

Intake and *in vivo* digestibility of *Indigofera* forage compared to *Medicago sativa* and *Leucaena leucocephala* by sheep

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Abstract

The voluntary intake and *in vivo* digestibility of forage from *Indigofera* species, *Medicago sativa* (lucerne) and *Leucaena leucocephala* (*Leucaena*) were determined using South African Mutton Merino sheep with the aim to assess the potential nutritive value of *Indigofera* compared to the other two species. Both lucerne and *Leucaena* had higher crude protein (CP) and lower neutral detergent fibre (NDF) concentrations than *Indigofera*. However, the apparent dry matter digestibility (DMD%) coefficients for *Leucaena* were lower than either *Indigofera* or lucerne. The forage species also differed in terms of NDF digestibility, dry matter intake (DMI) and CP intake (g/head/d), but not in terms of neutral detergent fibre intake (NDFI). The difference between *Indigofera* species and *Leucaena* forage in terms of DM intake per unit of metabolic body weight ($\text{g}/\text{W}^{0.75}/\text{day}$) and digestible organic matter intake (DOMI) was not significant, but forage DMI per unit metabolic body weight ($\text{g}/\text{W}^{0.75}/\text{day}$) of both *Indigofera* species and *Leucaena* was significantly lower than DMI of lucerne. In this specific study, lack of differences between *Indigofera* species and *Leucaena* in terms of DOMI and digestible NDFI indicates that *Indigofera* forage would likely support similar weight gains in ruminants as those of *Leucaena*, but lower than those of lucerne forage.

Keywords: Forage, *Indigofera*, intake, digestibility, *Leucaena*, lucerne

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Introduction

In the past three decades introductions of exotic fodder trees to sub-Saharan Africa disregarded indigenous browse species. Native species such as *Indigofera* are part of the existing flora of the semi-arid and arid areas. However, there is limited information on the nutritive value of these native species. Chemical composition and digestibility values often provide information on the quality of feed. However, the prediction of animal performance requires an accurate estimation of intake. Thus, voluntary intake is the most important factor determining the feeding value of a feed. Intake and digestibility determine the amount of nutrients available for production above that required for maintenance (McDonald *et al.*, 2002). In ruminants intake is limited by the rate of digestion and the rate of passage of undigested material. Rate of digestion is slower for less digestible feeds. Intake is more closely related to the rate of digestion in the rumen of ruminants than to the total digestibility of roughages (Meissner *et al.*, 1999). Feeds with a low intake are not able to support high levels of production, no matter how high the protein or mineral content of each unit of feed. Therefore, intake is equally important as digestibility in affecting production. Limited information on the intake of *Indigofera* forage is available and these have been restricted to rat bioassay studies (Strickland *et al.*, 1987). The present study was undertaken to assess voluntary intake and *in vivo* digestibility of *Indigofera* forage, as compared to *Medicago sativa* (lucerne) and *Leucaena leucocephala* (*Leucaena*), by sheep.

Materials and Methods

The study was conducted on the Hatfield Experimental Farm of the University of Pretoria. The *Indigofera* forage was collected as a bulk harvest from a characterization experimental area. The details of field layout, spacing and management practices were provided by Hassen (2006). In order of importance bulk forage material of *I. arrecta*, *I. amorphoides*, *I. cryptantha*, and *I. brevicalyx* was collected from the different plots and/or of various accessions. These were mixed thoroughly before being used in the intake study. Enough forage was produced from single varieties of lucerne and *Leucaena*. The total above-ground biomass of *Indigofera* and *Leucaena* species was separated into leaf, fine stem (< 3 mm diameter) and coarse

stem (>3 mm stem diameter) portions. Subsequently the leaves and fine stem fractions were mixed to simulate the edible forage material, and were used in this study. The lucerne was, however, fed as whole material.

Intake and *in vivo* digestibility of edible *Indigofera* forage, *M. sativa* and *L. leucocephala* were evaluated using 15 SA Mutton Merino wethers (mean live weight of 62.6 ± 13.44 kg) housed in metabolism cages. The wethers were randomly allocated to three groups, and each group received one of the three experimental diets which consisted of edible forage material prepared in the form of hay. During the trial each animal had free access to a mineral supplement and water. The intake and digestibility trial consisted of a 10 day adaptation followed by a seven day faecal collection period. Daily feed intake and faecal excretion were recorded for each animal. Total daily faecal excretion from each animal was stored frozen at -10 °C until the end of the collection period. The total faecal output from each animal was dried and then weighed, thoroughly mixed and a sub-sample of 10% was collected for subsequent grinding and laboratory analyses. One sample per forage species was taken every day, dried in a forced air oven at 60 °C to constant weight and then ground in a mill through an 1 mm screen. Both feed and faecal samples were analysed for dry matter (DM), organic matter (OM) and crude protein (CP) content according to AOAC (2000) procedures. Neutral detergent fibre (NDF) was determined according to the procedure of Robertson & Van Soest (1981). *In vitro* digestible organic matter (IVDOM) concentration was determined using the Tilley & Terry (1963) procedure, as modified by Engels & Van der Merwe (1967).

All parameters considered were subjected to an analysis of variance using proc GLM of SAS (2001). The model included the effect of forage species and where F ratios showed significance, differences (0.05% level of significance) between least squares means were declared using the Fisher-test (Samuels, 1989) by the PDIFF option of SAS (2001).

Results and Discussion

The chemical composition and *in vitro* digestibility of the three forage diets are presented in Table 1. According to Minson (1980) low quality forages are considered to have less than 80 g CP/kg DM. This is the critical level below which voluntary intake of tropical forages is limited. Although CP is not the only measure of quality, all three forage species contained two to three times this critical CP level, and satisfied the CP requirement of mature beef cows (70 g CP/kg; NRC, 1985). In this study the CP value recorded for *Indigofera* was lower than the values reported by Hassen (2006) for a number of *Indigofera* species.

Table 1 Chemical composition (Mean \pm s.e.; g/kg DM) of *Indigofera*, lucerne and *Leucaena* diets fed to sheep

Parameter	Forage		
	Lucerne	<i>Indigofera</i>	<i>Leucaena</i>
Ash	88 ^a \pm 5.1	42 ^b \pm 5.1	73 ^a \pm 5.7
Crude protein (CP)	204 ^a \pm 3.5	149 ^b \pm 3.5	191 ^a \pm 3.9
Neutral detergent fibre (NDF)	438 ^c \pm 8.0	577 ^a \pm 8.0	478 ^b \pm 8.9
<i>In vitro</i> dry organic matter (IVDOM)	677 ^a \pm 7.8	533 ^b \pm 7.8	462 ^c \pm 8.7

^{a,b} Means within rows with different superscripts differ significantly at $P < 0.05$

Forage cell walls provide the fibre that ruminant livestock require for normal rumen function. Concentrations of cell wall components normally have a large influence on forage digestibility, and limit feed intake and digestibility (Buxton, 1996). In this study both *in vitro* and *in vivo* organic matter digestibility of *Indigofera* were higher than that of *Leucaena* (Tables 1 and 2). The higher *in vitro* and *in vivo* digestibility values for *Indigofera* are in line with the higher NDF digestibility of *Indigofera* compared to *Leucaena* forage that had a lower NDF digestibility. The IVDOM is a measure of energy available to ruminants and is used in protein evaluation systems to calculate rumen fermentable OM, which in turn is used to estimate rumen microbial protein synthesis (Gosselink *et al.*, 2004). In this study the level of *in vivo* DM digestibility of *Indigofera* was higher than that of *Leucaena* and equivalent to that of lucerne (Table 2).

This indicates a possibility of higher rumen fermentation and consequently higher rumen microbial protein synthesis in *Indigofera* and lucerne fed wethers than in the case of *Leucaena* forage.

The dry matter intake (DMI) (g/head/day) of sheep fed *Indigofera* forage was not significantly different ($P > 0.05$) as compared to *Leucaena*, but it was significantly ($P < 0.05$) lower than that of sheep on lucerne (Table 2). Van Soest (1994) demonstrated that the DMI is negatively correlated with rumen retention time and positively correlated with ruminal volume and feed digestibility. High intakes have been associated with a reduction in the extent of ruminal digestion due to decreased ruminal retention time (Staples *et al.*, 1984). In this study, the differences observed in DMI (g/head/day) between plant species could be due partly to differences in digestibility of NDF and DM. The apparent digestibility of DM by sheep showed similar trends with significantly ($P < 0.05$) lower DM digestibility coefficients in *Leucaena* than in both *Indigofera* and lucerne. The low levels of intake obtained with *Leucaena* are in agreement with a low to a moderate (1.7 - 2.7% DMI as a percentage of body weight) level of voluntary intake reported elsewhere (Garcia *et al.*, 1996). The DMI of sheep fed *Indigofera*, as expressed either in g/head/day or in g/kg $W^{0.75}$ /day, was not significantly different ($P > 0.05$) compared to that of *Leucaena* (Table 2). However, the CP intake of *Indigofera* was significantly ($P < 0.05$) lower than the CP intakes of either lucerne or *Leucaena*.

Table 2 Apparent digestibility, voluntary intake and digestible intake (Mean \pm s.e.; g/kg DM) of three forage species by sheep

Parameter	Forage species		
	Lucerne	<i>Indigofera</i>	<i>Leucaena</i>
Apparent digestibility (g/kg DM)			
Dry matter (DM) %	66.8 ^a \pm 1.41	63.0 ^a \pm 1.41	57.4 ^b \pm 1.58
Neutral detergent fibre (NDF) %	46.0 ^{ab} \pm 2.01	51.7 ^a \pm 2.01	43.7 ^b \pm 2.25
Voluntary intake (g/head/day)			
Dry matter	1550.6 ^a \pm 48.01	1246.8 ^b \pm 48.01	1314.5 ^b \pm 53.67
Crude protein	316.1 ^a \pm 11.49	186.9 ^c \pm 11.49	251.1 ^b \pm 12.85
Neutral detergent fibre	679.4 ^a \pm 25.9	718.3 ^a \pm 25.9	628.0 ^a \pm 28.96
Voluntary intake (g/kg $W^{0.75}$ /day)			
Dry matter	72.8 ^a \pm 5.38	52.2 ^b \pm 5.38	67.2 ^{ab} \pm 6.01
Crude protein	14.9 ^a \pm 1.11	7.8 ^b \pm 1.11	12.8 ^a \pm 1.23
Neutral detergent fibre	31.8 ^a \pm 2.55	30.1 ^a \pm 2.55	32.3 ^a \pm 2.85
Digestible intake (g/head/day)			
Organic matter	963.2 ^a \pm 43.10	776.3 ^b \pm 43.10	719.1 ^b \pm 48.19
Neutral detergent fibre	313.9 ^{ab} \pm 20.17	371.0 ^a \pm 20.17	274.8 ^b \pm 22.55
Digestible intake (g/kg $W^{0.75}$ /day)			
Organic matter	45.3 ^a \pm 3.42	32.5 ^b \pm 3.42	36.6 ^{ab} \pm 3.83
Neutral detergent fibre	14.7 ^a \pm 1.51	15.5 ^a \pm 1.5	14.2 ^a \pm 1.68

^{ab} Means within rows with different superscripts differ significantly at $P < 0.05$

Digestible organic matter intake (DOMI) integrates both the quality and the quantity of feed ingested. In terms of metabolisable energy, a kg of DOMI of a pasture can provide approximately 15 to 16 MJ of ME for ruminants (Langlands 1987). The corresponding value of DOMI recorded in this study for the superior forage, lucerne, is within the range described by Tainton (1999) for the species.

Higher DMI and CPI were observed in lucerne forage than in either *Indigofera* or *Leucaena* forage, regardless of the similarity between lucerne and *Leucaena* in terms of chemical composition. It was suspected that the presence of secondary metabolites such as mimosine (in *Leucaena* spp.) and indospicine (in *Indigofera* spp.) might decrease the palatability; reduce the intake, negatively affecting digestibility (Hegarty, 1981). According to Allison (1985) animal performance is a function of feed intake, nutrient content and digestibility. In this specific study, lack of significant differences between *Indigofera* and *Leucaena* in terms of digestible nutrient intake (DOMI and DNDFI) means that, potentially *Indigofera* forage would support similar weight gains as *Leucaena* in ruminants, but definitely lower than lucerne.

Conclusions

Although animal performance is an accurate means to describe the feeding value of unconventional plants, the levels of digestibility and voluntary intake recorded in *Indigofera* are comparable to those of *Leucaena* and acceptable to support an optimal level of ruminant production. However, more studies need to be undertaken over an extended period of time to quantify the exact level of animal production that could be sustained by feeding *Indigofera* and also assess the potential toxicity effect of indospicine over a long period of time.

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