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Feeding Value of Oil Palm By-Products

2. Degradation properties in the rumen of Kedah-Kelantan cattle

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The shortage of feed supply is the major limiting factor for cattle production in Malaysia. However, she has great potential in the utilization of local agricultural by-products, especially oil palm by-products such as palm press fiber (PPF), palm kernel cake (PKC) and palm oil sludge (POS).

Although these by-products have potential importance to the animal industry, the information on their digestion characteristics, nutritive value and so on to the cattle is insufficient. Research information on these aspects is needed to utilize them as animal feed.

In continuation of the preceding paper[10], the degradation properties of the oil palm by-products are presented in this paper.

Materials and methods

Nylon bag trials were conducted under three feeding treatments. Details of the animals and the three feeding treatments, and the results of the total collection digestion trials were shown in the preceding paper[10].

The nylon bags were made of plain nylon cloth of 200 mesh. Care was taken in sewing the bags to assure a smooth interior with no pockets. The bags, 6 cm × 12 cm in size were tied to 3 cm × 20 cm acrylic plastic sticks and both ends of the sticks were weighted with lead. Twenty small holes were drilled, evenly spaced, along the stick to which the bag is to be tied. The sticks were attached to 50 cm of nylon fishing line.

The ruminal disappearance of dry matter, protein and fiber was determined for PPF, PKC and POS under three feeding treatments[10]. The determination was done twice for each treatment.

The samples were ground in a Wiley mill and sifted through 16- and 42-mesh screen to get samples between 16- and 42-mesh.

The samples (about 5–10 g) were placed in each pre-weighed nylon bag. After the drawstrings were drawn tightly and tied, the filled bags were re-dried for 24 hr at 65°C, and reweighed. The bags were tied to the sticks and soaked in water for about 30 sec just before suspending them in the rumen. The sticks and bags were placed in the rumen and imbedded in the rumen ingesta at 10:00 a.m., simultaneously with the oil palm by-product-based ration (OPR)[10] feeding.

The bags were removed after 1, 2, 8, 24 and 48 hr from the rumen, and immediately washed thoroughly with running water until the water was no longer colored by washing. They were oven-dried for 48 hr at 65°C, and then removed from the sticks. Contents of

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the bags were crushed by hand to facilitate drying and then dried for additional 24 hr. The bags were weighed and dry matter digestibility in the rumen was determined by weight difference.

The procedure developed by Ørskov and McDonald[8] was used. The equation

$$P(t)=a+b(1-e^{-ct}) \quad \text{.....(A)}$$

was fitted to the disappearance data from the nylon bag trials. The percentage of disappearance at the time t is expressed by $P(t)$ while the constant a is the intercept of the degradation curve at the time zero which can be interpreted as the rapidly soluble fraction. The b fraction represents the disappearance occurred subsequent to fraction a at the rate c. Equation (A) is transformed as follows:

$$\begin{aligned} P(t) &= a+b(1-e^{-ct}) \\ &= (a+b)-b\,e^{-ct} \end{aligned}$$

therefore,

$$(a+b)-P(t)=b\,e^{-ct}$$

and then, transform into natural logarithm

$$\begin{aligned} \ln[(a+b)-P(t)] &= \ln(b\,e^{-ct}) \\ &= \ln b+\ln e^{-ct} \\ &= \ln b-ct \quad \text{.....(A')} \end{aligned}$$

let $\ln[(a+b)-P(t)]=Y$ and $\ln b=B$, equation (A') becomes

$$Y=B-ct$$

$(a+b)$ represents the total digestibility which is asymptote of the degradation curve. We assumed that the extent of disappearance at 48 hr is 95% response of the total digestibility. Then, constant a, b and c was calculated by the linear regression analysis.

Results and discussion

The percentage of disappearance of dry matter (DM), crude protein (CP), and crude fiber (CF) occurred during each incubation interval for PKC, PPF and POS is shown in Tables 1, 2 and 3 respectively.

The DM disappearance (%) of PKC in the treatment 3 was lower than that of the other two treatments at 1, 2 and 8 hr but was the highest among the treatments at 24 and 48 hr. The similar trend was observed for CP and CF. The value at 48 hr in the treatment 3 was 69% which is close to the value of alfalfa obtained from steers on alfalfa-orchardgrass pasture[14].

The CP disappearance (%) of PKC at 1 hr was about 30% suggesting that the soluble protein content of PKC is about 30%. Van

Table 1. The DM disappearance (%) of PKC, PPF and POS in nylon bags suspended in the rumen of cattle, examined under three different feeding treatments

Feed	Incubation interval (hr)	Treatment			Treatment effect	l.s.d. (P<.05)
		1	2	3		
PKC	1	25.42	23.87	20.95	**	2.41
	2	28.39	24.53	21.57	**	2.77
	8	29.02	28.30	26.98	NS	
	24	42.85	38.73	46.72	**	4.10
	48	59.60	50.26	69.31	**	7.29
PPF	1	8.43	12.94	10.22	*	3.46
	2	9.49	15.06	12.04	**	3.64
	8	9.82	14.97	13.82	**	3.29
	24	14.43	17.77	18.23	NS	
	48	17.70	22.37	21.84	**	3.22
POS	1	33.55	36.63	35.99	NS	
	2	34.23	37.04	42.79	**	5.06
	8	36.41	43.59	50.56	**	8.52
	24	57.99	46.59	62.71	NS	
	48	67.53	59.69	82.57	*	16.49

Level of significance: * P<.05, ** P<.01, NS, Not significant.

Table 2. The protein disappearance (%) of PKC, PPF and POS in nylon bags suspended in the rumen of cattle, examined under three different feeding treatments

Feed	Incubation interval (hr)	Treatment			Treatment effect	l. s. d. (P<.05)
		1	2	3		
PKC	1	33.73	36.56	25.34	**	7.86
	2	38.11	38.16	21.55	**	11.86
	8	37.00	44.58	26.76	**	9.56
	24	43.93	51.09	48.98	*	6.04
	48	60.95	62.58	74.37	NS	
PPF	1	28.03	23.09	28.90	NS	
	2	33.40	27.76	27.07	NS	
	8	36.20	26.68	34.64	*	7.88
	24	39.55	38.19	45.96	*	7.22
	48	49.24	42.52	51.56	NS	
POS	1	24.88	28.56	34.39	NS	
	2	24.18	33.37	39.11	*	11.51
	8	30.16	40.45	47.83	*	12.53
	24	52.61	40.30	57.69	NS	
	48	61.91	54.30	84.95	**	17.89

*, **, NS: See Table 1.

Table 3. The fiber disappearance (%) of PKC, PPF and POS in nylon bags suspended in the rumen of cattle, examined under three different feeding treatments

Feed	Incubation interval (hr)	Treatment			Treatment effect	l. s. d. (P<.05)
		1	2	3		
PKC	1	28.07	21.91	21.55	NS	
	2	30.00	26.29	26.34	NS	
	8	34.45	25.96	28.41	NS	
	24	37.41	31.23	35.64	NS	
	48	45.56	40.29	47.92	NS	
PPF	1	3.70	3.70	2.56	NS	
	2	4.70	7.01	1.99	**	2.33
	8	4.33	3.89	6.04	NS	
	24	6.74	8.08	6.54	NS	
	48	10.46	11.22	11.88	NS	
POS	1	11.42	10.74	14.27	NS	
	2	9.25	12.04	22.83	**	6.72
	8	14.02	21.52	35.46	**	12.05
	24	40.75	28.47	50.38	NS	
	48	58.07	44.05	78.51	*	25.68

*, **, NS: See Table 1.

Soest[15] classified feeds containing 20 to 30% soluble protein, such as oats or soybean meal as intermediate solubility feed. Accordingly, PKC is regarded as intermediate solubility feed. The value at 24 hr of PKC was about 50% which is comparable to the value of corn[4].

The CF disappearance (%) of PKC at every incubation interval was not significantly different among the treatments. However, the value in the treatment 2 appears to be lower at 8, 24 and 48 hr than that of other treatments, though the rate of degradation at the beginning is similar to that in the treatment 3. It means that the rate and extent of the degradation of potentially digestible com-

ponent in CF depend on the basal ration fed.

The DM disappearance (%) of PPF was extremely low, showing only about 20% even at 48 hr in all the treatments due to low degradability of CF. These values are similar to the value reported by Aznam[2]. Omori and Kawabata[7] reported that the digestibility in the rumen (at 40 hr) of the straw (rice, wheat, barley and rye) was 37.6, 34.2, 28.6 and 31.4% respectively for DM, and 40.2, 39.2, 29.3 and 27.2% respectively for CF. The DM disappearance rate of PPF was almost half of straws.

Jelan[5] showed that the DM disappearance (%) of PPF increased substantially after sodium hydroxide treatment. But Devendra[3] showed that alkali treatment of PPF was associated with interaction of the fat present through saponification to form Na or Ca soaps. It is considered that increasing CF digestibility is needed to improve the nutritive value of OPR, so that the proper processing method to increase CF digestibility has to be found out.

POS was digested very rapidly in the rumen. The DM disappearance was about 35% at 1 hr in all treatments and 51, 63 and 83% at 8, 24 and 48 hr respectively in the treatment 3. The DM disappearance of POS was higher than that of PKC at the beginning but the CP disappearance was not. It implies that POS contains more soluble DM and less soluble CP than PKC. However, POS is also classified as intermediate solubility feed.

The disappearance (%) of DM, CP and CF at 48 hr was higher in the treatment 3 than in the treatments 1 and 2 in all by-products samples. But the pattern of degradation in the rumen was different according to the feed components or feeding treatment.

The rate and extent of degradation depend on the basal diet fed. Furthermore, there might possibly exist abrasive action between the bag surface and the rumen digesta in the treatment 3 because of higher intake and higher consistency of rumen digesta. The differences among the treatments causing different patterns of DM, CP and CF disappearance are not totally understood, but are probably due to a combination of ruminal microbial and physical factors.

Table 4. Estimated values for parameter *a*, *b* and *c* of protein

Feed	Treatment	Parameter			Degradation after 48 hr ($a+b$)
		a (%)	b (%)	c (hr^{-1})	
PKC	1	28.5	35.7	0.045	64.2
	2	33.7	32.1	0.045	65.8
	3	7.7	70.6	0.055	78.3
PPF	1	28.1	23.8	0.043	51.9
	2	22.8	22.0	0.048	44.8
	3	26.0	28.3	0.049	54.3
POS	1	18.1	47.0	0.055	65.1
	2	28.1	29.1	0.044	57.2
	3	25.5	64.0	0.050	89.5

The values of parameter a, b and c[8] were estimated from each CP disappearance pattern of PKC, PPF and POS, and are given in Table 4.

Shibui et al.[11] and Iriki et al.[4] showed that the degradation properties of feed proteins were divided into three types; A, B and C. Type A, which is divided into two subtypes A1 and A2, contains a remarkably large amount of fraction a. Type B contains a relatively small amount of fraction a but a large amount of fraction b and the degradation rate c of fraction b was medium. And in the type C, values of a, b and c were all very small.

The value of parameter a and b of PKC was different in the treatment 3 from the other two treatments. This might be caused by the error of estimation. Mertens and Loften[6] estimated the parameter of forage fiber digestion kinetics by logarithmic transformation and a direct nonlinear least squares procedure. They showed that the latter procedure provided a better fit of the data than the former. In this study, however, parameter a, b and c was estimated by logarithmic transformation, since Ørskov[9] showed a good agreement between the value of a, b and c determined by the iterative least square method and the method that was simply to plot the results and fit the curve by eyes.

Table 5. Contents of various fractions of PPF obtained by enzymatic analysis

Treatment	NDF	ADF	Lignin	Silica	OM	OM		OCW	
						OCC	OCW	Oa	Ob
Untreated	73.8	54.1	26.3	3.0	83.6	4.4	79.2	8.2	71.1
Steamed*	72.9	60.0	28.4	3.2	88.9	10.5	78.4	12.7	65.7

* 10 kg/cm², 15 min. (Takigawa[13])

OCC: Organic cellular contents, OCW: Organic cell wall,
Oa, Ob: Organic a, b presented by Abe et al.[1]

The values of parameter *a* of PKC and POS, which are considered as a protein source from their CP content, were between about 20 and 35% except one datum of PKC. These values were similar to those of rape seed meal, dehydrated alfalfa meal, soybean meal and linseed meal which were classified as type B. The values of parameter *b* of PKC and POS were between 30 and 70% and also similar to rape seed meal, dehydrated alfalfa meal, soybean meal and linseed meal. The parameter *b* in the treatment 3 were 70.6 for PKC and 64.0 for POS. It suggests that grass feeding improves the digestibility of potentially digestible CP. The values of degradation rate *c* of PKC and POS were between 0.044 and 0.055. These values were similar to those of dehydrated alfalfa meal and corn gluten meal.

From the above results, it is concluded that the degradation properties of PKC and POS are very similar to dehydrated alfalfa meal and classified as type B which shows medium degradation rate and good for cattle feed. However, proper physical treatment for PPF has to be investigated to utilize the oil palm by-products more efficiently.

Attempts have been made to increase the digestibility of wood by physical treatment to utilize biomass in Japan. Takigawa[12] showed that the digestibility of DM, CF and acid detergent fiber of white birch chips was increased remarkably by steaming treatment and their TDN content rose by about eight times to 65.5%, although the content of their components did not change greatly. Takigawa[13] also examined the effects of steaming and explosive depressurization treatment on the nutritive value of PPF used in this study. As shown in Table 5, the steaming treatment for PPF increased the total amount of "organic cellular contents (OCC) plus organic *a*", which is highly digestible[1], from 12.5 to 23.2% although organic cell wall content (OCW) did not change. This is attributed to the breakdown of crystalline cellulose in CW and decomposition of hemicellulose in OCW to OCC.

Table 6. Changes in OM digestibility of the PPF sample by steaming or explosive depressurization treatment

Treatment	Pressure (kg/cm²)	Time (min)	OM digestibility*	
			Mean	S.D.
Untreated	—	—	14.98	0.69
Steamed	10	15	26.12	1.44
	10	20	32.45	1.24
	15	10	42.16	0.93
Explosive-depressurized	20	1.5	27.67	0.94
	20	3	48.02	0.71
	25	1	42.08	0.10
	25	2	48.69	1.88
	30	1	51.55	0.58

* Organic matter digestibility by cellulase. (Takigawa[13])

As Table 6 shows, the digestibility of OM in untreated PPF was less than 15%, being similar to the result of the present nylon bag study. However, as steaming or explosive-depressurizing treatment markedly increased the digestibility of OM, the effect of these treatments on the nutritive value of PPF has to be studied in detail to utilize the palm oil by-products more efficiently. Fortunately, oil palm by-products are easily available in the large amount from mills of oil palm planta-

tions. Hence, there is a possibility of producing complete feed for sale by mixing steamed PPF with PKC and POS, and then cubing the mixture.

Summary

This study was carried out, utilizing three fistulated Kedah-Kelantan cattle, to investigate the feeding value of three oil palm by-products, i.e., palm press fiber (PPF), palm kernel cake (PKC) and palm oil sludge (POS), by determining the degradation patterns in the rumen under three different feeding programs.

The disappearance (in %) of PPF from the nylon bag after 48 hr of incubation was lower than that of PKC and POS for dry matter (DM), crude protein (CP) and crude fiber (CF). Especially, DM and CF disappearance was extremely low (17.7–22.4% for DM and 10.5–11.9% for CF). Therefore, it is necessary to improve the fiber digestibility of PPF by proper processing to increase the nutrient content of OPR.

PKC and POS were ranked as the same type as dehydrated alfalfa meal which showed relatively small value of fraction *a* but large value of fraction *b* and the medium degradation rate *c* in regard to degradation properties of the protein.

It was concluded that OPR is a good ration for KK cattle weighing approximately 250 kg. However, to make it better the digestibility of PPF has to be improved by proper treatment. In this connection, it is considered that the organic matter digestibility of PPF would be improved by steaming or explosive-depressurizing treatment.

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