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Utilization of Oil Palm Frond as Cattle Feed

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Abstract

A series of studies was conducted on the processing and utilization of oil palm frond (OPF) as a cattle feed. Chemical analysis revealed that OPF was composed of 70% fiber and 22% soluble carbohydrates on a dry matter basis. It was shown that OPF could be conserved as silage by determining the pH value and organic acid content in the silage. Urea addition at 1 to 2% (on a dry matter basis) at ensiling was found to be effective to prevent aerobic deterioration of OPF silage after opening of the silo by monitoring the change of temperature in the silage after exposure to the air. Nutritive value of OPF silage was found to be as high as that of rice straw based on voluntary intake and digestibility determined by the digestion trials using Kedah-Kelantan bulls. Feed intake, growth and carcass characteristics in Australian Commercial Cross fattening bulls, and feed intake and milk production in Sahiwal-Friesian lactating dairy cows were determined in the respective feeding trials and it was found that the optimal inclusion level of OPF in the diet ranged from 30 to 40% and was 30% for beef cattle and dairy cows, respectively. OPF has been found to be a suitable substitute for tropical grasses and has been successfully adopted by the ruminant producers in Malaysia.

Discipline: Animal industry
Additional key words: tropics, silage, digestibility, beef, milk

Introduction

Oil palm (*Elaeis quineensis* Jacq.) is the major oil crop grown in tropical/developing countries. The economic lifespan of the palm ranges between 20 and 30 years by which time the palms are 12 to 15 m tall with a basal trunk diameter of 0.6 m and an apical diameter of 0.4 m (Plate 1).

A very large amount of oil palm frond (OPF) is produced in Malaysia as a by-product of the palm oil industry all the year round (Fig. 1). The country produces about 60% of the world palm oil from oil palms grown over almost 2 million ha and leads the world in palm oil production[19]. As a result, it was estimated that 19 million t of OPF was produced on a dry matter basis annually during the pruning operations in the plantations in 1995[12] (Plate 1). Currently, OPF is abandoned in the field without being utilized (Plate 2).

On the other hand, it is important to develop

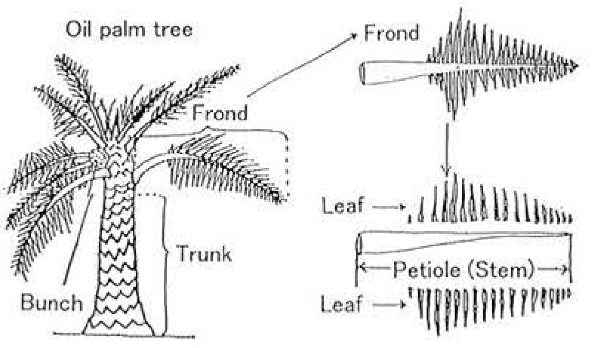

Fig. 1. Oil palm and oil palm frond

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Plate 1. Oil palm and pruning activity of oil palm frond

Plate 2. Oil palm frond left unused in the plantation

feed resources for ruminants in order to increase the supply of animal products from ruminants in Malaysia. In 1988, self-sufficiency in milk, beef and mutton was 3.4, 34.8 and 7.7%, respectively[20]. Efforts should be made to increase the numbers of ruminants and expand feed resources to support them.

Against this background, a series of studies was carried out to develop a technology for the processing and utilization of OPF as a ruminant feed and in this paper the results are summarized.

Chemical composition of OPF[13]

At the beginning of the studies, some laboratory analyses were performed prior to conducting animal trials to determine whether OPF should be utilized in animal trials. Chemical composition and *in vitro* dry matter digestibility (IVDMD) of OPF were determined by the feed analysis method based on neutral detergent system[8] and pepsin-cellulase digestion method[9], respectively.

Table 1. Chemical composition of oil palm frond

Items	Composition (%)
Dry matter	31.1
Percentage in dry matter	
Crude protein	4.2
Ether extract	2.0
Crude ash	4.7
Organic cell contents	25.7
NCWFE	22.3
NDF	69.5
Acid detergent fiber	50.9
Hemicellulose	18.5
IVDMD (%)	35.6

NCWFE: Nitrogen cell wall free extract,
NDF: Neutral detergent fiber,
IVDMD: *In vitro* dry matter digestibility.
Source: Ishida & Abu Hassan (1992)[13].

The results are shown in Table 1. Oil palm frond was composed of 70% fiber and contained about 20% nitrogen cell wall free extract (NCWFE)[1] which represents soluble carbohydrates in feed. *In vivo* dry matter digestibility of OPF was estimated to be 45% by the regression of *in vivo* dry matter digestibility on IVDMD[9]. These results showed that OPF could be used as roughage for ruminants.

Preservation of OPF as silage

A large amount of OPF is produced every day (about 100 kg on a dry matter basis per ha). The use of OPF as a feed might be increased, if OPF could be preserved in a proper way. Silage-making was selected as a preservation method and examined.

1) Effect of some additives on silage quality[2]

Water, molasses and urea were evaluated for use as additives to improve the OPF silage quality by packing chopped OPF into 200 liter metal silo with or without (control) additives and determining the pH value as well as contents of organic acids[11] and ammonia in the silage.

The results are shown in Table 2. The control silage had a pH value of 4.02 and 1.9% lactic acid on a dry matter basis. Forage in a silo becomes stable when the pH value decreases to 4.2 and the lactic acid content reaches a value of 1.5% after

Table 2. 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.
DM: Dry matter.
a,b,c means with different superscript differ ($p<0.05$).
Source: Abu Hassan & Ishida (1991)[2].

ensiling[18]. Therefore, the results obtained indicated that good quality silage could be prepared without using any additives, if OPF was ensiled under anaerobic conditions. However, mold was found on the top of the silo in the control, water and molasses treatment due to air leaking in the silo during the 6-month period of storage. Meanwhile, the silage treated with urea had no mold, which suggested that urea addition at ensiling prevented mold growth under aerobic conditions.

2) Prevention of aerobic deterioration of silage by urea addition at ensiling[16]

Forage can be preserved as silage, as long as it is kept under anaerobic conditions. However, once air penetrates into the silo after opening of the silo, the quality decreases due to aerobic deterioration (secondary fermentation). Since the humid conditions in the tropics promote such a deterioration, the use of silage has been difficult in the tropics. Therefore, the effect of urea addition at ensiling on aerobic deterioration was examined.

OPF was packed in a concrete bunker silo so that the urea concentration in the silage was either 0, 1, 2 or 3% on a dry matter basis. One month after ensiling, silo with each treatment was opened and the silage was taken into a 26 × 38 × 25.5 cm polystyrene box and left without cover at 29°C for exposure to the air. The temperature of the silage was continuously monitored by inserting an electrode from a recorder for 144 h.

Generally, in the process of aerobic deterioration, heat is produced in the silage. As shown in Fig. 2, the silage without urea started to produce heat 8 h after being exposed to the air, while only 1% urea addition delayed the initiation of heat production by 28 h. Besides, the maximum temperature

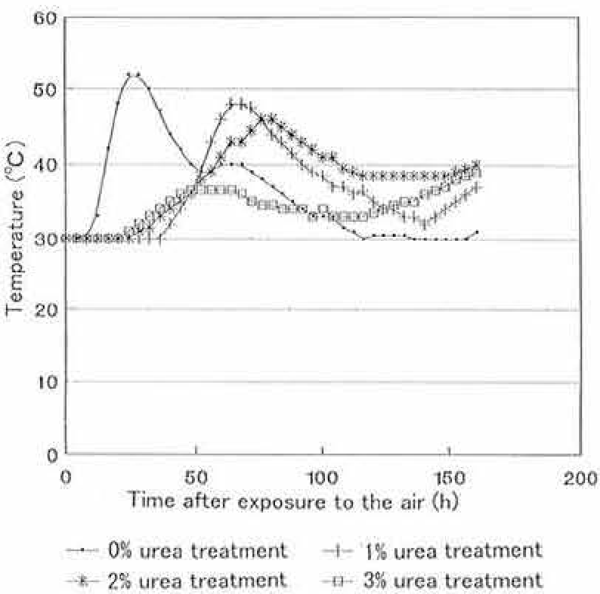

Fig. 2. Temperature of oil palm frond silage after exposure to the air[16]

decreased by the addition of urea at ensiling. It was found that urea addition could alleviate aerobic deterioration of OPF silage after opening of the silo in the tropics.

Nutritive value of OPF silage[14]

The digestion trials using Kedah-Kelantan bulls, the indigenous breed of cattle in Malaysia[10], were carried out to determine the nutritive value of OPF silage and the effect of urea addition on the nutritive value.

The results are shown in Table 3. The intake and digestibility data indicated that the nutritive value of OPF silage was as high as that of rice straw[7]. The total digestible nutrients (TDN) content was

Table 3. Effect of urea addition 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 [a]
Organic cell contents	20.8 [a]	20.0 [ab]	13.0 [c]
Neutral detergent fiber	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/MBS/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
Neutral detergent fiber	29.1	37.5	30.2
TDN (DM%)	45.5	49.2	37.5

DM: Dry matter, TDN: Total digestible nutrients.
[a,b,c] means with different superscript differ ($p<0.05$).
Source: Ishida & Abu Hassan (1992)[14].

higher than that (33% on a dry matter basis) of pelleted oil palm frond[5]. The reason for the difference in the nutritive value between the silage and the pellet was not clear but the process used for making pellets might have caused the nutrient loss of OPF. The silage without urea addition showed a higher content of lactic acid (>1.5%) and lower pH value (<4.2), which suggested that bacterial activity stopped and nutrient losses decreased during the preservation time. However, urea addition resulted in a higher pH value due to ammonia formation, which promoted bacterial activity and produced a larger amount of acetic acid and butyric acid. It was suggested that the digestibility in the 6% urea treatment decreased by nutrient losses which were caused by prolonged bacterial activity. However, in the 3% urea treatment, total acid production and TDN content were not different from those in the 0% urea treatment, which suggested that the nutrient losses were not as serious as to reduce the nutritive value. It was concluded that the treatment at a higher level of urea (more than 3% on a dry matter basis) reduced the nutritive value of the silage. The conclusions from this experiment and the study on aerobic deterioration mentioned above indicated that the addition of 1 to 2% urea to OPF was suitable for preparing the silage.

Production of beef and milk by cattle fed OPF silage

Because OPF was not used as feed, it was necessary to conduct feeding trials to analyze the effect of feeding OPF on the performance in beef and dairy cattle.

1) *Feeding of OPF to beef cattle*[15]

In Malaysia, Australian Commercial Cross (ACC) bulls, various crosses of Brahman with temperate cattle[10], have often been imported for mini-feedlots operated by small landholders as well as for large scale operators. Therefore, ACC bulls were used in the feeding trials.

Twenty four head of ACC bulls (6 head per treatment) were fed for 224 days with a diet containing either 10% (T1 treatment), 30% (T2 treatment), 50% (T3 treatment) urea-treated OPF silage or 50% OPF silage (T4 treatment) on a dry matter basis to examine the optimum incorporation level of OPF silage in the diet and the effect of urea addition on the performance in fattening bulls. The urea concentration in the urea-treated silage was 3% on a dry matter basis at ensiling. The silage was fed to bulls with palm kernel cake-based[6] concentrates. After growth trials, the bulls were slaughtered to evaluate the carcass.

The results are shown in Table 4 and Fig. 3. The bulls in all the treatments gained weight linearly against time after the initiation of feeding trials as shown in Fig. 3 and the animals did not exhibit any disorder. Daily gain decreased by the increase of the OPF level in the diet. However, the results in Table 4 show some of the advantages of feeding OPF to fattening bulls. Firstly, concentrates could be saved for carcass production. Secondly, the amount of fat in the carcass decreased by the feeding of OPF silage. Finally, lean meat production could not be reduced by the incorporation of OPF silage into the diet up to 30% on a dry matter basis.

These data showed that OPF could be used as roughage for fattening bulls and that the optimum

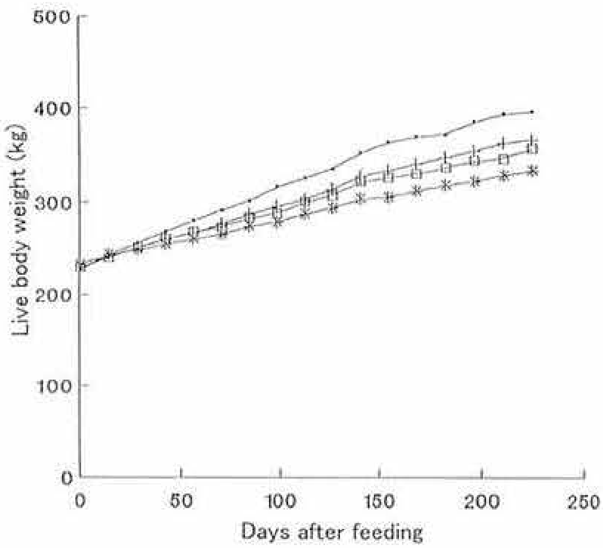

Fig. 3. Growth curve of Australian Commercial Cross bulls fed oil palm frond (OPF)-based diet[15]

Table 4. Effect of feeding oil palm frond on performance in Australian Commercial Cross bulls

Items	Dietary treatment			
	T1	T2	T3	T4
Number of bulls	6	6	6	6
Ingredient composition of diets (DM%)				
3% urea treated OPF	10	30	50	-
OPF silage	-	-	-	50
Concentrates*	90	70	50	50
Nutritive value				
Crude protein (DM%)	12.0	12.5	12.9	12.0
ME (MJ/kg DM)	10.4	9.0	8.3	7.3
Feed intake and body weight gain				
Daily gain (kg/day)	0.75^{a}	0.62^{ab}	0.45^{c}	0.57^{bc}
Feed intake				
OPF (kg DM/day)	0.70^{c}	1.83^{b}	2.74^{a}	2.79^{a}
Concentrates (kg DM/day)	6.32^{a}	4.26^{b}	2.74^{c}	2.79^{c}
Total diet (kg DM/day)	7.02^{a}	6.10^{ab}	5.48^{b}	5.58^{b}
ME (MJ/day)	73.0^{a}	54.9^{b}	45.4^{bc}	40.7^{c}
Carcass characteristics				
Carcass weight (kg)	237.2^{a}	210.2^{ab}	189.0^{b}	195.2^{b}
Dressing percentage	60.6^{a}	58.2^{ab}	57.6^{ab}	55.4^{b}
Percentage in carcass				
Meat	53.6	58.2	57.2	59.5
Fat	31.6^{a}	27.6^{ab}	24.2^{b}	23.7^{b}
Bone	16.0	16.1	17.7	18.4
Concentrates : carcass ratio	6.02^{a}	4.53^{b}	3.25^{c}	3.21^{c}

T1: 10% urea treated oil palm frond silage diet, T2: 30% urea treated oil palm frond silage diet, T3: 50% urea treated oil palm frond silage diet, T4: 50% oil palm frond silage diet.
OPF: Oil palm frond, DM: Dry matter, ME: Metabolizable energy.
*Palm kernel cake based-diet.
^{a,b,c} means with different superscript differ ($p<0.05$).
Source: Ishida & Abu Hassan (1993)[15].

Table 5. Effect of feeding oil palm frond silage on performance in 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]

T1: 30% oil palm frond silage diet, T2: 50% oil palm frond silage diet, T3: 50% fodder diet, DM: Dry matter, OPF: Oil palm frond, FCM: Fat corrected milk, ME: Metabolizable energy.
*Concentrates contained 24.0% crude protein and 11.3 MJ/kg of metabolizable energy.
[a,b,c] means with different superscript differ ($p < 0.05$).
Source: Abu Hassan et al. (1993)[3]

level of oil palm frond silage in the diet was 30 to 40% on a dry matter basis.

There were no significant differences in the feed intake, body weight gain and carcass characteristics between T3 (urea treatment) and T4 (no urea treatment), which indicated that urea addition to OPF at ensiling had no adverse effect on beef production.

2) Feeding of OPF silage to lactating dairy cows[3]

The dairy cattle population in Malaysia is mainly composed of Local Indian Dairy cattle[17]. However, Sahiwal-Friesian (SF) crossbred cows could be used in the future due to their higher milk production in Malaysia.

Therefore, the effect of OPF feeding on the performance of Sahiwal-Friesian lactating dairy cows was examined by feeding either a diet consisting of 50% tropical grass (control treatment), 30% OPF silage or 50% OPF silage to 27 cows (9 cows per treatment) for 27 weeks. The concentrates used in this experiment consisted of corn-soybean meal based-feed with 24% crude protein and 11.3 MJ/kg of metabolizable energy on a dry matter basis.

The results are shown in Table 5. The 4% fat-corrected milk production was not different between the control treatment and 30% OPF silage treatment but was lower in the 50% OPF silage treatment than in the control treatment. Among all the 3 treatments, a 30% oil palm frond based-diet produced the highest yield. It was also revealed that the efficiency of milk production in the 30% oil palm frond-based diet treatment was superior to the other treatments. OPF feeding did not cause any adverse effect on the flavor of milk.

Plate 3. Farmers chopping oil palm frond
Oil palm frond and cattle can be seen in the background (Pahang State in Malaysia).

The results obtained indicated that OPF silage could be fed to lactating dairy cows for milk production.

Technology transfer and farmer adoption of the OPF feeding technology[4]

The results of the studies were disclosed at a press conference held at the Malaysian Agricultural Research and Development Institute (MARDI) on February 11, 1992. Because mass media (television, radio and newspapers) in Malaysia reported the results, many farmers visited MARDI to obtain information on the feeding of OPF to ruminants.

Some farmers have already adopted the technology. For example, a farmer in Pahang state has been feeding OPF to 200 beef cows since June in 1992 (Plate 3). The owner constructed a machine to chop OPF by himself. A farmer in Kuala Selangor state is feeding chopped OPF to 100 fattening beef cattle. The Guthrie estate, one of the largest oil palm estates in Malaysia has been feeding chopped OPF to 10,000 sheep. OPF is collected by driving a tractor equipped with a chopper and a wagon to carry chopped OPF.

Generally, the producers who have adopted the technology confirmed that the supply of fresh OPF is abundant and that there is no urgent need to conserve OPF as silage. Advantages of OPF feeding are as follows: (1) solving the problem of roughage/feed shortage, (2) improvement of milk quality in a dairy farm and (3) reduction of feeding, operational and management cost.

OPF has been found to be a suitable substitute for tropical grasses and has been successfully adopted by the ruminant producers in Malaysia.

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