Productivity and Nutritive Values of Different Fractions of Oil Palm (*Elaeis guineensis*) Frond

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ABSTRACT : Productivity, nutrient contents, *in vitro* gas production and *in sacco* degradability of different fractions and whole OPF were determined to assess the feeding value of OPF as a ruminant feed. An *in vivo* digestibility trial was also carried out using goat. Freshly harvested OPF was randomly collected, partitioned and weighed. An OPF from 21 years older palm weighed 13.4 kg and the annual fresh matter yield of petiole, leaflet and midrib was 46.5, 11.8 and 3.4 ton/ha, respectively. Leaflet contained 439, 926, 698, 501, 168, 196, 748 and 52 (g/kg) of dry matter (DM), organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose (CE), hemicellulose (HC), total carbohydrate (TC) and non fiber carbohydrate (NFC), respectively. Petiole contained lower ($p<0.01$) DM, CP and EE contents than leaflet. Organic matter, CE and TC contents were higher ($p<0.01$) in petiole compared to leaflet. Silica and lignin contents were highest ($p<0.01$) in midrib followed by leaflet, whole OPF and least in petiole. The Ca, P, Na, K and Mg contents (g/100 g DM) of leaflet were 0.529, 0.182, 0.039, 0.876, and 0.168, respectively. *In vitro* DM digestibility (g/100 g) at 48 h of leaflet, petiole and midrib was 32.7, 38.7 and 30.2, respectively. The *in sacco* DM degradation (g/100 g) at 48 h of leaflet was higher than that of whole OPF, petiole and midrib. The *in vivo* digestibility of DM, OM, CP and ADF of whole OPF was 52, 56, 43 and 26%, respectively. It can be concluded that leaflet is the most nutritious fraction of OPF and midrib is the least. The nutrient content and digestibility of the whole OPF showed that OPF could be an alternative roughage source for ruminant diets. (***Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 8 : 1113-1120***)

Key Words : Oil Palm Frond, Productivity, Nutrient Contents, *In Vitro* Gas Production, *In Sacco* Degradability and *In Vivo* Digestibility

INTRODUCTION

Malaysia with, in 1995, 2.52 million hectares of oil palm (*Elaeis guineensis* Jacq.) plantations (Dahlan, 1996) accounts for about 52% of the world's palm oil production. The oil palm industry produces three by products that are important in the animal feed industry, namely palm kernel cake, palm oil sludge, and palm press fibre. Husin et al. (1986) reported that the estimated annual pruned OPF is approximately 17 million tons DM. A more recent estimate is 24.0 million tons DM/year (Dahlan, 1996). The huge biomass and non-seasonal availability make OPF a promising byproduct for animal feeding. Considerable researches have been conducted to assess its nutrient composition of the OPF and the feeding value for ruminants and herbivores (Dahlan, 1992; Dahlan et al., 1993; Dahlan, 1996; Islam and Dahlan, 1997). However, there has been no report on the potential degradability of fractions of the frond. It has been suggested that the rumen degradation characteristic is the initial step to evaluate fibrous feed, especially low quality fibrous residues (Ørskov et al., 1980; Preston, 1995). The value of different fractions of OPF has not been reported and information on the fibrous component and mineral contents of different fractions of OPF is also scarce. The present study was conducted to determine the productivity, nutrient availability, *in vitro*, *in sacco* degradability and *in vivo* digestibility of the fractions of OPF as well as the whole OPF.

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MATERIALS AND METHODS

Productivity

One hundred freshly harvested OPF were collected from Universiti Putra Malaysia (UPM) oil palm plantation comprising five age groups of palm: group A (21 and above years), group B (16-20 years), group C (11-15 years), group D (6-10 years) and group E (less than 6 years). The leaflet, petiole and midrib were then separated and weighed. Annual biomass yield (DM/ha) was estimated through the following equation (Islam, 1999).

$$\text{TDM (kg)} = \text{NOP} \times \text{NP} \times \text{NHP} \times \text{WP kg};$$

where, TDM-total DM yield; NOP-number of oil palm planted per ha; NP number of prunings per year, NHP-number of harvested fronds per pruning/palm, and WP-mean weight of OPF (kg). Similarly 100 OPF were randomly collected, segmented into basal, middle and top segment. Leaflets, petiole and midrib were then separated and weighed.

Preparation of samples

Samples of leaflet, petiole, midrib and the whole OPF (mixture of all the fractions) were oven-dried at 60℃ until constant weight, ground through 1 mm and 4 mm sieve for *in vitro* and *in sacco* studies, respectively.

Nutrient analyses

Dry matter was determined by drying samples at 105℃ overnight and ashed by igniting in a muffle furnace at 550℃ for 3.5 h to determine organic matter (g/kg DM). The procedure of AOAC (1984) was followed to determine the CP by automatic N analyzer (Tecator, KJELTEC 1030). Two-gram samples of each fraction were extracted with petroleum ether in a Soxlet apparatus (AOAC, 1984) followed by Soxtec System (HT 1043). The CF was determined with the aid of Fibrotec System 1010 Heat Extractor (Tecator) (AOAC, 1984). Procedures of Goering and van Soest (1970) and van Soest and Wine (1967) were used to determine the NDF and ADF and the cell wall fractions (cellulose, lignin and silica). The difference between NDF and ADF was taken as hemicellulose. The method proposed by Sniffen (1988) for estimating fiber and non-fibrous carbohydrate (NFC) was used. Total carbohydrate (TC)=1000-[(CP+EE+Ash) g/kg DM] and the NFC=TC-NDF. The rapid wet digestion method of Thomas et al. (1967) was followed for mineral analyses. The digestion was allowed to cool and diluted to 100 ml thoroughly mixed and filtered. Phosphorus was determined by using the spectrophotometer (Spectronic 3000) at 420 nm. The Zn, Mn and Cu concentrations were determined with atomic absorption flame photometer. Amino acid profiles were determined using the PICOTAG methods generated by Baseline (1990) using high performance liquid chromatography.

Dry matter degradability *in sacco*

Dry matter degradation was determined by incubating about 3.0 g of sun-dried samples in three fistulated cattle. The cattle were fed on 4 kg rice straw, 12 kg green grass and 3 kg mixed concentrate daily. The diet was offered twice daily at 0800 and 1600 h and the animal had free access to drinking water. Bags measuring 144×90 mm, made of nylon filler-cloth (pore size 20 to 40 μm) and stitched with polyester thread were used to incubate the samples. Washing losses were estimated by soaking two bags per sample in warm water (about 39℃) for an hour followed by washing and drying (Bhargava and Ørskov, 1987). Values for DM degradation at each incubation period of the samples were mathematically evaluated and fitted to the exponential equation $p=A+B(1-e^{-ct})$ (Ørskov and McDonald, 1979; McDonald, 1981), where p is the actual degradation at time t. The lag time was estimated by fitting the model p=A for $t=t_0$, and $p=A+B(1-e^{-ct})$ for $t>t_0$, and degradation characteristics of OPF fractions were defined as: the intercept 'A'=the rapidly degradable fraction (the washing loss representing, the soluble fraction of feed; 'B'=(A+B)-A, is the insoluble but potentiality degradable material in time t; 'c' is the rate of degradation of B, and the lag phase (L)=1/c $\log_e$[B/(A+B)-A] (Ørskov and Rye, 1990).

***In vitro* digestibility**

The different fractions of OPF were incubated with rumen fluid in glass syringes following the procedure of Menke et al. (1979). About 200±5 mg of dry samples were used for the study. Rumen fluids were collected from three rumen fistulated Kedah-Kelantan cattle (local breed of Bos indicus origin) that were daily fed with 40% OPF pellet and 60% concentrate (PKC 20%, rice bran 30%, crushed corn 10%, soybean meal 35%, molasses 3%, vitamin mineral premix 1.5% and salt 0.5%). Samples were incubated in the rumen fluid medium mixture for 4, 8, 12, 16, 20, 24, 28, 32, 42, 48, 56 and 72 hours. The volume of gas production with three duplicates was fitted to the exponential equation of $p=A+B(1-e^{-ct})$, (Ørskov and McDonald, 1979).

***In vivo* digestibility**

Eight Malaysian local male goats (Kambing Katjang), average live weight 20.4 kg, were used to measure the apparent digestibility of whole OPF. After a week of adjustment period, total collection procedures of feed and feces were used to measure the daily feed intake and fecal output for seven days. Freshly harvested and chopped (2.0 to 3.0 cm) OPF were offered *ad libitum* to the goat during the trial twice at 0800 and 1600 h. A commercial concentrate at the rate of 1% of live body weight was given in the morning prior to OPF offered. Nutrient analyses (DM, OM, CP and ADF) of feed, refusals and feces were analyzed using the methods described earlier.

About 200±5 mg of dry sample were used for the study.

Statistical analyses

The production data of the fractions of OPF were analyzed using analysis of variance in a completely randomized design. Nutrient content and gas production were analyzed in a one way analysis of variance. The least significance difference (LSD) test of means and standard error of mean differences (sem) were also used in presenting the mean data. The degradation data were analyzed in a 3×3 Latin square design and the rates of DM degradation of different fractions were analyzed using LSD of mean. All the statistical analyses were carried out with the aid of SAS (1997).

RESULTS

Productivity

Fresh biomass yields of leaflet, petiole and the whole OPF in different segments are presented in table 1a. Leaflet yield was highest in the middle segment while petiole yield was highest in basal segment. Leaflet:petiole ratio was highest in top segment of OPF followed by middle and basal segments. Overall leaflet:petiole ratio was 0.39.

Table 1a. Yield attributes of different fractions of oil palm frond in different segments

Segments	Wt. of leaflet (g/frond)	Wt. of petiole (g/frond)	Wt. of OPF (g/frond)	Leaflet: petiole ratio
Basal	184	5396	5580	0.04
Middle	1500	1300	2800	1.28
Top	1267	702	1969	2.82
Total	2951	7398	10349	0.39
sem	111.6	215.3	218.4	0.58
Significance level	0.01	0.01	0.01	0.01

Table 1b. Dried leaflet and petiole production in different aged oil palm

Palm age (years)		Dried leaflets (g/frond)	Dried petiole (g/frond)	Leaflet: petiole ratio
21	(A)	1258	4043.4	0.311
16-20	(B)	1228	3486.3	0.532
11-15	(C)	508	334.6	1.518
6-10	(D)	467	310.8	1.501
<6	(E)	110	62.3	1.769

Mean values of dried leaflet and petiole production from OPF of different age group of palms are presented in table 1b. Mean weight of dried leaflet produced highest in the OPF of the palm of group A (1258 g), which was 24% of the whole OPF. Similarly B, C, D and E, group produced 36, 60, 60 and 64% leaflet of whole OPF, respectively. The leaflet:petiole ratio of groups C, D and E was higher than that of A and B.

Proximate composition

Table 2 shows the proximate composition of fractions of OPF. Midrib showed a higher ($p<0.001$) DM content (591 g/kg) followed by leaflet, whole OPF and petiole. Organic matter content varied with a significant difference ($p<0.001$) between petiole and the other fractions. Ash content (g/kg DM) was the highest in leaflet (74.1) followed by whole OPF (39.2), midrib (33.7) and petiole (22.4). Crude fiber content (g/kg DM) was the highest ($p<0.001$) in petiole (487.7) followed by midrib and leaflet. Crude protein content was the highest in leaflet followed by midrib, whole OPF, and least in petiole. Crude protein content of leaflet showed a marked difference (131.2 vs. 38.2 g/kg DM) compared to midrib. Petiole and midrib had a lower EE content compared to leaflet and whole OPF. Leaflet had lowest NFE content among the fractions.

Fibrous component

Cell wall contents of the OPF and its fractions are presented in table 3. Neutral detergent fiber and ADF were higher ($p<0.001$) in petiole and midrib compared with other fractions. The higher NDF in midrib (734.5 g/kg DM) and petiole (734.1 g/kg DM) compared to leaflet suggested that midrib might be slowly degradable. Midrib and leaflet contained lower cellulose compared to whole OPF and petiole. The HC was higher in whole OPF followed by leaflet, petiole and least in midrib (table 3).

Minerals

The average contents of macro minerals are shown in table 4. All types of minerals were highest in leaflet compared to other fractions of OPF. The whole OPF consisted of 0.53, 0.11, 0.18, 0.049 and 0.69 (g/100 g DM) of Ca, P, Mg, Na and K, respectively. The Cu, Zn, Mn, Fe and S contents of whole OPF were 2.71, 11.2, 44.7, 106.7 and 0.09 mg/kg DM, respectively.

Amino acid profile

The essential and non-essential amino acid profile of whole OPF and leaflet are presented in table 5. Most of essential amino acids except methionine were present in leaflet as well as whole OPF. Leaflet was rich in glutamic acid (13.36 g/kg DM) followed by leucine, aspartic acids and alanine. The leaflet showed a better amino acid profile than whole OPF. Lysine and histidine were in low levels in leaflet as well as in whole OPF.

Dry matter degradation *in sacco*

The mean DM degradation values of different fractions of OPF and whole OPF are presented in table 6. Leaflet had the highest ($p<0.01$) DM degradability at 48, 72 and 96 h of incubation; value for petiole were higher up to 48 h. Petiole had the highest rapidly disappearing material (intercept A) value (20.3%) followed by leaflet, whole OPF and midrib (table 7). The insoluble but potential degradable fractions (B) were highest in leaflet (50.5 g/100 g DM) followed by petiole, whole OPF and midrib. The potential degradable fraction (A+B) was also highest ($p<0.01$) in leaflet (66.89 g/100 g DM) followed by

Table 2. Proximate components (g/kg) of different fractions and the whole oil palm frond

Fractions	DM	g/kg DM					
		OM	Ash	CP	EE	CF	NFE
Petiole	401^{c}	978^{a}	22^{c}	26^{d}	6.7^{c}	488^{a}	458^{b}
Leaflet	437^{b}	926^{c}	74^{a}	131^{a}	44.9^{a}	440^{b}	311^{d}
Midrib	591^{a}	966^{b}	34^{b}	38^{c}	5.4^{c}	446^{b}	477^{a}
OPF	419^{c}	961^{b}	39^{b}	65^{b}	16.6^{b}	476^{a}	403^{c}
LSD	18.85	5.67	5.67	5.07	4.01	12.29	14.4
Sig. level	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001

Means with different superscripts within a column differ significantly. LSD=Least significance difference; OM=Organic matter; CP=Crude protein; EE=Ether extract; CF=Crude fiber; NFE=Nitrogen free extract.

Table 3. Cell wall and cell constituents (g/kg DM) of petiole, leaflet, midrib and the whole oil palm frond

Fractions	Petiole	Leaflet	Midrib	Whole OPF	LSD	Significance level
NDF	734^{a}	698^{a}	735^{a}	740^{a}	81.6	NS
ADF	642^{a}	501^{b}	659^{a}	530^{b}	30.7	0.001
HC	92^{b}	196^{a}	75^{b}	211^{a}	91.4	0.01
CE	317^{a}	168^{c}	161^{d}	219^{b}	7.4	0.001
Lignin	172^{c}	274^{b}	360^{a}	190^{b}	33.9	0.001
Silica	7^{c}	38^{a}	39^{a}	14^{b}	3.4	0.001
Cell	266^{a}	303^{a}	266^{a}	260^{a}	81.6	0.001
TC	946^{a}	750^{d}	923^{b}	879^{c}	10.7	0.001
NFC	211^{a}	52^{b}	188^{a}	139^{a}	78.3	0.01

Means with different superscripts within a column differ significantly. LSD=Least significance difference; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; HC=Hemicellulose; CE=Cellulose; TC=Total carbohydrate and NFC=Non-fiber carbohydrates.

Table 4. Macro mineral contents (g/100 g DM) of different fractions and whole oil palm frond

Fractions	Ca	P	Mg	Na	K	S	Cu	Zn	Mn	Fe	S
Petiole	0.466^{b}	0.09^{b}	0.093^{c}	0.018^{b}	0.644^{c}	0.094^{a}	2.51^{c}	10.00^{c}	40.00^{b}	100.33^{b}	0.094^{a}
Leaflet	0.529^{a}	0.183^{a}	0.168^{a}	0.039^{a}	0.876^{a}	0.080^{a}	3.04^{a}	13.20^{a}	45.00^{a}	121.67^{a}	0.080^{a}
Midrib	0.370^{c}	0.188^{a}	0.117^{b}	0.043^{a}	0.726^{b}	0.076^{a}	1.569^{d}	9.733^{c}	40.00^{b}	85.33^{c}	0.076^{a}
OPF	0.530^{a}	0.108^{b}	0.180^{a}	0.049^{a}	0.697^{bc}	0.096^{a}	2.71^{b}	11.17^{b}	44.66^{a}	106.67^{b}	0.096^{a}
LSD	0.04	0.02	0.010	0.02	0.06	0.05	0.01	0.02	1.32	5.05	0.01
Sig. level	0.001	0.001	0.001	0.02	0.001	NS	0.01	0.01	0.01	0.01	0.01

Means with different superscripts within a column differ significantly. lsd=Least significance difference.

petiole (56.43 g/100 g DM) and whole OPF (50.85 g/100 g DM). Midrib showed the least potential degradable value (28.9 g/100 g DM). The rate of degradation was highest in midrib which denotes a rapidly degradation of the fraction B. Washing losses, which consist of water-soluble fractions and some small particles that escape from the bags are presented in table 8. Petioles showed a highest washing loss while leaflet showed a highest loss of small particles.

Metabolizable energy

Research conducted at Rowett Research Institute, Scotland, UK (E. R. Ørskov, personal communication and referred in Chowdhury and Huque, 1996) has shown that the 48 h dry matter loss (DML) is closely related to the metabolizable energy (ME) content. The relationship has been expressed as: ME (MJ/kg DM)=2.756+48 h DML% $\times$ 0.1073. The calculated (from the above equation) ME contents (MJ/kg DM) of the petiole, leaflet, midrib and the whole OPF are 6.46, 6.88, 5.70 and 6.76, respectively.

***In vitro* gas production**

The volumes of gas (ml) produced *in vitro* per

Table 5. Amino acids content (g/kg DM) of leaflet and whole oil palm frond

Amino acids	Leaflet	Whole OPF
Alanine	6.72	3.81
Arginine	5.22	2.59
Aspartic acid	3.31	7.32
Glutamic acid	13.19	5.90
Glycine	6.19	3.73
Histidine	1.14	-
Isoleucine	4.19	1.56
Leucine	10.15	8.37
Lysine	4.11	1.95
Phenylalanine	6.12	2.86
Proline	6.18	3.19
Serine	5.10	2.70
Tyrosine	3.20	1.27
Valine	6.34	3.15

200 mg DM sample recorded at 4, 8 16, 20, 24, 28, 32, 48, 56 and 72 h of incubation are shown in table 9. The digestion characteristics according to the equation of Ørskov and McDonald (1979) are shown in table 10. *In vitro* gas production at all levels of incubation were significantly higher ($p<0.001$) in petiole compared to that of leaflet, whole OPF and midrib.

Digestion characteristics

Table 10 shows the digestion characteristics based on the gas production value of different fractions of OPF. The rapidly disappearing material (soluble fraction A) was the highest in petiole followed by leaflet, whole OPF and midribs. Similar trends of rapidly disappearing material A, were observed in the *in sacco* degradability studies of the fractions (table 7). The insoluble but potentially degradable fraction B also showed a similar trend of the soluble fractions where petiole had higher values at all levels of incubation. The potential digestible fraction (A+B) was also the highest in petiole followed by whole OPF and leaflet. The midrib had the least potential digestible fraction which was also obtained in the *in sacco* experiment (tables 6 and 7).

Table 8. Washing loss (g/100 g DM) characteristics of the different fractions of oil palm frond

Washing loss	Petiole	Leaflet	Whole OPF	Midrib
Loss through nylon bags	19.99	17.25	18.77	9.93
loss through filter paper	8.56	5.51	7.41	3.67
Small particle loss	11.43	11.74	11.35	5.52

***In vivo* digestibility**

The DM, OM, CP and ADF intake data are presented in table 11. The feeding choices of the goats resulted in high refusals of the OPF. Goats preferred the leaflets, and petioles were almost all refused, although the petiole and leaflets both were chopped at 1.5 to 2.0 cm. The *in vivo* digestibility of the nutrients of fresh OPF are also shown in table 11. Dry matter digestibility of whole OPF was 52%. Organic matter, CP and ADF digestibilities of whole

Table 6. Dry matter degradation (g/100 g) of the fractions of oil palm frond at different hours of incubation

Hours of incubation	Petiole	Leaflet	Whole OPF	Midrib	SEM	Significance level
8	23.24	17.17	19.97	14.1	3.2	$p<0.01$
16	28.92	25.52	23.81	22.7	2.9	$p<0.01$
24	30.67	28.45	26.84	24.6	3.5	$p<0.01$
48	34.53	38.42	37.32	27.5	2.8	$p<0.01$
72	40.75	41.99	37.86	28.7	2.5	$p<0.01$
96	44.53	52.51	45.14	30.0	4.3	$p<0.01$

SEM=Standard error of mean deviation.

Table 7. Dry matter degradability (g/100 g) characteristics of the different fractions of oil palm frond

Fraction	A	B	(A+B)	c	L	RSD
Petiole	19.1	37.33	56.43	0.0109	-6.9	1.57
Leaflet	16.4	50.49	66.89	0.0123	3.5	2.7
Midrib	4.1	24.80	28.90	0.0875	1.9	1.12
OPF	16.0	34.85	50.85	0.0171	1.0	2.07

A=Rapidly degradable fraction (g/100 g); B=Insoluble but potentially degradable fraction (g.100g-1DM); c=Rate of degradation of B; (A+B)=Potential degradability (g.100g-1); L=Lag time (h) and RSD=Residual standard deviation.

Table 9. *In vitro* gas production (ml/200 mg) of petiole, leaflet, midrib and the whole oil palm frond

Incubation hour	Petiole	Leaflet	Midrib	Whole OPF	LSD	Sig. Level
4	17	16	12.7	16.7	2.607	0.01
8	23.7	18.7	16.7	20	2.977	0.01
12	28	21.7	19	23	2.369	0.0001
16	30	26.7	20.7	27	3.48	0.001
20	31.7	27.6	23.3	28	2.31	0.001
24	32.7	28.7	24.7	29.7	2.333	0.001
28	34	29.7	25.7	31	2.166	0.001
32	35	30	26.7	31.3	2.833	0.001
42	38	31.7	28.3	33	4.139	0.003
48	38.7	32.7	29.5	34	3.78	0.05
56	40	34	30.5	35	3.57	0.001
72	42.7	35.5	32	36	4.90	0.001

LSD=Least significance difference.

Table 10. Digestion characteristics (g/kg DM) through *in vitro* gas production of different fractions of oil palm frond according to the equation $p=A+B(1-e^{-ct})$

Fractions	A	B	(A+B)	c	RSD
Petiole	13.28	29.42	42.7	0.0465	1.41
Leaflet	11.17	24.02	35.19	0.0542	1.17
Midrib	9.38	23.49	32.87	0.0425	0.44
OPF	11.78	24.21	35.99	0.0588	0.67

A=Rapidly degradable fraction (g/100 g); B=Insoluble but potentially degradable fraction (g/100 g DM); c=Rate of degradation of B; (A+B)=Potential degradability (g/100 g).

Table 11. Dry mater, organic matter, crude protein and acid detergent fiber, offered, refused, intake and *in vivo* digestibility of fresh oil palm frond by goats

Items	DM	OM	CP	ADF
Offered (g)	641	599	48	337
Refused (g)	305	279	21	163
Intake (g/kg $W^{0.75}$)	32	51	6.3	21
Digestibility (%)	52	56	43	26

DM=Dry matter; OM=Organic matter; CP=Crude protein; ADF=Acid detergent fiber.

OPF were 56, 43 and 26%, respectively.

DISCUSSION

Oil palm frond produces a higher petiole yield than leaflet. When the oil palm frond was separated into three segments using the procedures of Islam (1999), the basal segment produced 53% of the total OPF production. The middle segment produced almost 51% of the total leaflet production while the top segment produced 42% of the total leaflet (table 1a). In OPF from the group A (above 20 years age) and B (16-20 years) palms, the mean petiole production was higher, which caused the lower leaflet:petiole ratios than in groups C, D and E. The dried leaflet:petiole of group A was 0.31 which is similar to the value reported by Dahlan (1992); the value for B (0.53) was also less than 1.0 and similar to the 0.47 reported by Sajem et al. (1996). The latter reported ratios for fronds of other palms: for nipah, sago and coconut they were respectively 0.80, 0.53 and 0.78.

Values for the proximate components of the fractions of the OPF and for the concentrations of minerals are in the main similar to those reported for OPF and conventional fibrous feeds, such as rice straw, bagasse and whole cane, by Hogan and Leche (1981), Islam et al. (1995), Jackson (1977), Molina et al. (1983), Preston (1995), De Castro et al. (1991), Amber and Djajanegara (1982), Dahlan (1992), Asada et al. (1991), Sajem et al. (1996), Oshio et al. (1989) and Wan Zahari et al. (1997).

The CP in the whole OPF dry matter (6.5%) was higher than the usual values for fibrous feeds, and of course was substantially higher in leaflet (13.1%) than in petiole (2.6%) and midrib (3.8%).

The latter two fractions would be less digestible than leaflet, and in the digestibility trial the goats selected leaflet from among the chopped OPF, almost entirely rejecting petiole. The DM and OM digestibilities of the whole OPF as offered (52 and 56% respectively) together with the CP content (6.5%) indicate it can be used as a maintenance feed for ruminants and to provide the maintenance component of production rations. If leaflet could be separated, it alone should provide for more than maintenance though it should be noted it has high contents of lignin (27.4%) and silica (3.8%); the lignin, particulary, adversely affects degradability and therefore digestibility and intake. Leaflet was found (table 10) to have less of the rapidly degradable fraction A and of the potentially degradable fraction B than petiole, though more of both than in midrib, and it did have the highest rate of degradation of fraction B. Differences in *in vitro* gas production corresponded with the differences in degradability, being highest for petiole. Values for both measures were broadly similar to those reported for OPF by Wong and Wan Zahari (1992), Abe et al. (1990), Ishida and Abu Hassan (1992) and Dahlan (1992); degradability values were higher than those reported for rice straw by Navaratne and Ibrahim (1988), Ibrahim et al. (1989) and Chowdhury and Huque (1997), indicating a higher nutritional value for OPF. The highest washing loss for petiole (table 8) and highest rapidly degradable fraction A reflect the high concentration of soluble carbohydrate (NFC) in this OPF fraction (table 3). NFC affect ruminal fermentation, high concentrations promoting an increased proportion of propionate in VFA production with benefit for animal performance (Sniffen, 1988) but, unfortunately, the goats in the digestibility trial indicated petiole is an unacceptable feed. It would be worthwhile to explore means of improving the acceptability to animals of this material.

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