile, sugarcane shoots combined with tithonia increased consumption by 9.5% (T1) and 14% (T2). Feed consumption will increase if the forage provided contains several plant variations. Arief et al. (2021) reported an increase in goat consumption by giving two types of forage compared to one type of forage alone. Goats quite like fermented tithonia because it smells good. Goats naturally love leaves. Ramírez-Rivera et al. (2010) reported that the combination of 20% tithonia with Taiwan grass in the ration increased feed consumption. However, at T3, there was a slight decrease in consumption from T2. Consumption that began to decline is thought to be due to the level of antinutritional tithonia exceeding the goat's tolerance threshold. Tithonia contains high phytic acid (Fasuyi et al., 2010). Phytic acid causes a bitter taste, so it can reduce feed consumption if the dose is excessive. Pazla et al. (2021b) reported a decrease in ration consumption in Pesisir cattle with a 30% tithonia level in the diet.

Adding avocado waste to a level of 1% can increase feed consumption. Avocado waste contains many minerals that stimulate the rumen microbes' growth and activity, like Ca, P, Mg, and Zn. Feed consumption increases due to increased digestibility due to rumen microbial activity in degrading feed (Suyitman et al., 2020).

Dry and organic matter consumption have the same pattern (Febrina et al., 2017). Consumption of organic matter increases along with the consumption of organic matter. The components contained in dry matter significantly affect the increase and decrease in consumption of organic matter (Kamalidin et al., 2012).

This study's dry matter and organic matter consumption were lower than those of Fardana et al. (2019), namely 895-1066 grams/head/day and 800-967 grams/head/day using forage corn and concentrate enriched with multi-nutrient blocks. Multinutrient blocks and maize have high palatability compared to sugarcane shoots.

Crude protein consumption is influenced by dry matter consumption and the protein content of the feed (Martawidjaja et al., 1999; Arief and Pazla., 2023). The consumption of crude protein in this study was lower than that reported by Laksana et al. (2013), which was 48-111g/head/day with rations prepared at 18.33% protein content and 65.23% TDN. Consumption of high protein rations is caused by the high protein content of the ration (Krisnan and Rantan, 2015; Marwah et al., 2010).

Nutrient digestibility of treatment ration

Table 5 shows that the treatment had a significant effect (P<0.05) on the digestibility of dry matter, organic matter, and crude protein. The highest dry matter, organic matter, and crude protein digestibility were found in the T2 treatment. After the further test of DMRT, the dry matter digestibility of T2 was significantly different (P<0.05) from T2, T0, and T3. T1 was not significantly different (P>0.05) from T0 but significantly different (P<0.05) from T3. T0 was significantly different (P<0.05) from T3. T2 organic matter digestibility was not significantly different (P > 0.05) from T1 but significantly different (P 0.05) from T0 and T3. T1 was not significantly different (P>0.05) from T0 but significantly different (P<0.05) from T3. T0 was significantly different (P<0.05) from T3.

Table 5: Digestibility of Kacang goat treatment.

Digestibility (%)	Treatment			
	T0	T1	T2	T3
Dry matter	56.19[bc]	58.76[b]	62.05[a]	52.71[d]
Organic matter	68.98[b]	71.08[ab]	73.01[a]	66.15[c]
Crude protein	75.63[c]	78.36[b]	81.72[a]	72.24[d]

Description: T0= 35% FSS + 5% F + 0% AW + 60% concentrate, T1= 35% FSS + 9.5% FT + 0.5% AW + 55% concentrate, T2= 35% FSS + 14 % FT + 1% AW + 50% concentrate, T3= 35% FSS + 18.5% FT + 1.5% AW + 45% concentrate. Different superscripts on the same line showed significant differences (P<0.05).

Crude protein digestibility of T2 was significantly different (P<0.05) from T1, T0, and T3. T1 was significantly different (P<0.05) from T0 and T3. T0 was significantly different (P<0.05) from T3. The lowest dry matter, organic matter, and crude protein digestibility were found at T3. An increase in tithonia and avocado waste from T0 to T3 and a decrease in the amount of concentrate in the ration from T1 to T3 indicated an increasing trend of dry matter, organic matter, and crude protein. However, the digestibility of dry matter, organic matter, and crude protein decreased significantly (P<0.05) from T2 to T3, i.e., When the proportion of tithonia increased to 18.5%, avocado waste increased to 1.5%, and concentrate decreased to 45%.

Feed digestibility (DMD, OMD, and CPD) increased from treatment T0 to T2 due to the addition of tithonia and avocado waste in the ration. The increase in the proportion of tithonia and avocado waste at T2 increased the rumen microbial population. The rumen microbial population increased because tithonia plants contain minerals and amino acids (Adrizal et al., 2021; Jamarun et al., 2020; Mahecha and Rosales, 2005), while avocados also contain vitamins and minerals that can stimulate rumen microbial growth. Avocado waste contains several high mineral elements, such as phosphorus and zinc, which play an active role in microbial protein synthesis and rumen microbial activity (Jamarun and Pazla, 2022). Avocado waste also contains vitamin A (Justina et al., 2016). Mabrouk et al. (2015) reported that vitamin A supplementation can increase body weight gain and improve health in goats. The increase in the rumen microbial population causes the enzymes produced to increase so that the nutrient degradation process in the rumen also runs optimally (Jamarun et al., 2017c). The degradation of organic matter will produce Volatile Fatty Acids (VFA) (Jamarun et al., 2017c; Pazla et al., 2021e). VFA is the primary energy source for goats (Jamarun et al., 2021). DMD, OMD, and CPD were positively correlated with VFA production in the rumen (Pazla, 2018; Putri et al., 2019, 2021). Pazla et al. (2022) reported an increase in DMD, OMD, and CPD with the addition of tithonia in the diet of dairy goats. The T3 treatment showed a decrease in the digestibility of dry matter, organic matter, and crude protein because it contained the highest level of titonia (18.5%). Tithonia contains antinutritional substances such as phytic acid, tannins, saponins, alkaloids, and oxalate. Excessive consumption of antinutrients will hurt the rumen bioprocess. It is suspected that in this treatment, the proportion of tithonia has begun to affect rumen microbes. The microbial performance began to be disturbed, causing decreased feed degradation. Increasing the number of avocados to 1.5% also hurts the performance of rumen microbes. Avocados also contain polyphenolic substances such as alkaloids, tannins, and saponins which, if consumed beyond the threshold, also interfere with the rumen fermentation process. Microbial protein synthesis in this treatment is also thought to decrease as the digestibility of crude protein decreases (Pazla et al., 2018a). Hoover and Stokes (1991) and Sari et al. (2022) stated that the rate of microbial protein synthesis would decrease when carbohydrate digestibility decreased A decrease in the amount of concentrate causes less easily digestible substances. The concentrate contains substances more easily fermented in the rumen than fibrous feed. The dry matter digestibility in this study was almost the same as that of Firsoni and Andini (2012), which was 54.73-61.06% in rations containing forage corn straw, field grass, and concentrates from a mixture of *Tithonia diversifolia* and *Moringa oleifera*. Crude protein digestibility in the study was higher than Laksana et al. (2013), which is 42.24-72.45% in forage-based rations of elephant grass with crude protein content18.33% and TDN of 65.23%. The treatment rations in this study contained tithonia, which has high protein and a high level of protein digestibility.

Production performance of treatment ration

Table 6 shows that the treatment significantly differed (P<0.05) in daily body weight gain and feed efficiency. The highest daily body weight gain and feed efficiency were found in the T2 treatment (Figure 1). After the further test of DMRT, body weight gain at T2 was not significantly different (P>0.05) with T1 but significantly different (P<0.05) with T3 and T0. T1 was not significantly different (P>0.05) from T0 but significantly different (P<0.05) from T3. T0 was not significantly different (P>0.05) from T3. The ration efficiency at T2 was significantly different (P<0.05) with T1, T0, and T3. T1 was not significantly different (P>0.05) from T0 but significantly different (P<0.05) from T3. T0 was significantly different (P<0.05) from T3. T3 treatment showed the lowest daily body weight gain and feed efficiency. Increased tithonia and avocado waste from T0 to T3 and decreased the concentrate in the ration from T1 to T3 showed an increasing trend of daily body weight gain and feed efficiency. However, daily body weight gain and feed efficiency decreased significantly

(P<0.05) from T2 to T3 when the proportion of tithonia increased to 18.5% and avocado increased to 1.5%.

Table 6: Performance of Kacang goat treatment.

Performance	Treatment			
	T0	T1	T2	T3
Daily weight gaint (g/day)	46.90^{bc}	56.50^{ab}	67.25^{a}	41.55^{c}
Fees efficiency (%)	14.98^{b}	16.62^{b}	17.10^{a}	12.31^{c}

Description: T0= 35% FSS + 5% F + 0% AW + 60% concentrate, T1= 35% FSS + 9.5% FT + 0.5% AW + 55% concentrate, T2= 35% FSS + 14 % FT + 1% AW + 50% concentrate, T3= 35% FSS + 18.5% FT + 1.5% AW + 45% concentrate. Different superscripts on the same line showed significant differences (P<0.05).

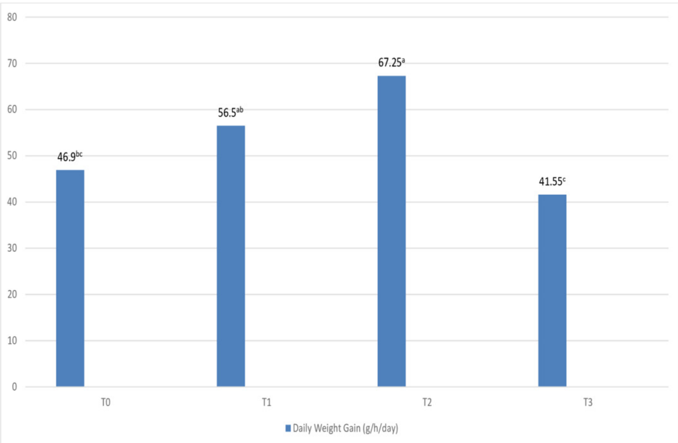

Figure 1: Daily weight gaint (g/day).
Description: T0= 35% FSS + 5% F + 0% AW + 60% concentrate, T1= 35% FSS + 9.5% FT + 0.5% AW + 55% concentrate, T2= 35% FSS + 14 % FT + 1% AW + 50% concentrate, T3= 35% FSS + 18.5% FT + 1.5% AW + 45% concentrate.

The graph of body weight gain is presented in Figure 1. The highest body weight gain was found in the T2 treatment. The composition of this treatment was able to optimize the performance of rumen microbes in degrading feed, especially crude protein. The ratio in this treatment was 14% Tithonia and 1% avocado. Tithonia is a forage source of protein, while avocado contains minerals, vitamins, and polyphenols that help the performance of rumen microbes in the feed fermentation process. Optimal rumen microbial performance in the feed fermentation process causes livestock performance to increase because much feed is digested so that it is converted into energy by livestock. Odedire and Oloidi (2014) reported that using 10-30% Tithonia in the diet of West African Dwarf goats increased growth, and high body weight gain at T2 was also due to high feed consumption at T2 (Table 4). When livestock consume more feed than their bodies require, they gain weight. Previous research from (Holguín et al., 2020), which mixed elephant grass with tithonia silage (67%:33%), was able to reduce methane gas production to 1.53 mmol/g compared to 100% elephant grass (2.43 mmol/g).

Increasing the dose of tithonia and avocado in treatment T3 (18.5% T + 1.5% Avocado) and decreasing the amount of concentrate to 45% resulted in a significant decrease in body weight gain (P<0.05). The addition of tithonia and avocado waste doses is thought to affect the performance of rumen microbes because the antinutrients from these feed ingredients have started to cause adverse effects on rumen bioprocesses. The lower amount of concentrate affects the profile of the direction of rumen fermentation to produce less propionate. Low propionate production causes less feed conversion into the muscle, which is not optimal for increasing weight gain (Pazla et al., 2018b). The increase in body weight of Kacang goats in this study was not much different from Fardana et al. (2019), which was 620 grams/head/day with a composition of corn and concentrate rations supplemented with multi-nutrient blocks. The feed efficiency describes the ration savings. High feed efficiency occurs when the ratio of body weight gain to the amount of ration consumed produces a high value. The higher the efficiency value of the ration, the better the ration. The feed efficiency in T2 was higher than in other treatments. The T2 ration showed the highest digestibility value and consumption, so food substances were more optimally converted into muscle.

The efficiency of the ration in this study was higher than that of Rostini and Zakir (2017), which was 8.96-11.65% in the Kacang goat ration, given field grass and concentrate. This study's rations contained various forage types, such as tithonia, sugarcane shoots, and avocado waste, with better nutritional content than field grass alone.

CONCLUSIONS AND RECOMMENDATIONS

The best ration formulation to increase feed consumption, nutrient digestibility, and production performance of Kacang goats is 35% fermented sugarcane shoots +14% fermented tithonia +1% avocado waste +50% concentrate (T2 treatment).

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NOVELTY STATEMENT

This study found a low-concentrate goat ration formulation to optimize body weight gain by using fermented tithonia (*Tithonia diversifolia*) and avocado waste (*Persea americana miller*) in fermented sugarcane shoot (*Saccharum officinarum*)-based rations

AUTHOR'S CONTRIBUTION

Conceptualization: Novirman Jamarun and Roni Pazla.
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Supervision: Arief and Novirman Jamarun.
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Writing-review and editing: Roni Pazla and Novirman Jamarun.

Conflict of interest

The authors have declared no conflict of interest.

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