

Utilization of Concentrate Supplements Containing Varying Levels of Sunflower Seed Meal by Growing Goats Fed a Basal Diet of Corn Silages

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Abstract: The objective of this study was to evaluate the effect of varying levels of sunflower seed meal on feed intake, digestibility and rumen fermentation of goats fed corn silage as roughages. Eight growing crossed Thai native x Anglo-Nubian goats between 8-10 months of age and pre-trial average body weight of 14.2 ± 1.7 kg were allotted into two groups on the basis of body weight in a randomized double 4 x 4 Latin square design to investigate the utilization of concentrate mixtures of varying levels of Sunflower Seed Meal (SSM). The four concentrate mixtures had SSM included at 0% (control), 7.3 % (SSM1), 14.5% (SSM2) and 22.0% (SSM3) in concentrate as replacing Soybean Meal (SBM) with SSM as 25% CP, 50% CP and 75% CP, respectively. On average, all parameters measured, including Dry Matter Intake (DMI), nutrients digestibility, ruminal ammonia-N ($\text{NH}_3\text{-N}$), ruminal total Volatile Fatty Acid (total VFA), individual VFAs concentration (mM/L), microbial N supply and N retention increased ($p < 0.05$) with the addition of SSM in concentrate up to 14.5% (SSM2) in concentrate, thereafter decreased ($p < 0.05$) in goats fed SSM 22% (SSM3). The results indicated that replacing SBM with SSM as 50 %CP (SSM2), resulted in higher animal performance as a consequence of improved ruminal fermentation, microbial yield and N balance, but decreased ($p < 0.05$) with 22.0% SSM diet. It is concluded that sunflower seed meal can successfully replace soybean meal 50% CP as a protein source in growing goats.

Key words: Sunflower seed meal, goats, corn silage, microbial protein synthesis

INTRODUCTION

Most concentrates for goat are grain-based to increase their energy concentration, which typically improves gain efficiency and cost of gain. The use of Soybean Meal (SBM) as a source of protein in animal feed has been well established for many years. However, high prices and fluctuation in production have raised the interest in alternative protein sources for feeding ruminants. The increased world production of sunflower has increased interest in Sunflower Seed Meal (SFM) as a high quality by-products for ruminants (Nishino *et al.*, 1980; Titi, 2003). The SFM, like SBM, is a high-protein supplement, contains 30-46% crude protein, 13-15% crude fiber, 9-12 MJ ME, Neutral Detergent Fiber (NDF) 47% and Ether Extract (EE) 1.5% (Nishino *et al.*, 1980; Titi, 2003; Irshaid *et al.*, 2003). Recently, SFM is becoming available in Thailand for ruminant nutrition and as a by-product of extraction of sunflower oil locally. SFM could be used as a substitute for SBM. As a protein supplement, SFM could replace SBM in rations of small ruminants with similar gain and feed efficiency (Richardson *et al.*, 1981; Irshaid *et al.*, 2003).

Therefore the objectives of this research were to study the effect of SFM on feed intake, digestibility of nutrients, microbial protein synthesis, nitrogen balance and on the performance of Thai native x Anglo-Nubian growing goats.

MATERIALS AND METHODS

Animals and management: Eight growing crossed Thai native x Anglo-Nubian goats between 8-10 months of age and pre-trial average body weight of 14.2 ± 1.7 kg were allotted into two groups on the basis of body weight in a randomized double 4 x 4 Latin square design to investigate the utilization of concentrate mixtures of varying levels of Sunflower Seed Meal (SSM). The four concentrate mixtures had SSM included at 0% (control), 7.3% (SSM1), 14.5% (SSM2) and 22.0% (SSM3) in concentrate as replacing Soybean Meal (SBM) with SSM as 25% CP, 50% CP and 75% CP, respectively. The goats were housed in individual pens and allowed 3 weeks to adapt to the experimental conditions. The goats were fed a basal diet containing corn silages supplemented with mineral and vitamin. The experimental diets were iso-nitrogenous (CP = 15%) and iso-energetic and based on corn silage, soybean meal, cassava pulp, molasses, urea, mineral and vitamins. Rations were formulated in accordance with NRC (1981) to achieve a medium activity and medium of growth rate. Drinking water was freely available to the animals. The dietary treatments and compositions are shown in Table 1.

Experimental procedure: The experiment consisted of three weeks of adaptation, following by four experimental

periods. The duration of each period was 32 days, i.e., three weeks of adjustment followed by 12 days of measurements. The latter consisted of 2 days of adaptation to the metabolic crates, 7 days of digestibility and N balance studies, 2 days of rumen fluid and blood sampling. Samples of feed refusal, faeces and urine were collected before feeding morning to determine digestibility and N balance.

Sampling methods: A daily faeces of each goat was weighed and a 10% sub-sample collected and stored at -20°C. Samples were dried (60°C) and ground through 1 mm sieve and stored until analysis.

Daily urine output was collected into a plastic container (containing 25 ml of 10% H₂SO₄). Approximately 10% of the volume was sampled and stored at -20°C pending energy and N analysis. A separate urine sample was collected for determination of Purine Derivatives (PD). The urine sample was diluted 4 times follows (to prevent crystallization of uric acid during storage), filtered through Whatman cellulose membranes (25 mm, 0.2 microns) attached to a syringe, thereafter, frozen at -20°C for later analysis of PD content using High Performance Liquid Chromatography (HPLC) according to Balcells *et al.* (1992).

Rumen fluid samples from all goats were collected using a stomach tube at 3 h post-feeding during the digestibility trial. It was strained through 4 layers of cheese cloth and pH measured immediately using a pH meter (Mettler Toledo MP 125) fitted with a combined electrode. The rumen fluid was then acidified with H₂SO₄ (50%, v/v) and stored at -20°C for analyses of ammonia and VFA.

Blood samples were taken from the jugular vein at 3 h post-feeding and after rumen fluid were sampled. The blood samples were prior to plasma separation by centrifugation (3,000 x g for 15 min) and plasma stored at -20°C for urea analysis.

Chemical analysis and calculations: Feed samples were collected twice a week. Representative samples of feed and faeces collected during the digestibility trial were analyzed according to AOAC (1985) for DM, ash and CP and fiber components (Van Soest *et al.*, 1991). Apparent digestibilities were calculated using equations of Schnieder and Flatt (1975).

Total VFA and molar proportions of acetic, propionic and butyric of rumen fluids were determined by Shimatzu GC-14 gas chromatography (Shimatzu, Japan) fitted with a Flame Ionization Detector (FID) and a packed column 5% Thermon-3000, Shincarbon A 60/80. Nitrogen was used as the carrier gas at 40 ml/min and the oven temperature was maintained at 220°C; injection and FID temperatures were fixed at 260°C. Plasma urea was determined by using a urea test kit (Sigma Diagnostics INFINITY™ BUN Reagent).

The purine derivatives allantoin, uric acid, hypoxanthine

and xanthine were analyzed by reverse-phase High Performance Liquid Chromatography (HPLC), which consisted of a multi-solvent delivery system Model 600 E (Water, USA), an injector Model 712, a multi-wavelength detector Model 490E, set to 205 nm and a double 4.6 x 250 mm, C-18 reverse-phase column, according to the technique of Balcells *et al.* (1992). Production of microbial N was calculated using the equation of Chen *et al.* (1992).

Statistical analysis: Data were analyzed as a 4 x 4 Latin square design using the General Linear Model (GLM) procedure of the Statistical Analysis System Institute SAS (1988). Duncan's New Multiple Range Test and Orthogonal Contrast Analysis (Steel and Torrie, 1980) were used to compare treatment means. Unless otherwise noted, significance was declared at p≤0.05 and non-significance was declared at p>0.05.

RESULTS AND DISCUSSION

The CP, ash, NDF and ADF contents of Sunflower Seed Meal (SSM) on dry matter basis were 34.4%, 7.2%, 47.4 and 33.1%, respectively (Table 1). Crude protein of Soybean Meal (SBM), cassava pulp and corn silage were 44.7, 2.1 and 6.3%, respectively. The inclusion of SSM further raised the NDF and crude fiber content are shown in Table 2.

Table 1: Proximate chemical composition of feedstuffs

Ingredients	Feedstuffs			
	Corn silage	Sunflower seed	Soybean meal	Cassava pulp
Dry matter, %	65.5	92.5	89.8	89.1
Analysis on DM basis				
Crude protein, %	6.3	34.4	44.7	2.1
Ash, %	8.5	7.2	2.2	4.4
Neutral detergent fiber	76.4	47.4	13.3	14.4
Acid detergent fiber	47.7	33.1	9.4	10.6
Crude fiber	38.3	26.2	5.9	7.3

Table 2: Percentage composition of concentrated mixtures and chemical compositions

Ingredients	% DM, concentrate mixtures			
	Control	SSM1	SSM2	SSM3
Sunflower seed meal	0	7.3	14.5	22.0
Soybean Meal (SBM)	15.0	11.3	7.7	3.8
Cassava pulp	63.9	61.3	58.7	56.1
Rice bran	12.0	11.0	10.0	9.0
Urea	2.1	2.1	2.1	2.1
Salt	1.0	1.0	1.0	1.0
Mineral/vitamin premix	1.0	1.0	1.0	1.0
Total	100	100	100	100
Chemical compositions (% DM)				
Crude protein	15.3	15.2	15.3	15.3
Ash	4.8	5.2	5.4	5.8
Crude fibre	9.7	11.7	12.5	12.8
Neutral detergent fiber	16.2	18.4	21.7	25.1

Control = SBM as a main source of protein in concentrate, SSM1 = replacing SBM with SSM as 25% CP, SSM2 = replacing SBM with SSM as 50% CP, SSM3 = replacing SBM with SSM as 75% CP

Table 3: Effect of varying levels of Sunflower Seed Meal (SSM) in concentrate on feed intake, nutrients digestibility and body weight change of goats

Parameters	Concentrate treatments				SEM
	Control	SSM1	SSM2	SSM3	
Corn silage intake (/day)					
g DM	359.2 ^b	362.6 ^{ab}	386.0 ^a	360.9 ^{ab}	4.13
%BW	2.23	2.20	2.33	2.18	0.310
g /kg W ^{0.75} /day	44.6 ^b	44.3 ^b	47.0 ^a	44.0 ^b	0.51
Total feed intake (/day)					
g DM	559.2 ^b	562.6 ^{ab}	586.0 ^a	560.9 ^{ab}	4.13
%BW	3.47	3.41	3.53	3.39	0.037
g /kg W ^{0.75} /day	69.4 ^b	68.8 ^b	71.3 ^a	68.3 ^b	0.55
Digestibility (%)					
Dry matter	54.6 ^{bc}	56.2 ^a	55.2 ^{ab}	53.3 ^c	0.24
Organic matter	57.0 ^c	58.7 ^b	60.5 ^a	55.3 ^d	0.33
Crude protein	54.0 ^{ab}	54.7 ^a	55.1 ^a	53.1 ^b	0.21
Neutral detergent fiber	52.1 ^a	50.0 ^b	49.1 ^b	46.4 ^c	0.32
Body weight change, g/day	57.0 ^a	57.5 ^a	59.5 ^a	52.5 ^b	1.07

SEM = standard error of the mean. ^{a,b,c}Means within row with different superscripts differ significantly (p<0.05). Control = SBM as a main source of protein in concentrate, SSM1 = replacing SBM with SSM as 25% CP, SSM2 = replacing SBM with SSM as 50% CP, SSM3 = replacing SBM with SSM as 75% CP

Table 4: Effect of varying levels of Sunflower Seed Meal (SSM) in concentrate on ruminal pH, ruminal NH₃-N, Total Volatile Fatty Acid (TVFA), individual VFAs and Plasma Urea Nitrogen (PUN) of goats

Parameters	Concentrate treatments				SEM
	Control	SSM1	SSM2	SSM3	
pH	6.7	6.8	6.8	6.9	0.27
NH ₃ -N, mg%	12.5 ^b	13.6 ^{ab}	14.5 ^a	12.0 ^b	0.28
TVFA, Mm/L	63.2 ^a	62.3 ^a	61.9 ^a	58.3 ^b	0.45
VFA proportion (%TVFA)					
Acetic	68.7 ^a	68.6 ^a	68.2 ^a	66.7 ^b	0.21
Propionic	20.6	20.3	20.6	20.4	0.28
Butyric	10.7	11.2	11.3	12.9	0.36
PUN, mg%	13.7 ^{ab}	14.9 ^a	15.2 ^a	12.8 ^b	0.31

SEM = standard error of the mean. ^{a,b,c}Means within row with different superscripts differ significantly (p<0.05). Control = SBM as a main source of protein in concentrate, SSM1 = replacing SBM with SSM as 25% CP, SSM2 = replacing SBM with SSM as 50% CP, SSM3 = replacing SBM with SSM as 75% CP

Table 3 shows the DMI, nutrient digestibility and body weight change of goats fed varying SSM in concentrates. Dry matter intake based on g/kg BW^{0.75}, increased (p<0.05) with the addition of SSM in concentrate up to 14.5% (SSM2) in concentrate, thereafter decreased (p<0.05) in goats fed SSM 22% (SSM3). Moreover, DMI (g/day, g/kg BW^{0.75}) in goats fed 14.5% SSM significantly higher (p<0.05) than goats fed the control (SBM). Organic matter, CP and NDF digestibility and body weight change increased (p<0.05) with the addition of SSM in concentrate up to 14.5% in concentrate, thereafter decreased (p<0.05) in goats fed SSM 22%. Body weight change of goats fed the control, 7.3% SSM and 14.5% SSM were not significantly (p>0.05) different in among treatments. This insignificant difference might be a result of the higher fiber content of the SSM and through less ability of digestion due to incomplete rumen functioning of those goats (Nishino *et al.*, 1980; Titi, 2003; Mir *et al.*, 2005). Ruminal NH₃-N, TVFA, acetic acid and PUN concentrations increased (p<0.05) with the addition of

SSM in concentrate up to 14.5% in concentrate, thereafter decreased (p<0.05) in goats fed SSM 22% (Table 4). However, ruminal pH, propionic acid and butyric acid were not significantly (p>0.05) different in among treatments. Mould and Ørskov (1993); Wanapat *et al.* (2000) demonstrated that cellulose digestion is limited when ruminal pH reaches values below 6.0. Ruminal VFA concentrations and fermentation rates are correlated (Leng and Leonard, 1965; McDonald *et al.*, 1995) and this relationship was also demonstrated in the present study (ruminal VFAs and digestibility). These results are in contrast to Koster *et al.* (1996) reported that TVFA increased dramatically in response to supplemental rumen degradable protein fed to beef cows. The excretion of urinary Purine Derivatives (PD) and microbial N supply are shown in Table 5. The results showed that total PD excretion, allantoin, uric acid, hypoxanthine, xanthine, microbial N synthesis (g N/day) and efficiency of microbial N supply (g N/ kg OM Apparently Digested in the Rumen (OMDR) of goats fed

Table 5: Effect of varying levels of Sunflower Seed Meal (SSM) in concentrate on urinary perine derivatives and microbial N supply of goats

Parameters	Concentrate treatments				SEM
	Control	SSM1	SSM2	SSM3	
Urinary PD, mM/d					
Allantoin	4.16 ^a	4.91 ^a	4.14 ^a	3.58 ^b	0.21
Uric acid	1.56 ^a	0.76 ^b	1.85 ^a	0.41 ^c	0.14
Hypoxanthine	0.48 ^b	0.50 ^{ab}	0.60 ^a	0.25 ^c	0.13
Xanthine	0.22 ^b	0.43 ^{ab}	0.48 ^a	0.12 ^c	0.11
Total PD	5.42 ^b	6.60 ^{ab}	7.05 ^a	4.35 ^c	1.12
Microbial N supply					
g of N/d	5.3 ^b	5.5 ^{ab}	5.9 ^a	3.3 ^c	0.38
g of N/kg DOMR*	21.4 ^a	22.0 ^a	22.6 ^a	15.1 ^b	1.98

SEM = standard error of the mean. ^{a,b,c}Means within row with different superscripts differ significantly (p<0.05). Control = SBM as a main source of protein in concentrate, SSM1 = replacing SBM with SSM as 25% CP, SSM2 = replacing SBM with SSM as 50% CP, SSM3 = replacing SBM with SSM as 75% CP

Table 6: Effect of varying levels of Sunflower Seed Meal (SSM) in concentrate on Nitrogen (N) balance of goats

Parameters	Concentrate treatments				SEM
	Control	SSM1	SSM2	SSM3	
N intake (g)	14.20	14.23	14.36	14.16	0.053
N excretion					
Faeces N (g)	6.54	6.44	6.45	6.64	0.036
Urine N (g)	4.05 ^{ab}	4.06 ^{ab}	3.76 ^a	4.24 ^b	0.064
N absorption (g)	7.66 ^{ab}	7.79 ^{ab}	7.91 ^a	7.52 ^b	0.044
N retention (g)	3.61 ^b	3.73 ^{ab}	4.15 ^a	3.28 ^b	0.081
N retention (%)	25.29 ^b	26.21 ^{ab}	28.90 ^a	23.11 ^b	0.534

SEM = standard error of the mean. ^{a,b,c}Means within row with different superscripts differ significantly (p<0.05). Control = SBM as a main source of protein in concentrate, SSM1 = replacing SBM with SSM as 25% CP, SSM2 = replacing SBM with SSM as 50% CP, SSM3 = replacing SBM with SSM as 75% CP

the control, 7.3 and 14.5% SSM in concentrates were significantly higher (p<0.05) than in goats fed 22.0% SSM.

There were no effects of dietary treatment on N intake and faeces N. However, N absorption (g/day) and N retention (g/day, %) increased (p<0.05) with the addition of SSM in concentrate up to 14.5% in concentrate, thereafter decreased (p<0.05) in goats fed 22.0% SSM. However, urine N of goats fed 14.5% SSM was lower (p<0.05) than goats fed 22.0% SSM.

Results of this study showed that the overall effect of dietary treatments were no significant differences on almost parameters of goats fed the control (0% SSM), 7.3% SSM and 14.5% SSM (replacing SBM with SSM as 0, 25 and 50% CP). These results agreed with earlier results indicated that SSM could replacing SBM as a protein source for ruminant feeding (Isobel *et al.*, 1990; Schingeothe *et al.*, 1996; Economides, 1998; Titi, 2003). Growth results of the control (SBM) and 7.3% SSM or 14.5% SSM agreed with other studies that showed no differences in these parameters (Economides and Koumas, 1999; Titi, 2003). On the other hand, earlier studies indicated that SSM proteins are more soluble under ruminal conditions than SBM proteins but used less efficiently due to less available carbohydrate and

high fiber of SSM (Schingeothe *et al.*, 1977; Economides, 1998; Irshaid *et al.*, 2003).

Higher DMI and nutrient digestibility of goats fed replacing SBM with SSM 50% of CP than the control treatment assumed that no effect on palatability during feeding. These results agreed with other results reported similar findings (Stake *et al.*, 1973; Economides and Koumas, 1999; Titi, 2003). Microbial N (g N/day) and the efficiency of microbial N supply [g N/kg OMDR] were significantly higher (p<0.05) in goats fed 14.5% SSM than 22.0% SSM treatments. The 21.4 TO 22.6 g N/kg OMDR obtained in this study for goats the control, 7.3% SSM and 14.5% SSM was approaching the values of 17-35 g N/kg OMDR suggested in the literature (ARC, 1984; Czerkawski, 1986; Sinclair *et al.*, 1995; Paengkoum *et al.*, 2006a, 2006b). Nitrogen excretions, particularly urine N increased with addition SSM. Kebreab *et al.* (2002) also reported similar finding and suggested that high urine N excretion has a higher adverse impact on environmental pollution. The above results thus support earlier reports that total N and particularly urine N excretions could be reduced through diet manipulation (Tamminga, 1996; Castillo *et al.*, 2001; Kebreab *et al.*, 2002).

Conclusions: There was an overall improvement in the performance of goats fed 7.3% SSM and 14.5% SSM as compared to the control diets. All the parameters measured indicated that although there was an overall improvement in DMI, nutrient digestibility, microbial protein synthesis and N utilization for goats fed additional SSM, there was no advantage of feeding them with more than replacing SBM with SSM as 50% CP. Results of the present study showed that approximate replacing SBM with SSM as about 50% CP to SBM as the expensive protein source could achieve an impressive about 60 g/d BW gain for growing goats. We postulated that addition of fibrolytic enzymes to the above diet (high SSM) would further enhance both of the efficiency of microbial synthesis and host animal performances.

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