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NUTRIENT CONTENTS AND *IN SACCO* DEGRADABILITY OF DIFFERENT FRACTIONS OF OIL PALM (*Elaeis guineensis*) FROND

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ABSTRACT

In Malaysia, oil palm frond (OPF) is widely used as a roughage source for ruminants. OPF consist of three major fractions namely, petiole, leaflets and midribs. Nutrient contents and *in sacco* rumen degradability of the three fractions were determined. Crude protein content of leaflet (131.2 g/kg DM) was significantly higher ($P<.01$) than petiole (25.5 g/kg DM). Calcium (Ca) and phosphorus (P) content were also higher in leaflet as compared to petiole and midribs. Midrib exhibited higher lignin (359.9 g/kgDM) followed by leaflet (274.2 g/kgDM) and petiole (172.3 g/kgDM). Silica content (38.5 g/kgDM) was also higher in midrib as compared to leaflet (37.5) and petiole. Both the petiole and midribs had higher NDF and ADF as compared to leaflet. Total carbohydrate of petiole was higher ($P<.0001$) than leaflet and midrib. The highest potential degradability (B) obtained from leaflet (527 g/kg DM) compared to midrib (449 g/kg DM) and petiole (346 g/kg DM). The 48h DM degradability of all fractions ranged between 340-390 g/kg. More than 73% of degraded portion of leaflet were degraded within 48h of incubation, whereas, in petiole and midrib the values were 77% and 87% respectively, meaning the prolonged incubation does not have any significant effect on DM degradation of petiole and midrib.

Key words: Oil palm frond, Nutrient contents, *In sacco* degradability

INTRODUCTION

Oil palm frond (OPF) is the leaf like part of oil palm (*Elaeis guineensis Jacq.*) which is produced continuously from the palm. Oil palm frond is made up of three fractions namely, petiole, leaflets and midribs. The petiole is the long structure from base to top and leaflets are arranged on both sides of petiole while the midrib is the sticky part of the leaflets from base to top (Islam and Dahlan, 1997). The estimated total OPF (on DM basis) production per year is about 24.0 million tonnes (Dahlan, 1996 and Akmar *et al.*, 1996). In the plantations, OPF is left to decompose and contribute to the organic matter recycling and soil conservation. The huge biomass and the year round availability makes OPF a promising by-product for animal feeds. Considerable research has been conducted the nutrient composition of the OPF and the response of feeding them to ruminants and in herbivores (Dahlan, 1992, 1996; Dahlan *et al.*, 1993; Ishida and Abu Hassan, 1992 and Asada *et al.*, 1991). However, there has been no report on the potential degradability of the components of OPF. It has been suggested that the rumen degradation characteristic is the initial step to evaluate fibrous feed especially low quality fibrous residues (Preston, 1986). Moreover, the nutrient content of the fractions of OPF with their nutritive values has not been well reported yet. The fibrous content and mineral contents of different fractions also scarce. The present study was conducted to determine the nutrient contents and *in sacco* degradabilities of the fractions of OPF.

MATERIALS AND METHODS

Preparation of samples

Representative samples of the fractions of OPF were collected from freshly harvested OPF of the older palm (>20 years). The

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samples were then oven dried (60^0C until constant weight), ground and packed in pillboxes for nutrient analyses. Samples were ground 1 mm and 4 mm sieve for chemical analysis and *in sacco* degradability studies respectively.

Proximate analyses

The procedures of AOAC (1984) were followed to determine the proximate components. Dry matter (DM) was determined by drying overnight the samples at 105^0C and ashed by igniting in a muffle furnace at 550 ^{0}C for 6 h. Organic matter (OMgkg^{-1}DM) was the difference of ash (gkg^{-1}DM) from 1000. The crude protein (CP) was determined by the automatic N analyzer (Tecator KJELTEC 1030). Two grams sample of each fraction was extracted with petroleum ether in Soxlet apparatus [Soxtec System HT 1043] and the loss in dried sample in thimble was taken as ether extract (EE). Crude fibre was determined with the aid of Fibrotec System 1010 Heat Extractor (Tecator).

Fibrous component

The procedures for determining cell constituents were carried out by Goering and van Soest (1970) and Van Soest and Wine (1967) which permits a determination of the cell wall fractions, neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose (CEL), lignin, and silica. The difference between (1000-NDF) was taken as neutral detergent soluble (NDS gkg^{-1}). The difference between NDF and ADF content was taken as hemicellulose (HC). The method proposed by Sniffen (1988) for estimating total fibrous carbohydrate and non-fibrous carbohydrate (NFC) was followed. The total carbohydrate (TC)= 1000 -[(CP + EE + Ash) g kg $^{-1}$ DM] and the non-fibrous carbohydrate (NFC)=TC-NDF.

Macro minerals

The rapid wet digestion method of Thomas *et al.* (1967) was followed. The digestion was allowed to cool and diluted to 100 ml thoroughly mixed and filtered. Phosphorus was determined by using the spectrophotometer Spectronic 3000 assay at 420 m and Zn, Mn and Cu concentration with Atomic Absorption Flame Photometer.

In sacco degradability

DM degradation was determined by incubating approximately 3.0 g of the sun-dried samples in three fistulated local cattle as suggested by Bhargava and Ørskov (1987). The cattle were feeding on 4 kg rice straw, 12 kg green grass and 3 kg mixed concentrate daily. The diet was offered twice daily at 8.00h and 16.00h and the animal had free access of drinking water. Bags measuring 144x90mm made of nylon filler cloth (pore size 20-40 micron) and stitched with polyester thread were used to incubate the samples. Washing losses were estimated by soaking two bags per sample in warm tap water (about 39 ^{0}C) for an hour followed by washing and drying as before.

Equation

The values for DM degradation at each incubation were mathematically evaluated and fitted to the exponential equation developed by Ørskov and McDonald (1979) and McDonald (1981) to calculate and rate and extent of rumen digestion of the test OPF samples. The equation is $p = A + B\ (1 - e^{-ct})$, 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 the degradation characteristics of the OPF fractions were defined as: The intercept 'A'= 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 Ryle, 1990 and Kibon and Ørskov, 1993). The calculation was made by using NAWAY program.

Statistical analysis

Values of nutrient content were analyzed by a one way analysis of variance of completely randomized design (CRD) with the least significance difference test (LSD) were also used to determine the difference between the treatment means (Gomez and Gomez, 1984). The degradation values were analyzed followed by 3X3 Latin square design. All the analyses were made with the aid of Statistical Analyses System (SAS, 1997).

RESULTS AND DISCUSSION

Proximate composition

Table 1 shows the proximate composition of different fractions of OPF. The midribs showed the highest ($P<.001$) DM followed by leaflets and petiole. Organic matter (OM) contents varied with a narrow range between petiole and midrib but the OM content of leaflet was the lowest. Ash content was highest in leaflet followed by the OPF, midrib and petiole. Highest OM and less ash content were in petiole while the leaflet contained the lowest OM and highest ash. The values are in agreement with the values reported by Dahlan (1992) and Ishida and Abu Hassan (1992). Crude fibre content (g kg^{-1} DM) was highest in petiole (487.7) followed by midribs and leaflets. Crude protein (CP) content was highest in leaflet followed by the midrib and petiole. The CP content (gkg^{-1}DM) of leaflet showed marked differences (131.2 vs 38.2) with midrib means leafy substance (exclude midrib) in leaflet might have more CP, which could be a good protein sources. The CP of leaflet was higher than the value reported by Dahlan (1992) but lower than the value reported by Oshio *et al.* (1989). Petiole and midrib had lower EE compared to leaflet. Higher CP and EE value of leaflet over petiole was also reported by Oshio *et al* (1989). However, the CP, CF and EE content (g kg^{-1}DM) of the whole OPF were 65.33, 476.1 and 16.33 respectively (Table 3). If compared with rice straw (Asada *et al.*, 1991) the CP of leaflet as well as OPF is higher (65.3 vs 35.6). Leaflet had low NFE content among the fractions. The highest DM, CP, and EE with lowest CF of leaflet make itself the highly nutritious fractions in OPF.

Fibrous component

The cell wall content (g kg^{-1}DM) of OPF and its fractions are presented in Table 4. Neutral detergent fibre and ADF were higher ($P<.001$) in petiole compared to the other fractions. Cellulose was lower in midrib and petiole while the hemicellulose was lower in midrib and leaflet (Table 2). The higher cell wall (NDF) in midrib (734.5) and petiole (734.1) over leaflet means the midrib is slowly digestible. The fibre and non-fibre (NFC) carbohydrate of different fraction are also shown in Table 2. Non fibrous carbohydrate (NFC) content was higher in petiole and midrib compared to leaflet. Non fibrous carbohydrate that generally affects on the balance of the microbial species of rumen proportion of VFA and the amount of energy provided in ruminant tissues. Energy concentration can be increased by providing more NFC but this can lead to alter the ruminal fermentation and disorder such as acidosis and milk fat depression. Petiole had higher cellulose and degradation in 48 h means the potential degradation was faster compared to the lower hemicellulose than leaflet (Table 2). The results agree with Oshio *et al.* (1989). They also stated that the higher cellulose compared to hemicellulose were present in both the fractions of OPF. Lignin content (g kg^{-1} DM)

Table 1. Proximate components (g kg^{-1}) of different fractions and the whole OPF

Fractions	g kg^{-1} DM						
	DM	OM	Ash	CP	EE	CF	NFE
Petiole	401.1^{c}	977.6^{a}	22.4^{c}	25.5^{d}	6.66	487.7^{a}	457.72^{b}
Leaflet	438.6^{b}	925.9^{c}	74.1^{a}	131.2^{a}	44.89^{a}	439.9^{b}	309.89^{d}
Midrib	591.0^{a}	966.3^{b}	33.7^{b}	38.2^{c}	5.41^{c}	445.9^{b}	476.82^{a}
OPF	418.6^{c}	960.8^{b}	39.2^{b}	65.33^{b}	16.63^{b}	476.1^{a}	402.77^{c}
LSD	18.85	5.67	5.67	5.07	4.01	12.29	14.4
Sig. Lev.	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001

Means with different superscripts within a column differs significantly. LSD = least significance difference

Table 2. Different cell wall and cell constituents (gkg^{-1}DM) of different fractions and the whole OPF

Fractions	NDF	ADF	HC	CEL	Lignin	Silica	Cell	TC	NFC
Petiole	734.1^a	642.0^a	92.2^b	317.4^a	172.3^c	7.4^c	265.9^a	945.5^a	211.3^a
Leaflet	697.5^a	501.1^b	196.4^a	168.1^c	274.2^b	37.5^a	302.5^a	749.8^d	52.3^b
Midrib	734.5^a	659.3^a	75.2^b	160.5^d	359.9^a	38.5^a	265.5^a	922.7^b	188.3^a
OPF	740.1^a	529.5^b	210.6^a	218.5^b	189.8^b	14.0^b	259.9^a	878.8^c	138.8^a
LSD	81.6	30.7	91.4	7.42	33.9	3.36	81.6	10.7	78.3
Sig. Lev.	NS	0.0001	0.01	0.0001	0.0001	0.0001	0.0001	0.0001	0.006

Means with different superscripts within a column differs significantly. LSD = least significance difference.

was highest in midrib (359.9) and leaflet (274.2) compared to petiole. Undoubtedly, lignin is the major factor that affects on digestibility of a feed. The negative correlation of lignin and digestibility is strong. Midrib and leaflet showed higher silica content (38.5 and 37.5) compared to petiole and the whole OPF. Higher silica and lignin of midrib resulted the higher silica and lignin content in leaflets. Leaflets as well as the whole OPF showed higher lignin content compared to rice straw. The whole OPF contained 189.8 g kg^{-1} DM lignin and 14 g kg^{-1} DM silica which is in narrow ranges between the conventional roughage like rice straw, wheat straw and baggasse.

Minerals

The macro minerals content are shown in Table 3. All types of mineral were highest in leaflet. The whole OPF consist of 0.53, 0.11, 0.18, 0.049 and 0.69 (g/ 100gDM) of Ca, P, Mg, Na and K respectively. When compared to rice straw, OPF contains higher Ca, Mg but lower K. This agrees with Wan Zahari *et al.* (1997).

DM degradation *in sacco*

Mean DM degradation of the fractions of OPF and the whole OPF are presented in Table 4. Leaflet had significantly highest (P<.01) DM degradability compared to petiole and midrib at 48 and 72 h of incubation. The degradability of petiole was higher up to 48 h incubation while compared to leaflet and OPF, but at a longer incubation it was less. The petiole reaches it maximum degradation in 48 h means the potential degradation was faster compared to the leaflet and

Table 3. Macro minerals content (g 100g^{-1} DM) of different fractions and whole OPF

Fractions	Ca	P	Mg	Na	K	S
Petiole	0.466^b	0.09^b	0.093^c	0.018^b	0.644^c	0.094^a
Leaflets	0.529^a	0.183^a	0.168^a	0.039^a	0.876^a	0.080^a
Midribs	0.370^c	0.188^a	0.117^b	0.043^a	0.726^b	0.076^a
OPF	0.530^a	0.108^b	0.180^a	0.049^a	0.697^{bc}	0.096^a
LSD	0.04	0.02	0.010	0.02	0.06	0.05
Significance level	0.0001	0.0001	0.0001	0.02	0.0001	NS

Means with different superscripts within a column differs significantly. LSD = least significance difference

Table 4. DM Degradability (%) of different fractions of OPF

Incubation h	Petiole	Leaflets	Whole OPF	Midrib	SED	Sig. Level
8	23.24	17.17	19.97	14.1	3.2	p<.01
16	28.92	25.52	23.81	27.7	2.9	p<.01
24	30.67	28.45	26.84	30.6	3.5	p<.01
48	34.53	38.42	37.32	35.5	2.8	p<.01
72	40.75	41.99	37.86	36.7	2.5	p<.01
96	44.53	52.51	45.14	40.7	4.3	p<.01

SED = standard error of means deviations.

midrib. This is probably due to the higher readily available cell soluble material in petiole than leaflet (Table 2). The degradation values of leaflet, petiole or the OPF are higher compared to the degradation values of tropical rice straw (Navaratne and Ibrahim, 1988).

The petiole had high washing loss value (A, 21.8%) followed by the leaflet and OPF. The high intercept value (A) of leaflet, petiole and OPF indicate that a high proportion of DM was rapidly degraded (Table 5). The midrib had the least rapidly disappearing material. The value of rapid disappearing material (Table 5) was higher than the value of rice straw, the conventional tropical roughage (Navaratne and Ibrahim, 1988 and Chowdhury and Huque, 1996).

The degradability of water soluble fraction (B) was highest in the leaflet (52.8%) followed by petiole, OPF and midrib. The potential degradable fractions (A+B).was also highest ($p<.01$) in the leaflets (66.9%) followed by the petiole (55.4%) and whole OPF (50.9%) and least in the midrib (38.0%). The degradation characteristics of OPF and it's fractions are higher than the values of OPF silage reported by Wong and Wan Zahari (1992).

The rate of degradation (c % fraction h^{-1}) was higher in midrib, which denote a rapid degradation of fraction B. Although the rate of degradation value (c) of midrib was the highest but the degradation of water soluble fraction B, and potential degradation (A+B) of midrib was the least. This is probably due to the high content of lignin and silica in the midrib (Table 2). However, the rate of degradation (c) of the whole OPF is in agreement with the (c) values for OPF reported by Wong and Wan Zahai (1992) and higher than the c value of rice straw (Navaratne and Ibrahim, 1988).

The degradability at 48h incubation, of the major fractions of OPF (petiole and leaflets) is almost 40%. The digestion characteristics are better than the conventional roughages like

Table 5. Digestion characteristics (g/100g DM) of different fractions and whole OPF

Fractions	A	B	(A+B)	c	L	RSD
Petiole	21.80	34.62	50.86	0.0109	-3.8	1.57
Leaflet	14.16	52.76	66.92	0.0123	3.5	2.7
Midrib	-6.94	44.0	38.0	0.0875	1.9	1.12
OPF	15.38	35.48	50.86	0.0171	1.0	2.07

A = washing loss (%); B = degradability of water soluble fraction (%); c = rate degradation of B (fraction h^{-1}); A+B = potential degradability (%); L = lag time (h); RSD= residual standard deviation rice straw, wheat straw (Navaratne and Ibrahim, 1988; Chowdhury and Huque, 1996 and Jelan, *et al.*, 1992). Preston (1986) reported that fibrous feed with around 40% and above degradability at 48h incubation can potentially be used as a feed to all ruminants and could be offer as a sole feed. The superior degradation characteristics of the leaflet over other fractions suggest that the leaflets of OPF deserve more consideration.

CONCLUSION

Based on *in sacco* studies, it is appeared that the 48h degradation of the whole OPF with its major share (petiole and leaflets) is almost 40%. The degradability of leaflets is higher compared to the other fractions of OPF. The fibrous components, protein content coupled with the mineral make OPF nutritious alternate roughage that could easily be used as a sole feed in the diet of ruminants. The year round availability and high yield accelerate itself to promote as a substitute of the present roughage crisis in the world. This result suggests that although, OPF can be fed directly to the ruminants, but it needs to be improved qualitatively to achieve a satisfactory (50-55%) level of degradation. However, future studies on the effect of pre-treatments of OPF on fermentation and digestibility is needed including practical animal feeding experiments.

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