Effect of tanniniferous *Acacia karroo* leaf meal inclusion level on feed intake, digestibility and live weight gain of goats fed a *Setaria verticillata* grass hay-based diet

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**ABSTRACT**

This study aimed to investigate the effects of tanniniferous *Acacia karroo* leaf meal inclusion level on performance of goats fed on a *Setaria verticillata* grass hay-based diet. Twenty indigenous male Pedi goats with an average initial live weight of 17.44 ± 2 kg were allocated, in a completely randomized design, to five dietary treatments containing *Acacia karroo* leaf meal inclusion levels of 20%, 25%, 30%, 40% and 50% of the total diet. Daily dry matter intakes were similar (P > .05) across the treatments. *Acacia karroo* leaf meal inclusion improved (P < .05) dry matter, organic matter, crude protein, neutral detergent fibre and acid detergent fibre digestibility coefficients. Dietary treatments had no effect on final live weights of goats. However, live weight gains were higher (P < .05) in goats fed a diet containing 50% *Acacia karroo* leaf meal inclusion level. Dry matter, crude protein and neutral detergent fibre digestibility coefficients were optimized at *Acacia karroo* leaf meal inclusion levels of 69.4%, 48.3% and 42.7%, respectively. *Acacia karroo* leaf meal inclusion improved nutrient digestibility and live weight gain of the goats and thus has potential to be utilized as a protein supplement when low-quality roughage is used as a basal diet.

1. Introduction

Goats play multiple roles in the livelihood of households of South Africa (Ngambi et al. 2013). They provide benefits in the form of meat, milk, manure, hide and skins, and cash (Peacock 2005). However, the productivity of these goats is constrained by shortage of good-quality feed, especially during the long dry season. Available feed resources during this period are generally deficient in nutrients such as protein, energy, minerals and vitamins, and hence cannot adequately meet the nutritional requirements for maintenance (Manaye et al. 2009). Earlier studies have shown that Pedi goats lose body weight and condition during the dry season (Ravhuhali et al. 2011). There is a need to identify more nutritious feed to alleviate the prevailing nutritional problems of indigenous goats in the communal areas during the dry season.

Browse tree legumes and shrub foliage have been identified as important sources of fodder for livestock in communal rangelands of Southern Africa (Solomon et al. 2008). An important attribute of browse trees is their positive effect on intake and digestibility when supplemented with fibrous basal feeds (Umunna et al. 1995). *Acacia* genus is widely distributed throughout the arid and semi-arid regions of Sub-Saharan Africa, and *Acacia karroo* is the most abundant indigenous tree legume species in Southern Africa (Mapiye et al. 2011). The tree retains its green leaves throughout the year (Barnes et al. 1996) and has potential as a crude protein supplement in ruminant diets. *Acacia karroo* was considered an ecological threat to natural rangelands and tends to be an invasive species (Mapiye et al. 2011). However, research attention has been diverted from its riddance as a weed to its utilization as a protein supplement for livestock, particularly goats (Mapiye et al. 2011; Brown et al. 2016).

Utilization of *Acacia karroo* leaves is restricted by the presence of secondary plant compounds such as condensed tannins (Mokoboki et al. 2005). High levels of extracted condensed tannins (55–110 g/kg DM) have been reported in *Acacia karroo* leaves (Mokoboki et al. 2005). Intake of condensed tannins by ruminants may depress feed intake and digestibility of diets, and hence adversely affect productivity of the animals (Waghorn 2008). Mixing of shrubs with grass hay-based diets has been hypothesized as an efficient way of diluting the negative effects of undesirable secondary compounds, such as tannins (Bhat et al. 2013). Ondiek et al. (2013) observed higher feed intake, average daily gain and nutrient digestibility in goats fed maize stover supplemented with tanniniferous *Acacia tortilis* or *Balanites aegyptiaca* leaf meals. However, the effects of tannin-rich *Acacia karroo* on intake, digestibility and performance of Pedi goats are not available. Additionally, information on the *Acacia karroo* leaf meal inclusion level for optimal productivity of Pedi goats is not available. The aim of this study was, therefore, to determine the effect of *Acacia karroo* leaf meal inclusion level on feed intake, digestibility and live weight gain of Pedi goats fed a *Setaria verticillata* grass hay-based diet.

2. Materials and methods

2.1. Location, experimental diets and feeding

The study was conducted at the University of Limpopo Experimental farm (latitude 27.55°S and longitude 24.77°E) in
October 2014. The ambient temperature at the study site ranges between 20°C and 36°C during summer (November–January) and between 5°C and 25°C during winter (May–July). Fresh leaves of *Acacia karroo* were harvested at the farm in August 2014. The leaves were air-dried in the shade to minimize nutrient losses to ultra violet rays (Dzowela et al. 1995) and then stored in air-tight bags until feeding time. *Setaria verticillata* hay was bought from the local farmer (Fourie Boerdery, Polokwane, Republic of South Africa). The grass and *Acacia karroo* leaves were passed through a hammer mill (13 mm screen) to reduce diet selection by the animals when fed. The chopped forage was thoroughly mixed with *Acacia karroo* leaves according to the dietary treatments in Table 1. The goats were fed ad *libitum*, allowing a 15% refusal of each diet, as suggested by Kaitho et al. (1996). Water was offered ad *libitum* and each goat had access to a mineral lick. There was a preliminary period of 14 days to familiarize the goats with the feeds and research protocol. The goats were individually offered feed once a day at 08:00 h. Feed offered was weighed and recorded daily and feed refusals were weighed every morning before fresh feed was offered. Dry matter values of the feeds and feed refusals were determined. The feeding trial lasted for 21 days, with the last 7 days being for data collection.

2.2. Animals, housing and experimental design

All procedures involving animals were approved by the Animal Research Ethics Committee of the University of Limpopo, South Africa. Twenty yearling male Pedi goats (a local breed in Limpopo province of South Africa) with an average initial body weight of 17.44 ± 2 kg (mean ± SD) were used in the study. Five treatment diets were offered in a completely randomized design with four animals per treatment. The goats were housed in individual holding pens. The pens were installed in a well-ventilated shed with one side open to natural light and roofed to protect goats against the sun and rain. The goats were weighed three times, at the start of the experiment, on the 14th day when data collection commenced and on the 21st day when data collection ended. The weighing of the goats was carried out before morning feeding to avoid feed effect (Sarwatt et al. 2003). All animals were drenched with anthelmintic (Valbazen® broad spectrum dewormer, manufactured by Pfizer Animal NY, USA) and sprayed with Diazinintol® (Alfasan international, Holland) before the start of the experiment.

2.3. Digestibility trial

On day 21, the goats were transferred to metabolic crates and each animal was fitted with a faecal bag for *in vivo* digestibility. The goats were adapted for three days to the carrying of faecal collection bag, which was followed by total faecal collection for a period of seven successive days for each animal. Faeces were collected from goats at 08:00 h before feeding. Faeces were weighed daily and subsamples (10% of total weight) were frozen at −20°C for chemical analysis. From the food consumed and faecal matter secreted, apparent digestibility of the nutrients was calculated (McDonald et al. 2011).

2.4. Chemical analysis

The pooled fresh samples of faeces, diets and orts were dried in a forced-air oven at 65°C for 72 h for analyses of DM, OM, CP, ash and fat. DM for all samples was determined by oven-drying at 105°C for 24 h. OM content was determined by combustion of samples at 550°C for 8 h in a muffle furnace according to the methods of AOAC (2002). Nitrogen content of the samples was determined using the Kjeldahl procedure (AOAC 2005). NDF and ADF were measured according to the procedures of Van Soest et al. (1991). Total phenolics were determined using Folin–Ciocalteu methods and expressed as tannic acid equivalent (% DM) (Makkar et al. 1993). Condensed tannins were determined using the Butanol–HCl method and expressed as leucocyanidin equivalent (% DM).

2.5. Statistical analysis

All data on feed intake, *in vivo* digestibility and live weight gain of goats were analysed using the General Linear Model procedures of SAS (SAS 2010). Fisher’s least significant difference (LSD) test was applied for mean separation where there were significant differences (*P* < .05). The responses in optimal intake, digestibility and body weight change to the level of browse inclusion were modelled using the following quadratic equation:

\[ Y = a + b_1x + b_2x^2 \]

where *Y* is the feed intake (g/day), digestibility (coefficient) or body weight change (g/day); *a* is the intercept; *b_1* and *b_2* are the coefficients of the quadratic equation; *x* is the level of inclusion value for optimal response. The quadratic model was used because it gave the best fit.

The linear relationships between browse inclusion level and responses in feed intake, digestibility and body weight changes were modelled using the following linear equation:

\[ Y = a + bx \]

where *Y* is the feed intake, digestibility or body weight change; *a* is the intercept; *b* is the coefficient of the linear equation; *x* is the level of inclusion.

| Table 1. Feed composition of the experimental diets. |
|-------------------------------|-------------------------------|
| Diet code | Diet description |
| S50A50 | A mixture of 80% *Setaria verticillata* hay and 20% *Acacia karroo* leaves |
| S70A30 | A mixture of 75% *Setaria verticillata* hay and 25% *Acacia karroo* leaves |
| S75A25 | A mixture of 75% *Setaria verticillata* hay and 25% *Acacia karroo* leaves |
| S70A30 | A mixture of 75% *Setaria verticillata* hay and 25% *Acacia karroo* leaves |
| S50A50 | A mixture of 50% *Setaria verticillata* hay and 50% *Acacia karroo* leaves |

3. Results

Nutrient composition and tannin contents of *Acacia karroo* and *Setaria verticillata* leaves are presented in Table 2. *Acacia karroo* had higher crude protein content than *Setaria verticillata* grass hay. However, NDF and ADF contents were higher in *Setaria verticillata* grass hay. *Acacia karroo* contained moderate levels of condensed tannins and total phenolics. Tannins were not detected in *Setaria verticillata* grass hay.
The nutritive values of dietary mixtures of *Setaria verticillata* and *Acacia karroo* are presented in Table 3. There were differences (p < .05) in the chemical composition of the dietary mixtures of *Setaria verticillata* and *Acacia karroo* leaves. The OM, CP, fat, condensed tannins and total phenolic contents were higher (p < .05) in the diet containing a 50% *Acacia karroo* leaf meal inclusion level, followed by 40%, 30%, 25% and 20% inclusion levels, respectively. The ADF and NDF contents of the diets increased (p < .05) as the proportion of *Setaria verticillata* grass hay increased in the diets. All the diets had similar (p > .05) ash content values.

The results of the effect of *Acacia karroo* leaf meal inclusion level on feed intake, digestibility and live weight change of Pedi goats fed *Setaria verticillata* grass hay-based diets are presented in Table 4. Daily dry matter intakes were similar (p > .05) across the treatments, ranging from 617 to 679 g per goat per day. Similarly, goats consumed the same (p > .05) amounts of dietary OM, CP, NDF and ADF contents. Intakes per metabolic weight were similar (p > .05) across the diets.

Diet DM, OM, CP, NDF and ADF digestibility values were different (p < .05) across the treatments. Diet DM digestibility values were higher (p < .05) in goats consuming a diet having a 50% *Acacia karroo* leaf meal inclusion level when compared to diets containing 20%, 25% or 30% *Acacia karroo* leaf meal inclusion levels. Similarly, DM digestibility values were higher (p < .05) in goats fed diets containing 30% or 40% *Acacia karroo* leaf meal inclusion levels than those on 20% or 25% inclusion levels. Organic matter digestibility values were higher (p < .05) in goats consuming diets containing 40% or 50% *Acacia karroo* leaf meal inclusion levels than those on 20%, 25% or 30% inclusion levels. Goats consuming diets having 30%, 40% or 50% *Acacia karroo* leaf meal inclusion levels had higher (p < .05) CP digestibility than those on diets having 20% or 25% inclusion levels. Goats consuming diets containing 25%, 30% or 50% *Acacia karroo* leaf meal inclusion levels had higher (p < .05) NDF digestibility values than those of goats on diet with 20% or 40% *Acacia karroo* leaf meal inclusion levels. Acid detergent fibre digestibility was higher (p < .05) in goats consuming a diet having 50% *Acacia karroo* leaf meal inclusion level than those on diets having 20%, 25% or 30% inclusion levels.

Goats had similar (p > .05) final body weights. However, live weight gains (ADG) were higher (p < .05) in goats fed a diet having a 50% *Acacia karroo* leaf meal inclusion level when compared to other treatment groups. Similarly, goats on diets having 30% or 40% *Acacia karroo* leaf meal inclusion levels had higher (p < .05) live weight gains than those on diets having 20% or 25% *Acacia karroo* leaf meal inclusion levels.

Dry matter, crude protein and neutral detergent fibre digestibilities were optimized at *Acacia karroo* leaf meal inclusion levels of 69.4%, 48.3% and 42.7%, respectively (Table 5). Organic matter (r² = 0.88) and acid detergent fibre (r² = 0.92) digestibilities, and live weight gain (r² = 0.91) increased linearly with increased inclusion levels of *Acacia karroo* leaves in the diet (Table 6).

### Table 2. Chemical composition (mean ± SD) of the experimental forages.

| Nutrient (% DM) | Acacia karroo leaves | Setaria verticillata hay |
|-----------------|----------------------|--------------------------|
| Dry matter      | 97.1 ± 2.01          | 96.2 ± 0.40              |
| Organic matter  | 92.1 ± 0.21          | 91.4 ± 0.12              |
| Crude protein   | 12.7 ± 2.02          | 7.9 ± 1.12               |
| Fat             | 2.4 ± 0.10           | 0.8 ± 0.01               |
| Ash             | 7.9 ± 0.40           | 8.6 ± 0.31               |
| Acid detergent fibre | 32.5 ± 3.02       | 50.7 ± 4.01              |
| Neutral detergent fibre | 38.0 ± 4.01   | 77.9 ± 3.02              |
| Condensed tannins | 2.0 ± 0.01       | ND                       |
| Total Phenolics | 1.95 ± 0.001        | ND                       |

*Condensed tannins as percentage DM leucocyanidin equivalent.*
*Expressed as tannic acid equivalent (%); ND: Not detected.

### Table 3. The nutrient composition of experimental diets (% DM basis).

| Nutrient | S0A0 | S2A10 | S2A15 | S2A20 | S2A30 | S2A40 | SEM |
|----------|------|-------|-------|-------|-------|-------|-----|
| Dry matter | 95.24± | 95.86± | 94.05± | 95.21± | 97.01± | 0.000 |
| Organic matter | 91.52± | 91.56± | 91.60± | 91.67± | 91.75± | 0.000 |
| Ash | 8.47± | 8.43± | 8.39± | 8.32± | 8.24± | 0.110 |
| Fat | 1.12± | 1.20± | 1.28± | 1.45± | 1.61± | 0.041 |
| Crude protein | 8.90± | 9.16± | 9.34± | 9.84± | 10.37± | 0.132 |
| ADF | 47.03± | 46.12± | 45.21± | 43.39± | 41.57± | 0.671 |
| NDF | 69.90± | 67.91± | 65.91± | 61.93± | 57.94± | 0.421 |
| Condensed tannins | 0.41± | 0.51± | 0.61± | 0.82± | 1.02± | 0.017 |
| Total Phenolics | 0.39± | 0.49± | 0.58± | 0.78± | 0.98± | 0.003 |

SEM, Standard error of the means; ADF, Acid detergent fibre; NDF, Neutral detergent fibre; *Condensed tannins as percentage DM leucocyanidin equivalent; **Expressed as tannic acid equivalent (%).**

### 4. Discussion

The diets containing 40% and 50% *Acacia karroo* leaf meal inclusion levels provided 9.84% and 10.37% CP contents, respectively. The high CP contents in these diets were due to higher *Acacia karroo* leaf meal inclusion levels. *Acacia karroo* leaves contain high levels of CP and essential amino acids (Halimani et al. 2002). The CP contents of all the experimental diets were above the minimum level of 8% required for optimal microbial function in the rumen (Norton 2003), suggesting that all the diets could support maintenance requirements and some production levels in ruminants (Van Soest 1994). Leaves of fodder trees have been used as supplements to grass hay-based diets, especially during the critical dry periods of the years (Tshabalala et al. 2013). These tree fodders have been incorporated into the rations of ruminants as substitutes for more expensive processed protein sources (Norton 1994).

The condensed tannin contents of the experimental diets varied from 4.1 g/kg DM for the diet containing a 20% *Acacia karroo* inclusion level to 10.2 g/kg DM for the diet containing 50% *Acacia karroo* Dube et al. (2001) and Mokoboki et al. (2005) indicated that *Acacia karroo* leaves contain high levels of extracted condensed tannins (CT), ranging from 55 to 110 g/kg DM. It has been reported that CT values above 50 g/kg DM in the diet can produce adverse effects when fed to ruminant animals (Frutos et al. 2004). The CT contents in the experimental diets were below 50 g/kg DM, the level that could be considered detrimental to the animal. According to Ben Salem and Smith (2008), intake of mixed diets is an efficient way of diluting the adverse effects of secondary compounds in plants, such as tannins.

The threshold NDF content beyond which feed intake and digestibility is adversely affected by ruminants is 600 g NDF/
Table 4. Effect of different inclusion levels of *Acacia karroo* on diet intake, digestibility and live weight change of Pedi goats fed a basal diet of *Setaria verticillata* hay.

| Variable          | S0 @A20 | S2 @A25 | S4 @A30 | S6 @A40 | S8 @A50 | SEM     |
|-------------------|---------|---------|---------|---------|---------|---------|
| Intake (g/goat/day) |         |         |         |         |         |         |
| DM                | 621     | 588     | 588     | 586     | 566     | 51.9    |
| OM                | 621     | 588     | 588     | 586     | 566     | 51.9    |
| CP                | 60      | 58      | 60      | 62      | 64      | 5.38    |
| NDF               | 475     | 430     | 423     | 392     | 358     | 36.6    |
| ADF               | 319     | 292     | 290     | 274     | 256     | 25.1    |
| Intake (g/kgW<sup>−0.75</sup>) |         |         |         |         |         |         |
| DM                | 68.2    | 72.3    | 69.7    | 64.8    | 61.1    | 6.92    |
| OM                | 62.4    | 66.2    | 63.8    | 59.4    | 56.0    | 6.35    |
| CP                | 6.07    | 6.60    | 6.50    | 6.30    | 6.30    | 0.70    |
| NDF               | 47.7    | 49.1    | 45.9    | 40.1    | 34.4    | 4.20    |
| ADF               | 32.1    | 33.3    | 31.5    | 28.0    | 24.6    | 2.97    |

Digestibility (coefficient)

| Factor              | Formula | AK level | Optimal Y-level | r²     |
|---------------------|---------|----------|-----------------|--------|
| DM digestibility    | Y = 0.310 + 0.015x + 0.0000108x² | 69.4 | 0.830 | 0.96 |
| CP digestibility    | Y = 0.0000149 + 0.024x + 0.0000248x² | 48.3 | 0.580 | 0.88 |
| NDF digestibility   | Y = 0.230 + 0.020x + 0.0000234x² | 42.7 | 0.657 | 0.35 |

Table 5. *Acacia karroo* leaf meal inclusion levels for optimal dietary dry matter, crude protein, neutral detergent fibre and acid detergent fibre digestibility (coefficient) in goats on a basal diet of *Setaria verticillata* grass hay.

| Factor            | Formula     | AK level | Optimal Y-level | r²     |
|-------------------|-------------|----------|-----------------|--------|
| DM digestion Y     | Y = 0.310 + 0.015x + 0.0000108x² | 69.4 | 0.830 | 0.96 |
| CP digestion Y     | Y = 0.0000149 + 0.024x + 0.0000248x² | 48.3 | 0.580 | 0.88 |
| NDF digestion Y    | Y = 0.230 + 0.020x + 0.0000234x² | 42.7 | 0.657 | 0.35 |

Table 6. Relationships between *Acacia karroo* leaf meal inclusion level (%) and organic matter and acid detergent digestibilities (coefficient) and live weight change (g/goat/day) in male Pedi goats on a basal diet of *Setaria verticillata* grass hay.

| Factor                        | Formula      | r²     | Probability |
|-------------------------------|--------------|--------|-------------|
| Organic matter digestibility  | Y = 0.436 + 0.0064x | 0.97 | .002        |
| ADF digestibility             | Y = 0.671 - 0.000474x | 0.03 | .795        |
| Live weight change            | Y = -6.707 + 1.252x | 0.91 | .011        |

<sup>r²</sup>: Coefficient of determination.

ADF digestibility: Acid detergent fibre digestibility.

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kg DM (Meissner & Paulsmeier 1995). The diet containing a 50% *Acacia karroo* inclusion level had 579 g NDF/kg DM, still lower than 600 g NDF/kg DM, indicating its high feeding value potential. However, Riaz et al. (2014) observed that goats appeared less responsive to increases in dietary fibre fractions (NDF and ADF) than other animal species, and that these feed fractions had a less negative impact on their dry matter intake.

All the experimental goats had similar feed intakes. This might be because all the diets had CP levels above the minimum level of 8% required for optimal ruminal microbial functioning (Norton 2003), and hence optimal diet intake. This result is similar to the findings of Dludla (2010), who reported non-significant differences in total intake when goats were fed *Acacia caffra* and *Euclea crispa* (with high CT concentrations), *Rhus lancea* (with moderate CT concentrations) and *Ziziphus mucronata* (with low CT concentrations). Animit et al. (2008) observed that intakes of DM and OM were similar in goats consuming diets with different levels of condensed tannins from *Lespedeza*. According to Reed (1995) and Frutos et al. (2004), condensed tannin concentration in the diet will depress feed palatability, reduce feed intake and slow down digestion. The reduction in palatability and intake is associated with the astringency in the mouth of the animals (Breslin et al. 1993). A decrease in feed intake has also been reported with higher CT concentration (Bhatta et al. 2002). In the present study, an increase in inclusion of *Acacia karroo* leaf meal in the diet did not adversely affect forage intake of goats.

Diets containing 30%, 40% or 50% *Acacia karroo* leaf meal inclusion levels improved crude protein digestibility, despite the relatively higher tannin contents. *Acacia karroo* leaf meal inclusion level of 48.3% optimized crude protein digestibility. *Acacia karroo* leaf meal inclusion increased ruminal protein levels, resulting in improved conditions for microbial growth and multiplication (Makkar 2003). Increased microbial population results in higher digestibility and intake of the diet. The nutritional benefit of CT in ruminant’s diet is also due primarily to the protection of plant proteins from microbial degradation in the rumen and the resultant increase in protein flow to the intestines (Waghorn et al. 1994; McNabb et al. 1996). Tannins in forages may enhance protein utilization and improve amino acid absorption in ruminants (Waghorn et al. 1987). These reports support the findings in the present study. Makkar (2003) observed that tannins bind with proteins at pH of 5.5–7.0, thereby slowing down microbial degradation of the proteins. The slower rate of microbial protein digestion in the rumen prevents nitrogen loss as urea, facilitating the absorption of amino acids in the small intestines, and improving overall nitrogen utilization (Mueller-Harvey 2006). It has also been documented that condensed tannins exert their inhibitory effect on protein degradation in the rumen by protecting plant protein from cleavage by proteases or directly inhibiting the proteases themselves (Aerts et al. 1999). The precise mechanism by which tannins reduce ruminal protein digestion and hence improve its overall utilization merits further study.

Diets containing a 50% *Acacia karroo* leaf meal inclusion level improved fibre digestibility. However, the level of inclusion for optimal NDF digestibility was 42.7%. Usually, tannins tend to reduce fibre digestibility by binding bacterial enzymes and forming indigestible complexes with carbohydrates, particularly hemicellulose, cellulose, starch and pectins, thus, rendering these nutrients inaccessible to microorganisms (Schofield et al. 2001). However, the present results indicate that fibre degradation in the rumen can be increased in animals consuming forage tannins. Waghorn et al. (1987), also, reported a 13% increase in fibre digestion in the rumen of sheep consuming Lotus *pedunculatus* containing 5.5% CT.

The increase in the inclusion level of *Acacia karroo* leaf meal resulted in increased daily weight gains of the goats. A significantly higher average daily gain was observed in goats consuming a diet with a 50% *Acacia karroo* leaf meal inclusion level. This might have been due to increase in diet digestibility with an...
increase in *Acacia karroo* inclusion level. Ash and Norton (1987) observed that body weight gain in goats is sensitive to protein and energy contents of the diet consumed. The improvement in body weight gain of Pedi goats might also, be associated with improved protein utilization by goats on diets with higher *Acacia karroo* inclusion levels (Solaaiman et al. 2010). This result is similar to the findings of Gwanzura (2011), who reported higher body weight gains in Pedi goats fed taniniferous Mucuna hay. Forages containing from 20 to 40 g of CT kg\(^{-1}\) DM increase rumen escape value of herbage (Terril et al. 1992) and enhance weight gains in ruminants (Turner et al. 2005).

Other authors have reported improved weight gain in goats and lambs fed forages high in CT (Douglass et al. 1995; Solaiman et al. 2010). Results of Njidda and Ikhiomiya (2010) with tannin-rich plants revealed that some rumen microorganisms are able to metabolize tannins or remain active in a high tannin environment and overcome their detrimental effects, which in turn improves animal performance. Higher concentrations of total polyphenols in a diet tend to reduce nutrient availability to the animals, thus adversely affecting their body weight gains (Tanner et al. 1990). However, in the present study, the high total polyphenolic content present in the diets having a 50% *Acacia karroo* inclusion level diet did not adversely affect the live weight of the goats.

5. Conclusion

Inclusion of *Acacia karroo* leaves improved nutrient digestibility and growth rate of goats. Dry matter, crude protein and neutral detergent fibre digestibilities were optimized at different *Acacia karroo* leaf meal inclusion levels of 69.4%, 48.3% and 42.7%, respectively. This may indicate that levels for optimal productivity will depend on the particular parameter in question. *Acacia karroo* leaf meal, therefore, has the potential of being utilized as a protein feed during the dry season when goats depend on low-quality roughages.

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