PIGEON PEA AS A RUMINANT FEED

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Summary

The study on the potential use of pigeon pea (PP) as a ruminant feed was carried out with sheep in 3 experiments. Digestibility of dry pigeon pea leaves (PPL) and pigeon pea seeds (PPS) determined by differential and regression methods respectively, with rice straw (RS) as a basal diet, revealed that PPS contained higher nutritive value and palatability than PPL. On dry matter (DM) basis, PPL and PPS contained 19.8 and 20.0% CP, 7.3 and 2.3% EE, 6.0 and 4.4% ash, 61.1 and 51.7% NDF, and 29.4 and 17.5% ADF, respectively. The trypsin inhibitor activity in the seed was 3 times of that in the leaves (19.5 vs 7.0 mg TIA/g DM). The digestibility of PPL and PPS were 50.2 and 72.2% in DM, 52.7 and 73.3% in OM, 51.0 and 65.1% in CP respectively. DM intake as well as the digestibility of most nutrients increased with the increasing level of PPS. Digestible energy (DE), Total digestible nutrient (TDN) and N-balance of sheep fed solely PPS, estimated by regression method, was 3.2 kcal/g, 71.1% and 6.3 g/d respectively.

Pigeon pea seeds can be well used to substitute soybean meal in concentrate rations for ruminants or directly supplemented to low quality roughages.

(**Key Words :** Pigeon Pea, Ruminant Feed, Sheep, Digestibility, N-Balance)

Introduction

The constraints on the feed supply both in roughages and concentrates has increased remarkably, especially during the last decade due to the intensive animal production in many parts of the world. Attempts were made to investigate the potential use of non-conventional feed to avoid the competition with human food and/or to improve the nutritive value of low quality feed.

Pigeon pea (PP) is an interesting plant to use as an animal feed due to the relatively high crude protein (CP) content in seeds and leaves. It is a perennial leguminous medium size shrub, relatively resistant to drought, pest and tolerant to poor soils. It is grown in many countries to prevent soil erosion on steep land, to improve the soil condition, to use as a human food and also for lac gum production.

The hybrid varieties contain 21 and 19% CP on dry matter (DM) basis in seeds and leaves, respectively. Their protein content is comparable to leucaena leaves (LL), which is popularly used as animal feed (Cheva-Isarakul, 1991). The limitations in utilizing it as a monogastric feed are their low protein quality, low metabolizable energy (ME), high crude fiber (CF) content of leaves and the presence of toxic substances, trypsin and chymotrypsin inhibitors (Jumbunathan and Singh, 1981; Visitpanich et al., 1985). Thus, the highest incorporation level of the seeds in monogastric diets should not exceed 20% (Tangtaweewipat and Elliott, 1989; Falvey and Visitpanich, 1980). While that of leaves in broiler diet should not be higher than 5% (Cheva-Isarakul et al., 1991).

Its potential use as ruminant feed is expected to be higher, due to the presence of micro-organisms in host's fore-stomach which assist the animal to rely less on amino acid pattern and/or tolerate better on high fiber content and toxic substances in feed. Positive effects on animal performances have been reported when cattles were grazed on PP bush pasture (Akinola et al., 1975; Whiteman and Norton, 1981) or fed with PPL (Parades et al., 1986; Seetakoses and Siri, 1986; Sruamsiri and Seetakoses, 1988). However, the information about the nutritive value of leaves and seeds and the potential use of seeds as a ruminant feed is still limited. Therefore, the objectives of this experiment were:

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1. To determine the nutrient digestibility of PPL and PPS by differential and regression method repectively, using RS as a basal diet.

2. To investigate the potential use of PPS as a substitute for Soybean meal in ration or its direct supplement to the low quality roughages.

Materials and Methods

Due to the lack of cattle and facilities, sheep were used as a model animal in all 3 experiments. The results are expected to be applicable to other ruminant species.

Experiment 1. The determination of digestibility of PPL by differential method.

Six mature native sheep were kept individually in metabolism cages where feces and urine were collected separately under the cage. They were fed with 100 g of air dried RS per head/day (h/d) as a basal diet plus sun dried unmilled PPL *ad libitum*. A 14 day preliminary period was followed by a 10 day collection period. Animal care and management, feed sampling and excreta collection as well as chemical analysis were done as described by Cheva-Isarakul and Saengdee (1987). Gross energy was determined in Adiabatic Bomb Calorimeter, while trypsin inhibitor activity (TIA) was analysed by the method described by Kakade et al. (1974).

Experiment 2. The determination of digestibility in PPS by regression method.

Four levels of PPS (200, 400, 600, and 800 g/h/d; air dry basis) were supplemented to RS (900, 800, 700, and 600 g/h/d; air dry basis respectively) and fed to 4 groups of mature native sheep, each with 5 replicates. The animals were kept individually in metabolism cages. Feeding, management, data collection and sample analysis were carried out conventionally as in experiment 1.

Nutrient digestibility in PPS was calculated by regression equation, $Y = a + bX$, where Y = digestibility of nutrients in total ration, X = nutrient intake from PPS as percentage of that nutrient in total diet (Lindermann, 1986).

Experiment 3. The potential use of PPS as a substitute for SBM in concentrate ration or supplement directly to RS.

Twelve male and 6 female lambs of initial liveweight (LW) 13.5 kg were randomly allocated on the basis of sex and weight to 3 dietary groups. They were kept in individual pen and fed *ad libitum* with chopped RS (3-4 inches long) plus 500 g/h/d of fresh para grass (started at week 7) to serve as a source of vitamins and carotene. Each group of animal was supplemented with one of the three concentrate diets at 250 g/h/d:

1. Concentrate which contained SBM as a main protein source.

2. Concentrate in which PPS was substituted for 50% of SBM.

3. PPS (97%) mixed with 3% mineral mixture.

All concentrate rations contained approximately 20% CP content. The composition is shown in table 1. Animals were fed twice a day at 08:30 and 15:30 h. Feed intake was recorded daily, while LW was measured weekly during the experimental period and on 3 consecutive days at the beginning and the end of the experiment. At the end of the 16 week long feeding trial, animals were transfered to metabolism cages for digestibility determination. The data from conventional method of total fecal collection was compared with those of the indicator method using acid insoluble ash (AIA) as an internal marker. Animal care, management and sample

TABLE 1. COMPOSITION OF EXPERIMENTAL CONCENTRATE RATIONS

Ingredients	Gr 1	Gr 2	Gr 3
Ground corn	41.0	25.5	–
Rice bran	30.0	30.0	–
Soybean meal	17.0	8.5	–
Kapok seed meal	10.0	10.0	–
Ground pigeon pea seed		24.0	97.0
Salt	0.5	0.5	1.0
Limestone	0.5	0.5	1.0[1]
Mineral premix[2]	1.0	1.0	1.0
Total	100.0	100.0	100.0

[1] Dicalcium phosphate was used instead of limestone due to the absence of rice bran, a phospherus source.

[2] 1 kg Mineral premix composed of 640 g salt, 180 g MgO, 140 g S, 22 g ZnO, 14.8 g $CuSO_4 \cdot 5H_2O$, 2.8 g MnO, 160 mg $CoCl_2 \cdot 6H_2O$, 80 mg KI and 160 mg NaSe.

analysis were as described by Cheva-Isarakul (1988b). Digestibility of nutrient using AIA method were calculated by:

$$Ci = \frac{(C_1 \times I_1) + (C_2 \times I_2) + (C_3 \times I_3)}{I_1 + I_2 + I_3}$$

Dry matter digestibility (DMD) of total feed =

$$\frac{C_f - C_i}{C_f} \times 100$$

where C_i and C_f = concentration of AIA in total feed and feces respectively

C_1, C_2, C_3 = concentration of AIA in RS, grass and concentrate ration

I_1, I_2, I_3 = intake on dry matter basis of RS, grass and concentrate ration.

Results and Discussion

Experiment 1. Digestibility of PPL by differential method

Chemical composition of PPL and RS compared to PPL, leucaena leaves (LL) and PPS from the other reports is shown in table 2. PPL contains higher CP than RS due to the nature of leguminous plant. Nutrient content of PPL in this experiment is similar to that reported by Seetakoses et al. (1990) and that of LL with the exception of CF and cell wall constituents (CWC).

Nutrient digestibility of PPL as compared to that determined by Seetakoses et al. (1990) and of RS and LL is shown in table 3. Pigeon pea leaves contains similar nutrient digestibility to RS with the exception of CP. Higher digestibility of CP in PPL might be due to the higher CP content of PPL than RS, which enhanced rumen microbes to increase their population and digestive activity. The CP concentration of total ration composed of 700 g PPL + 100 g RS was 19.7 % while that of RS was only 4.8%. The result agreed with Cheva-Isarakul and Cheva-Isarakul (1990) who reported that the increasing N content of RS by supplementing either in the form of natural protein or multi-nutrient block or urea treatment, improved the digestibility of CP. However, nutrient digestibility of PPL was lower than LL although both of them are legumes. This might be due to the higher CF and CWC of PPL.

Nutrient digestibility of PPL in this experiment is lower than those assessed by Seetakoses et al. (1990) in cattle by AIA method. This might be due to the different method of appraisal, animal species and/or associative effect which usually occures in ruminants when a feed is fed in combination with other feed.

TABLE 2. CHEMICAL COMPOSITION (% DM BASIS) OF PIGEON PEA LEAVES COMPARED TO RICE STRAW, DRY LEUCAENA LEAVES AND PIGEON PEA SEEDS

	Pigeon pea leaves[1]	Pigeon pea leaves[2]	Leucaena leaves[3]	Rice straw[1]	Pigeon pea seeds
DM	96.7	34.1	89.1	96.9	87.5
CP	19.8	21.1	24.3	5.0	20.0
EE	7.3	7.2	8.8[a]	2.3	2.3
CF	23.2	25.6	11.2[a]	36.5	9.6
NFE	43.7	40.0	45.5[a]	35.8	63.7
Ash	6.0	6.0	8.3	20.5	4.4
NDF	61.1	–	28.4	77.9	51.7
ADF	29.4	–	16.5	55.5	17.5
ADL	–	–	8.4	–	–
AIA	1.1	1.7	–	14.5	–
GE (kcal/g)	5.1	–	–	3.7	4.5
TIA (mg TI/g)	7.0	–	–	–	19.5

[1] Values investigated in this experiment.
[2] Fresh leaves and tops (Seetakoses et al., 1990).
[3] Cheva-Isarakul (1991).
[a] Cheva-Isarakul (1982, unpublished data).

TABLE 3. DIGESTIBILITY COEFFICIENTS OF NUTRIENTS IN PIGEON PEA LEAVES (PPL) COMPARED WITH OTHER PUBLISHED DATA ON PPL, RICE STRAW AND LEUCAENA LEAVES

	Pigeon pea leaves[1]	Pigeon pea leaves[2]	Rice straw[3]	Leucaena leaves[3]
DM	50.2	65.6	48.6	60.8
OM	52.7	–	53.9	63.6
CP	51.0	69.4	16.7	61.5
EE	45.8	63.8	43.8	42.7
CF	30.8	46.1	60.5	44.3
NFE	–	77.4	50.0	76.3
NDF	47.3	–	49.8	35.9
ADF	0.5	–	49.0	–
TDN	–	–	43.1	65.8

[1] Values investigated in this experiment by differential method.
[2] Determined in cattle by AIA method (Seetakoses et al., 1990).
[3] Cheva-Isarakul (1982, 1986; unpublished data).

Liveweight change and feed intake of sheep fed 100 g RS (air dry basis) as a basal diet supplemented with *ad libitum* PPL were shown in table 4. Sheep consumed 653 g PPL or 750 g of total feed, DM/h/d, which was 2.5% of BW or 57.9 g/kg $W^{0.75}$. These figures are higher than that reported by Cheva-Isarakul and Cheva-Isarakul (1985) when RS was fed as a sole diet. This might be due to the role of N in PPL which enhanced DMI. The result agreed with Crabtree and Williams (1971) who supplemented oat straw with concentrate diet. However, DM intake of RS + PPL was lower than those of RS supplemented with LL (Cheva-Isarakul, 1991) or LL as a sole diet (Cheva-Isarakul, 1986; unpublished data). This might be due to the low palatability

TABLE 4. BODY WEIGHT AND FEED INTAKE OF SHEEP FED 100 G RICE STRAW (RS) PLUS *AD LIBITUM* DRY PIGEON PEA LEAVES (PPL)

	Avg	SD
Initial weight	30.1	3.7
Final weight	31.2	4.0
Dry matter intake (DMI, g/head/day)	750.0	23.2
– % BW	2.5	0.2
– g/kg $W^{0.75}$	57.9	3.8
from PPL (g)	653.1	21.2
– from RS (g)	96.9	0

of PPL which has less pleasant smell. Animals might need a longer adapting period to get acquainted with this feed.

The amount of TIA consumed from PPL by sheep was 4.6 g/h/d which was lower than those from PPS, 3.4-13.7 g/d, in experiment 2. No toxic sign was found during the experiment.

Experiment 2. Digestibility of PPS by regression method

Chemical composition and feed intake intake

Chemical composition of PPS and RS in this experiment compared to that from other experiment and of soybean seeds is shown in table 5. The nutrient content of PPS was similar to that from Malaysia and India (cited by Gohl, 1981) or that reported by Visitpanich et al. (1985) with the exception of TIA. However, it contains lower CP and EE content but higher CF and CWC than soybean seeds.

Feed intake and LW of sheep are shown in table 6. Dry matter intake (DMI) of RS decreased with the increasing level of PPS. The result agreed with Mulholand et al. (1976), Devendra (1978), Bamualim (1986), and Cheva-Isarakul (1991). However, the extent of decrease of RS intake was less than the incresing rate of PPS, therefore total DMI increased from 100 to 108.8, 115.5 and 121.3% in sheep fed 200, 400, 600, and 800 g air dried PPS, respectively. This might be due to the higher nutrient content of PPS which promote microbial activities in digestion and hence

TABLE 5. CHEMICAL COMPOSITION (% DM BASIS) OF PIGEON PEA SEED, SOYBEAN SEED AND RICE STRAW

	Pigeon pea seed				Soybean seed (NRC, 1984)	Rice straw[1]
	Cheva-Isarakul[1]	Malaysia (Gohl, 1981)	India (Gohl, 1981)	Visitpanich et al. (1985)		
DM	87.5	89.0	91.8	88.3	92.0	93.6
CP	20.0	23.4	20.2	23.1	42.8	4.4
EE	2.3	0.9	1.9	1.6	18.8	2.0
CF	9.6	10.6	6.2	8.5	5.8	35.4
NFE	63.7	60.8	67.7	61.9	27.1	41.1
Ash	4.4	4.3	4.0	4.9	5.5	17.0
NDF	51.7	–	–	–	–	74.5
ADF	17.5	–	–	–	10.0	52.8
ADL	–	–	–	–	–	4.8
Ca	–	0.14	–	–	0.27	–
P		0.45	–	–	0.65	–
GE (kcal/g)	4.5	–	–	–	–	3.8
TIA (mg TI/g)	19.5	–	–	29.4	–	–

[1] Values investigated in this experiment.

TABLE 6. BODY WEIGHT AND FEED INTAKE OF SHEEP FED RICE STRAW (RS) PLUS VARIOUS LEVELS OF GROUND PIGEON PEA SEED (PPS)

	Level of PPS (g air dry matter/head/day)			
	200	400	600	800
Av. body weight (kg)	34.4	35.3	35.6	34.1
Dry matter intake (g/head/day)	1009.6	1098.9	1166.5	1224.8
– % BW	2.9	3.1	3.3	3.6
– g/kg $W^{0.75}$	71.5	76.1	80.5	87.7
Dry matter intake from				
– RS (g/head/day)	834.5	748.8	641.3	524.5
– PPS (g/head/day)	175.1	350.1	525.2	700.3
– PPS (% of total ration)	17.3	31.9	45.0	57.2
TIA intake (g/head/day)	3.4	6.8	10.3	13.7

increase rate of passage. The result agreed with Wongsrikeao and Wanapat (1985) and Cheva-Isarakul (1991) when RS was supplemented with LL and fed to buffaloes and sheep respectively. Siebert and Kennedy (1972) also found that the addition of lucerne, or urea and sulphate to spear grass (4.3% CP) increased DMI of cattle significantly. Apparently N and S from either source were required to overcome deficiencies and provide a favorable environment for the rumen microflora.

Total DMI of sheep fed RS plus 4 levels of PPS was 2.9, 3.1, 3.3 and 3.6% of LW, or 71.5, 76.1, 80.5 and 87.7 g/kg $W^{0.75}$ respectively. These values were higher than DMI of RS fed as a sole diet. (Cheva-Isarakul and Cheva-Isarakul, 1985) or RS supplemented with PPL (table 4). This results indicated the high palatability of PPS and its potential use to supplement RS.

The amount of TIA ingested increased with the increasing level of PPS. At 800 g PPS/d, sheep consumed 13.7 g TIA or 0.4 g/kg LW/day. However, no sign of toxicity was shown.

Digestion coefficient of nutrient

Nutrient digestibility, digestible energy (DE) and total digestible nutrient (TDN) of total ration as well as N-balance of sheep fed with different proportions of RS and PPS are shown in table 7. With the increasing level of PPS, most of the nutrient digestibility increased with the exception of CF, ADF and EE. This might be due to the higher nutrient content of PPS which promoted microbial activities as mentioned in Exp. 1. The result agreed with Devendra (1983) and Cheva-Isarakul (1988b) and also indicated that this amount of TIA had no effect on nutrient digestibility in ruminants especially the digestibility of CP. This might be due to the efficiency of rumen microbes in detoxifying these digestive inhibitors.

The decreased digestibility of CF and ADF with increasing PPS might be due to the characteristic of PPS which contains high soluble carbohydrate (NFE). Mould and Ørskov (1983/84) as well as Hoover (1986) proposed that added starch or readily fermentable carbohydrate (RFC) reduced fiber digestion through a series of events involving carbohydrate preference, reducing rumen pH, and decreased cellulolytic organisms especially when pH is lower than 6.0.

TABLE 7. DIGESTIBILITY OF NUTRIENTS IN RATIONS WITH DIFFERENT LEVELS OF RICE STRAW (RS) AND GROUND PIGEON PEA SEEDS (PPS)

	PPS level (g air dry matter/head/day)			
	200	400	600	800
Dry matter intake (g/day)	1009.6	1098.9	1166.5	1224.8
– RS	834.5	748.8	641.3	524.5
– PPS	175.1	350.1	525.2	700.3
Digestibility coefficients				
Dry matter (DM)	57.4	62.0	62.1	64.9
Organic matter (OM)	62.4	66.7	66.0	68.3
Crude protein (CP)	45.9	57.7	58.4	58.1
Ether extract (EE)	79.6	60.8	59.5	57.7
Crude fiber (CF)	61.9	63.7	57.0	55.5
Nitrogen free extract (NFE)	64.8	70.5	72.2	76.2
Neutral detergent fiber (NDF)	54.5	58.1	59.7	63.5
Acid detergent fiber (ADF)	48.3	49.5	46.1	46.4
Energy	60.1	65.2	64.5	66.7
Digestible energy (DE, kcal/g)	2.4	2.6	2.7	2.8
Total digestible nutrient (TDN, %)	55.6	65.6	70.1	77.4
N-balance (g N/head/day)	0.74	2.25	3.22	5.39

Mulholland et al (1976) demonstrated that the supplement of oat hay with different levels of concentrate resulted in increasing DM and digestible OM intake, while RS intake and digestibility of cellulose decreased. The result agreed with Devendra (1978). Digestible energy, TDN and N-balance increased with the increasing PPS. This is due to the high N-intake which promote N-digestion and N-retention.

Digestibility of nutrient in PPS, assessed by regression method when X was the percentage of nutrient ingested from PPS and Y was the digestion coefficent of nutrient in total ration when PPS was fed at different levels, is shown in table 8. The high regression coefficient (r) showed the precision of this method in appraising nutrient digestibility. Nutrient digestibility of PPS was around 70% with the exception of EE, CF and ADF which tended to decrease linearly with the increasing level of PPS. DE and TDN of PPS were 3.2 kcal/g DM and 71.1% respectively which were only 13.5 and 15.4% lower than those contained in SBM (solvent extract, 44% CP) reported by NRC (1984). The high nutritive value of PPS indicated its potential use as ruminant feed.

N-balance of sheep fed with PPS as a sole diet, appraised by regression equation, was + 6.28% while that fed with RS was −5.16 g N/h/d. It indicated that PPS contains enough

TABLE 8. DIGESTION COEFFICIENTS OF NUTRIENTS IN PIGEON PEA SEEDS (PPS) AND RICE STRAW (RS) PREDICTED BY REGRESSION EQUATION

Digestibility (%)	PPS[1]	RS[2]	Regression equation Y = a + bX
DM	72.2	55.1	Y = 55.1 + 0.17 X; r = 0.95
OM	73.3	60.7	Y = 60.7 + 0.12 X; r = 0.89
CP	65.1	31.0	Y = 31.0 + 0.34 X; r = 0.90
EE	34.4	84.9	Y = 84.9 − 0.50 X; r = −0.87
CF	28.0	65.2	Y = 65.2 − 0.37 X; r = −0.87
NFE	84.2	58.9	Y = 58.9 + 0.25 X; r = 0.99
NDF	75.8	51.6	Y = 51.6 + 0.24 X; r = 0.99
ADF	38.2	49.6	Y = 49.6 − 0.11 X; r = −0.73
GE	72.3	58.3	Y = 58.3 + 0.14 X; r = 0.88
DE (kcal/g)	3.2	2.2	Y = 2.23 − 0.009 X; r = −0.99
TDN (%)[3]	71.1	52.5	
N balance (g N/head/day)	6.3	−5.2	Y = −5.16 + 0.11 X; r = 0.95

[1,2] Predicted from regression equation when X = 100 and 0 respectively.
[3] Calculated by conventional method.
Y = Digestion coefficient of nutrient (%). r = regression coefficient.
X = Nutrient intake from PPS as % of that from total ration.

protein and digestible nutrient to promote protein retention for growth and production. The result agreed with Egan (1986) who concluded that supplemental proteins can alter N conditions in the reticulorumen affecting microbial protein synthesis and/or rate of fiber digestion, but also can provide additional amino acids in the small intestine. The negative N-balance of RS prevailed the insufficient CP intake to cover animal requirement, thus caused weight lost (Wongsrikeao and Wanapat, 1985).

Nutrient digestibility of RS can also be assessed by regression method when X = 0. The values are higher than those reported by Cheva-Isarakul and Cheva-Isarakul (1985). This might be a positive associative effect which may occur if the forage deficient in a specific nutrient (eg. fermentable N or S) is given to ruminant in combination with concentrate supplement provides such nutrient (Dixon, 1986).

Experiment 3. The substitution of PPS to SBM

Chemical composition of RS, fresh para grass and 3 concentrate rations was shown in table 9. All diets contained similar CP and OM content, 20 and 93% of DM basis respectively. However they are differ in EE, CF and CWC concentration due to the characteristic of PPS. Para grass contained 18.8% DM and 12.1% CP, similar to that reported by Cheva-Isarakul (1988b).

Sheep fed 250 g/h/d of either concentrate ration with *ad libitum* RS and 500 g/h/d fresh para grass ingested similar amount of DM (2.9-3.2% BW or 58.4-65.6 g/kg $W^{0.75}$; table 10) although the latter 2 groups fed with PPS tended to ingest more RS. Digestibility of nutrient of sheep in group 3 tended to be higher than group 2 and 1 respectively. The result agreed with higher DMI and with Blaxter (1962). Thus led to the higher digestible nutrient consumption of group 3 (table 11) and resulted in higher LW gain although no significant difference was found (table 10).

The average daily gain of approximately 62 g/d in this experiment is higher than those raised under conventional back yard system (Cheva-Isarakul, 1991) or fed with RS supplemented with LL at 0.5%-1.5% LW (Cheva-Isarakul, 1988a). However it is similar to those fed UTS or UMS supplemented with fresh LL 1 kg/d. (Cheva-Isarakul, 1988b) thus indicated the potential use of PPS for supplementing to RS.

Djanegara and Rangkuti (1989) pointed out that an intake of around 200 to 250 g digestible

TABLE 9. CHEMICAL COMPOSITION (% DM BASIS) OF CONCENTRATE MIXTURE, RICE STRAW AND PARA GRASS

	Conc. 1	Conc. 2	Conc. 3	Rice straw	Para grass
Dry matter	88.9	88.7	89.4	96.4	18.8
Organic matter	92.4	92.9	93.7	80.5	87.1
Crude protein	20.6	19.1	19.7	4.5	12.1
Ether extract	10.5	9.5	2.5	2.5	3.1
Crude fiber	7.5	11.3	9.8	35.2	31.6
NFE	53.7	53.1	61.7	38.4	40.4
Ash	7.6	7.1	6.3	19.5	12.9
NDF	21.4	27.6	34.6	74.9	72.7
ADF	11.3	14.7	17.1	54.1	43.0

Conc. 1 = used soybean meal (SBM) as a main protein source.
Conc. 2 = substituted 50% of SBM with pigeon pea seeds (PPS); the level of PPS in the ration was 24%.
Conc. 3 = 97% of PPS + 3% mineral mixtures.

TABLE 10. WEIGHT CHANGE, DRY MATTER INTAKE AND FEED CONVERSION RATIO OF SHEEP FED 3 DIFFERENT CONCENTRATE RATIONS

	Gr 1[1]	Gr 2[1]	Gr 3[1]
Initial weight (kg)	13.5[a] ± 2.1	13.5[a] ± 1.4	13.4[a] ± 1.3
Final weight (kg)	20.1[a] ± 2.3	20.6[a] + 2.3	20.6[a] ± 2.7
Liveweight gain (kg) (112 days)	6.6[a] ± 1.2	7.1[a] ± 1.3	7.2[a] ± 1.5
Average daily gain			
– Week 0-6, 42 days	51.6 ± 13.9	73.8 ± 16.7	69.0 + 19.0
– Week 7-16, 70 days	63.1 ± 11.2	57.1 ± 8.6	62.8 ± 12.9
– Week 0-16, 112 days	58.9 + 10.7	63.4 ± 11.6	64.3 ± 13.4
Total dry matter intake (DMI)			
– g/head/day	428.7[a] ± 39.8	508.8[a] ± 43.3	547.1[a] ± 39.8
– % BW	2.9 ± 0.3	3.0 + 0.1	3.2 + 0.3
– g/kg $W^{0.75}$	58.4 ± 4.2	60.8 ± 2.3	65.6 ± 3.7
Dry matter intake (g/head/day)			
– from rice straw	201.8 ± 39.8	228.1 ± 43.3	264.8 ± 39.8
from grass	58.8 ± 0	58.8 ± 0	58.8 ± 0
– from concentrate	222.2 ± 0	221.9 + 0	223.5 ± 0
Feed conversion ratio (kg DM feed/kg weight gain)	8.4[a] ± 1.1	8.2[a] ± 1.1	8.7[a] ± 1.1
Crude protein (% of DMI)	12.8	11.7	11.5

[1] Fed with concentrate ration 1, 2, 3, respectively (see table 9).

DM only meets the maintenance requirement of sheep. Supplements should be provided to increase the production. The result agreed with this experiment where digestible dry matter intake of the 3 groups was 295.3, 313.5, and 349.4 g/h/d respectively (table 11).

No significant difference was found on FCR. The figures are similar to those fed with UTS plus fresh LL but higher than RS plus dry LL (Cheva-Isarakul, 1988b, 1991). This might be due to the quality of feed in these 2 experiments (61.3-64.0 vs 49.2-48.0% DMD and 11.5-12.8 vs 7.2-11.7% CP of the total ration, table 10).

The overall result obtained from this experiment indicated that PPS could be used to partially substitute SBM in concentrate ration or mix with

TABLE 11. NUTRIENT INTAKE AND DIGESTIBLE NUTRIENT CONSUMED BY SHEEP FED RICE STRAW, AND PARA GRASS SUPPLEMENTED WITH 3 DIFFERENT CONCENTRATE RATIONS AND DIGESTIBILITY OF DRY MATTER CALCULATED FROM AIA METHOD COMPARED TO THAT OF CONVENTIONAL METHOD

		DM	OM	CP	EE	CF	NFE	NDF	ADF
Total nutrient intake (g/head/day)									
Group[1]	I	482.8^{a}	418.8^{a}	62.0^{ab}	30.1^{a}	106.4^{b}	220.5^{b}	241.4^{b}	159.6^{b}
	II	508.8^{a}	440.8^{a}	59.7^{b}	28.4^{a}	12.8^{ab}	229.0^{b}	275.0^{ab}	173.8^{ab}
	III	547.1^{a}	473.7^{a}	62.9^{a}	13.8^{b}	133.7^{a}	263.3^{a}	318.6^{a}	206.7^{a}
Digestibility coefficient of nutrient (%)									
Group	I	61.3^{a}	65.7^{a}	82.7^{a}	78.4^{a}	51.3^{b}	65.7^{a}	48.5^{c}	41.5^{a}
	II	61.8^{a}	66.1^{a}	81.6^{a}	76.1^{a}	58.9^{a}	64.1^{a}	52.6^{b}	42.5^{a}
	III	64.0^{a}	68.0^{a}	84.4^{a}	68.2^{b}	61.5^{a}	67.1^{a}	57.9^{a}	45.2^{a}
Digestible nutrient consumption (g/head/day)									
Group	I	295.3^{b}	274.5^{b}	51.3^{a}	23.6^{a}	54.5^{b}	144.5^{b}	116.3^{c}	66.2^{b}
	II	313.5^{b}	290.6^{b}	48.7^{b}	21.6^{b}	73.1^{a}	146.3^{b}	144.6^{b}	73.8^{b}
	III	349.4^{a}	321 4^{a}	53.0^{a}	9.5^{c}	82.1^{a}	176.3^{a}	183.8^{a}	3.0^{a}

	Group I	Group II	Group III	Average
DM digestibility (AIA method)	60.3 ± 3.2	59.9 ± 4.1	61.9 ± 2.8	60.7
% Recovery	98.4	96.0	96.7	97.0

[1] Fed with concentrate ration 1, 2, 3 respectively (see table 9).

mineral mixture and supplement directly to RS without adverse effect. It may be an alternative to farmers for avoiding weight loss of their animals during the period of feed shortage by growing PP and use leaves and seeds to supplement low quality roughage.

Digestibility determination by AIA method

No significant difference in DM digestibility was found between AIA and conventional method (table 11), thus indicating the precision of AIA as internal indicator in determining digestibility. The result agreed with Cheva-Isarakul and Cheva-Isarakul (1985) and Cheva-Isarakul (1991).

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