Feeding Value of Oil Palm By-Products

1. Nutrient intake and physiological responses of Kedah-Kelantan cattle

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Malaysia imports about 470 million liters of liquid milk equivalents and self sufficiency for beef is only 56% in 1982[7]. Beef and dairy cattle production in Malaysia highly depends on smallholders and major sources of forage supply are grasses taken from estates, paddy field levees, road side or unimproved communal grazing areas. The shortage of feed supply is the major limiting factor for cattle production. For example, Devendra and Wan Zahari[1] showed that better nutrition and management improved liveweight at slaughter by 64% and meat weight by 104% by comparing stall-fed experimental Kedah-Kelantan cattle with rural cattle.

On the other hand, the demand for beef and dairy products is increasing. However, the development of the livestock industry in Malaysia has to depend on high cost imported feeds. About 1 million t (metric) of residues, wastes and prepared animal fodder costing M$384 million was imported for animal feed purposes in 1982[7], though Malaysia has a great potential in the utilization of local agricultural by-products, especially oil palm by-products.

Malaysia produces 3.71 million t of palm oil in 1984, accounting for about 62% of the world production followed by 18% of Indonesia and 7% of Nigeria. This figure is projected to increase to 4.3 million t in 1985[8]. The three important by-products, parm press fiber (PPF), palm kernel cake (PKC) and palm oil sludge (POS), which can be exploited for animal feeds are estimated at 2.6, 0.5 and 0.1 million t respectively by using extraction rates presented by Devendra[2].

However, information on digestion characteristics and nutritive value of them as cattle feed is still insufficient, as no systematic research has been done. Research on digestible nutrient content and digestion characteristics of them is required in formulating efficient and economical rations. It is also desired to assess the heat load due to eating and digestion of them under tropical environments, especially for lactating cows sensitive to heat stress[12].

The result of the cooperative research between the Malaysian Agricultural Research and Development Institute and Tropical Agriculture Research Center is presented in this paper.

Materials and methods

1) *Animals*

Three fistulated Kedah-Kelantan bulls, about 2 years of age weighing approximately 250 kg were used for each treatment. They were kept in individual pens and had free access to water and mineral block.

2) *Feeding treatment*

Treatment 1: Oil palm by-product ration

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(Table 1) and rice straw with molasses.

Treatment 2: Oil palm by-product ration alone.

Treatment 3: Oil palm by-product ration and napiergrass.

The amount of feeds given in each treatment is shown in Table 2.

The amount of rice straw or napiergrass was planned to replace 30% of total dry matter (DM) intake. Rice straw with molasses, and napiergrass were fed in the morning (8:30) and evening (18:00). The amount of rice straw given was 0.5 kg with 0.3 kg of molasses in the morning and 1.1 kg with 0.7 kg of molasses in the evening. Napiergrass given was 3 kg in the morning and 4.5 kg in the evening. The oil palm by-product ration (OPR) (Table 1) was given at 10:00 for the treatments 1 and 3, whereas it was given twice daily in an equal amount at 10:00 and 18:00 for the treatment 2.

Table 1. Components of oil palm by-product ration

Palm kernel cake	30%
Palm press fiber	15
Palm oil sludge	18
Molasses	35
Urea	1
Mineral	1
Calculated nutrient contents	
Dry matter	82.8
Crude protein	12.9*

* DM basis.

3) *Measurement of physiological responses*

Heart rate, respiration rate, body temperature and rumen temperature were measured for 2 days from 8:00 to 18:00 in a day in each treatment.

Heart rate and respiration rate were recorded by using electrocardiograph (Polygraph, Nihon Denki Sanei Co., Ltd.) with three skin surface electrodes placed on the left shoulder, left anterior thorax and left rump. Body temperature and rumen temperature, and air temperature and wet bulb temperature were obtained by Pt-100 ohm resistance thermometer and recorded continuously. The data reading was done every 5 min for heart rate and respiration rate, every 6 min for body temperature and rumen temperature and every 30 min for air temperature and wet bulb temperature.

Results and discussion

1) *Environmental conditions and physiological responses*

Animal, especially ruminant, produces a

Table 2. The amount of feeds given in each treatment

Feed components	Treatment 1	Treatment 2	Treatment 3
Oil palm by-product ration (OPR)	3.572	5.92	3.98 (kg)
Palm kernel cake (PKC)	1.1	1.8	1.2
Palm press fiber (PPF)	0.5	0.9	0.6
Palm oil sludge (POS)	0.6	1.1	0.7
Molasses	1.3	2.0	1.4
Urea	0.036	0.06	0.04
Mineral	0.036	0.06	0.04
Rice straw with molasses (MRS)	2.6	—	—
Molasses	1.0	—	—
Rice straw	1.6	—	—
Napiergrass (NG)	—	—	7.5
Total	6.172	5.92	11.48

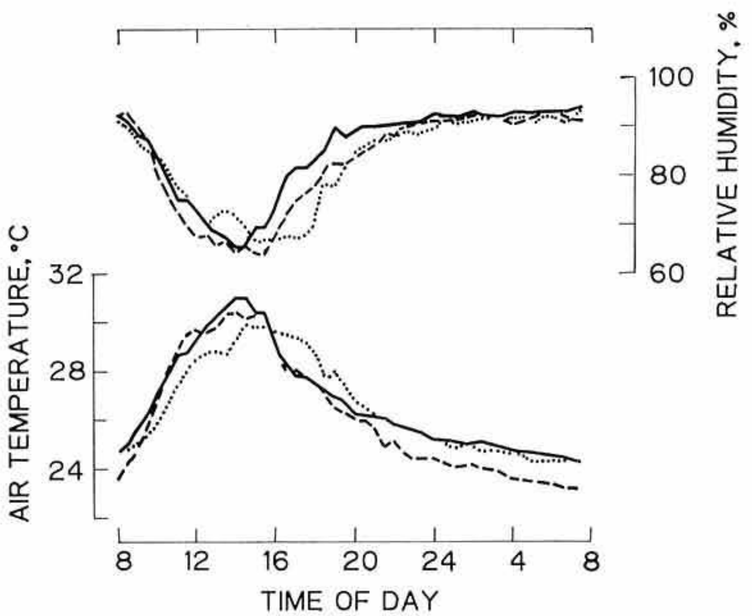

Fig. 1. Diurnal changes of air temperature and relative humidity
Measured at the interval of 30 min.
——: Treatment 1, ----: Treatment 2, ······: Treatment 3.

Table 3. Values of some physiological variables before and after feeding in each treatment

Item		Treatment 1	Treatment 2	Treatment 3	Treatment effect	l. s. d. (P <. 05)
Heart rate	Before feeding[a]	48. 4	56. 9	59. 2	**	4. 8
	After feeding[b]	71. 3	67. 2	86. 5	**	7. 1
Respiration rate	Before feeding	18. 2	15. 9	18. 7	N S	
	After feeding	19. 3	16. 9	20. 3	*	3. 1
Rumen temp.	Before feeding	38. 27	37. 90	38. 37	*	0. 40
	After feeding	38. 48	38. 15	38. 70	**	0. 35
Body temp.	Before feeding	37. 83	37. 57	37. 95	*	0. 35
	After feeding	38. 21	37. 86	38. 27	**	0. 23

a): Mean for a 30-min period before feeding.
b): Mean for a 3-hr period after feeding OPR.
Level of significance: * P<.05, ** P<.01, NS, Not significant.

large amount of heat by eating and digestion of feeds and heat produced in the body causes heat stress from the interior of the body. As the critical temperature varys with feeding level and type of feed, it is required to assess the feeding value not only from the nutritive value but also from physiological responses of animals under the tropical condition.

Air temperature and humidity of the day of physiological response measurement are shown in Fig. 1. Judging from the data reported by Johnson et al.[4] and McDowell[6], air temperature and humidity were not so severe to the Kedah-Kelantan cattle kept in a barn.

Table 4. Changes in certain physiological variables with time after feeding

Item	BF[a]	After RS or NG feeding[b]	Hr after feeding OPR							Differ-ences	l. s. d. (P <. 05)
			1	2	3	4	5	6	7		
Tratment 1											
HR	48.4	58.2	72.7	74.0	67.2	64.0	64.4	65.2	62.2	**	9.9
RR	18.2	17.9	19.9	19.3	18.7	17.1	18.2	17.6	18.1	NS	
RT	38.3	38.5	38.9	38.3	38.3	38.7	38.8	39.0	39.2	**	0.7
BT	37.8	37.9	38.2	38.2	38.2	38.4	38.6	38.8	38.9	**	0.3
Treatment 2											
HR	56.9	—	67.5	67.6	66.5	65.5	63.6	63.6	61.9	NS	
RR	15.9	—	17.8	17.5	15.4	17.1	16.1	16.4	16.8	NS	
RT	37.9	—	38.2	38.2	38.2	38.4	38.4	38.6	38.7	*	0.7
BT	37.6	—	37.7	37.9	38.0	38.1	38.2	38.3	38.3	**	0.2
Treatment 3											
HR	59.2	68.6	84.8	87.5	87.3	83.2	81.3	78.6	80.3	**	11.4
RR	18.7	20.2	21.5	19.8	19.7	19.1	20.2	20.6	21.3	NS	
RT	38.4	38.3	39.0	38.6	38.5	38.8	38.9	39.0	39.2	**	0.5
BT	38.0	38.0	38.2	38.3	38.3	38.4	38.5	38.6	38.8	**	0.5

OPR: See Table 2. *, **, NS: See Table 3.
HR: Heart rate, RR: Respiration rate, RT: Rumen temp., BT: Body temp.
a): Mean for a 30-min period before feeding.
b): Mean for a 1-hr period after feeding rice straw (Treatment 1) or napiergrass (Treatment 3).

Table 3 shows the physiological variables and Table 4 presents the changes in physiological variables with time after feeding.

Changes in respiration rate caused by feeding were not significant in all treatments though the respiration tended to increase slightly with feed intake.

Heart rate (mean for a 3-hr period after feeding) was significantly higher in the treatment 3 than in the other two treatments, suggesting that green chopped grasses cause high heart rate. Changes in heart rate with feeding were significant in the treatments 1 and 3. Heart rate is largely influenced by the level of feed intake rather than by ambient temperature[11,14,15]. In this experiment, total amount of feed given in the morning was larger in the treatments 1 and 3 than in the treatment 2. The higher rate of heart rate observed in the treatments 1 and 3 seems to be caused by a larger amount of feed intake.

Changes in rumen temperature with feeding were significant in all treatments. The increase in rumen temperature was very small in the treatment 2, while the rumen temperature decreased slightly by grass feeding in the treatment 3.

No clear peak of rumen temperature and heart rate occurred with feed intake in the treatment 2.

Yamamoto et al.[16] showed a close relationship between heart rate and rumen fermentation. Furthermore, Yamamoto and Umezu[17] suggested that high rumen temperature increases blood flow of rumen wall to promote heat exchange in the rumen and the increased blood flow caused an increased heart rate. Accordingly, it is considered that there is a close relationship among rumen fermentation, rumen temperature and heart rate. The fact that no clear peak of rumen temperature and heart rate occurred in the treatment 2 suggests that the fermentation in the rumen proceeded gradually when the oil palm by-product ration alone was fed.

Rumen temperature decreased with grass feeding in the treatment 3. It dropped markedly when cattle was drinking water. It seems that the decrease of it with grass feeding was caused by the same effect as drinking water because of high water content of the grass.

Body temperature tended to increase gradually from morning to evening along with the increase in air temperature. However, body temperature was maintained within a physiologically normal range and no significant increase caused by feed intake was shown by the comparison of the mean body temperature during the 1 hr period after feeding to the value before feeding in all treatments.

Yamamoto and Umezu[14] showed decreased body temperature caused by feeding high moisture corn silage when air temperature was below 25°C. However, no decrease in body temperature was observed after grass feeding in this study although rumen temperature decreased.

Body temperature and heart rate in the treatment 2 were lower than those of the other treatments, and body temperature was below 38.0°C until 13:00. It suggests that metabolic heat production was less when the oil palm by-product ration alone was fed than when rice straw or grass replaced a part of it. However, body temperature in the morning was low in all treatments, suggesting that no buildup of heat in the body occurred due to relatively cool night.

Thus, it can be concluded that the feeding treatments tested in this study are applicable to practical cattle feeding without a risk of heat stress as far as cattle are fed under shade. But further study is needed for calf, lactating cow and cattle not under shade.

2) Digestion trial

The chemical composition of the feeds is shown in Table 5. That of PKC showed no marked difference from the values already reported[2,3]. However, crude fat contents of PPF and POS, 2.3 and 6.3% respectively, are much lower than those reported by Devendra[2,3] but that of PPF is similar to Mohd. Sukri[9]. Such differences might occur due to difference of oil extraction and contamination by broken nut shell.

Crude protein (CP) and crude fiber (CF) contents (% DM) of PKC are similar to those usually reported for alfalfa meal. As the PPF showed the highest CF content and the lowest CP content, it is regarded as a roughage source. The mixture of three by-products, i.e., oil palm by-product ration, contained 13% of CP and 20% of CF. These values meet the recommended nutrient content of rations for growing dairy heifers and bulls or dry pregnant cows suggested by National Research Council (NRC)[10].

Table 6 shows the nutrient intake. It appears that the supply of grass stimulated the intake of oil palm by-product ration in the treatment 3 while some portion of the oil palm by-products and straw remained unconsumed in the treatments 1 and 2. However, there were on significant differences in intake of DM, digestible DM (DDM), organic matter (OM), DOM, CP, digestible crude protein (DCP), total digestible nutrients (TDN), gross energy and digestible energy.

According to Kearl[5], the nutrient require-

Table 5. Chemical composition of feeds

(% DM basis)

Item*	DM	Crude protein	Crude fiber	Crude fat	NFE	Crude ash	Energy (kcal/g DM)
OPR	83.96	13.33	19.96	3.13	53.26	10.32	4.156
PKC	92.86	16.62	25.94	3.53	49.42	4.49	4.330
PPF	92.17	5.02	41.56	2.28	45.54	5.60	4.587
POS	92.96	12.77	20.98	6.33	38.92	21.00	3.835
MRS	92.29	5.19	17.58	0.89	64.48	11.86	3.896
NG	14.11	7.77	35.34	1.90	45.90	9.09	3.999

* See Table 2.

NFE: Nitrogen free extract.

Table 6. Nutrient intake and body weight of cattle in each treatment

Item	Treatment 1	Treatment 2	Treatment 3	Treatment effect	l. s. d. (P < .05)
Total intake (kg)					
Dry matter (DM)	4.58	4.30	4.33	N S	
Oraganic matter (OM)	4.08	3.85	3.90	N S	
Digestible DM	3.05	2.88	2.62	N S	
Digestible OM	2.88	2.71	2.48	N S	
TDN	3.01	2.87	2.61	N S	
Crude protein	0.45	0.57	0.52	N S	
DCP	0.26	0.34	0.27	N S	
GE (Mcal)	18.53	17.86	17.83	N S	
DE (Mcal)	12.65	12.53	10.69	N S	
Nutrient content of the ration (% DM basis)					
TDN	66.09	67.18	60.41	**	3.53
DCP	5.66	7.89	6.22	N S	
Crude fiber	18.94	19.96	23.72	**	0.18
DE (Mcal/kg DM)	2.78	2.96	2.47	N S	
Body weight (kg)	252	262	290	**	15

**, NS: See Table 3.
TDN: Total digestible nutrients. DCP: Digestible crude protein.
GE: Gross energy. DE: Digestible energy.

ment of steer of 250 kg, gaining 250 g/day, is 5.3 kg (2.1% of body weight) of DM, 2.6 kg of TDN and 329 g of DCP. TDN intake shown in Table 6 exceeds that requirement in all treatments although DM intake was below the requirement. DM intake is influenced primarily by body size, energy density of the diet, and rate of digestion or fermentation[5]. In the case of oil palm by-product ration, it seems that large-size cattle can not consume DM up to a level shown by the requirement because of low digestibility and palatability of PPF. Furthermore, DM intake as percent of body weight will gradually decrease as the animal increases in size. Therefore, it is necessary to increase energy density of the diet for the cattle of bigger size or that getting daily gain more than 250 g or lactating cows. TDN concentration in the ration DM was significantly higher in the treatments 1 and 2 than in the treatment 3. The low TDN concentration in the treatment 3 was caused by low OM digestibility of napiergrass (42%) which was estimated by the data from the treatments 2 and 3.

DCP intake in the treatments 1 and 3 was below the requirement, because of low CP content of rice straw and grass. As the actual DM intake of rice straw or grass as percent of total DM intake was about 25% in this study, the upper limit of replacement by rice straw or grass for the oil palm by-product ration should be 25% of total DM of the ration. And also CP content of the ration should be increased by adding more urea or increasing PKC or POS content.

According to NRC standard[10], recommended TDN content of rations for growing dairy heifers and bulls was 60%. All the rations used in this study meet the recommended TDN content[10], particularly TDN of the ration in the treatment 3 was slightly over the recommendation[10].

NRC[10] also suggests the necessity of roughage of proper quantity and physical form to maintain normal milk fat percentage, to prevent displaced abomasum, and possibly to help controlling of other postcalving disorders. The minimum CF level of 15% of ration DM is advised for growing dairy heifers and bulls. The CF level in all the treatments was higher than 18%, exceeding the requirement for lactating cows.

The recommended CP content is 12% for growing heifers and bulls[10]. As the CP content (DM basis) of the ration in the treatments 1, 2 and 3 was 9.8, 13.3 and 12.0% respectively, only the ration in the treatment 1 was below the requirement. But DCP intake in the treatments 1 and 3 was below the requirement, indicating that some improvement of CP content is needed when rice straw or grass is used.

TDN and DCP contents of the oil palm by-product ration were above the NRC requirements[10], but intake and digestibility of nutrients, especially fiber fraction, were not very good. As feed intake and digestion capacity of the ruminant is limited by the rate of feed removal from the rumen[13], one of the main factors limiting intake of poor quality roughage, such as straw, palm press fiber, and so on, is the low digestibility in the rumen and slow rate of passage. Hence, it is important to improve the fiber digestibility for improving the intake of oil palm by-product ration.

Summary

The feeding value of oil palm by-product composed of palm press fiber, palm kernel cake and palm oil sludge was studied by determining the digestibility, nutrient intake and physiological responses to three different feeding treatments, using three fistulated Kedah-Kelantan cattle.

In the treatment 1, oil palm by-product ration and rice straw with molasses was used. In the treatment 2, oil palm by-product ration alone was used, and in the treatment 3 napiergrass replaced a part of oil palm by-product ration. The amount of rice straw or grass offered was planned to replace 30% of the total dry matter intake. The results are as follows:

1) The three feeding treatments tested in this study can be applied to Kedah-Kelantan cattle without a risk of heat stress as far as they are fed under shade. Further study must be made for calf, lactating cows and cattle not under shade from the standpoint of feeding and environmental physiology.

2) Intake of total digestible nutrients observed in all the treatments exceeded the requirement for steer of 250 kg, gaining 250 g/day, but digestible crude protein intake was higher than the requirement only in the treatment 2. The oil palm by-product ration meets the total digestible nutrients, digestible crude protein and crude fiber contents of rations for dairy cattle recommended by NRC.

3) Napiergrass feeding seemed to stimulate the intake of oil palm by-product ration but the result suggested that the upper limit of replacement should be 25% of total dry matter of the ration. The upper limit of rice straw also should be 25%.

4) The oil palm by-product ration is a good ration for the cattle weighing approximately 250 kg. But it is required to increase the nutrient content for applying it to the cattle of bigger size or lactating cows, i.e. the cattle of higher nutrient requirements.

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(Received for publication, March 9, 1987)