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Study of Palm Acid Oil (PAO) from Sludge Palm Oil Mill Effluent (POME) as Goat's Feed

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ABSTRACT

This study was conducted to determine the base dietary of animal feed for goat by utilizing solid waste and to investigate the effectiveness of different dietary of solid waste effect on growth performance of goats. Palm Acid Oil (PAO), Napier grass, coconut waste and water lettuce were used as the sample to produce animal feed for goats. POME is produced during palm oil mill process [1]. PAO is produced during the extracted process of POME. The solid waste produced has caused the pollution problem to the environment. The solid waste undergoes composting method to produce animal feed which is useful to the growth of goat. All these samples were collected and mixed by following the guideline book of title Nutrient Composition of Malaysian Feed Materials and Guides to Feeding of Cattle and Goats by Department of Veterinary Services Ministry of Agriculture and Argo-based Industry Malaysia [2]. Four adult does with an age of 6 months and weighting 23.30 ± 2.47 kg were used then fed with the dietary treatments for 14 days for adaptation and continued until the end of the study, which lasted for 120 days. The 3 indicators to be analysed were the growth performance and body weight gain (BWG) of goats, also the nutrient requirement by goats. In this study, 3 dietary treatments were used (D1, D2, D3) to be compared with control diet (CD). Each diet contains different nutrient and composition. All these samples have nutrient needed by the goat and have a big potential to produce an animal feed. Results showed that goat that takes D1 has the highest growth performance and body weight gain (BW).

1. Introduction

Malaysia is the largest producer and exporter of palm oil. Palm oil mill effluent (POME) which is highly polluting effluent is becoming a major problem to environment as if it not being treated well before discharged based on standard limit imposed by The Malaysian Department of Environment (DOE) for effluent discharged [1]. On average from about 434 palm oil mills operating throughout Malaysia, about 63 million tonnes of POME is generated [2]. POME contains a high concentration of organic matter [1]. This polluting effluent with its high content of chemical oxygen demand (COD), 50,000 mg/L, biological oxygen demand (BOD), 30,000 mg/L, oil and grease, 6000 mg/L, suspended solids, 59,350 and 750 mg/L of total nitrogen can easily cause severe pollution of waterways due to oxygen depletion and other related effects [3]. Palm acid oil (PAO) is a by-product obtained from the alkaline refining of palm oil. It is used for making laundry soaps and for producing calcium soaps for animal feed formulations. The properties and composition of PAO may differ according to variations in the palm oil feedstock and the alkaline refining process [4]. A significant amount of palm oil and its derivatives is used in animal nutrition, and the opportunity to increase usage in this sector is large.

Livestock continue to play a vital role in the nutrition of humans worldwide. Ruminant species such as goats provide this human food value while consuming in a large portion of their diet those

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materials that are unusable directly by humans, such as forages, roughages, cellulosic food-processing by-products, and browse plants [5]. Goat production in 2015 was 428,263 and increased slightly to 523,800 in 2018 and only meet 11.28% self-sufficiency level for goats in Malaysia [6]. There are many efforts taken by the government to accomplish 25% self-sufficiency in 2015 level of chevon production, such as importing new breeds to increase the numbers and quality of goats in Malaysia.

The feed is the hugest expense in domesticated animals' production, representing to as much as 60–70% of production costs [7]. However, because of the high cost and uncertain availability of traditional concentrates, farmers search for alternatives. Alternative feeds are usually by-products and waste products from the processing of various food and fiber crops, or crop residues. These alternative feeds can fit into a feeding program as the primary roughage, as a supplement to a regular ration, or as a replacement for part of the ration [8].

The significance of this research is to produce goat feed from the nutritious waste that help to reduce the environmental caused by effluents coming from industrial and agricultural waste that harm the environment. The nutrient in waste is investigated to make sure it is fulfilled the requirement needed by animal for their performance growth. Malaysia need increase the livestock production to meet at least 50% of the local product market to faced next industrial revolution. It focused the uses of solid waste to reduce the environmental and ensure sustainable development and conserve environment for the future generations.

2. Experimental

2.1. Experimental diet and management of animals

A total number of four (4) matured male goats (Boer × local) aged six months, with an average body weight (BW) of 23.3 ± 2.47 kg, were used for continuous 120 days experiment. Goats were adapted to the feeding management for 14 days before the start of data collection. During this time, the goats were fed with Napier grass (*ad libitum*) supplemented with commercial goat pellet at the rate of 1.0% of BW. The animals were vaccinated against *Pesté-Petit dé Ruminanté* (PPR/kata) using PPR vaccine at the rate of 1 ml per animal, treated l® against ecto-parasite using Diasuntol and were also treated against infections A® by using oxytetracycline LA at the rate of 1 ml per 10 kg body weight of animal to stabilize the animals before the commencement of the study.

At the end of the adaptation period, the goats were individually weighed and divided into four groups equally (n = 1) and fed with different feed formulations. All materials were supplied *ad libitum* twice daily (0800 h and 1500 h) to respective goats, while PAO was supplied once every morning. The goats were kept in individual pen measuring 1.5 × 1 m^2 and were cleaned weekly. Body weight was measured before implementation and the weight of goats was recorded daily and summarized weekly using a weighing balance [13,14]. After conducting the experiment, body weight gain and nutrient obtained of goat were used as indicators on growth performance of goats will be observed [12]. The animals in all groups were given the experiment feed twice a day, provided *ad libitum* to allow for 10% of refusal. To maintain rumen microbial activity and to prevent the risk of ruminal acidosis, the goats in formulated diet group were also given an additional amount of chopped Napier grass (400 g fresh/animal/d), which contained 22.1% dry matter (DM), 8.2% ash, 7.5% crude protein (CP) and 67.3% neutral detergent fiber (NDF) in DM form. The goats received an adequate supply of water and mineral blocks throughout the experiment [14]. In the adaptation period, all animals were vaccinated against clostridial diseases, treated for parasites, supplemented with vitamins A, D, and E by injection. The diet was formulated using the nutritional requirements of goats that suggested by [15]. It was estimated that the daily DM intake per goat would be 4% of the BW and the daily BW gain would be 100 g. The daily metabolic energy (ME) and CP requirements were calculated to be 7.9 MJ and 73 g, respectively. The daily feed intake was measured by weighing of daily offered feed and refusal of individual goats [14].

2.2. Preparation of sample

Before the implementation of feeding trial was conducted, the nutrient composition (DM, CP, CF and crude fat) for total mix ration of the feed given to the goats for each diet groups (control and treatment) were determined by proximate analysis. Proximate analysis is the most common analysis performed on feed samples, where it consists of a series of analyses to estimate the nutrient characteristic of feeds which includes the following nutritive intake. The total nutrient obtains need to achieve the total nutrient needed by goats in suitable condition. CP and ME was the important composition because high in that nutrients attracted the goats to consuming more feed intake [14]. All the analyses were performed according to certified procedures outlined by the feeding guides book which was developed according to procedures [15].

Water lettuce and coconut waste were collected and kept in the impenetrable compartment to avoid air contact [10]. Coconut waste was dried in a convection laboratory oven at 110 °C for 24 h to totally evacuate the moisture content or until the weight is constant [11]. The sample of coconut waste need to be weighed for initial and final weight of the dried sample process [9]. Meanwhile, after Napier grass was collected, the samples were stored in a room to preserved so that the nutrient component of the rough grass is not altered or destroyed [10]. POME was gathered from anaerobic processed POME at palm oil mill located in Gebeng, Pahang, Malaysia. Prior to pyrolysis, POME samples were dried in a convection laboratory oven at 110 °C for 24 h to completely remove the moisture content or until the weight is constant. The dried samples were kept in the airtight container to avoid air contact [11]. PAO samples were derived from alkali refining of oil palm fruits. The samples were collected from refineries only produced neutralized, bleached, deodorized palm oil by this process [4].

2.3. Formulation ration

In this study three formulations were applied for 3 does goats to be tested and will be compared with control goat that only be fed by its regular feeding treatment. Each formulation has different composition of solid waste. Each formulation has 3 kg total mixture of solid waste. All samples mixed according to the predetermined ratio. From the formulations result, they were compared with the nutrient required by the goats. Afterwards, these formulations were tested in goat's feed to analyze the predetermined indicators which are growth performance, nutrients needed and BWG.

From the composition above, we can calculate the nutrient in the feed that each dietary has. This step is important to determine whether the goats is having enough nutrient or another. The nutrient of DM, CP and CP for every 1 kg is obtained from DVS is shown at the Table 1. Meanwhile the nutrient that the goats required is 0.71 of DM, 0.09% of CP and 10.41% of ME for the does that average weigh about 20–30 kg. The goats are expected to gain weight of average 150 g/d (DVS, 2006). This nutrient is calculated based on Department of Veterinary Services feeding guides Series 2. This guidebook was used to assist and guide farmers on how to feed their animals in the right and effective way. D1 consist of 1 kg of

Table 1
Different composition of each formulation.

Treatment Diet	DM (kg)	CP (kg)	CF (kg)	ME (MJ/kg)
D1	1.49	0.24	0.23	13.12
D2	1.07	0.16	0.18	8.66
D3	1.51	0.21	0.25	11.58
CD	0.41	0.07	0.12	3.19
Nutrient Required	0.71	0.09	0.00	10.41

Napier grass, 1 kg of coconut waste, 0.5 kg of water lettuce and 0.5 kg of PAO.

2.4. Measurement of nutrient intake of materials

The amount of daily offered feeds and morning refusal per goat were weighed and recorded to calculate the daily feed intake. The feeding trial was continued for 3 months including the initial 14 days adaptation period. All the waste chosen was analysed the chemical composition and nutrient requirement to increase the body weight and growth performance of goats. All the analyses were performed according to certified procedures outlined by the feeding guides book which was developed according to procedures of by Department of Veterinary Services. Meanwhile the nutrient that the goats need is 1.04% of DM, 0.12% of CP and 0.22% of CF for the goats that having average weigh about 20–30 kg. The goats are expected to gain weight of average 100 g/d [15]. These nutrients were calculated based on Department of Veterinary Services feeding guides Series 2. This guidebook was used to assist and guide farmers on how to feed their livestock in the right and effective way.

2.5. Measurement of growth performance

The first parameter to assess growth performance is BWG. Initial BWs of the experimental animals were taken at the beginning of the study by two consecutive weighing in the morning before feeding. BW gain of each animal was recorded at 7 days interval, at 0800 h in the morning before feeding. The feeding trial was continued for 120 days including the initial 14 days adaptation period. Then, from the data, ADG was calculated and recorded to evaluate effectiveness of fed diets. The value recorded was compared between goats that applied D1, D2, D3 and CD. The BW gain was calculated by difference between the final BW and initial BW of the individual goats.

3. Results and discussions

3.1. Growth performance of goats

Among all superior traits for goat meat production, heavier body weight and faster growing rate are the most notable. According to the theoretical predicted that the goats grow up with the present of nutrient in the solid waste used to produce goat's feed. The observation of goats was recorded as a part of result of growth which explanation and discussion about the values in the result. Growth performance of goats were recorded daily and summarized weekly. The nutrient in the solid waste used from Napier grass, coconut waste, water lettuce and PAO may lead to be feed mixture which is useful to the growth of goat. Fig. 1 shows the growth performance within 17 weeks of goat A, goat B, goat C and goat D. After the weight of each goat was obtained, the different weight in each week was calculated and shown to compare the body weight gain for goat from difference diets. The different weight is to tabulate the growth performance curve that indicate the growth of each goat. However, the growth performance curve is tabulated using the cumulative value of the different weight. Each treatment goats were compared with control goats.

The graph above shows the effects of dietary treatment on the growth performance of goats based on feed conversion ratio during the experiment period. To compare the growth performance, the line chart is used. Fig. 1 shows the effect of dietary treatments on the growth performance of goats based on feed conversion ratio during the experiment period. All goats have a good growth performance. However, this study is to determine the effects of fed replacement on growth performance of goats. To do that, the comparison between each dietary treatment need to be compared with the control goats that was fed with Napier grass only. The comparison of treatment goats and control were shown above. When a ruminant did not get effective feed, the growth would be slower and good nutrient intake give best effect to the growth performance of goats. The growth rate of CD was lower than all goats

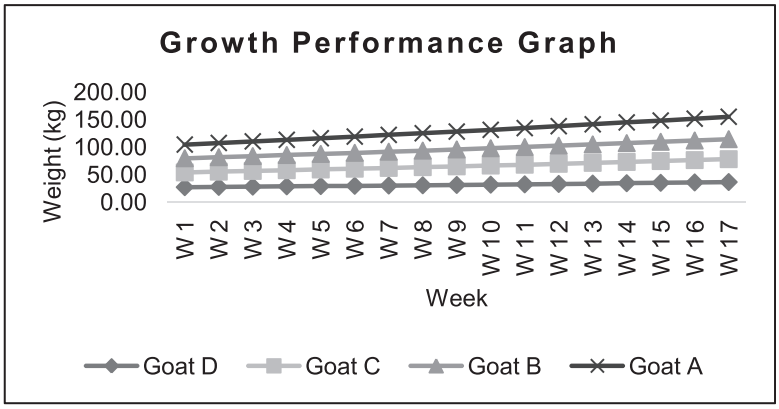

Fig. 1. Growth performance of goats.

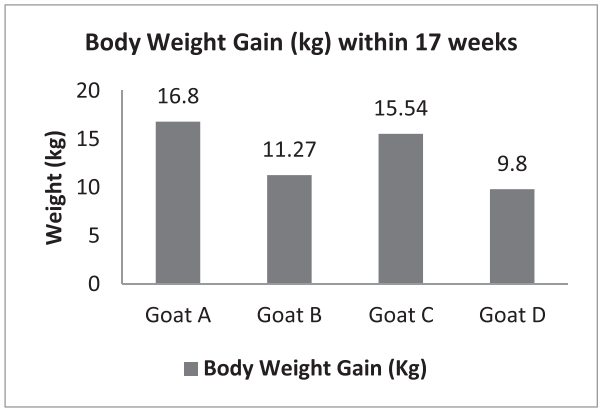

Fig. 2. Body weight gain of goat within experiment period.

along the experiment weeks. The results implied that both diets in the present study were enough to provide enough nutrients to increase the BWG of the goats. Greater quantities of Napier grass can be replaced with coconut residue, water lettuce and PAO in goats' diets treatment without any adverse effects on their growth performance. Feeding goats with organic waste in this study can contribute significantly to the improvement of the growth performance of goats by exploiting the use of locally available feed resources.

3.2. Body weight gain (BWG)

Four adult does were used in this experiment which is goat A, B, C and D. Each goat is given with different diets treatment. Goat A, B, C and D were fed with D1, D2, D3 and CD respectively. Fig. 2 shows the BWG (kg) by goat A, B, C and D within 17 weeks. The BW changes of goats in response to the experimental treatments were measured by taking the BW of individual goats at the commencement of the trial. This then followed by individual weighing per week last of experiment. The readings were recorded and tabulated for comparison. Figure shows the measurement of body weight in control and treatment group throughout feeding trial. For the results of BWG, at the beginning of experiment before feeding trial, the initial BWG in control and treatment group almost similar. Then, feeding trial, the final BW in treatment group shown a significant improvement compared with control group.

From the Fig. 2, goat A has highest body weight gain within 17 weeks with 16.8 kg as compared to the goat B, C and D. Goat A consuming D1 as its feed. According to [23] he states that by adding PAO in the combination of goat's feed formulation represents better result in body weight gain of goat. Goat B has 11.27 kg body weight gain within experiment period which is lower than body weight gain by goat A and C. Goat B using D2 as its feed. Next, Goat C has gaining 15.54 kg which is slightly lower than body weight gain by goat A. Goat C consuming D3 as its feed. As compared to goat D (Controlled), the body weight gain of goat A, B and C were increasing within the period. According to [23] he states that by adding some combination of solid waste in the goat's feed can achieve a better result than using the Napier grass only as goat's feed. This is because the value of CP, DM and ME of D1, D2 and D3 has more than the nutrient obtained in Napier grass. The higher in dry matter intakes, it provides more nutrients that increase the growth, milk production and reproduction. As reported by [13] high in CP and ME attracted the goats to consuming more the feed.

A key factor in efficient BWG is optimum nutrient intake. The better performance observed in goats fed treatment diets could be due to increased energy intake. It is also possible that the 16.79% crude protein and 4.98 MJ/kg of gross energy used in this study were adequate to support BWG in all the treatments. This study indicated additional materials positively influences the performance of animals and providing excellent BWG. Using different techniques of processing an agricultural by-product or wastes improved nutrient utilization and productivity of the goats which could be due to the balanced nutrients for optimum feed digestibility.

3.3. Nutrient obtained by goats

Each set of treatment has different ratio and composition. Four sets of diets treatment were produced to apply to the goats. The nutrient obtained from each formulation was compared with the nutrient required by the goats. Fig. 3 shows the graph of nutrient obtained and nutrient required by the goats. This step is important to determine whether the goats is having enough nutrient or another. From the literature review, the amount of DM, CP and CF for every 1 kg was obtained from [15].

D1, D2, D3 and CD are the diets that mixed with combination of Napier grass, coconut waste, water lettuce and PAO. Each diet was mixed with different composition. PAO has highest nutrient obtained as it indicates that D1 has big potential to give high growth performance to goat. The goats are expected to gain weight of average 150 g per day [16]. These nutrients are calculated based on Department of Veterinary Services feeding guides Series 2. The total nutrient for each treatment is shown on the table above to compare with the nutrient that the goat required to gain their weight up to 150 g per day. From the Fig. 3 all the dietary shows that the nutrients are more than the goat needs. D1 was the highest compare to the other treatment. In the previous study by [7] it is said that the more nutrient that the ruminants receive, the more benefits that the ruminants will receive. All the nutrient will determine how much the goat can gain and produce. Hence, the D1 is the best formulation as it has more nutrient compare to the other formulation. Figure above indicate the new dietary treatments by utilizing solid waste by-products. The DM contents of coconut residue and POME were almost similar, but water lettuce showed lower DM content than the others. On the other hand, the CP and CF contents of coconut residue, water lettuce and POME were similar, but lower ME content than the other feeds. Water lettuce contained higher contents of Ash, Ca and P followed by POME and coconut residue. In all the treatments, the Napier grass and PAO offered was consumed readily by the goats.

3.4. Composition of dry matter, crude protein and crude fibre

Dry matter is the thing that remains after all the water is evaporated out of a feed. Napier grass, water lettuce, coconut waste and PAO has high water content and will have a lower level of a dry matter than an identical load of dryer feed, for example, roughage or grain. Dry matter is a pointer of the measure of supplements that are accessible to the animal in a feed [17]. Animals need to devour a specific measure of dry matter per day (estimated in lbs or kg/day) to keep up wellbeing and production. The daily measurement of dry matter required relies on a few elements including, weight and phase of creation (lactating, pregnant, weaning, finishing) [18].

Goats need a toxic extent of their eating regimen to help the absorption. The crude fibres ensure that the sustenance is better retained [19]. Crude protein alludes to the sum of protein in a feed. Protein is comprised of amino acids that are fundamental for solid livestock. Amino acids are the structure of the protein and utilized for the development of tissues and muscle production. Protein is required for solid development, reproduction, and maintenance [20]. There are four diets that applied to 4 adults does. Each diet

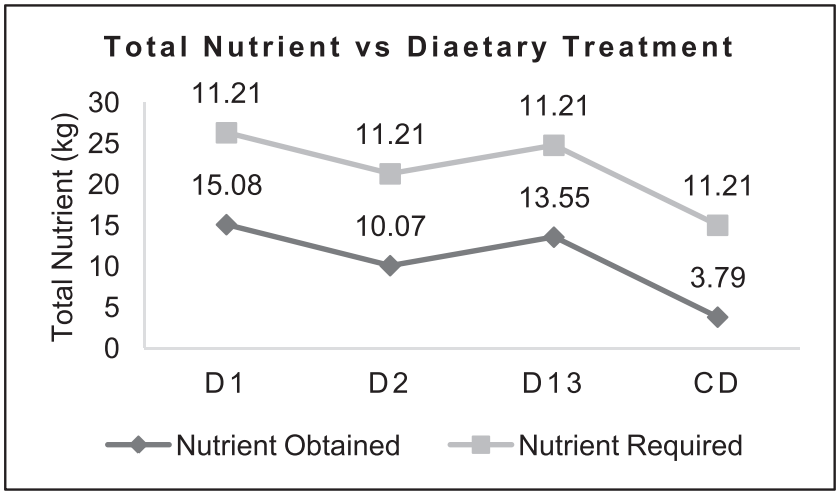

Fig. 3. Graph of nutrient obtained, and nutrient required by goats.

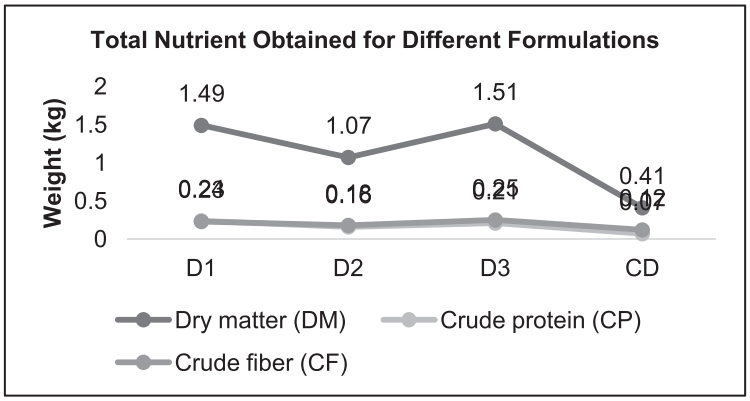

Fig. 4. Graph of nutrient obtained, and nutrient required by goats.

has different value of DM, CP, CF and ME according to ratio that have been decided. Fig. 4 shows the total nutrient obtained for different diets.

Fig. 1 indicate the value of DM, CP and ME of all diets are more than the nutrient in CD. The higher in DM intakes, provides more nutrients that increase the growth, milk production and reproduction [16]. DM is remains after all the water is evaporated out of a feed. DM is an indicator of the amount of nutrients that are available to the animal in a feed [21]. Livestock need to consume an adequate amount of DM per day to maintain health and production. The daily amount of DM needed depends upon several factors including, weight and stage of production [23].

All the waste chosen was analyzed their nutrient requirement for increase the weight performance of goat. Nutrient requirement was calculated based on manual provided by [15]. The nutrient calculated based on their weight of each material. [13] present the almost similar CP value of coconut waste which was 23.5%. CP of coconut waste is also approximately with [21] that get the CP value of coconut waste is 23.8% in their research. The dietary had compared with Napier grass which was the regular feed of the goat before they were fed. The Napier grass nutrient shown less than the nutrient in D1, D2 and D3. Fig. 4 show the differences of nutrient between D1, D2, D3 and CD. This result was justified with [13] where the CP, DM and ME value of Napier grass is less than coconut waste and commercial pellet. [22] also report the same result that the percentage of Napier grass CP, ME, and DM is lower that coconut waste and other material. The total nutrient obtain need achieve the total nutrient needed by the goat in suitable condition. CP and ME was the important composition because high in that nutrients attracted the goats to consuming more the feed [22].

All the daily offered diets were consumed. In all the treatments, the coconut residue offered was consumed readily by the goats. The total DM intake of the goats fed with the replacement diet was higher compared to those fed with the Napier grass diets. Intake of DM was significantly ($p < 0.05$) higher at D3 compared with D1 and D2. There were also significant ($p < 0.05$) differences in total CP and CF intakes among treatment group and replacement with solid wastes. Diet treatments contain coconut residue that have high in CP and ME. [14] reported that the chemical composition of coconut residue which is high in CP and ME attracted the goats to consuming more feed intake. Goats need an indigestible proportion of diet to support the digestion. The CF ensure the food for better absorbed. CP refers to the total amount of protein in a feed. Protein is made up of amino acids that are necessary for animal's health. Amino acids are the building blocks of protein and are used for the formation of tissues and muscle production. Protein is needed for healthy growth, reproduction, and maintenance. Result obtained indicate CP and ME obtain is relatively high and the goat in treatment group having reasonable BW gain.

Water lettuce contained high in moisture content and low in DM. In the present study, high in moisture content cause decreasing in DM intake. The chemical composition of water lettuce varies considerably according to the location and season. Due to its relatively high CP content (5.8–25.6%), water lettuce can be considered as a potential protein supplement for livestock which is commonly fed cereal crop residues whose contribute as a source of feed is

increasing [7]. The CP content of water lettuce in the current study is comparable to common fodders and have similar high protein content in the leaves and rapid growth potential for use as fodder for goats.

4. Conclusion

The purposes of these researches had two goals. First is to determine the base dietary of animal feed for goat by utilizing solid waste. The second and to investigate the effectiveness of different dietary of solid waste effect on growth performance of goats. Through this research, all goals had achieved. Solid waste from PAO, coconut waste, water lettuce and Napier grasses have been proven that contains nutrients which are important for the growth rate of goats. The nutrient contains in the wastes used are crude fiber, crude protein, ME and DM. According to [17] he states that PAO can be used to produce animal feed formulation because it has high free fatty acid. The function of free fatty acids is as a well-spring of energy and their capacities in energy transport inside the body are settled. Similarly, significant is a role that FFAs play in oxidative pressure following cell layer depolarization. A good feed covers the quality of the feeds production which it is compacted with a lot of nutrition and can increase the feed intake by suitable feeding system. The feed should have the nutrient that meets the nutrient requirement of the animal feed. If the treatment diet has a high nutrient content, it can help in increasing the growth performance of the livestock. Other than that, a feed that result in high feeds intake will be beneficial.

Large amount of waste can be reduced by utilizing them as valuable product for example animal feed. From this study, it has been proven that the total wastes can be reduced by 3600 kg per month. According to [19] he states that by utilizing solid waste to produce valuable product can reduce a lot of waste wasted. He also states that by utilizing solid waste to produce valuable product can generate income for a business.

In conclusion, a lot of money and resources could be saved if the solid waste used in this project which is Napier grass, coconut waste, water lettuce and PAO could be used as feed mixture in goat's feed. The used of solid waste can control the quality of waste disposal of landfill, reduce the environmental pollution and provide clean and health environment to community. Therefore, further research on PAO from sludge of POME and waste like Napier grass, coconut waste and water lettuce should be improved and new technology in goat's feed.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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