Fibre degradability of oil palm frond pellet, supplemented with *Arachis pintoi* in cattle

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Abstract

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Songklanakarin J Sci Technol 2002, 24(2) : 209-216

An experiment was conducted to evaluate the effect of different levels of *Arachis pintoi* (AP) supplementation on rumen environment [(rumen pH, ruminal ammonia nitrogen (NH_3N) and volatile fatty acids (VFAs) concentration)] and degradability of oil palm frond (OPF). Three Kedah-Kelantan (KK) cattle of about $2\frac{1}{2}$ years of age with an average body weight (BW)173±17.2 kg, each fitted with a ruminal cannula, were used. The cattle were kept in individual pens and fed the treatment diets at 1.5% of BW. The diets comprised the following four OPF:AP ratios; 80:20 (L20), 70:30 (L30), 60:40 (L40), 50:50 (L50) in a 4×4 incomplete Latin Square Design. The DM an NDF degradation rates of OPF were significantly affected by AP supplementation. Ruminal pH was not significantly different (p>0.05) among the four different diets. The concentration of NH_3N was significantly (p<0.05) higher in cattle fed L50 than those in L40, L30 and L20. Similarly, increasing levels of AP supplementation significantly increased the total VFAs concentration from 59.9 mmol/L for L20 to 69.2 mmol/L for L50. It is suggested that AP can be used as a protein supplement to improve fibre degradability of OPF in cattle.

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การย่อยได้ของเยื่อใยทางใบปาล์มน้ำมันที่เสริมด้วยถั่วลิสงเถาในโค

ว. สงขลานครินทร์ วทท. 2545 24(2) : 209-216

การศึกษาครั้งนี้ มีจุดประสงค์ที่จะศึกษาระดับของการเสริม ถั่วลิสงเถา (*Arachis pintoi* , AP) ที่มีผลต่อ (1) สภาพความเป็นกรด-ด่าง (2) ระดับความเข้มข้นของแอมโมเนียไนโตรเจน (3)ความเข้มข้นของกรดไขมันที่ระเหย ง่ายในกระเพาะรูเมน และ (4) การย่อยได้ของทางใบปาล์มน้ำมันอัดเม็ด (oil palm frond, OPF) โดยใช้โคพื้นเมือง พันธุ์เคดะห์ กะลันตัน (KK) จำนวน 3 ตัว อายุประมาณ 2 $^1/_2$ ปี มีน้ำหนักเฉลี่ย 173±17.2 กก. ที่ได้รับการผ่าตัด ฝังท่อที่กระเพาะรูเมนและมีสภาพสมบูรณ์ โคทดลองได้รับอาหารที่มีอัตราส่วนของ OPF ต่อ AP แตกต่างกัน คือ 80:20(L20), 70:30(L30), 60:40(L40) และ 50:50(L50) ในปริมาณ 1.5 % ของน้ำหนักตัว ตามแผนการทดลอง แบบ 4×4 จตุรัสลาตินไม่สมบูรณ์ จากการศึกษาพบว่า การเสริมถั่วลิสงเถามีผลต่อการย่อยได้ของวัตถุแห้งและผนังเซลล์ ของ OPF อย่างมีนัยสำคัญทางสถิติ (p<0.05) แต่ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติต่อความเป็นกรดเป็น ด่างในกระเพาะรูเมน (p>0.05) ที่ระดับ L50 ของการเสริมด้วยถั่วลิสงเถาพบว่าปริมาณความเข้มข้นของแอมโมเนีย ไนโตรเจนให้ค่าสูงกว่าที่ระดับของการเสริม L40, L30 และ L20 อย่างมีนัยสำคัญทางสถิติตามลำดับ ระดับความ เข้มข้นของกรดไขมันที่ระเหยง่ายทั้งหมดในกระเพาะหมักเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ (p<0.05) ตามระดับของ การเสริมด้วยถั่วลิสงเถา จาก 59.9 mmol/L ในระดับ L20 เป็น 69.2 mmol/L ในระดับ L50 จากการศึกษาในครั้งนี้ พอจะกล่าวได้ว่าถั่วลิสงเถาสามารถใช้เป็นโปรตีนเสริมเพื่อช่วยในการย่อยเยื่อใยของทางใบปาล์มน้ำมันอัดเม็ดในโคได้

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The benefits of using legumes supplementation to improve animal productivity fed poor quality feed have been well documented (Brewbaker, 1986; Reed *et al*. 1990; Muinga *et al*.,1995 and Norton, 1994). The species of *Arachis pintoi* has been given research priority in many tropical countries because of its value as forage (Cook *et al*. 1993), easy establishment, persistence and and its ability to combine well in mixture with a wide range of climate and soil conditions even under heavy grazing (Stur and Ndikamana, 1993). Recently, *Arachis pintoi* has been shown to be a potential feed for ruminants according to its high crude protein (CP) content (18%) and rapid degradation in the rumen (Khamseekhiew *et al*., 2001).

Agricultural by-products such as oil palm frond (OPF) and others have been shown to be available roughage feeds for ruminant animals. However, their low N and high fibre contents are the main factors limiting their digestibility and intake by ruminants. Abu Hassan (1996) reported that animal performance is affected when the content of OPF in the ration is more than 60%. It is commonly suggested that legume supplementation of up to 30% in low quality diet could improve animal performance (Preston and Leng, 1987). Until recently, the degradability of OPF and its rumen characteristic supplemented with *Arachis pintoi* in cattle had not been evaluated. Therefore, there is a need to investigate the effects of various levels of *Arachis pintoi* supplementation which would optimise the degradability and efficiency of OPF utilisation by cattle. The objective of this study was to compare the different levels of *Arachis pintoi* supplementation for improving rumen environments, (using rumen pH, ruminal ammonia and volatile fatty acids (VFA) concentration as indices) and their effect on dry

matter (DM) and neutral detergent fibre (NDF) degradability of OPF.

Materials and Methods

Arachis pintoi were harvested at about 6 weeks old from Research Farms of the Malaysian Agricultural Research and Development Institute (MARDI). Shoot samples of about 30 cm from the growing points of the plants were cut and sun dried for 2 days. Oil palm frond pellets were obtained from MARDI Serdang Research Station and oven dried at 60 °C for 48 h, ground through 2-mm screen sieve and stored for subsequent testing.

Animals and feeding

Three Kedah-Kelantan (KK) cattle of about $2\frac{1}{2}$ years of age with an average body weight (BW) 173±17.2 kg, each fitted with a ruminal cannulae were used in the study. They were kept in individual pens and fed the treatment diets at 1.5% dry matter (DM) of BW. The diets consisted of the following four OPF: *Arachis pintoi* ratios; 80:20 (L20),70:30 (L30), 60:40 (L40), 50:50 (L50) in a 4×4 incomplete Latin Square design (Table 1) (Upadisskul, 1983).

Table 1. Experimental design showing the various feeding treatments in the 4 experimental periods.

Animal	Treatment diet (OPF:*Arachis pintoi*)			
	Period 1	**Period 2**	**Period 3**	**Period 4**
1	L40	L30	L20	L50
2	L20	L40	L50	L30
3	L50	L20	L30	L40

The daily rations were offered to the cattle in two equal portions, one at 09:00 h and the other at 16:30 h during the experiment. The experiment was conducted over a period of 11 days, which consisted of 7 days of adaptation, and 4 days of measurement. Drinking water was freely available to the animals throughout the experiment.

Dry matter and neutral detergent fibre degradations

Dry matter and NDF degradations of OPF in the rumen were examined using the *in sacco* procedure of Ørskov and McDonald (1979). Nylon bags of 6 cm × 10 cm with pore size of 40 μm were filled with 5 g of ground OPF and incubated in duplicates in the rumen of each animal for 0, 4, 8, 16, 24, 48 and 72 h. Following the specific incubation periods, the bag were removed, washed in a washing machine for 10 min. and dried in an oven at 60° C for 48 h. Bags for 0 h were not incubated, but were washed in similar manner and dried and used to estimate washing loss.

Rumen fluid collection

On the last day (day 11) of each period, rumen fluids from each animal were collected at 0, 2, 4, 6 h after the morning feeding. Rumen pH was determined immediately after sampling by using a pH meter. The rumen fluid was preserved by adding 20 ml of 24% meta-phosphoric acid in 12 M sulphuric acid and later stored at -20° C pending analysis of volatile fatty acids (VFAs) and ammonia nitrogen (NH_3N) concentrations.

Chemical analysis

Dry matter and Kjedahl-N of AP and OPF were determined by the AOAC (1984). Neutral detergent fibre of OPF samples from the nylon bags were determined according to the methods described by Goering and Van Soest, (1970). Thawed samples were centrifuged at 1,800 g for 20 min. and clear supernatants were used for NH_3N analysis. The concentration of NH_3H of the rumen fluid samples was determined by direct distillation with sodium tetra-borate (NaB_4O_7) and filtration was done by an automatic N analyzer (AOAC, 1984). Volatile fatty acids from each sample of rumen fluid were analysed by the method of Minato and Kudo referred to by Jetana *et al*. (1996). All the above analyses were done in duplicates.

Data and statistical analysis

The DM and NDF degradation of samples

were fitted with the exponential equation of Ørskov and McDonald (1979) and McDonald, (1981) to calculate rate and extent of rumen degradation. The equation used was

$$P = A+B (1-e^{-ct}) \, ,$$

where ; P = actual degradation at time t ,

A = washing loss,

B = the insoluble but potential degradable material in time t and defined as B = (A+B)-A,

A+B = the potential degradability,

c = the rate of degradation of B and constant in the equation of log phase (L).

L = 1/c log e [B/(A+B)-A] (Ørskov and Ryle, 1990 and Kibon and Ørskov, 1993). The effective degradability (%), where fraction out flow rate (k) is accounted for its effect on degradability, and the three out flow rates of 0.02, 0.05 and 0.08 per h were also estimated by the equation of Ørskov and McDonald (1979).

The parameters measured in the degradability studies were calculated using the NEWAY computer program. The mean of each parameter measured: ruminal DM and NDF degradability, pH, VFAs and NH_3N, were analysed by analysis of variance (ANOVA) techniques according to the General Linear Model (GLM) procedure of the Statistical Analysis System Institute (SAS, 1998). The differences between treatment means were tested using the least significant difference method (LSD) (Gomez and Gomez, 1984).

Results and Discussion

DM and NDF degradations

Chemical composition of *Arachis pintoi* and OPF are presented in Table 2. The *in sacco* DM degradation rates of OPF as affected by *Arachis pintoi* supplementation are presented in Table 3. The DM washing loss (A) of the test material was 17.2%. Degradability of water insoluble fraction (B) of OPF supplemented at L50 was significantly higher (p<0.05) than those of L30, L40 and L20. Although DM potential degradability of OPF increased significantly with increased *Arachis pintoi* supplementation, the improvement

Table 2. Chemical composition of *Arachis pintoi* and oil palm frond (OPF) (% DM basis).

Components	*Arachis pintoi*	Oil Palm Frond
Organic matter	93.9	94.7
Crude protein	18.1	6.25
Neutral detergent fibre	40.8	67.6
Acid detergent fibre	26.2	45.5
Lignin	20.6	26.6
Tannin	2.0	8.5
Ash	606	5.3
Energy (cal/g)	4,105	4,197

was only 4.4% unit from 38.4% in the 20% supplementation (L20) to 42.8% in the 50% supplementation (L50).

The insoluble but potentially degradable fraction (B) of NDF was not affected by the various treatment levels. The potential degradable fraction (A+B) of NDF was also low, with the highest value of 34.5% recorded for L40 (Table 3). The results of the present study conform with those reported by Islam, (1999) who reported that higher NDF in the whole OPF than those for the leaflet, petiole and midrib, which showed lower degradability values. The low degradability of OPF is believed to be due to its fibre constituents, particularly cell wall (NDF) content. Van Eys *et al*., (1986); Ahn, (1990) and Vadiveloo and Fadel, (1992) reported that cell wall of tropical feed was generally rich in cellulose and hemicellulose.
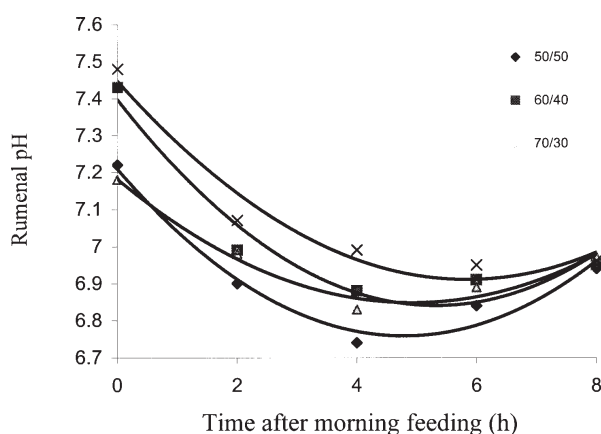
Rumen pH

The effects of the different levels of *Arachis pintoi* supplementation on ruminal pH after morning feeding are shown in Figure 1. Ruminal pH did not differ significantly at all levels of OPF and *Arachis pintoi* combinations at different time after feeding. The values declined gradually after feeding and reached the lowest levels between 4 to 6 h post feeding. However, the drop in ruminal pH was small and remained within the range of 6.8 to 7.0 . This agrees with the statement of Islam, (1999) who used an OPF diet supplemented with three levels of concentrates (40, 50, and

Table 3. **Dry matter (DM) and NDF degradability of oil palm frond (OPF) as affected by different levels of legume supplementation in OPF based diet.**

Items	Level of *Arachis pintoi* Supplementation (%)			
	20(L20)	**30(L30)**	**40(L40)**	**50(L50)**
DM degradability parameter (%)				
A	17.2	17.2	17.2	17.2
B	21.5 [c]	24.6 [b]	24.6 [b]	25.3 [a]
A+B	38.5 [c]	41.3 [b]	41.9 [ab]	42.6 [a]
c	38.4 [c]	41.7 [b]	41.8 [b]	42.8 [a]
Effective degradability (%)				
Outflow rate				
0.02	32.2	32.1	32.5	34.4
0.05	27.2	26.5	26.5	28.5
0.08	24.6	24.0	23.7	25.5
NDF degradability parameter (%)				
A	3.2	3.2	3.2	3.2
B	26.9	31.1	31.3	29.1
A+B	29.1 [c]	34.3 [a]	34.5 [a]	32.3 [b]
c	26.9 [c]	34.2 [a]	34.4 [a]	32.5 [b]
Effective degradability (%)				
Outflow rate				
0.02	18.6	22.0	22.4	21.6
0.05	12.5	15.0	14.9	14.2
0.08	9.4	11.8	11.3	10.5

A   = washing loss;   **B** = the insoluble but potentially degradable material in time t;
A+B = the potential degradability and **c** = the rate of degradation of B.
[a, b, c]   = Means in the same row with different subscripts are different significantly (p<0.05).

Figure 1. Changes of ruminal pH after morning feeding as affected by vari levels of *Arachis pintoi* supplementation in an OPF based diet.

60 %).   However, the rumen pH of all time of sampling of the three tested diets ranged between 6.82 to 7.74. The high pH recorded in this study seem to suggest that the rumen environments were conduciced to cellulolytic bacteria fermentation. It could also be due to the low VFAs production from the highly indigestible OPF-based diet.

Ruminal NH$_3$N

The average NH$_3$N production in the rumen fluid of cattle fed various levels of *Arachis pintoi* is shown in Table 4. The maximum NH$_3$N production occurred 2 h post feeding in the morning and gradually declined thereafter until the next feeding 6 h later. This result was similar to those reported for sheep (Jetana *et al*.,1998) and buffaloes (Wanapat and Pimpa, 1998) under tropical

Table 4. The mean value of ruminal pH, molar proportion (%) of volatile fatty acids (VFAs) and total VFAs in cattle fed four combinations of OPF and *Arachis pintoi* in KK cattle.

Items	Level of *Arachis pintoi* Supplementation (%)				
	20(L20)	30(L30)	40(L40)	50(L50)	SEM
NH$_3$N (mg-N/L)	43.6 [a]	74.2 [b]	88.9 [c]	91.9 [d]	0.05
Molar proportions of VFA (%)					
Acetate	78.6	78.7	77.6	78.1	0.06
Propionate	19.4	19.5	19.1	19.7	0.02
Butyrate	1.2 [a]	1.5 [ab]	3.1 [c]	2.0 [b]	0.03
Other	1.1 [a]	1.4 [b]	2.2 [c]	1.6 [a]	0.01
Acetate:Propionate	4.1	4.0	4.1	4.0	-
Total VFA (mmol/L)	50.9 [a]	59.12 [b]	63.7 [c]	69.2 [d]	0.04

[a, b, c, d] **: Means in the same row with different subscripts are different significantly ($p < 0.05$).**

SEM : Standard error of the mean.

environment. As ammonia (NH$_3$) is the primary source of N for rumen microbes, any increase in rumen NH$_3$ will stimulate microbial growth. There is considerable evidence to suggest that the optimum concentration of rumen NH$_3$N, at which microbial growth is maximal, varies with quality and type of diet. Satter and Slyter (1974) indicated that the optimum concentration of rumen NH$_3$N for maximum bacterial growth was between 50 to 80 mg N/l of rumen fluid. The positive response of *Arachis pintoi* supplement could, therefore, be due to the fact that it provided valuable NH$_3$N to enhance efficient microbial growth (Hungate, 1966; Leng and Nolan, 1984 and Balcells, 1993) and perhaps to some extent amino acids which could assist in significantly higher ruminal DM and NDF degradations. The results of NH$_3$N production in the present and published studies, indicate that a minimum level of 40% *Arachis pintoi* supplementation is required to effectively improve the utilisation of OPF-based diets.

Rumen VFAs

The average rumen VFAs production after morning feeding for the different treatments is presented in Table 4. Increasing levels of *Arachis pintoi* supplementation significantly (p<0.05) in-

creased the total VFAs from 50.9 mmol/L for L20 to 69.2 mmol/L for L50. Preston (1986) and McDonald *et al*. (1995) reported that total VFAs is positively related to fermentation rate. This relationship was also demonstrated in the results of present study where these parameters (rumen VFAs concentration and fermentation rates) increased proportionally with increasing levels of *Arachis pintoi* supplementation (Table 4). The above observation is attributed to the fact that increased rumen NH$_3$N concentration could have provided an increased quantity of soluble N and amino acids necessary for microbial protein synthesis and growth. An increased microbial population, particularly under the pH of 6.8 to 7.2 (Figure 1) could have enhanced cellulolytic fermentation of OPF as observed.

Conclusion

Rumen NH$_3$N and VFAs concentrations were significantly increased with increased levels of *Arachis pintoi* supplementation in an OPF-based diet. As a result of the above effects, fibre (OPF) digestion was increased. The results of the present study, indicate that a minimum level of 40% *Arachis pintoi* supplementation is required

to increased the ruminal NH$_3$N close to 100 mg N/L, the level which is generally suggested as the minimal level for efficient microbial production, and hence effective digestion of feed materials. In conclusion, *Arachis pintoi* has the potential for use as a protein supplement to improve efficiency of fibre utilisation in ruminant diets.

Acknowledgments

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