NITROGEN UTILIZATION BY DAIRY GOATS OFFERED DIFFERENT NITROGEN SOURCES AS SUPPLEMENTS IN HIGH ISOCALORIC ENERGY CONCENTRATES

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ABSTRACT

Twelve growing female goats (Anglo-Nubian) were assigned to a multiple latin square design experiment to evaluate the effectiveness of additions of nitrogen (N) supplements to a high isocaloric energy ration on N utilization. In this experiment, microbial synthesis and N balance were assessed. The daily rations were either unsupplemented barley meal (BM), or BM supplemented with one of three nitrogen sources. All rations were isocaloric (3.0 Mcal ME/kg DM) and the N supplements were soybean meal (BSBM), cottonseed meal (BCSM) or urea (BU) to provide 2.9% N in the concentrate component. The unsupplemented BM contained 1.7% N. The addition of N supplements to the ration enhanced N utilization in dairy goats. The organic matter (OM) intake, N intake, N balance, and microbial N synthesis for BM, BSBM, BCSM and BU were 660.5 g, 721.9 g, 728.1g and 703.5 g; 13.5 g, 21.5 g, 20.9 g and 20.7 g; 2.7 g; 7.1 g, 5.4 g, and 5.7 g; and 14.1 g 19.1 g, 19.1 g, and 20.0 g, respectively. It can be concluded that when sufficient dietary energy was available for ruminal microbial activities, the source of N did not affect N balance, and microbial N synthesis.

Keywords: dairy goats, energy, microbial N synthesis, nitrogen balance, nitrogen sources

INTRODUCTION

The world goat population and its importance are growing, especially in rural developing countries to provide an opportunity for profitable and sustainable diversity for small farms (Asih, 2006). However, goat production in those countries is usually low because of the intake and balance of nutrients especially at the critical stages of production are most likely to be below the feeding standards (Dahlanuddin, 2004). To increase goat productions (growth rate and milk production) in developing countries need protein supplementation to increase their nutritional value because the available feed resources are often low in protein and energy content (Leng, 1985; Morand-Fehr, 2004), especially during dry season when most feeds are obtained from agricultural by-products (Santoso and Hariadi, 2009; Wahyuni et al., 2009). Even goats fed high quality forages such as gliricidia leaves (Gliricidia sepium) and hibiscus leaves (Hibiscus tilliacius), still need concentrate supplementation to increase fermentation metabolites and growth performance of Ettawah Crossbred (Putra et al., 2009). However, conventional protein supplements (meat meal, fish meal, soybean meal and other legume grains) are very expensive in developing countries and animal use of such protein sources are often in direct competition with limited human food resources. Soybean for example, is used for producing tempe and tofu. Therefore, it is important to find out available-cheaper-nitrogen sources for dairy goats in developing countries.

Ruminant animals derive their protein from undegradable dietary protein, microbial protein synthesized in the rumen, and endogenous protein. Under most dietary conditions, microbial protein constitutes a major source of protein (Ærskov, 1992; Posada et al., 2005). Microbial protein is of relatively good quality in terms of its amino acid content and digestibility (Broderick et al., 1989). Therefore the quantity and the quality of protein for ruminants are partially determined by the production of microbial protein in the rumen. A review by ARC (1984) indicated an almost a fourfold variation in microbial N flowing

into small intestine (14 – 60 g microbial N) per kg DOMR (Digestible organic matter in the rumen). This variation was apparently related to the diet and the rumen environment (Preston and Leng, 1987; Chen and Gomes, 1992; Mondher, 1994). Variation in responses to different N sources may have been associated with the extent of microbial protein synthesis in the rumen. NRC (1985) suggests that understanding the efficiency of utilization of N sources (protein and non-protein nitrogen) in goats' diets depends upon knowledge of the basic principle underlying microbial N metabolism and the associated metabolic changes that occur in the animal. Therefore, it is important to find out the response of goats fed different types of dietary N on nitrogen balance, efficiency and microbial N synthesis in the rumen by considering the same energy and proportion of N type contribution in diets. Thus, there is some question about the value of nitrogen supplementation in high-energy diets for ruminants, especially for dairy goats.

The aim of the present study was to determine the effectiveness of different nitrogen supplements (barley meal plus soybean meal, cotton seed meal or urea) in high energy diets on nitrogen utilization (N balance and microbial N synthesis) in growing dairy goats.

MATERIALS AND METHODS

Twelve fifteen-months-old female-Anglo-Nubian weighing 29.7 ± 3.1 kg were kept in individual metabolism cages. The goats were allowed cages adjustment period of 4 weeks before starting the experiments. Four high isocaloric (3.0 Mcal ME/kg DM) concentrate supplements were tested. The control concentrate contained barley meal only (BM). The nitrogen supplemented concentrates were barley meal plus soybean meal (BSBM), barley meal plus cottonseed meal (BCSM) and barley meal plus urea (BU). Except for BM (1.7% N), all concentrate mixes were also isonitrogenous (2.9% N) and the N contribution from barley meal was between 57 and 59% (Table 1). The barley hay contained 1.1% N and 1.55 Mcal ME/kg DM.

The amount of concentrate and hay offered was calculated on the basis of 90% feed intakes as measured in the adjustment experiment. The ratio of concentrate to hay offered was also based on the amount of concentrate and hay eaten during the adjustment period, it was about 65:35, and offered twice daily (09:00 and 17:00). A mineral block designed for goats (Go-Block, manufactured by Olsson Industries Pty Ltd.) and fresh water was always available.

A Multiple latin square design (4x4x3 rectangle) based on a design by Mead and Curnow (1983) was used in this experiment to study N balances and microbial synthesis. The experiment consisted of four treatment periods of three weeks duration (two weeks adjustment period and one week measurement). Digestibility and N utilization measurement were made during the first 5 days of the third week followed by purine derivatives measurement on urine collected on the last 2 days based on method as described by Balcells et al. (1991).

Daily feed intake of hay and concentrate were determined by subtracting any refusals from the amount offered. Hay and concentrate refusals were mechanically separated for chemical analysis. ME values were based on standard feed composition tables (NRC, 1985).

Faecal output of each animal was measured daily and a 10% sub-samples stored at -16^0 C and pooled at the last day of each collection period. The sub-samples were dried in a forced draught oven at 60 ^{0}C until the samples reached constant weights (2 - 4 days depended on the total faecal output and water content). The dried sub-samples were ground to 1 mm particle size prior to the chemical analysis. Daily urine was collected into a plastic container containing glacial acetic acid (50 ml) and 10% sub-sample from each animal were taken and stored at -16 ^{0}C for later N analysis. For purine derivates, daily urine was collected into a plastic container containing 10% sulfuric acid (100 ml) and prepared as suggested by Chen et al. (1995). The content of dry matter (DM), ash and organic matter (OM) of feeds, feed refusals and faeces samples were determined according to standard procedures (AOAC, 1984). The nitrogen contents were analyzed using an automatic FP-200 nitrogen analyzer (manufactured by LECO Corporation, Michigan, USA) based on the combustion method (Sweeney, 1989). Purine derivates (allantoin, uric acid, hypoxanthine and xanthine) were analyzed by reverse-phase HPLC, using two μBondaPak C18 (300 mm x 3.9 mm particle size 10 μ) columns, according to the technique described by Balcells *et al*. (1992).

The data was analyzed by using General Linear Model (GLM) procedure of SAS$^{\rightarrow}$ (SAS Institute, Inc. 1990). The differences between means were tested using LSMEANS Test.

Table 1. Composition of Concentrate

Composition	Concentrate			
	BM	BSBM	BCSM	BU
BM (%)	89.00	83.50	82.00	86.30
SBM (%)	0	16.50	0	0
CSM (%)	0	0	17.80	0
Urea (%)	0	0	0	2.50
Oil (%)	3.50	0	0.20	3.50
Sugar (%)	7.50	0	0	7.70
DM concentrate (%)	92.49	91.74	91.56	92.38
N concentrate (%)	1.52	2.59	2.52	2.60
ME concentrate (Mcal)	2.87	2.71	2.66	2.81

BM : Barley Meal
SBM : Soybean Meal
CSM : Cotton Seed Meal
DM : Dry Matter
BU : Barley Meal plus Urea
ME : Metabolizable Energy
BSBM : Barley Meal plus Soybean Meal
BCSM : Barley Meal plus Cotton Seed Meal
N : Nitrogen

RESULTS AND DISCUSSIONS

Nitrogen Balance

The barley hay had 90.9% DM; 1.14% N; 30.4% ADF; 62% NDF; 11.1% ash and 1.55 Mcal ME/kg. The chemical compositions of the concentrate mixtures are shown in Table 1. These concentrate mixtures were high isoenergetic and almost isonitrogenous except for the BM control, and almost isoproportional in terms of N contribution from barley meal.

There were positives of N balances across the treatment in the present study (Table 2), although the control was significantly lower ($p<0.01$) compared to the additional nitrogen treatments. The significant difference of the control in N balance was due to the significantly lower ($p<0.01$) N intake (no additional N source). Among the N source treatments, there were no significant different in N balances if it was expressed in g/day. However, when it was expressed in metabolic weight (g/kg $BW^{.75}$ day^{-1}), the BSBM treatment gave significantly higher ($p<0.01$) in N balance among the type of N sources treatments. It is not clear yet which one is more precise expression, but in fact those N source treatments had the same responses in growth rate of young dairy goats (Asih and Young, 2003). To increase N balance of the young dairy goats, the ration should be added by N sources to increase N utilization.

Interestingly, with the urea treatment (BU), the fecal N excretion was significantly lower ($p<0.01$) than the rest of mean treatments, although the difference of the N balance among treatments was not significant ($p>0.05$). The percentage of the fecal excretion of N intake was also the lowest (20.8%) compared to other treatments being 35.6%; 22,4%; 24.9%, respectively for BM; BSBM and BCSM. That means the NPN in the BU diet was probably recycled back into the rumen of the goats, because of the availability of fermentable energy in the rumen sufficient for utilizing those N recycles.

Efficiency of Microbial N-synthesis and Microbial N Supply

Ruminant animals like dairy goats obtain their nutrient requirements mainly from the products of rumen fermentation (i.e., microbial cells and VFA) and, in some situations, dietary bypass nutrients. The goats receive the majority of their essential amino acids from microbial protein on forage-based diets, particularly when they are

Table 2. Nitrogen Utilization and Nitrogen Digestibility Coefficient by Goats of Isocaloric Diets Containing Different Nitrogen Sources

Nitrogen Utilization	Treatment				
	BM	BSBM	BCSM	BU	SEM
N intake (g day^{-1})	13.5^{a}	21.5^{b}	20.9^{b}	20.7^{b}	0.39
Fecal N (g day^{-1})	4.8^{a}	4.8^{a}	5.2^{a}	4.3^{b}	0.12
Urinary N (g day^{-1})	6.0^{a}	9.6^{b}	10.3^{b}	10.7^{b}	0.57
N balance (g / day)	2.7^{a}	7.1^{b}	5.4^{b}	5.7^{b}	0.54
N balance (g/kg $BW^{.75}$ day^{-1})	0.16^{a}	0.49^{c}	0.37^{b}	0.39^{b}	0.04
Digestibility coefficients (%)					
Nitrogen (N)	69.0^{a}	78.0^{b}	73.7^{c}	78.5^{b}	0.92

Means within the same row with different superscripts are high significant different ($p<0.01$); SEM = Standard Error Mean

low in true protein (Leng, 1997). It is, therefore, important to consider how microbial growth efficiency, and therefore amino acid availability from this source, can be maximized so as to minimize or replace the need for expensive bypass protein supplements by providing fermentable energy in their diets.

The addition of N to the high-energy concentrate component of the diet significantly increased efficiency of microbial synthesis and microbial N supply, but the type of N sources gave similar results (Table 3). The urea treatment in the present study maintained similar levels of nutrient supply to support microbial activities in the rumen of young dairy goats, as did the other treatments. This is in agreement with ARC (1984), which emphasised that there seems to be little consistent advantage from the use of protein rather than NPN as a source of high fermentable energy supplementary diets for ruminants. Similarly, Wahyuni et al. (2009) found that increasing levels of nutrient rich supplementation on ration treatments could increase the amount of easily fermented carbohydrate and NPN source in rations consumed resulted in enhancement of rumen microbial biomass. They concluded that microbial protein production was highly depended on the availability of easily fermented and degraded organic matter. In the present study, the concurrent release of readily available energy from barley meal and ammonia from urea apparently produce satisfactory conditions for microbial growth in the rumen. This finding is also supported by Sahoo and Walli (2008) who reported that microbial protein yield (calculated from purine derivatives excreted in urine) of kids given different N sources (RDP and UDP of untreated mustard cake and formaldehyde treated mustard cake) in high energy concentrate treatments with molasses as an energy source was similar. They concluded that higher UDP intake improved growth performance in kids and supplementation of molasses as an energy source, with or without ruminal escape CP, has no added advantage.

On the other hand, the present study was not in line with Astuti and Wina (2002) who found that different N sources in the concentrates (iso-nitrogenous) given to lactating Ettawah Crossbred goats resulted in significant different efficiency of microbial synthesis and microbial N supply. This may be due to the different energy contents of the concentrates used and the calculation based on the gross energy which may have different coefficient digestibilities. This means that the type and the contents of energy in the concentrates more important instead of the type of N sources for producing microbial N supply.

As the quantity of microbial crude protein synthesised in the rumen is closely correlated with availability of digestible organic matter intake (DOMI), each kg DOMI can yield about 120-135 g microbial protein (Waldo and Glenn, 1984). In their review, Brun-Bellut et al. (1987) assumed that goat's microbial protein yield was the same as for cattle and sheep, i.e. between 100 and 190 g/kg DOMR. However, according to Laurent (1985), microbial crude protein yield in goats

Table 3. Microbial Synthesis by Goats of Isocaloric Diets Containing Different Nitrogen Sources

Item	Treatment				
	BM	BSBM	BCSM	BU	SEM
Nitrogen intake (NI), g/day	13.5[a]	21.5[b]	20.9[b]	20.7[b]	0.41
Organic matter intake (OMI), g/day	660.5[a]	721.9[b]	728.1[b]	703.5[b]	12.89
Microbial nitrogen (N) supply, g/day	14.1[a]	19.1[b]	19.1[b]	20.0[b]	1.07
Efficiency of rumen microbial protein synthesis, g microbial N/kg DOMR	42.2[a]	51.7[b]	53.3[b]	56.2[b]	2.21
Microbial N : NI ratio	1.05	0.90	0.92	0.97	0.05

Means within the same row with different superscripts are high significant different ($p<0.01$)
SEM = Standard Error Mean

varied between 105 and 180 g/kg DOMR. In the present study, the values were very much higher and varied from 184.1 to 226.4 g/kg DOMR. Besides the high energy content in the present diets, maybe the growing goat also has faster growth rate of rumen microbes. It is of interest to note that the daily microbial N supply reported in Laurent's work (1985) was in line with the findings of the present study (15-20 g/day vs 15.2-20 g/day, respectively).

Many published studies on the efficiency of rumen microbial N synthesis are available for cattle and sheep, but very few are available for goats. For forages, the mean efficiency of microbial N synthesis is about 19.5 g/kg DOMR, but values ranged from 15.7 to 49.3 g/kg DOMR with the low values usually associated with feeds of lower protein content (ARC, 1984; Minson, 1990). The present study found much higher microbial N efficiency compared to most of the published data for cattle (Waldo and Glenn, 1984; Kolade, 1994), sheep (Corbett and Pickering, 1983; Dove and Milne, 1994; McMeniman et al., 1986; Chen et al,. 1992), and also goats (Laurent, 1985). Species differences might explain these findings, since Laurent (1985) observed that goats had higher microbial N synthesis (25.4 g/kg DOMR) than sheep (17.4 g/kg DOMR) when fed the same feed (a maize silage diet).

Interestingly, the goats were given BM supplemented treatment (un-supplemented N sources) which containing only 1.7% N produced microbial protein higher (42.2 g N/kg DOMR as shown in Table 3) than suggested by Laurent (1985): 105 to 140 g microbial protein/kg DOMR or 16.7 to 22.4 g microbial N/kg DOMR. This BM supplemented treatment was efficiently enough used for microbial protein synthesis because more efficient used of rumen ammonia N for microbial protein synthesis by reducing the secretion of N urine (Widyobroto et al., 2010). In this case high available energy concentrates may be more responsible to the relative higher microbial N production than N level in the concentrate because goats have ability to re-utilize the N recycling to the rumen (Engelhardt and Hinderer, 1976; Shkolnik and Choshniak, 1985). Even the goats in this treatment (BM treatment) produced microbial N synthesis per day (14.1 g) higher than their daily N intake (13.5 g) as shown in Table 3. That may be the contribution of N recycling to the rumen by significantly ($p<0.01$) reduce N excretion through the urine (Table 3).

CONCLUSION

The addition of N supplements to the high energy diets enhanced the N balance, and microbial protein synthesis in young dairy goats. However, the addition of different types of N sources did not show any differences of those measurements. It can be concluded that the urea is still as a promising N source for young dairy goats, because it can minimize the use of expensive bypass protein supplements.

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