Utilization of Oil Palm Frond - Based Diets for Beef and Dairy Production in Malaysia

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ABSTRACT : Oil palm fronds (OPF) are one of the main by-products of the oil palm industry in Malaysia. It contains about 38.5 % crude fibre with ME values of about 5.65 MJ/kg dry matter. OPF has great potential to be utilized as a roughage source or as a component in a complete feed for ruminant animals. This paper briefly reviews the availability of OPF in Malaysia and its importance in the local beef and dairy industry. About 26 million metric tonnes of OPF are produced on dry matter basis annually during pruning and replanting operations in the plantations. The nutritive value of OPF and studies to improve its feeding value is highlighted. The optimum level of inclusion for ruminant feeding is 30 % and improvement to intake and digestibility can be further enhanced with addition of other oil-palm by-products. Performances of beef and dairy cattle fed fresh OPF or as silage, pellets and cubes are shown. Good quality OPF silage can be produced without using any additive and the significant improvement on the rate of growth and milk yield were shown. With good formulations, OPF based diets can allow live weight gains of between 600-850 g/day and for local crossbred dairy animals, milk yield of about 11.1 to 20.3 liter/day can be obtained. Pellet based on ground OPF seemed to be less well utilized for ruminant feeding due to its smaller particle size. OPF based cubes which have longer particle size is more suitable for beef and dairy cattle. Long-term feeding of OPF based feeds have been shown to produce good quality carcasses, and the meat is safe for consumption.
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Key Words : Oil Palm Fronds, Beef Cattle, Dairy Cattle, Production, Silage, Cube, Pellet

INTRODUCTION

Oil palm, *Elaeis guinensis*, is an important crop of Malaysia and other tropical countries. The production of palm oil has expanded rapidly and is an important contribution to the national income. In Peninsular Malaysia, the oil palm planted area increased from 96,900 hectares in 1965 to 2.05 million hectares in 2000. In Sabah, about 38,433 hectares were planted with this crop in 1970 and with rapid expansion, the planted area rose to 1,000,777 hectares in 2000. In Sarawak, the planted area rose from 975 hectares in 1970 to 330,387 hectares in 2000. The private estate sector occupied the largest area, amounting about 53.1% of the total area. The rest of the estates were government and state-owned (29.7% and 8.0% respectively) and smallholdings (9.2%). The overall growth from 1991-2020 is forecast to be at 2.2%. The Malaysian palm oil industry is primarily export-oriented and in 2000, about 9,081,011 tonnes of palm oil and 520,280 of palm kernel oil were produced.

There are several by-products of oil-palm and these include oil palm trunk (OPT), oil palm fronds (OPF), empty fruit bunches (EFB), palm kernel cake (PKC), palm oil mill effluent (POME) and palm press fibre (PPF). The first three biomass were from oil palm growing in plantations and the remaining three from palm oil processing. OPF in particular has been given emphasis lately as it has great potential to be utilized as a roughage source or as a component in complete feed for ruminants. The supply of OPF is substantial and it can support a reasonably large population of ruminants locally. This is important for the development of a domestic ruminant industry, especially as the country is only about 20% self sufficient in beef, 6% in mutton and 5% in milk. Currently, the total population of beef cattle, dairy cattle, sheep, goat and swamp buffaloes in Malaysia are 660,000, 12,000, 160,000, 200,000 and 100,000 heads respectively. Some effort should be made to increase the local ruminant population and at the same time to expand feed resources to support these animals.

AVAILABILITY OF OIL PALM FRONDS

The average economic life-span of the oil palm is about 25 years. OPF is obtained during replanting and either during harvesting or pruning. As such, it is available daily throughout the year. On an annual basis, about 24 fronds are pruned per palm tree and the weight of fronds varies considerably with age of the palm, with an average annual

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pruning of 82.5 kg of fronds/palm/year (Chan et al., 1981). Most of the OPF are left rotting between the rows of palm trees, mainly for soil conservation, erosion control and ultimately for the long-term benefit of nutrient recycling. The need to increase the net return per hectare, has resulted in fronds being exploited as starting resource material for paper pulp, extraction of vitamin E and animal feed. The large quantity of fronds produced by a plantation each year makes this biomass a very promising source of roughage feed for ruminants. It is estimated that about 26 millions metric tonnes of OPF is produced on a dry matter basis annually during the pruning and replanting operations in the plantations (Table 1).

NUTRITIVE VALUE OF OIL PALM FRONDS

An OPF is made up of three main components i.e. a petiole, rachis and leaflets. About 70 percent of the dry matter in the OPF is from the petiole and the rest from leaves and rachis. The leaves contain a higher percentage of crude protein (CP) and ether extract (EE) than the petioles. The dry matter content of OPF is about 31.0% and *in vitro* digestibility of dry matter of leaves and petioles was uniform throughout the length of the fronds with mean values of 35.6% (Ishida and Abu Hassan, 1992). OPF also contains about 18.5% hemicelluloses. The moisture content (%) of chopped fresh OPF, solar dried chopped OPF, steam dried ground OPF and OPF pellet were 58.6, 44.6, 12.7 and 14.7 respectively while the respective density values were 0.27, 0.08, 0.12 and 0.53 (Oshibe et al., 2001). The chemical composition of OPF in comparison with other oil-palm by-products is shown in Table 2.

Rumen degradability is an appropriate assessment of the nutritive value of a fibrous feed for ruminants because it relates to the availability of nutrients. Table 3 shows the degradation characteristics of different fractions of OPF. A degradability value of 40% or more at 48 h incubation indicated that OPF could be fed directly to ruminants. However, some improvement in terms of nutritive value is needed to increase the degradability level further. The characteristics of rumen degradation, digestibility, voluntary intake and palatability of several types of processed OPF have been reported (Kawamoto et al., 1999).

IMPROVEMENT OF NUTRITIVE VALUE OF OPF

A number of processing techniques have been developed to improve the feeding qualities of OPF. These include urea and molasses treatments, preservation as silage, alkali treatment, steaming under high temperature and high pressure (Table 4), pelletizing and enzymatic degradation. Urea and molasses treated OPF can almost meet the maintenance requirements of ruminants for energy and protein. The optimum level of urea inclusion in the OPF based diet was 30 g/kg ration. Steaming was reported to increase OPF digestibility. Increasing the level of urea in

Table 1. Estimated availability of oil palm fronds (metric tones, dry matter basis) in Malaysia

Year	Oil palm fronds production		Total
	Replanting	Pruning	
1990	0.25	16.92	18.49
1992	0.64	17.64	21.67
1994	0.88	17.89	22.37
1996	0.83	19.09	24.28
1998	1.42	18.18	27.08
2000	1.34	17.85	26.21

(Mohamad, H. et al., 1986)

Table 2. Chemical composition (% of dry matter) and nutritive values of oil palm fronds and other oil-palm by-products

By-products	CP	CF	NDF	ADF	EE	Ash	ME (MJ/kg)
Palm kernel cake	17.2	17.1	74.3	52.9	1.5	4.3	11.13
Palm oil mill effluent	12.5	20.1	63.0	51.8	11.7	19.5	8.37
Palm press fibre	5.4	41.2	84.5	69.3	3.5	5.3	4.21
Oil-palm fronds	4.7	38.5	78.7	55.6	2.1	3.2	5.65
Oil-palm trunks	2.8	37.6	79.8	52.4	1.1	2.8	5.95
Empty fruit bunches	3.7	48.8	81.8	61.6	3.2	-	-

Notes: CP: crude protein, CF: crude fibre, NDF: neutral detergent fibre, ADF: acid detergent fibre, EE: ether extract and ME: metabolisable energy. (Wong and Wan Zahari 1992; Wan Zahari et.al., 2000)

Table 3. Rumen degradation (dry matter %) of whole and different fractions of OPF at different incubation time together with the constants of the equation $p = a + b(1-e^{-ct})$

Incubation (hours)	Petiole	Leaflet	Midrib	OPF	LSD	Sig. Level
8	23.3	24.5	14.1	22.8	3.1	P<0.01
16	34.7	30.9	27.7	27.2	3.5	P<0.01
24	40.3	34.3	30.6	30.1	3.9	P<0.01
48	43.9	42.3	35.5	36.8	2.7	P<0.01
72	44.3	46.1	36.7	38.3	2.5	P<0.01
96	46.4	54.6	40.7	47.6	4.6	P<0.01
a (g/kg)	21.2	21.7	14.4	18.4		
b (g/kg)	24.7	46.1	28.3	38.3		
c (%)	2.8	1.2	1.5	2.5		
(a+b)	45.8	67.8	42.7	56.7		

p=The actual e actual degradation at time t. (Islam et al., 1997)
a=Represents intercepts.
b=Insoluble but potentially degradable component at time t.
c=Rate of constant of b
(a+b)=Total degradability

Table 4. Chemical composition of untreated and steam-processed OPF (g/100g DM)

Treatment	DM[1]	NDF	ADF	HC[4]	ADL[2]	NDS[3]	Ash	CP
Untreated	932	70.9	44.1	26.8	8.5	29.1	4.5	4.3
Fresh steamed								
10 kg / cm^2	940	60.7	52.2	8.5	18.9	39.3	4.4	4.3
12.5 kg / cm^2	935	59.8	49.0	10.8	15.7	40.2	4.6	4.5
15 kg / cm^2	935	65.8	51.2	14.6	17.7	34.3	4.7	4.5
Predried steamed								
10 kg / cm^2	933	59.8	50.1	9.7	19.9	40.2	4.7	4.2
12.5 kg / cm^2	935	58.3	48.3	10.0	18.0	41.7	4.7	4.3
15 kg / cm^2	936	56.1	53.3	2.8	20.9	43.9	4.8	4.3

[1]DM : dry matter (g/kg). (Bengaly et al., 2000)
[2]ADL: acid detergent lignin.
[3]NDS : neutral detergent soluble (%NDS = 100 - %NDF).
[4]HC : hemicellulose.

the steamed OPF resulted in reduced DMI and digestibility, and possibly higher energy expenditure to detoxify the high plasma ammonia concentration in dairy goats (Basery et al., 2001).

FEEDING FRESH OPF

Freshly chopped OPF has been extensively used by local farmers for feeding beef and dairy cattle in Malaysia (Abu Hassan, 1995). This is attributed mainly to the successful R&D on the feeding value of OPF initially developed by MARDI and consequently the impact of the transfer of technology to various target groups, including small farmers, entrepreneurs and private sectors. Since the official release of the OPF technology in 1992, the acceptance by the public and private sectors can be described as an early technology push transforming ultimately into technology pull. Marked increased in local production of forage chippers for chipping OPF were seen in tandem with an increase in beef feedlotting or cattle rearing under plantation systems.

The growth performance of Brahman-Australian Commercial Cross (ACC) beef cattle fed iso-nitrogenous diet based on freshly chopped OPF and PKC-based mixture is shown in Table 5. Diet 3 (feeding 40% OPF: 70% PKC based mixture) was the most economical as indicated by feed cost per weight gain value. Better FCE and ADG were obtained by diet 5 (20% OPF: 80% PKC based mixture) but it was not conducive in terms of cost, moreover there were higher percentage of fat in the carcass (16.7%). Carcass weight and dressing percentage were improved with increasing levels of OPF in the diet.

The demand for processed OPF began to increase after the ensilation and pelleting processes were introduced,

Table 5. Growth performance and carcass composition of Brahman-Australian Commercial Cross beef cattle fed varying ratios of fresh chopped oil palm fronds and palm kernel cake (PKC) based mixture*

Variables	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
OPF	60%	50%	40%	30%	20%
PKC-based mixture	40%	50%	60%	70%	80%
No of animals	24	24	24	24	24
Initial LW (kg)	289.8	279.0	284.4	279.0	278.9
Final LW (kg)	340.2	327.5	343.0	343.5	356.9
ADG (kg/day)	0.64	0.61	0.67	0.75	0.85
DMI (kg/head/day)	6.12	6.02	6.50	7.08	7.56
FCR	9.56	9.87	9.70	9.44	8.89
Feed cost+	3.09	3.11	3.04	3.45	3.23
Carcass composition					
Dressing %	54.0	56.3	54.8	57.8	57.2
Meat:Bone	2.9	2.57	2.88	3.03	2.85
Meat (% carcass wgt)	66.6	57.0	59.3	55.7	55.6
Bone (% carcass wgt)	22.7	21.9	20.9	18.7	19.5
Fat (% carcass wgt)	9.6	14.2	14.7	17.2	17.2

NOTE: * Iso-nitrogenous diets (containing about 16.4 % CP). PKC based mixture contained soya bean meal, vitamin-mineral premix and urea. All animals were fed palm fatty acid distilates (PFAD) at 3 % of DMI for energy source + RM/kg gain over 86 days experimental period (1 US: RM 3.8).

FCR: Feed conversion ratio. CF % of diet 1, 2, 3, 4 and 5 were 31.5, 28.6, 25.6, 22.2 and 19.2% respectively. The respective TDN values were 58.2, 60.2, 62.3, 65.3 and 67.3 %. (Mohd. Sukri et al., 1999)

especially when storage and ease of handling became necessary to commercial farms. However in some locations, there was no urgent requirement to conserve OPF for silage as fresh OPF is abundantly available.

PRESERVATION OF OPF AS SILAGE

Whole OPF can be chipped (about 2-3 cm in length) and conserved as silage, which could last for several months when properly stored. Numerous trials were carried out to study the effect of additives on silage quality. These include water, molasses and urea (Table 6). The results indicated that good quality silage could be produced without using any additives, provided that OPF was ensiled under anaerobic conditions. Urea addition at the rate of 1-2% prevented mold growth and delayed the initiation of heat production by 28 hours. Inclusion of more than 3% of urea reduced the nutritive value of the silage. However, no adverse effect on animals was observed when urea was used at 3% inclusion level (Table 7).

OIL PALM FROND PELLETS AND CUBES PROCESSING FOR ANIMAL FEEDING

Research collaboration between MARDI and JICA was established for the development of livestock feeds from oil palm by-products. The feeds are targeted mainly for ruminant animals and other species such as horses, deer and ostriches. Large scale utilization of OPF as animal feed involves various commercial production segments which include raw materials handling and processing (both at the farm and the mill), plant capacity and feasibility; economical processing methods for the production of

Table 6. Effect of water, molasses and urea addition at ensiling on the fermentation characteristics of oil palm frond silage

Items	Treatment			
	Control*	Water	Molasses	Urea
pH value	4.02[b]	3.93[b]	3.93[b]	7.38[a]
Organic acids (DM %)				
Lactic acid	1.89[bc]	2.30[b]	3.55[a]	1.51[c]
Acetic acid	0.89[b]	0.65[b]	0.78[b]	8.99[a]
Butyric acid	1.07[b]	0.99[b]	1.04[b]	1.66[a]
Percentage of spoilage	13.9[a]	9.0[a]	1.6[a]	0.0[b]

*No additives. (Abu Hassan and Ishida, 1992)

DM: dry matter.

[a,b,c] Means with different superscript differ ($p<0.05$).

Table 7. Effect of urea level at ensiling on chemical composition, fermentation characteristics, voluntary intake and digestibility of oil palm frond silage

Items	Urea level, DM %		
	0	3	6
Chemical composition			
Dry matter (%)	30.1[ab]	30.7[a]	28.6[b]
Percentage of dry matter			
Crude protein	6.7[c]	11.4[b]	17.2
Organic cell contents	20.8[a]	20.0[ab]	13.0[c]
NDF	73.2[b]	73.9[b]	80.3[a]
Fermentation characteristics			
pH value	3.78[a]	4.89[b]	7.81[c]
Total acids (DM %)	3.68[b]	4.76[b]	8.96[a]
Composition of acids (%)			
Lactic acid	91.0[a]	37.4[b]	13.0[c]
Acetic acid	6.1[c]	25.8[b]	72.9[a]
Propionic acid	0.1[b]	3.8[a]	0.8[b]
Butyric acid	0.9[c]	30.9[a]	6.7[b]
Ammonia (DM %)	0.0[c]	0.6[b]	1.1[a]
Voluntary DM intake (g/day)	39.9[a]	32.1[a]	24.0[b]
Digestibility (%)			
Dry matter	45.3	46.8	35.7
Organic cell contents	100.0	91.7	86.1
NDF	29.1	37.5	30.2
TDN (DM %)	45.5	49.2	37.5

DM: dry matter, NDF: neutral detergent fibre, TDN: total digestibility nutrients. (Ishida and Abu Hassan, 1992)
[a,b,c] means with different superscript differ ($p<0.05$).

marketable products and various others. The major operations in the production of OPF pellets and cubes is shown in Figure 1. The success and economics of production of OPF based feed depends on efficiencies in field collection and transportation of OPF, pre-drying and drying systems, and manufacturing into pellet and cube forms. Major cost components in the production of OPF pellets and OPF cubes are in collection, drying and packaging.

THE USE OF OPF SILAGE FOR FATTENING BEEF AND DAIRY CATTLE

Digestibility studies conducted using mature Kedah-Kelantan bulls indicated a dry matter digestibility (DMD) value of about 45% for OPF silage and it was significantly reduced when urea inclusion was at 6% (Ishida and Abu Hassan, 1992). Further long-term feeding trials were conducted on growing and finishing beef cattle, and lactating cows (Abu Hassan et al., 1993; Ishida et al., 1994). The feed required for Australian Commercial Cross (ACC) bulls for body weight gain and lean meat production was reduced with the higher inclusion levels of OPF silage (Table 8). This is reflected in a reduction to the feed cost.

The potential of OPF silage as a source of roughage for lactating dairy cows is shown in Table 9. The cows fed 30% OPF silage produced more milk than those fed 50% OPF silage. There were no adverse effects on the animals, milk yield and flavour even when the level of OPF silage was increased to 50%.

It is interesting to note that live weight gain of swamp buffaloes fed 30% OPF silage was comparable to those fed 50% sago meal (Shamsudin et al., 1993). Recent studies on sheep indicated that OPF silage was better utilized compared to Nipah fronds silage. Additionally, the provision of molasses was reported to increase the potential degradability of both types of fronds (Abdalla et al., 2001). In this trial, ammonia-N in the rumen liquor of the animals fed OPF supplemented with 0% and 30% molasses were found conducive for optimum rumen environment with values of 141.5 mg/liter and 142.9 mg/liter respectively. These values were however lower than the suggested levels of 200-250 mg/liter for ruminants reported by Preston and Leng (1997).

THE USE OF PELLET AND CUBES BASED ON OPF FOR FATTENING BEEF AND DAIRY CATTLE

Beef cattle

The effects of varying levels of OPF pellet on intake

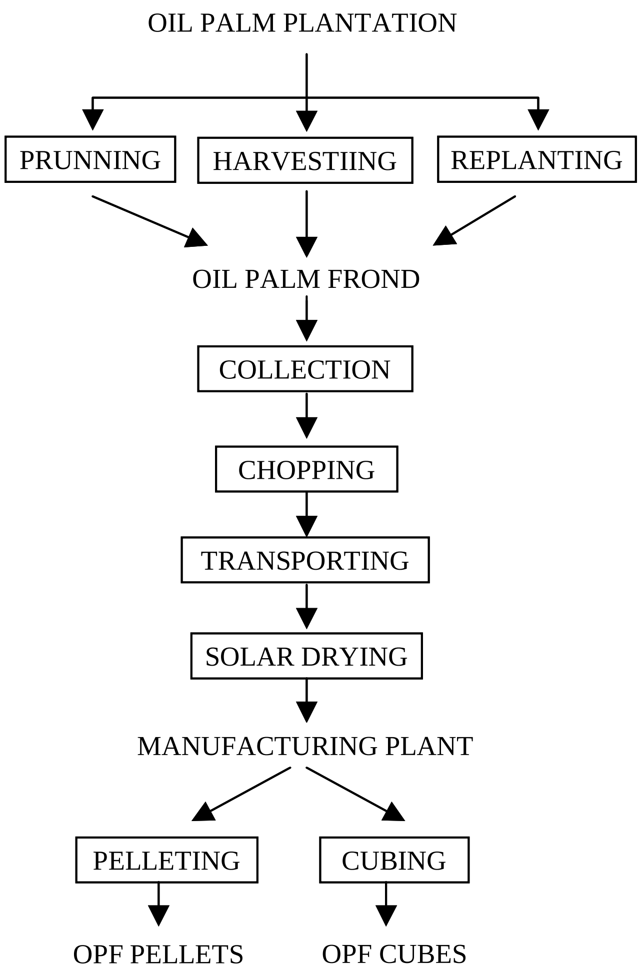

Figure 1. Operations in OPF feed Production (Mat Daham et al., 2002)

and growth performance of local beef cattle has been reported (Oshibe et al., 2000). Following this, a trial was conducted to evaluate the effect of OPF based diets varying in CP content on intake and growth performance of growing Charolais X Kedah Kelantan (KK) crossbred cattle. The animals were fed iso-caloric pelleted diets (containing about 9.13 MJ/kg DM) based on ground OPF at the 30% inclusion level. Over the 172 days feeding period, the LWG achieved were 0.50, 0.52, 0.30 and 0.44 kg/day respectively when the animals were fed 10, 12, 14 and 15% CP respectively (Table 10). The respective mean DMD of the diets were 55.7, 68.6, 56.8 and 52.7. The weight gains obtained were comparable to those raised on 30% roughage and 70% concentrate. Provision of 12% CP has improved the DMD by about 23% as compared to those fed 10 % CP. Further addition of protein did not increase intake or DMD, as shown in the groups fed higher CP levels. What contributed to the differences was not clear as energy content between diets were almost similar. It is unlikely that this is due to small differences in CF content as the values from the four diets only varied from 20.5 to 23.3%. Levels of EE for all of the diets were lower than 5% and was unlikely to cause any significant impairment in CF digestibility for pelleted diet based on OPF.

Body scoring of cattle fed 30% OPF based diets was between medium to good. Meat quality was excellent with less deposition of fat in the carcasses. The rumen were generally distended with milky or frothy rumen content. Irrespective of protein levels, the ranges for carcass weight and mesenteric fat were between 130.9 to 215.3 kg and 5.0 to 6.6 kg respectively. The meat to bone ratio ranged from 0.7:1 to 3.1. Distended rumen was also reported in beef heifers fed pellets made from ground OPF at 30% inclusion level (Wan Zahari et al., 2002). This is associated with the rapid rate of passage of finely ground materials from the pellets which is not favourable for optimum rumen fermentation. Faster passage of feed through the rumen was known to depress DMD. Hence, rumen retention time should be reduced to stimulate better digestibility. Longer particle size (>15 mm) should be considered for making complete diets based on OPF. One option is by making cubes, a process which does not require grinding (Hayakawa and Ariff, 2000). Small particle size of the diet was also known to depress the population of protozoa in the rumen, but what particle size is best for the protozoa to stimulate optimum fermentation is another issue. High density of the protozoa population could also increased the requirements for supplementary protein. Additionally, reducing the population of protozoa in the rumen generally increases animal productivity on low-protein diets. Moreover, optimum ratio of nitrogen (N) to sulphur (S) is vital for efficient ruminal microbial growth for diets based on fibrous materials like OPF. Contrary to what has been thought, distention of the rumen was not associated with bolus formation which has been found in growing sheep raised on OPF silage and urea molasses mineral blocks (Wan Zahari, unpublished). There seems to be large variations between animals irrespective of the treatments on the weight of the rumen, intestine and other organs (Table 11). There were also no abnormalities with regard to the structural and physical appearances of organs and other body tissues. The meat and organs were safe for consumption and of superior quality due to less deposition of body fat (Wan Zahari et al., 2000; Wan Zahari et al., 2002). A recent study revealed that the average concentration of plumbum (Pb) residues in OPF feed was lower than the concentration specified for the maximum residual limit level (3000 ppb) (Faridah et al., 2002)

The LWG of Brahman X Kedah-Kelantan male cattle fed diets containing 70% OPF: 30% cassava fodder was significantly less compared to those fed 70% OPF: 30% grain concentrate or 70% OPF: 15% cassava fodder: 15% grain concentrate (Tung et al., 2001). The values for DMI

Table 8. Effect of oil palm frond levels on the growth performance and carcass characteristics of Australian commercial cross bulls

Parameters	Treatments			
	T1	T2	T3	T4
Live weight (kg)				
Initial weight	229.10	226.50	232.90	229.40
Final weight	396.3[a]	336.4[ab]	333.8[b]	357.2[ab]
Daily gain (kg/day)	0.75[a]	0.62[ab]	0.45[c]	0.57[bc]
Feed intake (kg DM/day)	7.02[a]	6.10[ab]	5.48[b]	5.58[b]
Carcass weight (kg)	237.2[a]	210.2[ab]	189.0[b]	195.2[b]
Weight of carcass components (kg)				
Meat	127.8	121.5	107.0	116.7
Fat	76.4[a]	58.1[ab]	45.8[b]	46.0[b]
Bone	37.6	33.4	33.2	36.1
% in carcass				
Meat	35.6	58.2	57.2	59.2
Fat	31.6[a]	27.6[ab]	24.2[b]	23.7[b]
Bone	16.0	16.1	17.7	18.4

[a, b, c] Means in a row with different letters differ (P<0.05). (Ishida et al., 1994)

T1 : 10 % of Urea OPF silage + 90% PKC based concentrate. T2 : 30 % of Urea OPF silage + 70% PKC based concentrate.

T3 : 50 % of Urea OPF silage + 50% PKC based concentrate. T4 : 50 % of OPF silage only + 50% PKC based concentrate.

PKC : Palm kernel cake.

Table 9. Effect of feeding oil palm frond silage on performance of Sahiwal-Friesian lactating dairy cows

Items	Dietary treatment		
	T1	T2	T3
Number of cows	9	9	9
Body weight (kg)	417	451	450
Ingredient composition of diet (DM %)			
OPF silage	30	50	-
Fodder	-	-	50
Concentrates*	70	50	50
Feed intake and milk production			
DM intake (kg/day)	6.46[b]	5.86[c]	8.28[a]
Yield of 4% FCM (kg/day)	6.93	5.73	6.48
4% FCM: ME intake ratio (kg/MJ)	0.109[a]	0.088[b]	0.096[b]

[a,b,c] Means with different superscript differ (p<0.05). (Abu Hassan et al., 1993)

T1: 30% OPF silage diet. T2 : 50% OPF silage diet. T3 : 50% fodder diet.

DM: dry matter. FCM : fat corrected milk. ME: metabolizable energy

*Concentrates contained 24.0% CP and 11.3 MJ/kg of ME

(kg/head/day), N retention (% of N intake) and LWG (g/head/day) for the respective treatments were 4.01, 4.78 and 4.66, 15.49, 19.04 and 17.93 and 277.8, 412.7 and 373.0.

DAIRY CATTLE

Research and development on OPF feeding to dairy cattle is in line with the intensive system of rearing which is suitable for Malaysia considering the high cost of pasture land. Several experiments were conducted which were aimed at developing feeding programs based on OPF pellets or OPF cubes.

A study was conducted to evaluate ground OPF based diets as a complete ration for lactating Sahiwal Friesians. The lactation performance and body weight change of the animals fed 30% OPF pelleted ration is shown in Table 12. Milk yields of cows used in this experiment varied from 11.1 to 20.3 liters/day for the duration of the trial. The highest 28-day period of milk yield recorded was 609 liters which translated into an average daily yield of 21.75 litres. The overall milk fat % obtained from this study was 3.5 and supplementation with 100 g long hay was insufficient to increase the fat content to the level of 4.6- 4.8 as obtained from concentrate -grass mixture or dairy cattle pellets (Abu Hassan et al., 1991).

In a separate study, Sahiwal-Friesian heifers fed molasses-treated OPF supplements were observed to consume 30% more ($p<0.05$) total feed dry matter compared to untreated-OPF (Abu Bakar et al., 2000). The improvement in intake could be attributed to improvement in the palatability and digestibility of nutrients. The study also revealed that there was no obvious advantage of brine treatment in stimulating intake of OPF pellets. LWG of the animals fed molasses treated-OPF were comparable to those fed brine-treated OPF with values of 0.69 kg/day and 0.68 kg/day respectively. By comparison, Sahiwal-Friesian heifers fed maize stover silage and guinea grass produced gains of 0.43 and 0.47 kg/day respectively (Abu Bakar et al., 1990). In addition, Friesian heifers fed complete rations based on 70 % sugarcane bagasse as roughage recorded mean LWG between 0.38-0.56 kg/day depending on quality of the energy-protein sources used (Van Horn et al., 1980). Dried grated coconut meal (containing CP: 64 g/kg, CF: 359 g/kg; EE: 24 g/kg and ME: 10.8 MJ/kg) and PKC are equally good as supplemental feed to OPF pellets for growing Sahiwal-Friesian heifers diets, provided that its protein content is enriched (Abu Bakar et al., 1999).

CONCLUSION

A major reason for the slow growth of the ruminant industry in Malaysia is the lack of good quality feed resources. OPF has been shown to be a promising source of roughage for ruminants and can be used as a substitute for grasses for fattening beef cattle as well as for intensive dairying, especially in cases where forage or fodder is limiting. The abundant availability of OPF throughout the country is well suited for increasing the domestic beef and milk supply. The availability and utilization of various by-products in the oil palm plantation, particularly OPF, will provide avenues for a more practical and a cost-effective

Table 10. Intake and growth performance of beef cattle raised on OPF pellet based diet

Treatment	Mean DMI (kg/day)	Dry matter digestibility (%)	Initial LW (kg)	Final LW (kg)	LWG	Mid abdomen (cm)
10 % CP	6.40	55.7	242.5	328.5	0.50	181 - 214
12 % CP	5.94	68.6	234.8	324.0	0.52	172 - 226
14 % CP	5.88	56.8	231.5	283.4	0.30	182 - 192
15 % CP	5.94	52.7	236.6	312.6	0.44	171 - 212

(Wan Zahari et al., 2000; Wan Zahari et al., 2002)

Table 11. Body composition of beef cattle raised on oil palm fronds based diet

Parameter	Bull	Heifers
LW before slaughter (kg)	274.0 - 407.0	186.0 - 238.0
Carcass weight (hot) (kg)	130.9 - 215.3	98.7 - 136.4
Rumen weight (empty, kg)	7.50 - 10.40	4.2 - 5.8
Intestinal wgt (full, kg)	10.85 - 13.30	8.0 - 11.0
Intestinal wgt (empty)	6.0 - 9.0	3.8 - 7.0
Liver (kg)	2.15- 4.40	1.92 - 3.96
Spleen (kg)	0.758 - 1.172	0.71 - 1.82
Kidney (kg)	0.508 - 0.714	0.175 - 0.304
Mesenteric fat (kg)	5.00 - 6.60	2.60 - 5.50
Fat in carcass (kg)	3.50 - 10.1	1.52 - 4.47
Sirloin (kg)	1.36 - 3.40	0.74 - 2.00
Loin (kg)	2.60 - 9.30	2.52 - 4.10
Meat:Bone ratio	2.70 - 3.10	2.42 - 3.10

Breed: Kedah-Kelantan X Charolais crosses. (Wan Zahari et al., 2000; Wan Zahari et al., 2002)

Table 12. Effects of OPF based pellets on milk yield and milk composition

Rations	Milk yield (Litres/28 days)	Milk fat (%)	Milk protein (%)	Weight change (kg)
30 % OPF pellets	366	3.5	3.5	22.5
30 % OPF pellets + LG	375	3.5	3.5	16.5

Notes: LG: Unchopped guinea grass hay given at 100 g/cow/day as long fibre supplement

4 Sahiwal - Friesian cows per group, assigned to a treatment sequence in a 4 × 4 Latin square design involving four 28 day periods following a 2-week adjustment period.

Daily ration fed to each cow was limited to 14 kg/day (Abu Bakar et al., 2001) feeding system, besides maintaining competitiveness in the international roughage market. A significant development in the processing and supply of pellets and cubes based on OPF either as an ingredient for total mixed rations or as a complete and balanced feeds can encourage further growth in the local beef and dairy industry. In addition, intensive rearing of beef cattle in oil palm plantations offers tremendous potential for beef production in view of the availability of OPF and other by-products to be utilized as feeds. Further evaluation on the performance of beef and dairy cattle is urgently needed especially when oil palm frond is being utilized as one of the main ingredients in their feeds. This is especially so for large-scale beef and dairy operations.

Demand for local production of feed in Malaysia is growing due to changes in the production systems, i.e. towards semi-intensive and fully intensive systems. There is a huge demand for OPF pellets and cubes from Japan, South Korea, Taiwan and the Middle-East, apart from the domestic market. There is also an urgent need for locally produced equine feeds to meet the growing demand for cheaper feeds since the industry is entirely dependent on imported feeds. Promotion and marketing of these processed OPF fibre has to be intensified to further expand its use and commercialization potential.

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