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Palatability, Digestibility and Voluntary Intake of Processed Oil Palm Fronds in Cattle

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Abstract

Preference tests and digestion trials of 4 different types of fronds of oil palm (*Elaeis guineensis* Jacq.), i.e. oven-dried form, pellets, silage and sodium hydroxide (NaOH)-treated silage, were carried out to analyze the influence of processing methods on the palatability, digestibility and voluntary intake in cattle. These processed oil palm fronds (OPFs) for digestion trials at maintenance level or under *ad libitum* feeding were mixed with a basal ration, mainly composed of palm kernel cake and fed to Kedah-Kelantan cross cattle. The digestibility of OPFs *per se* was calculated from the digestibility of the mixed ration and that of the basal ration. The results were as follows; the digestibility of OPF pellets was considerably lower than that of the other types of processed OPFs. However, OPF pellets had a high palatability and the dry matter intake (DMI) of the mixed ration, which includes OPF pellets, was higher than that of the other types of processed OPFs. These findings suggest that OPF pellets could be utilized as a silage additive to increase the dry matter content of crops with a high moisture level. The digestibility and DMI of ensiling OPFs were equivalent to those of oven-dried OPFs and the palatability of ensiling OPFs was high. Ensiling is the most suitable method to preserve OPFs at a low cost and can be recommended to farmers. NaOH-treated silage had a higher digestible DMI than the other types of processed OPFs, although it had a low palatability. It was confirmed that alkali treatment can effectively improve the nutritive value of OPFs. Therefore, introducing alkali treatment to the production of processed OPFs should be promoted if a safe and cost-effective method is to be developed.

Discipline: Animal industry
Additional key words: agro-industrial by-products, silage, sodium hydroxide treatment

Introduction

Oil palm fronds (OPFs) are one of the most abundant agro-industrial by-products available in Malaysia. Almost all of the pruned fronds are discarded on the plantation. A series of studies to utilize OPFs as feed for ruminants were conducted during a collaborative project between the Malaysian Agricultural Research and Development Institute (MARDI) and the Tropical Agriculture Research Center (Presently: Japan International Research Center for Agricultural Sciences). Chemical analysis revealed that OPFs were composed of approximately 70% fiber and contained about 20% soluble

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carbohydrates[4]. OPF silage with a good quality can be prepared without any additives[2]. The digestibility data of OPF silage by cattle indicated that the nutritive value of OPFs was equivalent to that of rice straw[5]. These results showed that OPFs have a potential to be utilized as a roughage source or as a component in compound feed for ruminants. However, optimal utilization and practical processing methods for OPFs are required for commercialization as a ruminant feed. Pelletizing is considered to be one of the practical methods for distribution and storage of OPFs. Sodium hydroxide (NaOH) treatment has also been found to be a suitable technique for improving OPF quality[10]. Thus, this study was carried out to analyze the palatability, digestibility and voluntary intake of 4 different types of processed OPFs, i.e. oven-dried form, pellets, silage and NaOH-treated silage.

Materials and methods

1) Sampling and processing of OPFs

The OPFs used in this experiment were collected from the University Putra Malaysia farm. The materials were transported to the feed plant in MARDI, Serdang, immediately after pruning. The OPFs were chopped with an engine-driven chopper to a length of 1 cm, approximately. The chopped materials were then subjected to 4 treatments as follows: dried OPFs, OPFs were chopped twice before oven-drying; OPF pellets, after oven-drying, OPFs were ground and compacted into pellets 12 mm in diameter; OPF silage, freshly chopped OPFs were stored in 100 L drums for 1 month; NaOH-treated OPF silage, freshly chopped OPFs were stored in 100 L drums after mixing with 15 kg of 10% NaOH solution and 100 kg of fresh OPFs. These 4 types of processed OPFs were used for the preference tests and digestion trials in cattle.

2) Chemical analysis

Dry matter (DM) content was determined by drying at 105ºC and crude ash (ASH) content by heating at 600ºC. Crude protein (CP) and ether extracts (EE) contents were determined by the Kjeldahl method and Soxlet method, respectively. Organic cell wall (OCW) content was determined by the method of Abe et al.[1]. The silage pH value was determined with a glass electrode.

3) Preference test

Sixteen Kedah-Kelantan (KK) cross calves, weighing approximately 160 kg and kept in individual pens, were used in this preference test, but 5 of the 16 calves did not respond to the test. For this reason, the test was conducted with 11 calves. Two out of the 4 types of processed OPFs were introduced to each animal at the same time and the palatability was determined based on their preference. When a certain type of processed OPFs was chosen by the animals similarly after replacing the position of the bucket including the OPFs on either side, it was estimated that the animal preferred a certain type of processed OPFs to the compared OPFs. The order of palatability was determined based on the total number of calves preferring each type of processed OPFs to the compared OPFs. For example, in the case of OPF pellets, 3 combination trials (OPF pellets vs. dried OPFs, OPF pellets vs. OPF silage, OPF pellets vs. NaOH-treated OPF silage) were conducted and the total number of animals preferring OPF pellets in these combination trials was determined.

4) Digestion trial at maintenance level

Each type of processed OPFs was mixed with the basal ration before being given to the animals. The basal ration consisted of 50% palm kernel cake, 20% palm oil mill effluents, 16% tapioca waste (dry), 10% rice bran, 2% mineral vitamin mixture, 1% salt and 1% urea. Each type of processed OPFs was mixed with the basal ration at 40% on a DM basis. The same 16 KK cross calves as those used in the preference tests, were subjected to the trials. Three or 4 animals were used to measure the apparent DM digestibility of each ration by the total feces collection method. The experiment consisted of an initial ten-day adaptation period and a five-day measurement period. The animals were offered 2.3 kg of the mixed ration on a DM basis twice a day (9:00 am and 4:00 pm). Besides these trials, the digestibility of the mixed ration containing 60% OPF pellets was conducted to determine the digestibility of the basal ration by the same procedures.

5) Digestion trial under ad libitum *feeding*

Voluntary DM intake (DMI) and apparent DM digestibility under *ad libitum* feeding were determined using the same calves as those subjected to the preference tests and the digestion trials at maintenance levels. The duration of the experiment was as follows; initial six-day adjustment period and three-day measurement period. Other experimental procedures were similar to those adopted in the digestion trials at maintenance levels, except for the *ad libitum* feeding level.

6) Statistical analysis

The data for digestibility and intake were subjected to the analysis of variance. Significant differences between means were assessed by least significant difference tests when significant F values were observed.

Table 1. Chemical composition of processed oil palm fronds (OPFs) and basal ration

Item	DM	CP[a)]	EE[b)]	OCW[c)]	ASH
	(%)	(%DM)			
Dried OPFs	86.8	4.9	1.7	79.5	5.0
OPF pellets	87.5	4.3	1.8	81.1	5.5
OPF silage	30.2	4.7	1.7	80.4	4.9
NaOH-OPF[d)]	28.1	4.8	1.7	73.3	10.2
Palm kernel cake	88.3	14.6	2.8	65.3	5.1
Palm oil mill effluents	94.2	10.1	11.3	30.5	35.7
Tapioca waste	87.0	1.9	0.2	33.2	4.2
Rice bran	89.0	11.0	10.7	18.7	5.0

a): Crude protein, b): Ether extracts, c): Organic cell wall, d): Sodium hydroxide-treated silage.

Results

1) Chemical composition

The pH value of OPF silage and NaOH-treated OPF silage was 3.62 and 5.74, respectively. The chemical composition of the processed OPFs and the basal ration are shown in Table 1. All the types of OPFs showed almost similar CP and EE contents. However, NaOH-treated OPF silage had a lower OCW and higher ASH content than the other types of processed OPFs.

2) Palatability of processed OPFs

The results of the preference tests are shown in Table 2. Total number of animals which preferred dried OPFs, OPF pellets, OPF silage, and NaOH-treated OPF silage to the compared OPFs, was 15.5, 24, 23.5 and 3, respectively. OPF pellets were most preferred by the calves. OPF silage also showed a high palatability. On the other hand, most of the calves did not select NaOH-treated OPF silage. These results indicated that the palatability order of processed OPFs was as follows; OPF pellets > OPF silage > dried OPFs > NaOH-treated OPF silage.

3) DM digestibility at maintenance level

DM digestibility of the OPF rations at maintenance level is shown in Fig. 1-A. The mixed rations of dried OPFs, OPF pellets and OPF silage displayed a similar DM digestibility (dried OPFs: 57.7%, OPF pellets: 55.7%, OPF silage: 58.7%). Mixed ration of NaOH-treated OPF silage had a significantly ($P<0.05$) higher DM digestibility (63.0%) than the other mixed rations.

The DM digestibility of the mixed ration of 60% OPF pellets was 47.4%. The DM digestibility of the basal ration, calculated by the difference in the digestibility of the mixed ration of 40% and 60% OPF pellets, was 69.5%. The value was used for estimating the digestibility of each type of processed OPFs *per se*, as shown in Fig. 1-A. The DM digestibility of OPF pellets *per se* (34.7%) tended to be lower than that of the other types of processed OPFs (dried OPFs: 39.8%, OPF silage: 42.6%). On the other hand, the DM digestibility of NaOH-treated OPF silage *per se* (54.0%) was significantly ($P<0.05$) higher than that of the other types of processed OPFs.

Table 2. Effect of processing methods on the palatability of oil palm fronds (OPFs)

Item	OPFs				Total
	Dried	Pellets	Silage	NaOH-S[a)]	
Dried	–	3	2.5[b)]	10	15.5
Pellets	8	–	7	9	24
Silage	8.5[b)]	4	–	11	23.5
NaOH-S	1	2	0	–	3

a): Sodium hydroxide-treated silage,
b): One cattle could not select dried OPFs or OPF silage.
Values refer to the number of cattle which chose a particular OPF against the compared OPFs (See text).

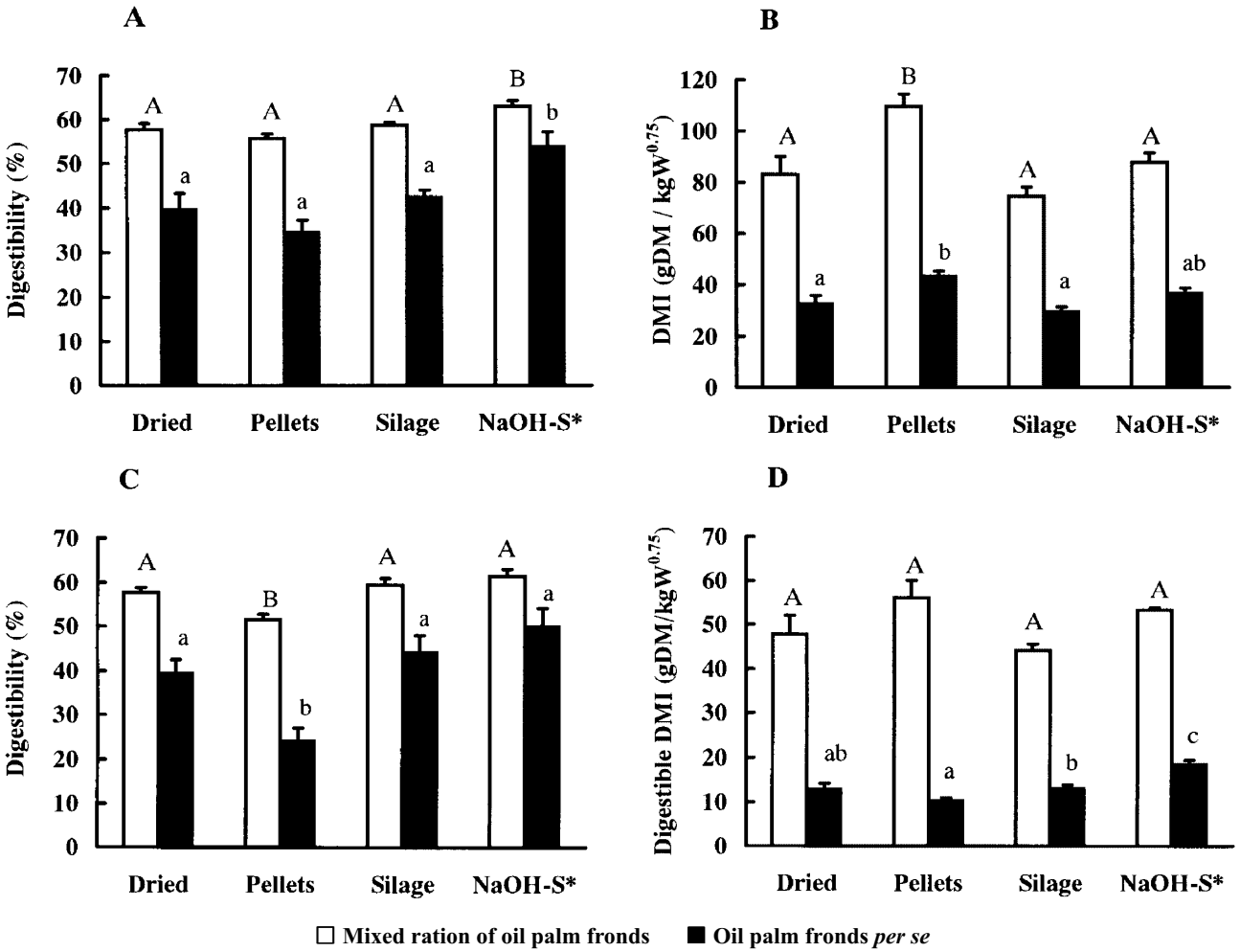

Fig. 1.

A: Effect of processing methods on DM digestibility of mixed ration of oil palm fronds and oil palm fronds *per se* at maintenance level

B: Effect of processing methods on DMI of mixed ration of oil palm fronds and oil palm fronds *per se* under *ad libitum* feeding

C: Effect of processing methods on DM digestibility of mixed ration of oil palm fronds and oil palm fronds *per se* under *ad libitum* feeding

D: Effect of processing methods on digestible DMI of mixed ration of oil palm fronds and oil palm fronds *per se* under *ad libitum* feeding

A,B: Values with different super scripts are significantly different at $P<0.05$.

a,b,c: Values with different super scripts are significantly different at $P<0.05$.

Means of 3 or 4 cattle with standard errors. *: Sodium hydroxide-treated silage.

4) DMI and DM digestibility under ad libitum *feeding*

DMI (gDM / $kgW^{0.75}$) of processed OPFs under *ad libitum* feeding is shown in Fig. 1-B. The DMI of the mixed ration of OPF pellets (109.5 g) was significantly ($P<0.05$) higher than that of the other types of processed OPFs (dried OPFs: 83.0 g, OPF silage: 74.6 g, NaOH-treated OPF silage: 87.7 g). The DMI of OPF pellets *per se* (43.4 g) was significantly ($P<0.05$) higher than that of dried OPFs (33.0 g) and OPF silage (30.0 g).

DM digestibility of OPF rations under *ad libitum* feeding is shown in Fig. 1-C. The DM digestibility of the mixed rations of OPF pellets (51.6%) was significantly ($P<0.05$) lower than that of the other types of processed OPFs (dried OPFs: 57.6%, OPF silage: 59.4%, NaOH-treated OPF silage: 61.4%). The DM digestibility of OPF pellets *per se* (24.3%) was also significantly ($P<0.05$) lower than that of the other types of processed OPFs (dried OPFs: 39.6%, OPF silage: 44.4%, NaOH-treated OPF silage: 50.2%).

Digestible DMI (gDM / $kgW^{0.75}$) of OPF rations under *ad libitum* feeding is shown in Fig. 1-D. The digestible DMI of the mixed rations of OPF pellets (56.1

g) tended to be higher than that of dried OPFs (47.8 g) and OPF silage (44.2 g). The digestible DMI of the mixed rations of OPF pellets and NaOH-treated OPF silage (53.3 g) was almost identical. However, the digestible DMI of OPF pellets *per se* (10.5 g) tended to be lower than that of dried OPFs (13.1 g, $P>0.05$) and OPF silage (13.3 g, $P<0.05$). On the other hand, the digestible DMI of NaOH-treated OPF silage *per se* (18.6 g) was significantly ($P<0.05$) higher than that of the other types of processed OPFs.

Discussion

It has been suggested that voluntary intake of roughage is related to the amount of digesta in the reticulorumen, which is a function of the rate of digestion of feed particles and their rate of passage out of the rumen[8]. Poppi et al.[11] observed a continuous rise in the resistance to feed particles leaving the rumen as the particle size increased. Grinding of OPFs reduced the size of feed particles and increased the probability of particles escaping from the rumen. Short retention time in the rumen depressed the digestibility of OPF pellets considerably. Grinding of OPFs resulted in a faster passage of feed through the rumen, which decreased the digestibility. On the other hand, the DMI of the mixed rations of OPF pellets was higher than that of dried OPFs and OPF silage. The rumen retention time of OPF pellets should be shorter to allow the stimulation of voluntary intake. In the present study, the higher intake of the mixed ration, which included OPF pellets, compensated for the low digestibility of OPF pellets *per se*. In addition, the palatability of OPF pellets was superior to that of the other types of processed OPFs. These results suggest that OPF pellets can be utilized as a component of mixed diets to adjust the moisture content, especially it could be utilized as a silage additive to increase the DM content of crops or by-products with a high moisture level. Taking account of the nutritive value or fiber effectiveness, the grinding process of pelletizing should be avoided to prevent the decrease of digestibility. It would be more suitable for ruminant feed to maintain a longer chop length, for example in the form of a cube or wafer.

The low pH value of OPF silage suggested that silage fermentation was dominated by lactic acid bacteria. OPFs contained about 20% soluble carbohydrates, the high content of which secured lactic acid fermentation of OPFs[6]. McDonald[7] indicated that if the lactic acid bacteria had been dominant, nutrient losses during fermentation would have been considerably lower. As such, the proximate composition and digestibility of good-quality silage is similar to that of fresh material. It is suggested that nutrient losses during the ensiling process of OPFs were very low and OPF silage had a similar digestibility to that of the artificially dried form (dried OPFs). On the other hand, high contents of specific primary fermentation acids like lactic acid can limit the intake[12]. In the present study, DMI of OPF silage was not lower than that of dried OPFs. These results indicate that silage fermentation of OPFs did not decrease the nutrient content or the palatability of OPFs. Therefore, ensiling is the most suitable method to preserve OPFs at a low cost and can be recommended to Malaysian farmers.

Numerous studies have demonstrated the effectiveness of NaOH treatment in improving the digestibility of low-quality forages[3] and Oshio et al.[9] reported that NaOH treatment of OPFs increased the digestibility. Based on these findings, the digestibility of NaOH-treated OPF silage is expected to be higher than that of the other types of processed OPFs. In the present study, decreasing the cell wall content and increasing the DM digestibility by NaOH treatment might have contributed to the higher DMI of NaOH-treated OPF silage compared with the other types of processed OPFs. Therefore, it was confirmed that alkali treatment can effectively improve the nutritive value of OPFs and introducing alkali treatment to the production of processed OPFs should be promoted. NaOH-treated OPF silage produced a sufficient amount of acid to neutralize the alkali during storage in the drums. However, the pH value exceeded 4.2, which is considered to be a critical value for the stability of silage fermentation[12]. It is suggested that the low fermentation quality decreased the palatability of NaOH-treated OPF silage. Further investigations should be carried out to study the effect of NaOH treatment on the silage palatability, and since the chemical is caustic and dangerous, a safer procedure for treatment and a more cost-effective method should be developed.

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