WIJAS 3: 37–49 (2022)

Welwitschia International Journal of Agricultural Sciences (WIJAS)

W I J A S http://www.unam.na E.mail: editor4wijas@unam.na (+264) (0) 61 206 3111

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Effect of legume hay supplementation on feed intake, growth, digestibility and volatile fatty acid production of Xhosa goats

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Abstract

The objective of this study was to evaluate the effects of sex and supplementing *Chloris gayana* hay with either *Lablab purpureus* or *Vigna unguiculata* on growth, apparent nutrient digestibility and volatile fatty acid production. Eighteen one-year-old goats (14.13 ±0.24kg) was apportioned in a completely randomized design to three diets which are treatment one (T_1); 71% Vigna hay, 19% Katambora hay, salt (0.5%), molasses (3%), maize (5%) and mineral vitamin premix 1.5%; treatment two (T_2) ; 90% lamb and ewe pellet plus 10% Katambora hay; and treatment three (T_3); 72% Lablab hay 19% Katambora hay, salt (0.5%), molasses (2%) maize (5%) and mineral vitamin premix 1.5%. - Animals were housed individually with 6 animals per treatment composed of three males and three females. The goats gained at a rate of 35.0g/d; 45.0g/d and 38.3g/d for T_1, T_2, and T_3, respectively. Animals on T_1 exhibited a significantly lower FCR ($P < 0.05$) than T_2 and T_3. Apparent DM digestibility were significantly different ($P < 0.05$) among treatment diets. Diets significantly ($P < 0.05$) influenced butyrate concentration. It was concluded, that Cowpea and Lablab forages can support growth but have lower DM digestibility, and lower butyrate production levels compared to commercial pellets.

Key words: nutrient digestibility, small ruminants, forage legumes, rumen fermentation

1. Introduction

The importance of goat farming has recently gained momentum in sub-Saharan Africa. This has been necessitated by the fact that goats have a short growing period, low nutrient input requirements and fast

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Received 03 June 2021. Received in revised form 12 November 2021. Accepted 30 June 2022. Available online 11 Septemder 2022. *Corresponding author: Washaya S (E-mail: jabulaniwashaya@yahoo.com).

economic returns, compared to large ruminants. Hozza *et al.* (2014) reported that goats produce more meat and milk per unit live weight per year compared to large ruminants. However, goat production in tropical developing countries is based on extensive feeding management, characterized by browsing and/or grazing poor quality natural pastures.

In sub-Saharan Africa recent years have been characterized by continued severe droughts. This has been linked to the effects of climatic change (Ondiek *et al*., 2013) leading to an ever increasing animal feed shortage particularly in the arid and semi-arid areas. Ruminant animal production systems in these areas are predominantly of natural grass pastures. These pastures possess very little amounts of protein during the dry season, which cannot sustain basic animal maintenance. Moreover, dietary protein intake from protein of animal origin is low in the tropics, therefore there is a need to find suitable protein supplements which will be available during drought conditions. Furthermore, ruminant animals are endowed with the ability to degrade and utilize forages because of their symbiotic relationship with rumen microbes. In earlier studies, Babayemi (2007) reported that ruminant animal production is influenced by the quality, seasonality, low intake and poor digestibility of native pastures. In spite of these limitations ruminant animals are still reared under inadequate dietary conditions and survive. This phenomenon has been demonstrated by Lapierre and Lobley (2001) when they reported that between 40 and 80% of urea-N synthesized by the liver is returned to the gut, and 35 to 55% of this is converted to further anabolic use in both cattle and sheep. Furthermore, the average small scale farmer cannot afford to use conventional feedstuffs due to soaring retail prices (Mako *et al*., 2012). The introduction of legume forages as a source of protein in ruminant diets is recognised and accepted (Baloyi *et al*., 2008; Katsande *et al*., 2016). These have been shown to improve the amount of N available for rumen fermentation at the same time improving the mineral content of a diet (McDonald et al., 2011). Rezai *et al.* (2012) also observed that forage legumes that possess rumen undegradable protein, consequently provide growth-limiting amino acids such as lysine and methionine. These improve rumen fermentation kinetics and improve rumen microbial protein production which is a key source of nutrients for a ruminant animal.

However, there is a vast array of annual legume forages that a farmer can utilize. These have diverse agronomic requirements for effective production. It is after this realization that Lablab and Vigna were chosen for this study. These two legume forages are endowed with drought tolerance and very high forage production ranging between 6tDM/ha – 9tDM/ha (NRC 2007) and these attributes suite the local farmer. However, information is still lacking on the extent to which these forages influence the nutrition of small ruminant animals in Southern Africa. Therefore the objective of this study was to evaluate the effects of sex and feeding Lablab and Vigna hay as protein supplements on voluntary feed intake, growth, apparent nutrient digestibility and volatile fatty acid production in Xhosa goats.

2. Materials and Methods

2.1 Description of study site

The research was conducted at the University of Fort Hare Research Farm, in the Eastern Cape Province of South Africa during November 2014 summer season. The farm is located at a latitude of 32º46' S and longitude 26º50' E at an altitude of 535 metres above sea level. It has a warm temperate climate with an average annual rainfall of about 575 mm received mainly during the summer months of November to March. The maximum and minimum temperature was 24.6^0C and 11.1^0C with an average temperature of 17.8^0C".The soils are deep and alluvial, of the Oakleaf form, belonging to the Ritchie family. The vegetation is dominated by grasses such as *Themeda triandra* and *Cympogon plurinodis* with woody plants such as *Acacia karro* and shrubs that are encroaching some parts of the grazing lands (Mucina and Rutherford 2006).

2.2 Animal management

The study was approved by Animal Research Ethics (Certificate Number MUP121SWAS01) of the University of Fort Hare. Eighteen goats (9 castrated males and 9 females) with an average body weight of 14.2±0.24 kg and 12 months old were used in this experiment. Goats were dewormed using niclosamide 20% (Lintex L, Bayer Health Casre) and dipping was done using a pour on accaricide (Coopers Redline, ANB Veterinary Wholesalers). Animals were injected with a mineral and vitamin complex (Cipla Agrimed, Cipla Foundation South Africa) prior to housing and thereafter, every 14 days. Animals were housed individually in metabolic pens measuring 1.5 x 1.0 m and were acclimated to the environment and experimental conditions for 14 days, which was followed by 40 days of growth trial and 6 days of digestibility trial. Animals were fed two equal portions at 08:00 and 15:00 hours daily and the amount on offer was adjusted based on body weight measured every 15 days. Feed refusals were collected and weighed thrice every week in the morning before fresh feed was offered to determine voluntary dry matter intake weekly. Clean water was available to animal's *ad libitum.*

2.3 Treatment diets

Animals were subjected to three treatments of treatment one (T_1); 71% Vigna hay, 19% Katambora hay salt (0.5%), molasses (3%), maize (5%) and mineral vitamin premix 1.5%; treatment two (T_2) ; 90% lamb and ewe pellet plus 10% Katambora grass hay; and treatment three (T_3); 72% Lablab hay 19% Katambora hay, salt (0.5%), molasses (2%) maize (5%) and mineral vitamin premix 1.5%. Treatment two was the positive control diet. All diets were formulated to contain CP and energy to meet the minimum recommendation for intensive feeding (i.e. 14% CP and 9 MJ ME/ kg DM) (NRC 2001). Animals were fed at 3% of metabolic body weight.

2.4 In vivo digestibility

After 53 days feed refusals and total faecal samples were collected once every day, for seven days before morning feeding. Twenty percent of the faecal samples from each pen were dried at 68^0C for 48 hours, ground through a 1mm screen and sent for lab analysis. Digestibility co-efficiencies of DM and OM were determined using the standard formula:

$$DMD(g/kg) = \frac{DM\ in\ feed - DM\ in\ faeces}{DM\ in\ feed} x\ 100 \quad (1)$$

$$\text{OMD (g/kg)} = \frac{OM\ in\ feed - OM\ in\ faeces}{OM\ in\ feed} x100 \quad (2)$$

2.5 Volatile fatty acid production

Rumen liquor samples were collected from each goat 45 minutes after slaughter and stored immediately at -20^{0}C until required. Acids were cleaned prior to analyses according to Siegfried et al (1984). After cleaning acids, gas chromatography (Agilent 6890 N G1530 N GIC – FID) was used to detect retention peaks and data was subjected to GC Chemstation software for analysis using crotonyl acid as a standard.

2.6 Chemical analysis

The feed proximate composition, including dry matter (#930.15), ash (#942.05), total nitrogen (#954.01) and ether extract (EE; #920.39), were determined according to AOAC (2005) official methods. Crude protein (CP) was calculated by multiplying nitrogen content by a factor of 6.25. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest et al. (1991). Neutral detergent fibre, ADF and ADL were expressed inclusive of ash.

2.7 Statistical analysis

A completely randomized design in 3x2x5 factorial arrangements (three diets; two sexes and five time intervals) was used. The data on dry matter intake (DMI), average daily gain (ADG), digestibility and VFAs were subjected to analysis of variance (ANOVA) using the General Linear Model of SAS version 12 (SAS 2003). An F test at 5 % probability level was used to test for significance and means were separated using Tukey HSD test. The following model was used for data analysis:

$$Y_{ijkl} = \mu + Ti + S_j + D_k + TS_{ij} + TD_{ik} + SD_{jk} + TSD_{ijk} + e_{ijkl}. \quad (3)$$

Where Y_{ijk} is the response variables, DMI, ADG, total gain, etc
μ is the overall mean,
T_i is the effect of dietary treatments (T_1, T_2, and T_3,)
S_j is the effect of sex (1, 2)
D_k is the effect of time (0, 15, 30, 45 and 60)
TS_{ij} is the effect of interaction between treatments and sex of animal
TD_{ik} is the effect of interaction between treatment and time
SD_{jk} is the effect of interaction between sex and time
TSD_{ijk} is the three way interaction among diet, sex and time
eijk is the random error

3. Results

3.1 Chemical composition of diets

Three diets were given to growing goats over a period of sixty days and the dietary inclusions are listed in Table 1. The three diets were formulated to provide the same amount of protein (iso-nitrogenous) and energy (iso-energetic). The basis was the pellet diet which had a CP level of 14 % and ME of 8.87MJ/kg.

The CP level of experimental diets were above the minimum requirement of 12.6% as recommended by NRC (2007).

3.2 Feed intake and body weight gain of Xhosa goats

The results of the growth performance are shown in Table 2. Treatment diets and sex significantly ($P < 0.05$) affected DMI, total gain, ADG, and feed conversion ratio (FCR). Animals on T_2 showed higher ($P < 0.05$) DMI of 24g/d and 6.7g/d compared to T_1 and T_3, respectively. Animals under T_2 exhibited the highest ADG and total gain with the lowest FCR ($P < 0.05$). Male animals exhibited higher DMI ($P < 0.05$) compared to female animals. Sex had no significant ($P > 0.05$) effect on FCR, however male animals significantly ($P < 0.05$) gained less than females by 0.2kgs. Body dimensions were not significantly ($P > 0.05$) different across treatments and sex except for neck girth, which was larger in male than female animals ($P < 0.05$).

Table 1: Chemical composition (% for DM and % DM for others) of treatment diets

Nutrient	Diet 1 Katambora /Vigna (1:4)	Diet 2 Pellets	Diet 3 Katambora/Lablab (1:4)
DM %	92.3	89.92	92.72
CP %	13.93	13.49	13.77
NDF %	35.41	32.39	37.51
Fat %	2.17	5.92	1.97
ME MJ/kg	8.60	8.87	8.90

DM=dry matter; CP=crude protein; NDF=neutral detergent fibre; CF= crude fibre; ME = metabolizable energy.

The weight gain showed an interaction between treatment and time effect ($P < 0.05$) and no effect between sex and time ($P > 0.05$) (Table 3). Animals fed T_1 showed the highest ($P > 0.05$) rate of gain of 1.5kg from day 30 to d45; while T_2 showed a gain of 1.48kg from d15 to d30 and T_3 showed a gain of 1.54 kg from d0 to d15. Animals fed T_1 and T_2 exhibited the lowest gain of 0.06kg and 0.3kg, respectively from d0 to d15 while animals fed T_3 had their lowest rate of gain of 0.22kg from d45 to d60. Generally animals on T_3 showed an increase in weight gain at a decreasing rate post d15.

Table 2: Feed intake, growth parameters and morphometric data of Xhosa goats under three dietary treatments.

Variables	Treatment (T)			SE	Sex (S)		SE	P values		
	T_1	T_2	T_3		M	F		T	S	T x S
DMI(g/d)	670.8[c]	694.8[a]	688.1[b]	4.612	716.1[a]	653.0[b]	3.766	0.001	0.001	0.026
Growth Parameters (kg)										
Initial weight	14.13	13.96	14.02	0.469	14.9	14.71	0.392	0.103	0.113	0.481
Final Weight	16.81	16.34	16.57	0.444	16.90	16.31	0.374	0.684	0.439	0.024
Total gain	2.08[c]	2.68[a]	2.55[b]	0.077	2.4[a]	2.6[b]	0.008	0.04	0.043	0.035
ADG (g/d)	35.0[b]	45.0[a]	43.0[a]	0.002	40.0	43.0	0.001	0.003	0.44	0.030
FCR	19.16[a]	15.44[b]	18.11[a]	0.155	17.2	16.65	0.023	0.030	0.200	0.320
Morphometric data(cm)										
Body length	48.42	47.81	48.25	1.492	49.31	47.00	1.258	0.954	0.170	0.421
Heart girth	54.50	54.56	52.42	2.413	54.68	52.97	1.77	0.764	0.546	0.113
Height at wither	51.29	53.88	52.08	1.20	52.47	52.36	1.060	0.323	0.936	0.561
Pelvic width	56.75	55.44	54.92	2.420	57.71	53.69	1.690	0.849	0.145	0.541
Neck girth	24.37	24.81	23.42	0.655	25.29[a]	23.11[b]	0.483	0.301	0.008	0.451

[abc] Means with different superscript letters within treatments and sex in the same row differ significantly ($P < 0.05$). T_1= 71% Vigna hay, 19% Katambora hay salt (0.5%), molasses (3%) ,maize (5%) and mineral vitamin premix 1.5%; $T_{2=}$ 90% lamb and ewe pellet plus 10% Katambora grass hay; $T_{3=}$ 72% Lablab hay 19% Katambora hay, salt (0.5%), molasses (2%) maize (5%) and mineral vitamin premix 1.5%

Table 3: Least square means (LSM) of the body weight (kg) of Xhosa goats for sixty days

Days	Treatment				Sex			P values		
	T_1	T_2	T_3	SE	M	F	SE	TD	SD	TSD
0	14.13	13.96	14.02	0.982	15.53	14.71	0.837	0.161	0.626	0.509
15	14.73^b	13.66^b	15.56^a	0.982	15.38	15.733	0.837	0.006	0.455	0.217
30	14.97^b	15.14^b	16.10^a	0.982	16.05	15.78	0.837	0.036	0.908	0.807
45	16.17^a	15.50^b	16.35^a	0.982	17.00	16.29	0.837	0.005	0.7343	0.607
60	16.81	16.34	16.57	0.982	18.47	18.02	0.837	0.809	0.947	0.449

^{ab}Means with different superscript letters within treatments and sex in the same row, differ significantly (*P* < 0.05). T_1= 71% Vigna hay, 19% Katambora hay salt (0.5%), molasses (3%) ,maize (5%) and mineral vitamin premix 1.5%; $T_{2=}$ 90% lamb and ewe pellet plus 10% Katambora grass hay; $T_{3=}$ 72% Lablab hay 19% Katambora hay, salt (0.5%), molasses (2%) maize (5%) and mineral vitamin premix 1.5

The effects of treatment diets and sex on apparent nutrient digestibility of Xhosa goats are shown in Table 4.

3.3 Nutrient digestibility

Table 4: Nutrient digestibility (%) of forage legume hay as a protein source fed to Xhosa goats

	Treatments				Sex			P values		
	T_1	T_2	T_3	SE	M	F	SE	T	S	T x S
DM[1]	37.39^b	68.36^a	46.49^b	5.11	63.10^a	38.7^b	4.600	0.040	0.050	0.030
OM[1]	32.10	27.50	26.90	5.070	28.00	29.60	4.130	0.051	0.809	0.430
CP	34.50	37.80	38.10	1.720	36.40	37.20	1.400	0.428	0.714	0.571
NDF	37.60	40.50	41.20	1.760	44.70^b	44.80^a	1.440	0.466	0.040	0.253
ADF	23.30	27.90	32.60	2.11	30.80^a	25.10^b	1.720	0.171	0.144	0.015

^{abc}Means with different superscript letters within treatments and sex in the same row differ significantly (*P* < 0.05). DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fibre, ADF = acid detergent fibre, NSC = non-structural carbohydrate. T_1= 71% Vigna hay, 19% Katambora hay salt (0.5%), molasses (3%) ,maize (5%) and mineral vitamin premix 1.5% ; $T_{2=}$ 90% lamb and ewe pellet plus 10% Katambora grass hay; $T_{3=}$ 72% Lablab hay 19% Katambora hay, salt (0.5%), molasses (2%) maize (5%) and mineral vitamin premix 1.5%

[1] DM and OM values are represented on As-fed basis.

Forage legumes had a significant (*P* < 0.05) effect on DM digestibility while sex significantly influenced DM, and NDF digestibilities (*P* < 0.05). No significant differences (*P* > 0.05) were observed for OM and CP digestibility among treatments and sex**.** However, animals on T_3 exhibited a non-significant (*P* > 0.05) CP, NDF and ADF digestibilities compared to T_1 and T_2. Male animals showed the highest (*P* < 0.05) DM digestibility than female animals. Female animals exhibited significantly (*P* < 0.05) higher NDF digestibility than males. The results of the volatile fatty acids production are given in Table 5.

Table 5: Effect of Lablab and Cowpea feeding on rumen volatile fatty acids production

Acid (mM)	Treatment (T)			SE	Sex(S)		SE	P values		
	T_1	T_2	T_3		M	F		T	S	T x S
Acetate	4.59	14.95	4.79	6.261	4.31	11.92	4.939	0.3482	0.2643	0.2056
Propionate	0.76	1.67	0.67	0.545	0.63	1.44	0.430	0.3004	0.1773	0.1994
Butyrate	0.25^b	0.95^a	0.25^b	0.239	0.25	0.71	0.189	0.0408	0.0872	0.0624
Iso butyrate	0.19	0.64	0.22	0.240	0.20	0.49	0.179	0.2353	0.2314	0.2479
Valeric	0.15	1.04	0.15	0.422	0.16	0.74	0.333	0.1775	0.2082	0.1785
Iso valeric	0.15	0.45	0.14	0.149	0.15	0.34	0.118	0.1887	0.2382	0.2288

[abc] Means with different superscript letters within treatments and sex in the same row, differ significantly ($P < 0.05$). T_1= 71% Vigna hay, 19% Katambora hay salt (0.5%), molasses (3%) ,maize (5%) and mineral vitamin premix 1.5%; T_2 = 90% lamb and ewe pellet plus 10% Katambora grass hay; T_3= 72% Lablab hay 19% Katambora hay, salt (0.5%), molasses (2%) maize (5%) and mineral vitamin premix 1.5%

There were no significant ($P > 0.05$) differences in individual VFA's molar concentrations between treatment diets and between sexes for acetate, propionate, valerate, iso-butyrate and iso-valerate. However, diets significantly influenced butyrate concentration ($P < 0.05$); T_2 showed the highest butyrate concentration compared to T_1 and T_3. The percentage molar concentration for acetate was 75%, 73%, and 77% for T_1, T_2, and T_3 respectively while the propionate concentration was 12%, 8% and 10.7 % respectively. The acetate to propionate ratio was 6.2, 9.12 and 7.15 for T_1, T_2, and T_3 respectively.

4. Discussion

4.1 Feed intake and efficiency

The daily DM intake of goats in this experiment is within the range of 2.6 to 4.0% reported for South African goats by Dzakuma *et al.* (2004) and Asnakew (2007). Although animals showed significantly low forage intake for Vigna compared to Lablab and pellets; this did not significantly affect their growth rate (Table 2). The lower DM intake for Cowpea can be explained by the fact that Vigna is known to possess a significantly higher ADL content (Criscioni *et al.* (2016). This would imply that Vigna is less suitable for goats but animals feed on Cowpea attain comparable performance to those fed Lablab and pellets. Another possible reason for a reduced consumption of Vigna diet could be the lower NDF value of Vigna because less degradable NDF reduces DMI (Askar *et al*., 2016).

It is generally expected that forages with higher dietary NDF and NDF digestibility result in a greater improvement in DMI, although results have not been consistent. For example, Grant *et al*. (1995) and Dado and Allen (1996) show a positive effect of high NDF (37 – 40%) on DMI and milk yield. On the other hand, Robinson and McQueen (1997) reported higher DMI and milk yield regardless of dietary NDF content.

Following this line of thinking it can therefore be concluded that the low NDF content for Cowpea negatively influenced its DMI and growth of goats. Furthermore, higher NDF content may lead to saliva production that promotes a buffer hence lowering feed intake (Washaya *et al.*, 2017). It has been reported that low DMI of high quality forages is associated with longer resident time which should translate into higher digestibility (Mc Donald *et al*., 2011). However, this was not the case with Vigna, therefore suggesting the possible effect of ADL on digestibility. The conversion ratio of feed to weight was low for Vigna compared to Lablab and pellets; thereby influencing total weight gain which was significantly lower for T_1 (Table 2). Another possibility would be that Vigna might have stayed longer in the rumen, thus increasing microbial protein yield (Katsande *et al*., 2016) but with no influence on digestibility as indicated in the current study. Propionate has also been linked to higher DMI as it enhances the release of insulin into the blood thereby stopping any further energy intake. This could be a possible way by which DMI of Lablab was high since its propionate yield was lower resulting from smaller negative feedback on the satiety centre as suggested by Quigley and Heitmann (1991). Baloyi *et al.* (2008) reported that legume supplements increase fibre digestion in the rumen by promoting the growth of cellulolytic microbes. They also observed that the addition of legume fodder to poor ruminant diets increases voluntary intake and digestibility of the rations. McDonald *et al*. (2011) reported that a minimum of 11.2 g/kg DM of CP is required in feeds to support microbial activity. Diets used in the current study contained adequate amounts of CP to sustain ruminant production. This is evident by the fact that there was no significant difference in growth among treatments (Table 2). Dung *et al.* (2005) and Van (2006) reported that fodder shrubs and tree leaves are capable of partially or totally replacing concentrate feeds without decreasing digestion or growth of sheep and goats. The results from the present study also confirm this observation.

4.2 Growth performance

There were no significant differences in growth of goats fed the three experimental diets. However, treatment diets differ on the total gain, ADG, FCR and DMI. The differences in total gain among treatments are due to differences in DMI. Results of the average daily gain in the present study were within the acceptable range of 29 to 51 g/day reported for Small East African goats (Wallie *et al*., 2012). However, this gain was slightly higher than what was observed by Seid *et al*. (2012). Growth rates between 36 – 53g/day and 42-65 g/day have also been reported for goats (Mengistu *et al*., 2007). The differences in the growth rates were diet related compared to the current study. Vargas *et al.* (2007) observed that body linear dimensions are closely related to the size or weight of an animal. In the present study, however, male animals showed significantly higher neck girth than females. Concurring, Asrat (2004) reported that concentrate supplementation on goats fed with low to moderate quality basal diets did not affect body length and heart girth. The response of goats to treatment diets over time was different and thus influenced their rate of gain. It, therefore, can be concluded that goats adapted faster to Lablab than Cowpea and/or pellets.

Furthermore, female animals are known to lay fat faster than males and castration tend to prolong skeletal growth, particularly of long bones, accompanied by a retarded increase in bone diameter (Webb *et al*., 2016). This explains the difference in the total gain between sex in the current study.

4.3 Nutrient digestibility

Farmer et al (2014) observed *in-vivo* NDF digestibility of 46 – 49 %, ADF 23 – 34%, CP 67.9%, DM 58%-62%, and OM 61 – 64% in Holstein cows fed forage consisted of a mixture of corn and silage. Similar digestibility values were also obtained by Gusha *et al*. (2015) and Askar *et al*. (2016) in goats. Serment *et al*. (2011) also observed higher ADF digestibility when goats were fed concentrates. The current study also observed similar DM, OM and ADF digestibilities; however, NDF and CP digestibility were low. Generally forage legumes have low NDF and ADF values which in most cases are complexed with anti-nutrients particularly tannins (Kholif *et al*., 2014). To overcome low digestibility, Kholif *et al.* (2014) reported that provision of undegraded protein increase DMI and therefore improving digestibility. There were no differences in fibres (NDF and ADF) digestibility for treatment diets in the present study possibly because the diets supplied adequate CP for better microbial activities leading to similar digestibilities of fibrous materials. Results from the present study show higher NDF digestibility compared to those observed by Malecky et al. (2017) when goats were fed potato vines. The low levels of NDFD especially in Cowpea could have influenced DMI as was also reported by Singh *et al*. (2006). This is so because a higher NDF content stimulates an increase in microbial population leading to an increased digestibility rate of fibre hence result in higher DMI (Mc Donald *et al* ., 2011). On the other hand, low NDFD increases saliva production which acts as a buffer to rumination hence lowers DMI or by increasing retention time in the rumen which also lowers the rate of passage hence lowers DMI. Crude protein and OM digestibility from this study are generally below expectations according to NRC (2007). Furthermore, Singh *et al*. (2006) concluded that digestible CP, OM and DM are not linearly related to digestible ADF and NDF in their study with Cowpea grain as a protein supplement in growing sheep... In addition, the presences of tannins have been observed to increase insoluble protein associated with the plant cell wall (NRC 2007) thereby limiting digestibility.

4.4 Volatile fatty acid production

Dietary effects on individual VFAs have been reported by Oba (2011). Although not significant, total molar VFA concentrations for T_2 were high compared to T_1 and T_3, which indicates the effects of fermentable sugars on VFA production (Criscioni *et al.*, 2016). The percentage molar concentration for acetate and propionate fall within normal ranges as was observed by Singh *et al*. (2011) and Criscioni *et al*. (2016), however butyrate concentration was low. Acetate to propionate ratio in the current study for T_2 was high while T_1 and T_3 had normal ratios compared to the study by Singh *et al*. (2011). The ratios in the current study were also higher than those reported by Serment *et al.* (2011). The higher butyrate concentration exhibited by T_2 is expected since concentrate diets have higher readily fermentable sugars compared to legume forages. This was also observed when sucrose was substituted for corn or hay (Ribeiro *et al*., 2005). Another possible reason for a higher butyrate concentration in the current study for T_2 diet would be related to its absorption across the rumen wall. Penner and Oba (2009) reported that if rumen pH increase, butyrate absorption through the walls is reduced therefore a higher concentration is retained in rumen fluid. A high acetate: propionate (A: P) ratio is indicative of increased fibre intake in goats (Singh *et al.*, 2011). This was observed in the current study as goats consumed almost all of the Katambora particularly for T_2. This was not preferred since animals on a concentrate diet generally produce less acetate due to a higher acetate to propionate ration, as well as the hydrogen sink effect of propionate. Volatile fatty acids are very important in ruminant nutrition since they indicate fermentability of OM (Despal *et al*., 2011); the higher the total VFAs produced the higher the OM fermentability. This study confirms that the consumption of concentrate results in a decrease in the proportion of acetate with an increase of propionate as reported by Cantalapiedra-Hijar *et al*. (2009). High propionate concentration is important in ruminant animals since it's mainly used for the biosynthesis of glucose or fat deposition by the host animal (Christopher *et al*., 2008).

5. Conclusion

Lablab and Cowpea can support the same level of growth as commercial pellets. Lablab exhibited a significantly higher DM intake, ADG, and total gain and lower than Cowpea. . Cowpea however exhibited higher OM digestibility than Lablab and pellets. Male goats consumed more feed, but total gain and ADG were low, with a higher FCR than female goats. Nevertheless male animals had the highest DM, ADF digestibility compared to female goats. There were no significant differences in individual VFA's molar concentrations between treatment diets and sex. The butyrate concentration was significantly influenced by treatment diets. Acetate to propionate ratio was higher than recommended for the control diet.

6. Acknowledgement

This research was financially supported by the South African Government through the Govan Mbeki Research & Development Centre- National Research Foundation fund T 579.

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