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EFFECT OF OIL PALM FROND UTILISATION AS GREEN ROUGHAGE FEED ON KATJANG GOAT'S BODY WEIGHT

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ABSTRACT

The impact of providing various types of fodders as the primary green feed for Katjang goats was assessed. Twelve male Katjang goats were divided into three groups and randomly assigned to three experimental diets: (1) oil palm frond (OPF) ad libitum*; (2) undergrowth (UG)* ad libitum*; and (3) Napier grass (NG)* ad libitum*. The results of this study indicated that the daily fresh intake of green roughage was significantly higher (*$p<0.05$*) in the UG treatment group than in the OPF and NG treatment groups. However, feeding green roughage from OPF is equivalent to increasing the body weight of goats compared to using UG and NG. OPF is the most considered because it is more cost-effective than NG, which must be planted and maintained. Furthermore, OPF is a by-product of oil palm cultivation, whereas UG is limited in oil palm areas. Therefore, OPF is recommended for use as green roughage feed for Katjang goat farming in oil palm agriculture.*

Keywords: Katjang, Napier grass, oil palm frond, roughage feed, undergrowth.

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INTRODUCTION

The Katjang goat is a meat-type goat breed that is native to Southeast Asia, including Malaysia, Indonesia, Thailand, Philippines, Taiwan and the Southwest Japan Islands (Devendra, 1983; Mohamad *et al*., 2018; Tsukahara *et al*., 2008). As an indigenous goat, this breed has the advantages of natural tolerance towards heat stress and diseases such as parasitic infestation (Ernie-Muneerah *et al.,* 2010; Thukahara *et al*., 2008), which are believed to be inherited genetically (Pralomkarn & Boonsanit 2012). Devendra (1983) has highlighted the advantage of the Katjang goat, where it performs well under low levels of nutrition, which is highly anticipated in smallholder production systems. In many instances, incorporating native breeds is suggested to retain their unique adaptive qualities and ensure successful participation in goat production (Khandoker *et al*., 2016; Shrestha & Fahmy, 2005). The local indigenous Katjang goat is highly prolific but has a small body size and poor growth performance compared to exotic breeds such as the Boer goat. A study has been done by Predith *et al*. (2020) by cross-breeding Katjang and Boer, but it involves only minimal alternation with genetics and still requires access to sufficient feed and nutrients to ascertain their genetic potential. Even though breed improvement may be used to enhance livestock performance (Liu *et al.,* 2022), it is time-consuming and expensive to apply, particularly for small farms.

Some researchers have highlighted the importance of management practices rather than breeds as the key success factor for goat production (Nor-Azlina *et al*., 2011). Improvements in livestock management methods may have a direct effect on the performance of animals. Feed management is one of the most crucial aspects of livestock management that ensures success (Liu *et al*., 2022). Therefore, more focus should be given to the management practices, specifically the feeding, that can be altered for improvement as required by goat farmers. Feeding management involves the provision of a roughage source as the main feed input for goats, which is normally

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green forage such as natural grass, pasture, or improved pasture. Green roughage feed is the most important component since it is the primary source of energy for goats (Banakar *et al*., 2018). However, as a green roughage feed source, natural pasture paddocks are rare in this country, and their availability is extremely limited for goat grazing. Therefore, goat farmers in Malaysia need to grow improved pastures as a green roughage source for feeding large numbers of goats. Commonly planted improved pastures are Napier grass (NG) and some other grasses that have the potential to survive in the long term, such as *Stenotaphrum secundatum*, *Panicum laxum*, *Paspalum notatum*, *P. wettsteinii*, *Brachiaria humidicola* and *Panicum maximum* (Ng *et al*., 1997). NG and *B. humidicola* are the two improved pastures that are popularly grown by farmers as green roughage feed for feeding ruminant livestock through the cut-and-carry system. However, growing the improved pastures involves higher costs in terms of paddock establishment, maintenance and harvesting, which are less affordable, specifically for small farmers or smallholders. Growing improved pastures for feeding goats does not look viable from an economic and profitability point of view. Therefore, alternative green roughage feeds that are technically and economically viable should be established to support goat farming development in Malaysia.

As an alternative, goat farmers may shift to using agriculture by-products as roughage feed for goat farming. Oil palm fronds (OPF) are one of the agriculture by-products that are abundantly available for use as green roughage feed, especially for goat farming in the oil palm industry. It is estimated that this country's annual harvest of OPF totals at 50 million tonnes (Tafsin *et al*., 2019). After harvesting, almost all these OPF are arranged in the frond stacking rows for nutrient recycling (Abu Hassan & Ishida, 1992). The abundance of OPF in this country has resulted in a major interest in its potential use as ruminant livestock feed. Several studies found that OPF can be used successfully as a viable ruminant livestock forage source (Ghani *et al*., 2017). Previous studies have shown that OPF is suitable for use as feed for ruminants, especially cattle (Ghani *et al*., 2017). However, the optimum inclusion of OPF in the diet ratio for beef and dairy cattle should not exceed 30% (Wong & Wan Zahari, 2011) for optimal growth, body weight gain and milk production. Nevertheless, study findings regarding OPF utilisation as the main green roughage source and its effect as feed on small ruminants, especially goats, are extremely limited. Therefore, this study was carried out to determine the suitability of OPF as a source of green roughage feed for goat farming in the oil palm agriculture system.

MATERIALS AND METHODS

Study Site and Experimental Diets

This study was carried out at the MPOB Research Station in Keratong (2° 77′ N latitude and 102° 91′ E longitude), Pahang, Malaysia. The care of livestock was carried out according to the guidelines established by the Department of Veterinary Services (DVS), Malaysia (DVS, 1992). Fresh OPF from harvesting activities of fresh fruit bunches (FFB) were collected daily at the station in the oil palm plantation. Only half of the OPF in the upper part was taken as the green roughage feed for goats in this trial. NG was planted in between rows of the Double Avenue oil palm planting area. NG was harvested daily from different plots in the trial plot. It was harvested at 45-50 day intervals to obtain similar quality throughout the experimental period. The NG plots were fertilised using 200 kg of compound NPK 15:15:15 fertiliser and 75 kg of urea fertiliser/ha annually. Undergrowth (UG) was harvested from oil palm planting areas in the station daily. No herbicide spray was permitted in the oil palm planting areas allocated for UG collection. Green roughage feeds of OPF, NG and UG were managed following a cut-and-carry system for feeding goats in the goat house. The OPF, NG, and UG were chopped into 5-7 cm lengths using a chopper machine. The chopped materials were fed to the goats on a fresh basis according to the diet treatments. Commercial soyhull pellets as a supplemental feed for goats in this trial were supplied by an appointed supplier every month.

Management of Animals

Goats for this study were selected from an available stock at the MPOB Research Station in Keratong, Pahang, Malaysia. Twelve males of the Katjang goat breed, aged between 13 and 15 months, were used in this feeding trial. The initial body weight of goats falls within the range of 15-25 kg. Goats were individually weighed and divided into three groups with an approximately similar total weight. Goats were familiarised with the feeding management for 14 days before the start of the actual feeding trial and data collection. Each group was fed a specific green roughage feed diet treatment (*ad libitum*) and supplemented with commercial soyhull pellets at 200 g/day/ahead (Zainal Rasyidi *et al*., 2019). The feeding trial was carried out for 95 days after a 14-day adaptation period. Three green roughage feed diet treatments were tested on goats in this trial as follows: Treatment 1 - OPF, Treatment 2 - NG and Treatment 3 - UG. All goats were supplemented at 3.0% of body weight (BW) in dry matter (DM) intake, based on the maximum body weight gain per day. These green roughage feeds were fed *ad libitum* to the respective groups, normally about 130.0% of the average fresh intake of the previous day, twice daily (morning and afternoon). A supplemental feed of soy hull pellets was fed to all goats once in the morning before their green roughage diet treatment. The nutritional composition of soy hulls includes 26.2% crude protein, 8.8% crude fat, 22.8% crude fibre, 64.2% total digestible nutrients and metabolic energy content is 9.68 MJ/kg. For internal parasite control, all goats were dewormed prior to the feeding trial using Ivermectin according to the prescription by the product's manufacturer (Merial Limited, Duluth, GA 30096, USA). The goats were penned separately according to the specific diet treatment group. Clean water and mineral blocks were made available at all times in the pens.

Feed Intake and Body Weight Change

The intake of green roughage feed by goats was measured by weighing the amount of feed offered and the amount of feed balance refused by individual goats. Remnants of green roughages (refusal feed) were collected and weighed every morning before feeding the supplemental feed. The difference between the amount of green roughage offered and the amount of remaining green roughage is the quantity of green roughage fed to the goats. The dry matter intake of roughage feed was calculated by multiplying the intake of green roughage feed by the percentage of dry matter in the respective green roughage feed. The body weight changes in goats in response to the different green roughage feed diet treatments were measured by taking each individual goat's initial body weight before the start of the feeding trial. Then, it was followed by weighing an individual goat on a monthly basis until the end of the feeding trial period (Upreti *et al*., 2008). The final weight of the goats was taken on day 95. The difference between the goat's final live weight and initial live weight divided by the number of days of the feeding trial served as the basis for calculating average daily weight gain (ADG).

Feed Sampling and Analysis

Green roughage feeds were sampled on a biweekly basis. Samples were dried in an oven at 70°C for two days or until a constant weight was reached. The dry matter content of the green roughages was calculated by dividing the sample's oven-dry weight by the sample's fresh weight. The value was then converted to a percentage. The dried samples were prepared for analysis by grinding with a mill and sieving through a 1 mm sieve. Ground composite samples were analysed following the method of the Association of Official Analytical Chemists (AOAC, 1990) for dry matter, ash, and nitrogen (N). Crude protein was calculated by multiplying N by 6.25 (N x 6.25). Fibre fractionation analysis was conducted using the Goering and Van Soest's method (1970). Metals analysis was done with an atomic absorption spectrophotometer, and phosphorus was analysed using the Molybdate-metavanadate complex method. Crude fat was measured after being treated by boiling with diluted sulphuric acid. The total digestible nutrient was determined according to McDowell *et al*. (1974). Metabolisable energy was analysed using Menke's "Gas Test" methods (1979).

Statistical Analysis

Data on feed intake and body weight changes were analysed using SAS (version 9.2, SAS Institute Inc., Cary, NC, USA). An analysis of variance was performed, and mean values were tested for differences between treatments with the least significant difference using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Nutritional Composition Oil Palm Fronds (OPF), Napier Grass (NG) and Undergrowth (UG)

Other than concentrates, vitamins, and minerals, forage is the most important feed component for ruminants to meet their daily nutritional needs. In this study, the nutrient content of OPF, natural UG, and NG, three commonly used forage sources by oil palm growers in livestock farming, was evaluated. *Table 1* presents a summary of these nutritional analysis findings. The dry matter of OPF was 43%. It was higher than NG and UG. However, NG and UG had a similar dry matter percentage (13%). For nutritional content, OPF had lower crude protein (7%) compared to NG and UG, which contained an approximately similar percentage of crude protein (11%). The fibre content of OPF (37%) was also higher than that of NG (34%) and UG (31%). Total digestible nutrients of OPF (52%) were lower than those of NG (61%) and UG (60%). Meanwhile, metabolisable energy was also slightly lower in OPF compared to those of NG and UG. Overall, OPF had slightly lower nutritional attributes as goat feed compared to NG and UG. However, UG and NG had about the same nutritional level.

The most important nutrient discussed and concerned about is the protein content of a feedstuff. Protein is required for all forms of life, including animals and plants. Ruminant animals can utilise urea or plants with poor protein and carbohydrate quality for growth, wool production,

TABLE 1. NUTRITIONAL COMPOSITION (%, DRY MATTER)

Parameter	OPF	NG	UG
Dry matter (DM), %	43.00	13.00	13.00
Crude protein (N x 6.25), %	7.20	11.10	11.50
Crude fat, %	1.33	0.90	0.97
Crude fibre, %	37.07	33.73	31.57
Ash content, %	5.27	9.93	9.27
Calcium (Ca), %	0.27	0.23	0.17
Phosphorous (P), %	0.10	0.10	0.08
Total digestible nutrient (TDN), %	52.30	60.50	60.33
Metabolisable energy, MJ/kg DM	7.74	9.24	9.04

Note: OPF - oil palm frond; NG - Napier grass; UG - undergrowth.

and milk production. This process is performed by rumen microbes that may use urea nitrogen, inorganic nitrogen, or nitrogen from low-quality plant proteins for their own needs. Among the three green roughage feed sources examined in this study, OPF contained the least amount of crude protein (average: 7.2%). The findings of this study also indicated that the UG vegetation (average: 11.5%) and NG (average: 11.1%) had better crude protein content compared to OPF (*Table 1*). Dahlan *et al*. (1992) reported a leaflet crude protein content of 11.0%, while Zainal *et al*. (2016) observed an even higher crude protein content in leaflets, reaching 12.3%. These values fall within the range of crude protein typically quantified for UG vegetation, which spans from 11.5%-16.3%. The National Research Council (NRC) suggests that a modest range of 11.0%-14.0% crude protein is recommended for ruminant production (NRC, 2007). In line with this, Devendra and McLeroy (1982) noted that 11.0% crude protein is considered ideal for achieving normal weight gain in goats, as reported by Bamigboye *et al*. (2013). To overcome the issue of low crude protein in OPF, one strategy is to utilise the upper one-third portion of the OPF, which contains more leaflets. This can contribute to an increased protein content in the overall feed.

In this study, TDN values in the OPF diet treatment (average: 52.30%) were lower than those in the NG (average: 60.50%) and UG (average: 60.33%) diet treatments, respectively (*Table 1*). The difference in TDN value was about 8.00% lower in OPF compared to NG and UG. Otherwise, NG and UG had about the same amount of TDN. The TDN value indicates the energy that can be extracted from feedstuffs and is a crucial factor in determining the amount of energy provided to animals. According to Jayanegara *et al*. (2019), there is a negative association between TDN values and neutral detergent fibre and lignin concentration. OPF contain a higher level of neutral detergent fibre (NDF), indicating a greater presence of structural carbohydrates compared to NG and UG. This contributes to a lower TDN in OPF. Akmar *et al*. (1996) reported that OPF are more in lignin and silica, contributing to a reduction in their nutritive value when utilised as feed for ruminants. Lignin, known for its resistance to degradation, poses a challenge as it is not readily digestible by most animals. Therefore, providing feed with highly neutral detergent fibre and lignin content is ineffective as an energy source for animals. The quantity of fibre and lignin in plants is contingent on the plant type and age. Research by Imsya *et al.* (2013) indicates that, in comparison to NG, OPF generally exhibit higher lignin content. Additionally, as plants age, there is a tendency for fibre content to increase.

Nutritionally, fibre contributes to the physical and chemical functions of the ruminant digestive system, involving chewing activity and enzymatic degradation through the fermentation process (Banakar *et al*., 2018). The process of chewing determines the amount of saliva produced for digestion, and it is influenced by the type of forage, the forage-to-concentrate ratio, forage intake, and the physiological status of livestock (Banakar *et al*., 2018). OPF have a slightly higher crude fibre content (average: 37.07%), followed by NG (average: 33.73%) and UG (average: 31.57%). According to the findings of Haji Baba *et al*. (1998), crude fibre content was adequate for the growth of goats. Lu *et al.* (2005) recommend a diet with a crude fibre content exceeding 23.00% for the optimal growth of goats. In general, the results of this study indicated that OPF had lower nutritional attributes compared to NG and UG - Improving the performance of OPF can be achieved through physical processing, employing mechanical methods such as chopping, grinding, or shredding to reduce particle size. This enhances digestibility, making OPF more palatable for livestock. Additionally, chemical treatments, such as exploring alkaline or ammonia treatments, can be employed to break down lignin and enhance the nutritional quality of OPF.

Factors Affecting Feed Intake

In contrast, the daily dry matter intake of roughage feed was significantly higher for the OPF diet treatment compared to those of the NG and UG diet treatments (*Table 2*). Dry matter intake was 2-3 times higher for the OPF treatment compared to the NG and UG diet treatments. However, the NG and UG intakes were not significantly different. Supplemental feed was readily consumed by all goats without any balance. Therefore, the feed's total dry matter intake was significantly higher for the OPF treatment. It was two times higher than those of the NG and UG diet treatments.

The level of feed palatability reflects the level of feed intake by livestock. The higher the palatability of the feed, the higher the feed intake. In this study, fresh feed intake of green roughage by the goats for the UG diet treatment (average: 3.24 kg/day) was significantly higher ($p<0.05$) compared to NG (average: 2.63 kg/day) and OPF (2.68 kg/day) diet treatments, whereas the intake of fresh NG was similar to that of the OPF. A significantly higher intake of UG vegetation could be due to the higher palatability of the UG, which improved intake compared to other treatment diets. The higher palatability of UG could be due to the varieties of underbrush vegetation species that comprise the diet treatment. UG in this study consists of a combination of grasses and foliage such as *Asystasia gigantica*, *Paspalum conjugatum*, *Fimbristylis miliacea*, *Ageratum haustonianum*, and *Cleome pentaphyll*. The variety of grass and foliage types offers freedom of choice and increases the rate of feed intake (Fedele *et al*., 2002). *Asystasia gigantica* is the most preferred foliage by goats that graze in oil palm planting areas (Nobilly *et al*., 2021). Norlindawati *et al*. (2019) revealed that the crude protein content of *A. gigantica* ranged from 19.0%-21.9%.

In contrast, the other two treatments have only one type of green roughage that is similar in palatability. The similar palatability of NG or OPF might limit the goats' daily fresh intake of that feed. According to Kalio *et al*. (2006), plant species, presentation style, stage of maturity, processing techniques, and the chemical components of the fodder, all affect the intake of forage. The level of anti-nutritional factors such as tannins may also affect the palatability of forages and hence the animals' preferences. The smell of the foliage also influences the intake of green roughage. Tannins are one of the chemical compounds in foliage that influence the smell and are known to reduce palatability and intake by ruminants (Mueller-Harvey, 2006). The OPF contains a high level of tannins (Jaffri *et al*., 2011) and is also high in NG (Johnson & Chime, 2018). Tannins act as a defence mechanism in plants against pathogens, herbivores and hostile environmental conditions. Tannin in the feed usually reduces feed intake in ruminant animals. Tannins may reduce intake by decreasing palatability.

Palatability, which depends on both plant and animal factors, influences the choice of feed. Among the plant characteristics that affect palatability are species, intraspecific variation, chemical composition, morphology or physical characteristics, succulence or maturation, and forage shape. Chemical composition such as phenolics, alkaloids, and tannins, irrespective of the nutritional value of the feed (Marten, 1978). Animal elements include the senses, breeds, species, individual variance, previous exposures, and physiological state (Marten, 1978). According to Personius *et al*. (1987), herbivores are able to identify some harmful substances by scent before eating or just after the first bite. Flavour (taste and odour) is thought to be the most significant food sign. The inclusion of taste, smell, or texture in the assessment implies that these sensory factors may play a significant role in determining the palatability of each feed, as noted by Ngwa *et al*. (2003).

Effect of Oil Palm Fronds (OPF)on Body Weight Gain

Feed intake has a direct effect on body weight gain in livestock under a feeding trial. Different diet treatments may have different effects on body weight gain in goats. Showed that, although it is

TABLE 2. DAILY DRY MATTER INTAKE OF FEED BASED ON DIFFERENT DIETS

Treatment	Roughage (g/day/head)	Supplemental feed (g/day/head)	Total feed intake (g/day/head)
Oil palm fronds (OPF)	1,152.30[a]	180.00[a]	1,332.30[a]
Napier grass (NG)	368.35[b]	180.00[a]	548.35[b]
Undergrowth (UG)	420.92[b]	180.00[a]	600.92[b]
LSD $_{(0.05)}$	59.71	0	59.71
CV $_{(\%)}$	31.25	0	24.45

Note: Mean values in the same column with a similar superscript are not significantly different at $p<0.05$ (Duncan's Multiple Range Test (DMRT).

not significantly different, numerically the UG-fed goats had the highest body weight gain (average: 5.33 kg), followed by goats in NG (average: 4.50 kg) and OPF (average: 4.33 kg) diet treatments (*Table 3*). The difference in body weight gain was 1.0 kg higher for the UG diet treatment compared to that of the OPF diet treatment. The goats in the NG diet treatment had a 0.83 kg higher body weight gain compared to those in the OPF diet treatment (*Table 3*). However, the difference in body weight gain of the goats in this study did not differ significantly between diet treatment groups. Similarly, goats in the UG diet treatment showed a daily weight gain of 56.00 g/day compared to those in the NG (47.33 g/day) and the OPF diet treatments (45.67 g/day), respectively. These average daily weight gains were also not significantly different between goats in diet treatment groups at $p< 0.05$ (*Table 4*).

Farming ruminant livestock in oil palm planting areas is a good approach for increasing domestic livestock production by maximising the usage of oil palm land and its natural resources. UG or understory vegetation in oil palm planting areas is a vital natural source of green roughage feed for ruminant livestock rearing in oil palm planting areas. Cattle, goats and sheep can graze on the UG vegetation available in oil palm planting areas for their daily feed requirements. Grassing of ruminants in oil palm planting areas is normally carried out following a continuous grazing system or a rotational grazing system. A free grazing practice is also carried out, especially by oil palm smallholders. Grazing livestock in oil palm planting areas can reduce production costs for feed, especially roughage feed. This, will in turn improve the overall economic return from the livestock production system.

Success in livestock integration with oil palm also largely depends on the availability of good UG as a green roughage feed source. Sometimes, the availability of UG vegetation for livestock grazing is affected by several factors, such as herbicide spraying activity, oil palm age, drought, flooding, and replanting programmes. Contaminated UG caused by herbicide spraying is fatal to livestock when grazed. Old oil palm areas and the drought season can also reduce the growth rate and dry matter yield of UG vegetation for livestock. Meanwhile, flooding and replanting programmes may require the livestock to be relocated to other suitable areas. Therefore, alternatives should be sought to overcome these limitations that affect the rearing of livestock in an oil palm ecosystem.

Goats grazing in the oil palm ecosystem usually face the problem of insufficient green forage where UG limitations are caused by problems such as floods, droughts, and the effects of oil palm management programmes such as weeding, replanting, *etc*. Therefore, a wider grazing area is needed since the goats are vulnerable to predators, the threat of grazing poisonous weeds, and eating rodenticide, all of which can directly cause death to the goats. The UG's cut-and-carry system is less effective due to the difficulty of harvesting the diverse and uneven UG, leading to a longer harvest time. Meanwhile, green roughage from NG requires a suitable area to be planted and needs to be maintained from time to time in open areas, which costs more. Therefore, with the existence of available green roughage feed sources in the oil palm planting areas, such as OPF, which can also be considered agricultural product waste, there are alternatives for farmers seeking a cost-effective source of green roughage. Although OPF has a low nutritional value compared to UG and NG, OPF feed provides an almost similar body weight gain effect as using UG and NG did not make a significant difference.

CONCLUSION

OPF is abundant and available year-round as agricultural waste in oil palm planting areas and is the alternative for farmers seeking a cost-effective source of green roughage feed. A comparison has been made in this study by using UG and NG as a control, and it was found that the effect of daily weight gain is not significant, whereas the effect of weight gain is almost equivalent for Katjang goats for all three green roughages used in this study. Therefore, goat farmers, especially

TABLE 3. BODY WEIGHT CHANGE OF GOATS FED DIFFERENT GREEN ROUGHAGE DIETS

Treatment diet group	Initial weight (kg)	1^{st} month weight (kg)	2^{nd} month weight (kg)	Final weight (kg)	Difference in BW (kg)	ADG (g/day)
Oil palm fronds (OPF)	19.33^a	21.67^a	22.67^a	23.67^a	4.33^a	45.67^a
Napier grass (NG)	17.00^a	19.17^a	21.50^a	21.50^a	4.50^a	47.33^a
Undergrowth (UG)	18.67^a	20.83^a	22.83^a	24.00^a	5.33^a	56.00^a
$LSD_{(0.05)}$	7.45	10.27	11.01	11.77	4.95	52.06
$CV_{(\%)}$	20.33	25.00	24.68	25.55	52.47	52.46

Note: Mean values in the same column with a similar superscript are not significantly different at $p<0.05$ (Duncan's Multiple Range Test (DMRT). BW - body weight; ADG - average daily weight.

TABLE 4. BODY WEIGHT CHANGE OF GOATS FED WITH OIL PALM FROND (OPF), NAPIER GRASS (NG) AND UNDERGROWTH (UG)

Parameter	Diets		
	OPF	NG	UG
Initial body weight (kg)	19.33 [a]	17.00 [a]	18.67 [a]
Final body weight (kg)	23.67 [a]	21.50 [a]	24.00 [a]
Body weight gain (g/day)	45.67 [a]	47.33 [a]	56.00 [a]
Gain to feed ratio	0.034 [b]	0.086 [a]	0.093 [a]

Note: Mean values in the same row having a similar superscript are not significantly different at $p<0.05$.

oil palm growers, should embrace OPF as an untapped green roughage resource that produces a similar effect on livestock performance as other commonly planted roughage such as NG. Indeed, the current era presents an opportunity to champion sustainable agriculture practices. Advocacy for the heightened utilisation of OPF is crucial in this context. This entails maximising OPF usage while concurrently minimising its environmental impact.

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