Status of Utilization of Selected Fibrous Crop Residues and Animal Performance with Emphasis on Processing of Oil Palm Frond (OPF) for Ruminant Feed in Malaysia

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Abstract

The ruminant sub-sector is not as developed commercially compared with the swine and poultry sub-sectors in Malaysia. Traditionally, ruminants such as cattle, goat and sheep are owned by smallholders. Due to this subsistence level of production, attempts to improve the productivity of ruminant farming have not been successful. Therefore it is suggested that Malaysian ruminant livestock farmers should switch their orientation from farming to agri-business (production for profit). Fibrous crop residues (agro-industrial by-products) continue to play a significant role in ruminant feeding systems. Profiles of selected crop residues such as those from oil palm, rice, cocoa, pineapple and sago, incorporated with concentrates as complete feeds enabled to achieve animal performances ranging between 0.5 to 0.9 kg of an average daily gain (ADG) in a feedlot system. Some of these by-products are available in abundance but have a limited scope in their utilization. In contrast, some by-products are available in a limited quantity but their usage is only limited to *in situ* production and utilization in feeding systems for commercial animal production. Due to these limitations attempts were made to generate information on new feed resources such as oil palm frond (OPF) based on the availability, possibility for improvement and wider scope of utilization in the feeding systems. Oil palm fronds can be collected, processed, preserved and manipulated into feeds in forms that are acceptable to the ruminants. Recent results have showed that OPF could be processed into chips, preserved into silages and that its fermentation characteristics were outstanding. Combination of OPF silages with concentrates into complete feeds resulted in satisfactory intake and growth when the materials were fed to bulls in digestion and growth studies. Current information demonstrates that it is technically or biologically possible to use OPF as a source of ruminant feed. Studies should be undertaken to demonstrate that the utilization of the material is financially sound (marketable) to gain its acceptance by the industry and society.

Introduction

Ruminant production in Malaysia has not made significant progress in the last two decades. Most of the ruminants in the country are owned by smallholder farmers with the exception of government farms, two large open pasture ranches and a few large commercial feedlots. One of the major constraints on the increase of livestock production by the

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smallholders is the difficulty in providing feed in sufficient quantity and of suitable quality throughout the year, especially during peak cropping periods when most of the land is under cultivation. Good agricultural land is usually intensively cultivated and not available for fodder production. It is strongly advocated (Joseph, 1990) that any conversion of tropical rainforest to pastures for grazing animals in Malaysia has no justification both from economic as well as environmental considerations. Due to these limitations, grazing of ruminants on land used simultaneously for crop production, commonly designated as "integration" was slowly introduced and found to be a system that provides a more efficient utilization of resources. However, constraints did exist in certain areas depending on the location and growth stage of the crops (Chen and Shamsudin, 1991). Low forage availability was observed which could not support the grazing pressure and as a consequence the reproductive performance of cattle was characterized by a high percentage of anestrous animals. Therefore supplementary feed should be produced to compensate the deficit in such a system. Intensive feeding of ruminants (feedlot) using selected fibrous crop residues (agro-industrial by-products) such as palm press fiber (PPF), palm kernel cake (PKC), oil palm trunk (OPT), rice straw (RS), cocoa pod husk (CPH), pineapple waste (PAW) and sago waste (SAW) was developed and applied by the farmers. Certain limitations were recognized in the utilization of these materials due to the restricted scope of usage and requirement for further improvement (additional processing costs, etc). On the contrary, some by-products are readily utilized in the feeding system but only available in certain locations and low in supply/quantity. Efforts for the identification of new feed resources such as oil palm frond (OPF) were made to complement or enhance current and future development of the ruminant industry. Currently there are about 1.8 million hectares of land planted with oil palm in Malaysia (Basir, 1989) and about 17 million metric tons (on a dry matter basis) of pruned oil palm could be produced annually (Mohd. Hussin *et al.*, 1986) by the year 2000. Therefore, with proper planning and management, this large amount of by-products could be transformed/converted into value-added materials for the industry.

Selected fibrous crop residues

The selected materials are evaluated on the basis of various factors such as potential availability, proven nutritive value and their practical application in the animal versus crop feeding systems (Table 1 and 2).

Table 1 Profiles of diets and performance of animals fed selected fibrous crop residues in Malaysia
a) Oil palm

Crop residues	Level of inclusion in the diet (%DM)	Feeding system	Species	Animal performance ADG (kg/head/day)	Source
Oil palm					
a) PPF	20% PPF + Concentrates	Feedlot	Swamp buffaloes	0.59	Mohd. Sukri, H. I. *et al.*, 1988
b) PKC	100% PKC	Feedlot	Beef cattle	0.75	Jelan, Z. A. *et al.*, 1991
c) OPT	30% OPT + Concentrates	Feedlot	Beef cattle	0.70	Oshio, S. *et al.*, 1990

Note : PPF = Palm Press Fiber
PKC = Palm Kernel Cake
OPT = Oil Palm Trunk

Oil palm tree by-products are produced more abundantly than other crops because the cultivated area is rapidly expanding. Three major by-products namely palm press fiber (PPF), palm kernel cake (PKC) and oil palm trunk (OPT) have been found to be a beneficial source of feeds to ruminants.

Feeding of swamp buffaloes with 20% PPF in the diet in feedlot systems resulted in an average daily gain (ADG) of 0.59 kg/head/day (Mohd Shukri *et al.*, 1988). Therefore PPF is considered to be a useful roughage and could be utilized in the ruminant feeding system.

PKC has a high protein and energy content. The material is widely used as ruminant feed in Malaysia. Jelan *et al.*, (1991) compared the feeding of 100% PKC to various types of beef cattle breeds in feedlot and found that an ADG of 0.75 kg/head/day could be obtained for Droughtmaster cattle with the highest dressing percentage of 52.2% as compared to other types of breeds. PKC, is currently used extensively in supplement rations and in feedlot/fattening operations.

Oil palm trunk (OPT) is available in large quantity during the replanting activities of oil palm plantations. OPT was found to be an excellent source of roughage for ruminants (Abu Hassan *et al.*, 1989). Incorporation of 30% OPT in the total ration (Oshio *et al.*, 1990) for beef cattle resulted in a body weight gain of 0.70 kg/head/day. Further studies are being conducted to evaluate or investigate the higher level of inclusion of OPT in ruminant diet for efficient/effective use of resources.

Oil palm by-products, are fibrous in nature but if properly manipulated and utilized they should be able to confer a satisfactory level of production and quality for the animal products (Dahlan *et al.*, 1988). In their study, meat from feedlot animals fed on oil palm by-products was more tender than that of grazing animals. The diet promotes the formation of a larger amount of intramuscular fat and this study showed that good quality buffalo meat can be produced through the use of oil palm by-products. Shibata and Abu Hassan (1988) also concluded that the feeding of oil palm by-products to beef cattle is safe, applicable and

Table 2 Profile of diets and performance of animals fed selected fibrous crop residues in Malaysia
b) Rice, Cocoa, Pineapple and Sago

Crop residues	Level of inclusion in the diet (%DM)	Feeding system	Species	Animal performance ADG (kg/head/day)	Source
a) Rice					
RS	30% RS + Concentrates	Feedlot	Beef cattle	0.72	Oshio, S. *et al.*, 1990
b) Cocoa					
CPH	35% CPH + Concentrates	Feedlot	Beef cattle	0.54	Bacon, A and Anselmi, J., 1984
c) Pineapple					
PAW	55% PAW + Concentrates	Feedlot	Beef cattle	0.90	Ong, J., 1991
d) Sago					
SAW	26.5% SAW + Concentrates	Feedlot	Dairy cattle	0.72	Md. Yusoff, S., 1988

Note : RS=Rice Straw
CPH=Cocoa Pod Husk
PAW=Pineapple Waste
SAW=Sago Waste

practical without any risk of heat stress as long as cattle are fed under intensive system or under shade.

Besides oil palm by-products, rice straw ranked the second highest in order of importance, followed by cocoa pod husk, pineapple waste and sago waste.

Rice straw (RS) is available in abundance in rice-growing areas (mainly double cropping), mostly in the form of short straws (from combine harvester). Feeding of 30% RS in total ration (Oshio *et al.*, 1990) to beef cattle was successfully implemented with a weight gain of 0.72 kg/head/day in feedlot. For the utilization of RS, stronger emphasis should be placed on methods of processing into complete commercial feed.

After harvesting in cocoa plantations, cocoa pod husks are produced and various studies have been conducted on the utilization of the residues. Bacon and Anselmi (1984) utilized cocoa pod husks at 35% level in the diet and obtained a weight gain of 0.54 kg/head/day which is satisfactory in a system for the utilization of cocoa pod husks in plantations to suppress the multiplication of cocoa pod borer pests.

Pineapple waste (PAW) is obtained from the canning factories. By the inclusion of about

Table 3 Status of utilization of selected fibrous crop residues in the ruminant feeding systems in Malaysia

Crop residues	Production and availability	Production areas	Utilization and limitation
a) PPF	Abundance	Oil palm plantation (National)	Limited use, not>20% in diets
b) PKC	Abundance	Palm oil refinery (National)	Widespread (100%) Large export market Needs manipulations for efficient use
c) OPT	Abundance	Oil palm plantation (National)	New resource Needs to reduce processing costs
d) RS	Abundance	Rice areas (North and Central)	% Utilization low Collection problem
e) CPH	Limited	Cocoa areas (Central, South and East Malaysia)	Usage - *in situ*
f) PAW	Limited	Pineapple canning (Southern Johore)	Usage - *in situ* Highly commercialized
g) SAW	Limited (Peninsular Malaysia) Abundance (East Malaysia)	Johore and East Malaysia	Usage - *in situ* Also commercialized

Note : PPF=Palm Press Fiber
PKC=Palm Kernel Cake
OPT=Oil Palm Trunk
RS=Rice Straw
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55% PAW in the diet of beef cattle, a weight gain of 0.90 kg/head/day was recorded (Ong, 1991) which is representative of fibrous materials with long fibers and which contain more soluble fermented carbohydrate sources (Preston and Leng, 1978).

Sago industry in Malaysia generates sago waste (SAW). The performance of dairy cattle fed on SAW was studied (Yusoff, 1985) and the improvement in body weight gain reached 0.72 kg/head/day.

Advantages and limitations of utilization of fibrous crop residues

PPF can be utilized as a roughage source but due to its lower digestibility and slower rate of passage, a higher level of inclusion is not recommended (not more than 20% in the diet). PKC is widely used as ruminant feed. Due to the large export market for the material (95% exported to EEC), the conditions are not favourable for local ruminant enterprises. There is a need for implementing a policy to ensure that PKC is made available to the producer at an economical price throughout the year and at the same time to ensure that quality fluctuations of the material are minimal (Jalaludin *et al.*, 1991) due to shell content contamination (Table 3).

OPT will be available in greater amount by the year 2000. Due to its potential for use as ruminant feed, the current processing technique has to be modified for economical/practical application of OPT. Production cost of twenty cent (20) per kg dry matter of OPT should be further reduced (Ismail *et al.*, 1990) in order to make OPT an attractive material for utilization in ruminant feeding systems. Various aspects of feeding of RS have been intensively studied and the low utilization of RS is mainly due to the difficulty in collection and to various economic considerations. Only *in situ* utilization of CPH is possible and limited to cocoa production areas. There is a strong linkage or symbiotic relationship between commercial feedlot operations and pineapple canning factories. PAW has been commercialized and local utilization (demand) is higher than the supply. A similar situation occurs in the utilization of SAW, except that the distribution of SAW is wider (open market).

Processing of oil palm frond (OPF) for ruminant feed

As mentioned earlier in this paper, a very large amount of OPF is available in Malaysia due to pruning activities of the plantations. Currently the materials are being left rotting in the estates and the only justification for that form of cultural practice is for nutrient recycling and soil conservation. On the other hand, the pruned fronds provide an ideal breeding ground for snakes and rats which causes management constraints in the plantations.

In taking account of the feed deficit in all systems of ruminant production and the large amount of fibrous residues from OPF, efforts have been made to promote information on, and collection, processing, treatment, storage/preservation and utilization of the material for ruminants (Fig. 1).

First, attempts were made to study the effect of the addition of water, molasses and urea on OPF silage quality and acceptability by the animals (Table 4).

The fronds were collected and chopped to a length of about 2-3 cm using a Junkkari Chipper and forage chopper. The treated OPF and control OPF were tightly packed in a 200 liter steel drum and left outdoors for six months. Thereafter the drums were opened to observe the fermentation characteristics, spoilage and to carry out the palatability test. The pH values for the control, water and molasses treatment were within acceptable limits with the exception of urea-treated OPF which recorded a higher value of 7.38 due to the influence of degradation of urea to ammonia. Good quality silage can be prepared without any additives if OPF is ensiled under anaerobic conditions. There was evidence of spoilage (mold) in the upper part of the drums in the control, water and molasses treatment, but no mold was

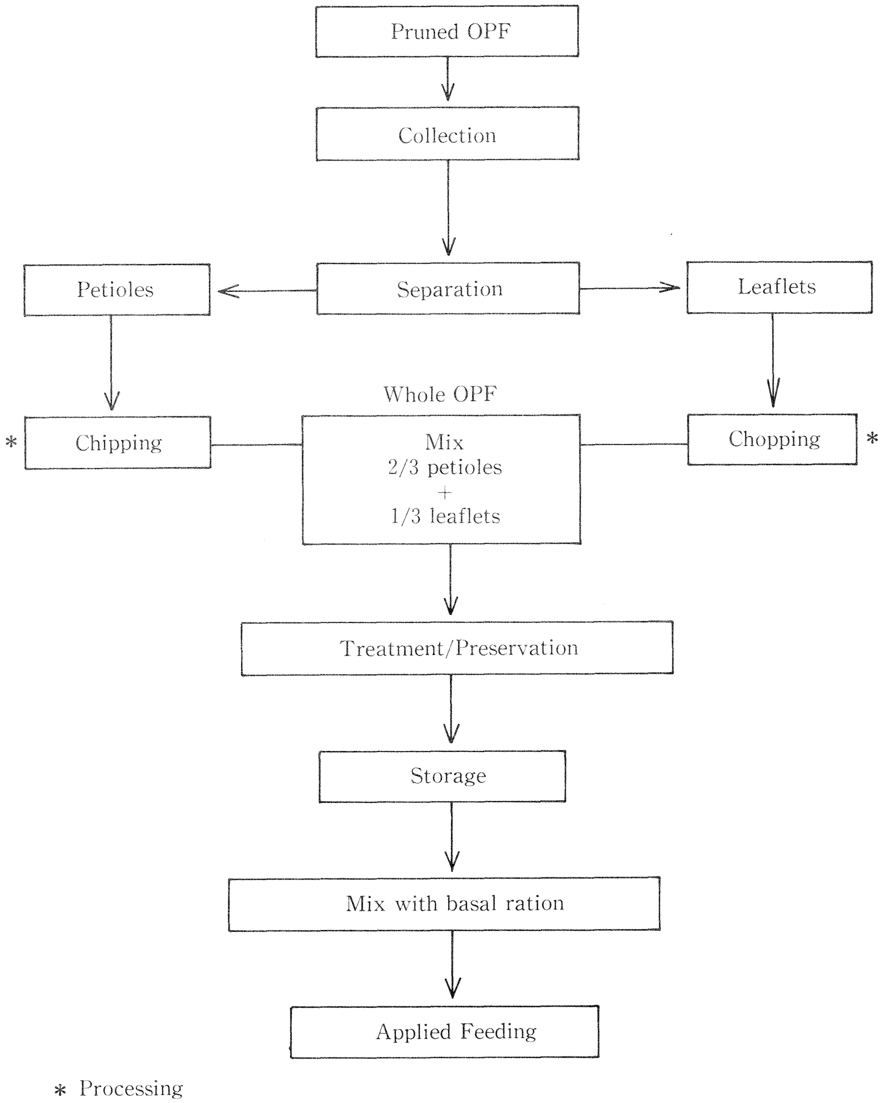

Fig. 1 Flow of activities in collection, processing, treatment, preservation and utilization of OPF.

detected in the urea-treated OPF silage and a strong ammonia smell was also noted. The mold could not grow presumably due to the sterilization effect of ammonia.

The samples were also analysed for organic acid content using HPLC (Shimazu Ltd.). The fermentation of urea-treated silage was characterized by a higher pH value and higher acetic acid contents. It is possible that acetic acid was produced from the hemicellulose by ammonium hydroxide hydrolysis of the fiber components. Simultaneously, the physical evaluation of the petiole tissues showed that the petiole of urea-treated silage was softer than that of control silage. The results suggested that the urea treatment may have improved the digestibility because similar observations on rice straw (Sundstøl and Coxworth, 1984)

Table 4 Effect of water, molasses and urea addition on fermentation characteristics and palatability for bulls of oil palm fronds silage

Item	Treatment			
	Control	Water	Molasses	Urea
Fermentation characteristics				
pH-value	4.02^{b}	3.93^{b}	3.93^{b}	7.38^{a}
Organic acids contents, 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, DM%	13.9 ^{a}	0.0 ^{b}	1.6 ^{b}	0.0 ^{b}
Palatability trials				
Dry matter intake, kg/24hr.	2.6^{ab}	3.8 ^{a}	2.8^{ab}	2.0 ^{b}

Note : ^{a,b,c} Means in the same row with different superscripts differ ($P<0.05$).

Table 5 Effect of urea-treatment levels on fermentation characteristics in OPF silage

Item	Urea-treatment levels (DM%)			S. E.
	0	3	6	
Fermentation characteristics				
pH-value	3.78^{a}	4.89^{b}	7.81^{c}	0.20
Organic acid				
Total acid, DM%	3.68^{b}	4.76^{b}	8.96^{a}	0.65
Composition of acids, %				
Lactic acid	91.0 ^{a}	37.4 ^{b}	13.0 ^{c}	5.4
Acetic acid	6.1 ^{c}	25.8 ^{b}	72.9 ^{a}	5.6
Propionic acid	0.1 ^{b}	3.8 ^{a}	0.8 ^{b}	0.7
Butyric acid	0.9 ^{c}	30.9 ^{a}	6.7 ^{b}	2.0
Ammonia-N, DM%	0.00^{c}	0.58^{b}	1.12^{a}	0.13

Note : ^{a,b,c} Means in the same row with different superscripts differ ($P<0.05$).

Table 6 Effect of urea-treatment levels on nutritive value of OPF silage in Kedah-Kelantan bulls

Item	Urea-treatment levels (DM%)			S. E.
	0	3	6	
Nutritive value				
Voluntary intake, DM g/$W^{0.75}$kg/day	39.9^{a}	32.1^{a}	24.0^{b}	34.3
Dry matter digestibility, %	45.0^{a}	44.2^{a}	35.8^{b}	5.2
Crude protein, DM%	5.1	11.4	23.1	-

Note : ^{a,b,c} Means in the same row with different superscripts differ ($P<0.05$).

showed that the urea treatment improved the organic matter digestibility. Although urea-treated OPF silage had a strong ammonia smell, it was accepted by the bulls.

Since the addition of urea to OPF prevented the spoilage of OPF silage and enriched the preserved material with NPN, varying levels of urea addition were considered and implemented (Table 5).

The three treatments applied in this study consisted of 0, 3 and 6% urea, respectively. There were significant differences in all the treatments in the pH value, as anticipated due to the increased level of urea. The 6% urea treatment of OPF silage resulted in the largest amount of total organic acid but the lactic acid (%) composition was highest in the OPF silage, followed by 3% urea OPF. These data showed that 0% urea OPF (silage) and 3% urea OPF resulted in acceptable fermentation for good silage-making or preservation. The materials (OPF) in 0, 3 and 6% urea OPF silage were fed to bulls to determine the nutritive value as shown in Table 6.

There were no significant differences in the voluntary intake and dry matter digestibility % (DMD) between 0 and 3% urea OPF. Analysis of crude protein (CP) showed an increase in the value of CP along with the increase of the urea levels. Based on these results, it was clearly demonstrated that the urea level in OPF should not exceed 3% because at 6% urea, the voluntary intake and DMD% were significantly reduced when compared to the other two treatments.

In trying to harness the large potential availability (gross estimate) of OPF, it is important to gain practical experience in the field while collecting and processing OPF (Table 7).

The basic data on pruning and collection of OPF revealed that a substantial amount of OPF (100% collection of pruned fronds) could not be collected (3,108 kg/month/ha on DM basis) for processing as feed resource to sustain a viable ruminant production within the oil palm production system. In order to achieve the objective, various techniques of feed processing, preservation and improvement must be employed for solving the problems at a certain cost.˙ However, this effort is in agreement with the statement of Devendra (1990), who pointed out that for the more efficient use of available feeds or new feed resources, especially of crop residues for ruminants, the following main factors require serious consideration, such

Table 7 Basic data on pruning and collection of OPF (18 years old oil palm trees/plantation)

Activities	Quantity
Pruning cycle	14 day interval
No. of pruned fronds	3 fronds
Wt. of one frond	10 kg (wet basis)
One frond - 1/3 leaflets	3.33 kg
2/3 petioles	6.67 kg
One (1) hectare of oil palm plantation	148 trees (± 55-60 trees/acre)
Amount of pruned fronds/cycle (14 days)/ha	4,440 kg (wet basis)
Amount of pruned fronds/month/ha	8,880 kg (wet basis)
Dry matter contents of fresh OPF	35%
Amount of pruned fronds/month/ha on dry matter basis	3,108 kg

as overcoming feed deficit/rising cost of production, low nitrogen content of bulky cellulose roughages of poor quality, unknown harmful effects of the feeds on the animals, economically justifiable technology versus conversion to usable products and others. Therefore in an overall systems approach to the formulation of strategies for efficient utilization of fibrous materials, Devendra (1984), also stressed the importance or justification, where improved or better quality ruminants are used (which have a higher genetic potential for production) or alternatively where these animals are reared in large intensive units, of the fact that the demand for a higher level of nutrition may well justify the use of more sophisticated processing or treatment methods.

Conclusion

Improved efficiency in diet development and nutrition for the ruminant sector is essential for current and future progress of overall animal production in Malaysia. Certain crop residues are being utilized commercially but with a low supply to meet the national demand. Oil palm normally has an economic life span of 25-30 years. There are more opportunities to explore the potential of oil palm-based lignocellulosic materials such as oil palm frond as non-conventional feed resources and its utilization as animal feed is not fully realized. Since agricultural wastes are at present costly to dispose of, therefore serious efforts should be made to justify the viability (technically and financially). The successful commercialization of any products or by-products will help to improve the profitability of the industries and increase the living standards of the population, where most of the economic palms are located.

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