

Nutrient Intake and Digestibility of Fresh, Ensiled and Pelleted Oil Palm (*Elaeis guineensis*) Frond by Goats

I. Dahlan*, M. Islam and M. A. Rajion¹

Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM, Serdang Selangor, Malaysia

ABSTRACT : Oil palm frond (OPF) is a new non-conventional fibrous feed for ruminants. Evaluation on the nutritive values and digestibility of OPF was carried out using goats. In a completely randomised design, 20 local male goats were assigned to evaluate fresh and different types of processed OPF. A 60 day feeding trial was done to determine the digestible nutrient intake of fresh, ensiled and pelleted OPF and its response on live weight gain of goat. The pelleting of OPF increased ($p < 0.05$) intake compared to fresh or ensiled OPF. The OPF based mixed pellet (50% OPF with 15% palm kernel cake, 6% rice bran, 6% soybean hull, 15% molasses, 2% fishmeal, 4% urea, 1.5% mineral mixture and 0.5% common salt) increased ($p < 0.05$) nutrient intake, digestibility and reduced feed refusals. The mixed pellet also increased digestible dry matter intake (DDMI) and digestible organic matter intake (DOMI) at 80% and 63% level respectively than the fresh OPF. The increased digestible nutrient intake on the OPF based mixed pellet, resulted in increased live weight gain of goats. Furthermore, OPF has a good potential as a roughage source when it is used with concentrate supplement. OPF based formulated feed in a pelleted form could be used as a complete feed for intensive production of goat and other ruminants. (*Asian-Aus. J. Anim. Sci.* 2000. Vol. 13, No. 10 : 1407-1413)

Key Words : Oil Palm Frond, Goats, Nutrient Intake, Digestibility, Fresh, Ensiled, Pelleted

INTRODUCTION

Resource evaluation for non-conventional feed production in the tropics need to be aggressively studied by animal scientist in order to create new feed supply for increasing demand of feeds by livestock population in the world. Researchers have always shown great interest in the utilisation of crop residues and agricultural by-products in livestock feeding in the tropics, in order to reduce the cost of feeds and feeding. The utilisation of agricultural by-products in livestock feeding is becoming more important since recycling the agricultural by-products or waste into animal feeds will reduce the pollution and improve the efficiencies of livestock production system in the tropics. Oil palm (*Elaeis guineensis* Jacq.) frond are abundant waste fibrous material from oil palm plantation derives from the harvesting of oil palm fruit bunches and the pruning management is a new source of forage for livestock-crop production systems (Dahlan, 1992a). The OPF belongs to fibrous by-products group and utilisation of OPF in ruminant feeding has been evaluated (Dahlan, 1992a, b). During the last decade, much works have been done on the possibility of utilising OPF in ruminant livestock feeding (Islam and Dahlan, 1997; Islam et al., 1997b, 1998a). Dahlan et al. (1993) suggested the fresh OPF

as feed for pre-slaughter goats and reported that it could provide the sufficient amount of both metabolisable energy (ME) and protein for maintenance. On the other hand, Nasir et al. (1997) stated that OPF silage does not support maintenance requirement of milking goats which required high energy intake based on OPF diet alone and due to low intake of OPF silage. Dahlan et al. (1994) have included OPF as a main ingredient in rabbit feed. They found out that OPF is a suitable fibre feed source for rabbit. Oil palm frond contained high fibre and low protein (<70 g/kg, Dahlan, 1992a and Islam and Dahlan, 1997) but moderate (<400 g/kg at 48 h) DM degradability (Islam et al., 1997b). Different techniques of processing and supplementation of fibrous feed by addition of non-protein nitrogenous substance and soluble carbohydrate can improve the nutrient quality, nutrient intake and the digestibility (Leng, 1990; Coombe, 1959; Minson, 1990; Boda, 1990) and protein supplements that escape fermentation in the rumen (by-pass protein) are effective in enhancing growth rates of ruminants when fed low quality fibrous diet (Leng et al., 1987). Earlier study (Dahlan, 1996; Islam et al., 1998a) showed that preserved OPF with either urea or molasses increased the nutrient content of OPF. Moreover, ensiling and pelleting also increased the digestion characteristics of OPF measured by *in sacco* (Islam et al., 1998b). Although, studies on *in vitro* and *in sacco* evaluation of OPF have been conducted on nutrient content, preservation and improvement of the OPF (Islam et al., 1997b, 1998b), but the intake and digestibility of OPF by the ruminant species are not well documented.

* Address reprint request to I. Dahlan. Tel: +60-3-89486101 ext. 1855, Fax: +60-3-89432954, E-mail: dahlan@agri.upm.edu.my.

¹ Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.

Received December 14, 1999; Accepted May 25, 2000

Therefore, this study was done to determine the effect of pre-treatments and processing of OPF on the nutrient intake, digestibility and live weight changes of goat.

MATERIALS AND METHODS

A feeding trial was conducted for 60 days with an adjustment period of 10 days at the Farm, Department of Animal Science, University Putra Malaysia (UPM).

Animals and diets

The study was carried out with 20 local male goats of 7-8 months of age with an average live weight of 20.5 ± 0.5 kg. The goats were born on the farm and reared on a OPF based diet. The goats were divided into 5 homogenous groups according to age and weight and 4 goats were in each group. The goats were kept in individual pens on a raised wooden slated floor.

Five experimental diets based on OPF were formulated and offered to the goats. The composition of diets are shown in table 1. The different types of fresh and processed OPF were used in the diets. The fresh and processed OPF were: freshly harvested and chopped OPF (D₁), chopped OPF ensiled without any preservatives (D₂), chopped OPF ensiled with 15% molasses (D₃), OPF pellet (D₄) and OPF and agricultural by-product based mixed pellet (D₅).

Preparation of diets

Fresh and chopped OPF: Freshly harvested OPF were collected from the nearest Universiti Putra Malaysia (UPM) oil palm plantation during oil palm fruit bunch harvesting. Then the OPF were transported to the Animal Experimental Unit, UPM. Collected OPF were chopped by a simple electric chopper (STAR FARM SF 1400) in 2.0-3.0 cm. The OPF were chopped and fed daily to goats under treatment D₁.

Ensiled OPF: The diet D₂ (ensiled OPF) was

prepared using chopped OPF. The chopped OPF were packed in 200 l metal drums without any preservative. The packed drums were tightly sealed to provide anaerobic conditions and were kept at room temperature for 60 days.

Molasses mixed ensiled OPF: The diet D₃ (OPF preserved with molasses) was prepared as for diet D₂ except 5% molasses was mixed based on the DM basis of OPF.

OPF pellet: The preparation of OPF pellet (diet D₄) is described in detail below.

Drying of OPF: The freshly harvested OPF were chopped by STAR chopper (SFC2310, Japan). The chopped OPF were sun-dried for a day followed by mechanical drying for one hour until the DM content is >850 g/kg.

Grinding: The dried and chopped OPF then ground by Delta Frond Grinder (FG 5000).

Mixing, moulding and pelleting: The ground OPF were then mixed, moulded and pelleted (2-5mm sieve) by KAHLE pelleting machine (HTR 150, Germany).

Mixed pellet preparation: Mixed pellet (diet D₅) is a complete feed. The ground OPF were mixed with the formulated ingredients (table 1) and then pelleted. The ingredients were included to correct the basic limitation of OPF.

Feed offered and measurement of feed intake

Fresh and chopped OPF, OPF silage and OPF preserved with molasses, were offered *ad libitum* basis, in two times of the day 8.00 h and 16.0 h. Fixed concentrate (@1% of the live weight) was offered in the morning. Mixed pellets and OPF pellets, were offered *ad libitum*. Daily feed intake was measured by recording the fresh feed offered and feed refusals.

Digestibility trial

The conventional digestion trial of the diets was conducted between the 3rd and the 6th week of the feeding trial using the method described by Swift et al. (1950). The goats (4 in each group) were kept in

Table 1. Experimental diets

Diets	Oil palm frond	Concentrate*
Fresh OPF (D ₁)	Freshly harvested OPF were collected and chopped	Goat pellet at 1% of the LW
Ensiled OPF (D ₂)	Chopped OPF were ensiled	Goat pellet at 1% of the LW
Molasses mixed ensiled OPF (D ₃)	Chopped OPF were mixed with 15% molasses and ensiled	Goat pellet at 1% of the LW
OPF pellet (D ₄)	OPF was pelleted	Goat pellet at 1% of the LW
Mixed pellet (D ₅)	50% OPF mixed with, 15% palm kernel cake (PKC), 6% rice bran, 6% soybean hull, 15% molasses, 2% fishmeal, 4% urea, 1.5% mineral mixture and 0.5% common salt (NaCl)	

* Goat pellet and all the other ingredients were procured from commercial sources.

individual metabolic crates. The diet was placed in each feed trough and the refusals were left. During the trial the amount of feed offered and the refusal left were recorded daily. The weight of their faeces were collected in the morning (before any feed was given) and their weight was recorded. Ten per cent of the total well-mixed droppings were collected from each crate every morning and weighed. Feed, refusals and faecal samples were further sub-sampled. The samples were then dried, ground and stored in pill boxes. The apparent digestibility of different nutrients (dry matter (DM), organic matter (OM), crude protein (CP) and acid detergent fibre (ADF)) was determined by subtracting the nutrient voided through the faeces from the intake of the nutrient and these were divided by the nutrient intake.

Live weight gain measurement

The goats were weighed weekly. Each goat was weighed in the morning before any feed was given. All the goats were weighed for two consecutive days before commencing the study for the determination of initial live weight. This practice was continued till the trial was over.

Nutrient analyses

The determination of DM, OM, and CP contents of feed, refusals and faeces were done according to the method of AOAC (1984) and the ADF contents were determined using the method Goering and van Soest (1970). All the analyses were conducted in duplicate and results presented on DM basis.

Statistical analyses

Data were analysed by statistical methods using analysis of variance (Steel and Torrie, 1980) for a completely randomised design (CRD) and the mean values were tested for difference using Duncan's new multiple range test (SAS, 1997).

RESULTS

Nutrient content

The nutrient contents of the different types of OPF based diets are presented in table 2. Dry matter contents of the mixed pellet, OPF pellet and commercial goat pellet were within a narrow range. Similarly, for fresh OPF and the silages of OPF, DM content were within a narrow range. Organic matter contents of the feed ranged between 912 to 935 g/kg DM. The OM content of the mixed pellet and commercial pellet were similar but the OPF silage and fresh OPF showed higher OM content than the pellets.

The CP content of OPF was increased by ensiling and pelleting when expressed on DM basis. The CP content of mixed pellets that are based on OPF

Table 2. Nutrient contents (g/kg) of different feeds

Diets	g/kg DM			
	Dry matter	CP	OM	ADF
Fresh OPF (D ₁)	458.2	71.7	933.0	524.7
Ensiled OPF (D ₂)	399.5	103.1	935.0	479.9
Molasses mixed ensiled OPF (D ₃)	376.6	138.2	912.0	478.7
OPF pellet (D ₄)	923.1	100.1	922.0	525.8
Mixed pellet (D ₅)	888.2	169.6	921.0	314.1
Commercial goat pellet	920.0	171.9	922.0	188.5

showed a slight difference than the commercial goat pellet. Acid detergent fibre (ADF) was higher in the OPF pellet and fresh OPF compared to the ensiled OPF and mixed pellet which indicated that pre-treatment of OPF reduced the ADF content. The DM, CP, ADF and OM content of the fresh OPF and OPF silages are almost similar to the values reported in earlier studies (Islam et al., 1998a).

Refusals

The amount of OPF offered and OPF refused are shown in table 3. It was observed that goats refused almost 50% of the offered OPF when either fresh or ensiled OPF was given. On the other hand goat fed on OPF pellet refused only 10%. These results showed that the use of pelleted OPF can reduce the feed wastes. The OPF intake by the goats fed different diets shown in table 3. The results showed that OPF intake was higher in the mixed pellet and OPF pellet. Mixed pellet showed 88% higher intake of OPF while the OPF pellet showed an increase of 67%. This is supported by Minson (1963) who reported that grinding and pelleting of fibrous crop residues increased intake of the feed. Ensiling of OPF also increased the OPF intake by 13-16%. This might be due to the softer and sweetish smell of ensiled OPF which may improved palatability of the feed. The higher intake in the OPF silage compared to the fresh OPF is in contrast with the statements of Wilkins (1988) and Demarquilly and Jarrige (1973) about grass and legumes silages. Demarquilly and Dulphy (1977) reported that ensiling of forages reduced the intake 1-64%. The results of pelleting on OPF showed that the goat consumed more OPF when the OPF was pelleted ($p < 0.05$). This supports the report of Boda (1990) that pelleting increased the DMI of fibrous feed.

Nutrient intake

The intake of nutrient measured per unit of metabolic body weight ($LW^{0.75}$) is shown in table 3. The OPF pellet and the mixed pellet showed higher total dry matter intake (TDMI) compared to those fed

Table 3. Nutrient intake of goats (g/kg W^{0.75}) and digestibility (%) of nutrient of either fresh or preserved/processed OPF by goats

Item	Diets					SEM
	D ₁	D ₂	D ₃	D ₄	D ₅	
OPFDM offered (g)	544.1 ^b	516.4 ^b	551.3 ^b	547.7 ^b	663.2 ^a	56.9
OPFDM refused (g)	262.8 ^a	178.1 ^b	209.5 ^b	56.3 ^d	110.3 ^c	81.4
OPFDMI (g/kg W ^{0.75})	29.7 ^b	33.6 ^b	34.7 ^b	49.6 ^a	55.7 ^a	11.3
TDMI (g/kg W ^{0.75})	53.9 ^b	57.7 ^b	58.0 ^b	73.0 ^a	79.3 ^a	11.1
TOMI (g/kg W ^{0.75})	50.5 ^b	53.8 ^b	51.5 ^b	67.3 ^a	73.1 ^a	10.3
TCPI (g/kg W ^{0.75})	6.5 ^c	7.6 ^c	9.2 ^b	12.4 ^a	13.5 ^a	3.0
TADFI (g/kg W ^{0.75})	19.9 ^b	16.6 ^{bc}	20.3 ^b	30.5 ^b	33.8 ^a	7.5
DMD (%)	46.8 ^b	51.0 ^{ab}	53.4 ^{ab}	52.7 ^{ab}	60.7 ^a	5.1
OMD (%)	51.7 ^b	54.1 ^b	54.7 ^b	53.3 ^b	65.7 ^a	5.6
CPD (%)	41.9 ^d	53.0 ^c	59.4 ^{bc}	66.4 ^{ab}	70.6 ^a	11.4
ADFD (%)	22.3 ^{bc}	20.0 ^a	40.5 ^a	34.0 ^{ab}	42.8 ^a	10.4

Means with different superscripts in the same row differ significantly.

on either OPF silages or fresh OPF. The higher dry matter intake (DMI) of OPF resulted in a higher organic matter intake (OMI), higher crude protein intake (CPI) and higher acid detergent fibre intake (ADFI). The apparent trend of the DMI of the pelleted OPF can be explained that the pellets with a low moisture content is easy to eat. The OMI by the goats fed different diets shown in table 3. The CPI of the goats showed differences among the different diets and highest CPI was in the group fed on OPF based mixed pellet. This might be due to inclusion of protein rich ingredients with the OPF and the higher OPF intake due to the pelleting which increased density of the feed.

Digestibility of nutrient

The digestibility values of fresh and chopped OPF, were higher than the reported values of Nasir et al. (1997) but lower than the values of ensiled or pelleted OPF observed in this study (table 3). Dry matter digestibility in goats can vary widely according to the diet of animal (Ranjhan, 1980). Goats fed on OPF based mixed pellet showed a higher ($p < 0.001$) digestibility compared to the other groups. The OPF silages and OPF pellets showed higher digestibility than the fresh but chopped OPF. However, there was no difference in digestibility of OPF silage and OPF pellet. The OPF based mixed pellet showed an increased DM, OM, CP and ADF digestibility by 29, 15, 68 and 89%, respectively. Although, the ensiling and pelleting of OPF increased the digestibility but they were significantly lower than the digestibility values of nutrient in OPF based mixed pellets diet. The increased digestibility of OPF in the mixed pellet may be due to mixing urea as a fermentable N during pelleting. Moreover, molasses (a fermentable and soluble sugar source) were also added with a little share of fish meal as bypass protein. The

supplementation of urea, molasses and fishmeal to increase the nutrient intake and digestibility of a feed is well accepted by many workers. The addition of bypass protein with NPN and molasses could increase the nutrient intake and digestibility (Leng, 1989; Islam et al., 1997a; Coombe, 1959) of straw and other fibrous crop residues.

Digestible nutrient intake

The intake of digestible dry matter (DDM), digestible organic matter (DOM), digestible crude protein (DCP) and digestible acid detergent fibre (DADF) are presented in the table 4. The digestible dry matter intake (DDMI) and digestible organic matter intake (DOMI) of the goats fed on OPF based mixed pellet and OPF pellet were higher compared to the values of goat fed on the other diets. However, goats fed on OPF silages and fresh OPF did not show much difference in digestible nutrient intake. The digestible crude protein intake (DCPI) differed to a greater extent among the diets. Goats fed on OPF based mixed pellets showed the highest DCPI (9.51 g/kg W^{0.75}) followed by OPF pellet, molasses mixed OPF silage, ensiled OPF and fresh OPF.

Live weight gain

The live weight gain (g/day) of goats fed on different experimental diets are shown in table 4. It is clearly evident that OPF based mixed pellet increased live weight gain of goats. There was no difference between the goats fed on two silages but the goats fed on pelleted OPF showed higher ($p < 0.05$) live weight gain compared to the goats fed on silages or fresh OPF. This might be due to the higher digestible nutrient intake especially higher digestible crude protein intake (DCPI) compared to the other groups (figure 1). Figure 1, also shows the relationship between the DCPI and live weight gain of goats. The

Table 4. Digestible nutrient intake of goats (g/kg W^{0.75}) fed either fresh or preserved/processed oil palm frond

Item	Diets					SEM
	D1	D2	D3	D4	D5	
DDMI (g/kg W ^{0.75})	25.59 ^c	29.23 ^c	31.06 ^{bc}	38.13 ^d	46.29 ^a	8.22
DOMI (g/kg W ^{0.75})	26.43 ^c	28.96 ^c	28.29 ^{bc}	35.60 ^b	43.10 ^a	6.88
DCPI (g/kg W ^{0.75})	2.76 ^e	3.99 ^d	5.48 ^c	8.22 ^b	9.51 ^a	2.83
DADFI (g/kg W ^{0.75})	4.64 ^d	3.25 ^d	8.30 ^{bc}	10.25 ^b	14.46 ^a	4.49
Initial wt. (kg)	20.50 ^a	20.50 ^a	20.61 ^a	20.87 ^a	21.37 ^a	0.33
Final wt. (kg)	21.12 ^a	21.25 ^a	21.50 ^a	22.25 ^a	23.62 ^a	0.37
Live wt. gain (g.day ⁻¹)	10.33 ^c	12.50 ^{bc}	14.83 ^{bc}	23.00 ^{ab}	37.50 ^a	11.08

Means with different superscripts in the same row differs significantly.

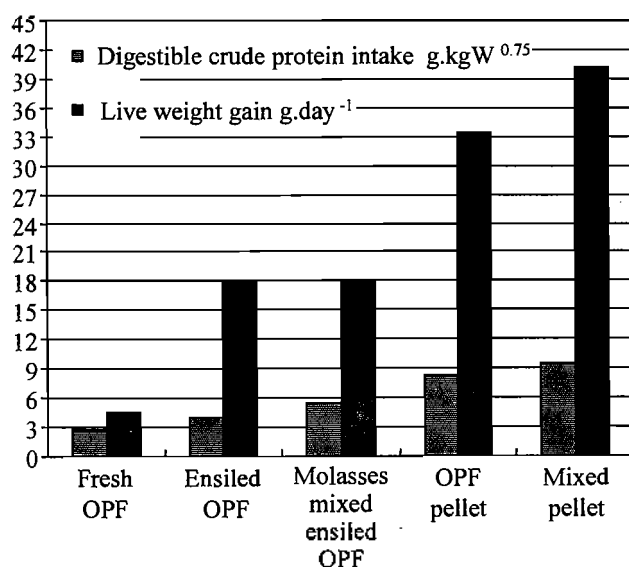
highest digestible crude protein intake was from the diet D₅ and followed by D₄, D₃, D₂ and D₁. The live weight gain ran in parallel to DCP intake. The results showed that there is a positive relationship between DCPI and the live weight gain.

DISCUSSION

This study showed that processed OPF can enhance the intake of OPF and live weight gain of goats. The effective feeding strategy using OPF can accelerate the intensive ruminant production in Malaysia. Oil palm frond belongs to agricultural by-products fibrous feed (Dahlan et al., 1994; Dahlan, 1996). The major disadvantage of this fibrous feed is low in voluntary intake that has been observed in fresh and chopped OPF based diets for ruminant (Nasir et al., 1997). The best option to maximise the utilisation of OPF depends on the increased voluntary intake. Although, grinding and pelleting sometime decreases the

digestibility of other fibrous feed like rice straw, wheat straw (Minson, 1990) supplementing or correcting the deficiencies of the feed, could overcome the problem (Leng et al., 1987). The results of this study also showed that by correcting the nitrogen deficiencies of OPF in the mixed pellet, intake and digestibility can be increased. Eventually, the live weight gain of the goats was higher. The fresh OPF contain low protein and high fibre. In the OPF based mixed pellet the protein content was increased by mixing urea and fishmeal. The mixing of molasses with OPF might increase the palatability of OPF.

It was found that pelleted OPF showed above 50% increased intake over the fresh and ensiled OPF. Pelleting increased the nutrient digestibility and the mixed pellet producing an increased intake and digestibility of nutrient. Although the ADF digestibility in the mixed pellet was low (42%) the ADF digestibility of OPF was increased by almost 87% by supplementing urea, molasses and fish meal in the mixed pellet. This study showed that by using urea, molasses and fish meal the quality of processed OPF can be improved and its utilisation increased. This is further evident that using urea and molasses can improve the nutrient intake and digestibility of low quality roughages. Islam and Huque (1995) reported that using both urea and molasses with rice straw increased nutrient intake as well as reduced the concentrate level without affecting milk production in dairy cattle. Bowman et al. (1995) also reported that the addition of bypass protein with NPN and molasses could increase the nutrient intake and digestibility. It was also found that ensiling OPF with molasses could increase the intake and digestibility to a greater extent. Although the DMI and DDMI increased with the ensiling of OPF, the refusals did not reduce and they were almost similar to fresh and chopped OPF. The higher amount of refusals tend to increase biomass losses and eventually increase cost of feed.



Different types of oil palm frond based diets

Figure 1. Relationship between digestible crude protein intake and live weight gain of goat fed different types of OPF based diet

CONCLUSION

The results of this study suggested that pelleting of

OPF can increase the OPF intake and reduce feed refusals. The digestible nutrient intake of goats suggested that the mixed pellet (50% OPF) was the best for increased live weight gain. The results also suggested that goats and other ruminant species can be intensively reared by pelleted OPF based diets. It can be concluded that OPF treated with urea and molasses mixed with fishmeal can maximise its utilisation in the ruminant diet. Finally, OPF based formulated feed in a pelleted form could be used as a complete feed for intensive production of goat as well as for other ruminant species.

ACKNOWLEDGEMENTS

The Malaysian Intensification of Research in Priority Areas (IRPA) grants No. 01-01-0400161-UPM (51233) is greatly acknowledged for funding this research.

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