Feed intake, growth performance and digestibility in goats fed whole corn plant silage and Napier grass

Khaing[1], K.T., Loh[1], T. C., Ghizan[2], S., Halim[2], R. A. and Samsudin[1*] A. A.
[1]Dept. of Animal Science, [2]Dept. of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor
*Corresponding author: anjas@upm.edu.my

Abstract

Shortage and inconsistent quality of forage in developing countries are the major constraints to the development of ruminant sector. To overcome these problems, feeding of ruminants with conserved forages is an important feeding strategy to ensure the success of ruminant production in the third world countries. The use of whole corn plant as silage has drawn many attention due to high protein efficiency, relatively high digestible energy and total digestible nutrients. Thus, the objective of this study was to determine feed intake, growth performance and nutrients digestibility in goats fed different inclusion level of whole corn plant silage to Napier grass based diets. Fifteen male Boer cross goats around six months old and approximately 18.54 ± 1.83 kg of body weight were used as experimental animals. The goats were assigned into five treatment groups consisted of different proportions of Napier grass (G) and whole plant corn silage (CS) –T1:100/0 G/CS; T2:75/25 G/CS; T3:50/50 G/CS; T4:25/75 G/CS and T5:0/100 G/CS. The increase of corn silage to Napier grass proportion demonstrates increase in dry matter intake and growth performance in the goats. The highest nutrient digestibility was observed in T5:0/100 G/CS and T3:50/50 G/CS. It can be concluded that high proportion of corn silage to grass diets had resulted in increases in feed intake and growth performance of goats. Feeding the animals with T5 and T3 resulted in high nutrient utilization compared to other treatments. However, the highest growth performance was observed in animals that were fed with T5 diets.

Keywords: corn silage, Napier grass, feed intake, growth performance, digestibility, goats

Introduction

Small ruminant production is a very significant component of livestock production throughout the world and more specifically in the developing countries (Ketema, 2007; Thornton *et al.*, 2009). Goat has the ability not only to survive different environmental conditions but also able to utilize poor quality feed (Abedo *et al*., 2013). Feed resources for ruminant livestock in the tropical regions are normally of natural pastures and poor quality grasses which are limited in supply during the dry season. Thus, feeding of ruminants with conserved forages has become an important feeding strategy since they could be made available throughout the year. In addition, the nutritive values of

the feed would be more consistent for daily feeding. Nowadays, the use of corn silage as green forage in ruminant feeding has increased rapidly (Hafezl, 2012) due to its high yielding properties, relatively high content of energy, palatability and easy incorporation in total mixed ration (Cherney *et al*., 2004; Kononoff *et al*., 2003). Corn silage can be an economic source of nutrients for domestic animals, especially on large farms where feeding can be mechanized (Oelker *et al*., 2009). However, corn silage contains high amount of starch which could possibly attribute to depression in fibre degradation (Grant and Mertens, 1992).

Kung and Shaver (2001) reported that corn silage can be used not only as a main source of feed for cattle but also as a combination with other forages including pasture grass. Chizzotti *et al.* (2009) described that the incorporation of different forage sources can be a viable alternative to improve the performance of animals. Niderkom and Baumont (2009) reported that one feedstuff can affect the nutritional value of another feedstuff in the diets. Adoption of this feeding method offers the potential to increase productivity because of the associative effects of mixed forage diets on nutrient supply to cattle (Phipps *et al*., 1995; Wilkinsoon *et al.,* 1998). The amount of feed intake increased when corn silage was included in the grass silage based diets as the sole forage in beef cattle (Souza *et al*., 2006). Similarly, Juniper *et al.* (2005) reported that the progressive inclusion of corn silage to grass silage has the potential to reduce the time required to finish beef cattle. However, consequently inclusion of corn silage to grass silage showed decrease overall OM digestibility in dairy cattle (O'Mara *et al.*, 1998). Adogla–Bessa and Aganga (2000) stated that the production and reproduction of livestock was improved by supplying the right amount of corn silage.

Dietary manipulation is used to improve animal performance as well as ruminant production. A few studies have evaluated the effects of the inclusion of whole corn plant silage to grass silage. Currently a vvery limited number of goat farmers are feeding their animals with whole corn plant silage in Malaysia. This feeding practice is showing interest in including whole corn plant silage to Napier grass to the ruminants particularly small ruminants like growing goats to improve the efficiency of nutrient utilization and to obtain optimum body weight. Therefore, the objective of this study was to determine feed intake, growth performance and nutrient digestibility in goats fed different inclusion levels of whole corn plant silage to Napier grass based diets.

Materials and Methods

Experimental Animals and Diets

The experiment was carried out at Field 2, Ruminant Farm, Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, Serdang Selangor. Fifteen Boer crossbred male goats around six months old and of approximately 18.54 ± 1.83 kg of body weight were used in this study. These animals were housed in individual pens

and randomly and equally assigned in a completely randomized design into five treatment groups with three goats per treatment. The diets consisted of 60% forage and 40% concentrates. The five treatment groups were made up of the various proportion of Napier grass (G) and whole corn plant silage (CS): T1/100:0 G:CS, T2/75:25 G:CS, T3/ 50:50 G:CS, T4/25:75 G:CS and T5/0:100 G:CS.

The Suwan corn forage variety was planted and harvested at the one third milk line stage of maturity around 90 d. The crop was cut into around 2 cm particles in length using a mechanical machine and the cut forage was kept tightly in polyethylene barrels for 2 mo before been given to the animals. Napier grass harvested and used in this experiment was around 2 to 2.5 mo in maturity and harvesting was done daily in the morning. After that, it was chopped mechanically to around 2 cm in length before been fed to the animals.

Feeding Trial

The length of the feeding trial to determine feed intake and growth performance was 84 d. The goats were fed with Napier grass and whole corn plant silage mixed with commercial pellets for 14 d for adaptation period before the start of data collection. The goats were fed with treatment diets *ad libitum* twice daily around 09:00 and 17:00 h. For each animal, the amounts of feed offered and refused were recorded every morning before new feed was offered to calculate the daily feed intake. Feeding troughs were cleaned every morning to prevent contamination with detrimental microorganisms such as yeasts and moulds and undesirable bacteria forming on the silage. During the feeding trial, body weight (BW) was measured every 2-wk interval before the morning feed was offered. The average BW gain was calculated by dividing the initial and final live weight differences by the total number of experimental days (84 days). Feed conversion ratio was calculated as the ratio between feed intake and body weight gain.

Digestibility Trial

On the completion of the feeding trial, a digestibility trial was conducted from the day 85 until day 97. All goats were transferred to metabolic crates with facilities to separate the collection of urine and feces. After a wk of adaptation period in the metabolic crate, the collection period was carried out for 5 d. During the collection period, the amount of feed offered was recorded, and refuse was collected, weighed and sampled daily for chemical analysis. Feces voided was collected and recorded daily during collection period. Ten percent of the fecal sample was taken daily and stored in a deep freezer for 5 d before chemical analysis was done. After five consecutive d, fecal samples from each goat were pooled and added with 5 ml of 15 % H_2SO_4 to prevent N loss, and then oven dried at 60˚C for three d for further chemical analysis. The pooled samples of dried feed, orts and feces were ground and screened through a 10 mm sieve and preserved for chemical analysis.

Apparent nutrient digestibility was calculated as follows:

$$\text{Nutrient digestibility (\%)} = \frac{\text{Nutrient intake - Nutrient voided in the feces}}{\text{Nutrient intake}} \times 100$$

Measurement of pH and Fermentation Acids from Corn Silage Samples

The value of pH and the concentration of fermentation acids of corn silage were measured from samples of whole corn plant silage which were taken throughout the feeding and digestibility trials. The pH of each sample was determined in triplicate using 25 g wet ensilage that was mixed with 100 ml of distilled water. After hydration for 30 s using a blender, the filtrate was filtered through Whatman filter paper (No.1) to obtain the extracts. Immediately after extraction, the pH was measured using a pH meter (Filya, 2003).

Immediately, after the pH measurement was completed, the remaining filtrate was preserved with 2-3 drops of 5% sulphuric acid and kept frozen at -20˚C pending for fermentation acid analysis. Lactic acid and VFA concentration in the silage extract were determined by using gas chromatography (Agilent 69890N Series Gas Chromatography System from Agilent 97 Technologies, USA) equipped with a flame ionization detector.

Chemical Analysis

Ground samples of feed offered, orts, and feces were analyzed for DM, OM and CP percentage of whole corn plant silage according to the procedure of AOAC (1990), while the percentage of NDF, ADF and ADL were determined according to Van-Soest *et al*. (1991).

Statistical Analysis

Data from the feeding and digestibility trials were analyzed with one way analysis of variance (ANOVA) using the general linear model (GLM) program of SAS (package version 9.2) appropriate for completely randomized design and differences between treatment means were compared using Duncan's multiple range tests.

Results and Discussion

Corn silage was considered well fermented as recorded by the low pH, and high concentration of lactic acid and acceptable level of VFA contents. Fermentation analysis of whole corn plant silage and chemical composition of feed and experimental diets are presented in Table 1-3. All values except DM were expressed on DM basis. The Napier grass contained higher NDF and ADF content than the whole corn plant silage although other chemical parameters were relatively similar. The inclusion of whole corn plant silage to basal diet of Napier grass had contributed to a reduction in NDF, ADF and ADL contents and an increase in the content of ME in the experimental diets.

Table 1: Fermentation analysis of whole corn plant silage

Fermentation acids	**%**
pH	3.7
Lactic acid	**73.03**
Acetic acid	9.31
Propionic acid	0.72
Butyric acid	0.12

Table 2: Chemical composition of feedstuffs

Items	DM %	OM %	CP%	NDF %	ADF%
Napier grass	23.4	97.1	8.0	74.8	42.6
Corn silage	23.3	96.1	8.1	58.6	35.1
Commercial pellet	89.2	91.0	15.4	37.0	8.3

Table 3: Chemical composition of experimental diets

Parameter	Treatment				
	T1	T2	T3	T4	T5
DM (%)	95.6	95.5	95.0	94.9	94.5
OM (%)	95.7	95.5	95.7	95.2	95.4
CP (%)	10.6	10.6	10.7	10.8	10.8
NDF (%)	59.2	56.8	54.7	52.5	49.5
ADF (%)	23.5	22.3	21.0	19.9	19.2
ADL (%)	8.3	7.8	7.7	6.3	6.1
ME(MJ/kg DM)*	9.47	10.06	10.73	11.04	11.65

*Calculated ME value (MJ/kg DM) = 0.016 DOMD (g digestible organic matter/kg DM (AFRC, 1998)
T1; Napier grass : Corn silage (100 : 0), T2; Napier grass : Corn silage (75 : 25), T3; Napier grass : Corn silage (50 : 50), T4; Napier grass : Corn silage (75 : 25), T5; Napier grass : Corn silage (0 : 100)

The daily dry matter intake (DMI) increased linearly ($P<0.01$) with the addition of whole corn plant silage to Napier grass (Table 4). Highest daily DMI was observed in goats fed with T5 diet. This could be due to the higher palatability and good fermentation characteristics of feed which attracted the goats to consume more amount of the whole corn plant silage. Another reason

for the increase in the DMI of the feed might be due to the chemical composition of the whole corn plant silage which had lower cell wall content and high amount of fermentable carbohydrate and energy, which had increased the digestibility of the silage compared to Napier grass. Okoruwa *et al.* (2012) reported that the fermentation process of high fiber diets had taken longer compared to low fiber diets by rumen microorganisms. Higher feed conversion ratio was also observed with the increase in the inclusion level of whole corn plant silage to the Napier grass-based diet (Table 4). Kariuki *et al*. (2001) and Widiawati and Thalib (2009) stated that cell wall content of Napier grass degraded slowly in the rumen and was more resistant to rumen microbial fermentation. The increase in DMI of whole corn plant silage relative to grass silage was due to more rapid fermentation and physical breakdown in the rumen (Dewhurst, 2013). The DMI differences had been attributed to rapid rate of fermentation occurring in the rumen (Beever, 1996) as well as rate of degradation and clearance of digesta from the rumen (Jamot and Grenet, 1991). Wiese *et al.* (2003) reported that higher DMI might be due to a better availability of nutrients which are readily been degraded by rumen microbes. Inclusion of corn silage to the grass silage had a positive effect on feed intake as observed by Browne (2000). However, Van de Vyver *et al*. (2013) reported that the DMI of Merino lambs decreased as the inclusion level of corn silage increased in the oat-hay based diet. This is due to high moisture and NDF content of the silage which physically restricts DMI.

The body weight of the goats is presented in Table 4. BW gain increased linearly with inclusion levels of whole corn plant silage in the basal diet of Napier grass and the highest BW gain was observed in T5 (125.4 g/day) and the lowest was T1 (35.7 g/ day). This might be due to increased DMI and also high content of digestible nutrient and energy in the whole corn plant silage than Napier grass. In contrast, Browne *et al.* (2004) stated that voluntary intake and growth performance were negatively affected by the substitution of high amount of corn silage to the basal diet of the grass silage due to the accumulation of high level of fermentation acid which might have depressed the activity of cellulolytic bacteria in the rumen. Salam (2009) mentioned that the diets containing high energy content will help in increasing the amount of microbial protein synthesis due to the synchronization of available energy and ammonia nitrogen in the rumen which contributes to an increase in nutrient digestibility and BW gained. In addition, high concentration of lactic acid in silage may have been metabolized into propionic acid by rumen microorganisms (Abedol *et al.,* 2013). Propionic acid is then absorbed into blood stream via rumen wall and converted to glucose in the liver. The glucose formed will be used by the animal as energy source for maintenance and production activities (Hariadi and Santoso, 2010).

Table 4: Effect of experimental diets on feed intake (g/day) and growth performance of goats

Parameter	Treatment					SEM	P value
	T1	T2	T3	T4	T5		
Initial BW (kg)	18.8	18.0	18.4	18.5	18.4	1.3	-
Final BW kg)	21.8 ^{de}	22.8 ^{cd}	24.8 ^{c}	26.5 ^{b}	28.9 ^{a}	1.04	*
Total BW gain (kg)	3.0 ^{e}	4.8 ^{d}	6.4 ^{c}	8.1^{b}	10.5 ^{a}	0.77	**
Daily BW gain (g)	35.7 ^{e}	57.1 ^{d}	75.6 ^{c}	96.0^{b}	125.4 ^{a}	2.13	**
Daily DMI(g, DM)	276.8 ^{e}	338.9 ^{d}	380.7 ^{c}	406.6^{b}	464.4 ^{a}	20.12	**
FCR	7.8 ^{e}	6.0^{d}	5.0 ^{c}	4.2 ^{b}	3.7 ^{a}	0.14	**

*Significantly different at 5% level (P<0.05), **significantly different at 1% level (P<0.01), $^{a, b, and c}$ Means with different superscript in each row differed significantly

T1; Napier grass : Corn silage (100 : 0), T2; Napier grass : Corn silage (75 : 25),
T3; Napier grass : Corn silage (50 : 50), T4; Napier grass : Corn silage (75 : 25),
T5; Napier grass : Corn silage (0 : 100)

The effect of treatment diets on nutrient digestibility is shown in Table 5. The apparent digestibility percentages of DM, OM, CP, NDF and ADF were significantly different among the treatments. The nutrient digestibility increased linearly with addition of whole corn plant silage to Napier grass diet at the inclusion level 25 % and 50 % (T2 and T3). This might be due the low content of structural carbohydrate in the whole corn plant silage making it more available to rumen microbial degradation compared to Napier grass. However, the nutrient digestibility was lower in T4 diet compared to T3 diet. This is probably due to the physical and chemical constituents of combined diets. The apparent digestibility of CP also increased linearly with substitution of 25% (T2) and 50% (T3) whole corn plant silage to Napier grass diet. This might be due to high uptake of nitrogen content in the diet. However, it declined significantly at 75 % inclusion level (T4) of whole corn plant silage incorporated in Napier grass which could be due to negative associative effect of the combined diets. Nevertheless, the highest DM, OM, CP, NDF and ADF digestibility was observed in 100% of whole corn plant silage diets. This is because the silage contained high amount of fermentable carbohydrate that increased the digestibility and nutrient utilization by the animals. Both DM and OM digestibilities increased linearly (P>0.01) with inclusion level of corn silage to grass silage diet (Browne *et al.*, 2005). Cavalcante *et al.* (2004) stated that no significant difference was observed in the digestibility of DM, OM, CP and NDF of steers fed increasing level of corn silage to the Tifton-85 hay. However, the highest NDF digestibility was observed at the inclusion level of 31% corn silage to the diets. Hunt *et al.* (1988) reported that the highest positive effect was observed in 25 % inclusion level of alfafa hay to wheat straw diets when different levels of substitution (0, 25, 50 and 75 %) were evaluated. Increase in DM, OM, CP and NDF digestibility was also observed after inclusion of sorghum silage to the grass silage (Chizzotti *et al*., 2005). Similarly, Juniper *et al.* (2005) and Vranic *et al.* (2008) reported that the inclusion of corn

silage to the grass silage had resulted in linear or quadratic responses of total gastrointestinal tract digestibility.

Table 5: Effect of dietary treatments on nutrient digestibility in goats

Digestibility (%)	Treatment					SEM	P value
	T1	T2	T3	T4	T5		
DM	58.35 ^{d}	61.31 ^{cd}	67.39 ^{ab}	65.31 ^{bc}	71.00 ^{a}	1.43	**
OM	59.18 ^{d}	62.89 ^{cd}	69.02 ^{ab}	67.06 ^{bc}	72.79 ^{a}	1.43	**
CP	57.70 ^{b}	59.07 ^{ab}	63.45 ^{a}	59.33 ^{ab}	63.65 ^{a}	1.25	**
NDF	52.99 ^{b}	55.20 ^{ab}	60.45 ^{a}	55.78 ^{ab}	61.33 ^{a}	1.82	*
ADF	43.83 ^{b}	47.87 ^{ab}	52.13 ^{a}	48.32 ^{ab}	53.12 ^{a}	1.45	*

*Significantly different at 5% level (P<0.05), **significantly different at 1% level (P<0.01),
^{abc} Means with different superscript in each row differed significantly
T1; Napier grass : Corn silage (100 : 0), T2; Napier grass : Corn silage (75 : 25),
T3; Napier grass : Corn silage (50 : 50), T4; Napier grass : Corn silage (75 : 25),
T5; Napier grass : Corn silage (0 : 100)

Conclusion

The result of the present study showed that inclusion of whole corn plant silage to the basal diet of Napier grass had resulted in linear increase in feed intake, BW gain and feed conversion ratio. The highest efficiency of these parameters was observed in goats fed with T5 diet. Moreover, the highest nutrient digestibility of DM, OM, CP, NDF and ADF were observed in T5, followed by T3, T4, T2 and T1. It can be concluded that animals that are fed with 100 % whole corn plant silage would most likely show the highest growth performance and better nutrient digestibility compared to other percentages of corn silage in the Napier diet.

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