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Feed utilization and growth of Dorper wethers on *Opuntia*-based diets

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Abstract

Incremental levels of sun-dried and coarsely ground cactus pear (*Opuntia ficus-indica* var. Algerian) cladodes were used to substitute part of the lucerne hay in balanced diets fed to Dorper wethers (n = 28; 33.90 ± 2.98 kg) during a trial period of 63 days. The three treatment diets (T0, T24 and T36) comprised respectively (air dry basis) 0, 240 and 360 g/kg *Opuntia*; 660, 410 and 285 g/kg lucerne hay; 300 g/kg maize meal; 0, 10 and 15 g/kg feed grade urea; and 40 g/kg molasses meal. Apparent DM digestibility coefficients increased significantly (0.714, 0.732, and 0.756) with *Opuntia* inclusion in diets. Feed dry matter (DM) intake (1.368, 1.345 and 1.317 kg DM/day) and average daily gain (117.8, 116.4 and 95.6 g/day) decreased slightly as *Opuntia* inclusion increased. Similar to previous studies the ingestion of *Opuntia* caused the production of wet faeces by the wethers. It was concluded that adequate nutrients were provided by these diets for maintenance and a moderate level of production in the Dorper wethers.

Keywords: Cactus pear, digestibility, feed intake, live weight gain, sheep, sun-dried
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Introduction

Cactus pears (*Opuntia* spp.) are used as livestock feed during the frequent periods of drought or food shortages in many arid and semi-arid regions (De Waal *et al*., 2006). These plants are drought resistant and produce high yields of biomass (Zeeman, 2005; De Waal *et al*., 2006). *Opuntia* is an important livestock feed in areas where few other crops can be produced (Reynolds & Arias, 2001) and is particularly attractive because of its efficiency of using water to produce dry matter (Tegegne, 2001). In terms of available land and water, about 3 to 4 ha of spineless cactus can be planted for each ha of lucerne (De Kock, 1980).

The spineless cactus pear (*Opuntia ficus-indica*) fruit industry in South Africa has increased in recent years (Zeeman, 2005; De Waal *et al*., 2007). Large quantities of fruit are exported and thus large quantities of fresh cladodes also become available when the plants are pruned to improve fruit production and quality (Zeeman, 2005; De Waal *et al*., 2007). This creates the prospect of utilizing the large quantities of plant material that are produced annually as a feed source for livestock (De Waal *et al*., 2007).

In a previous study, Zeeman (2005) substituted lucerne hay in diets for Dorper wethers with up to 36% sun-dried and coarsely ground *Opuntia* cladodes and recorded no apparent detrimental effects over a relatively short trial period. However, similar to other studies, inclusion of *Opuntia* cladodes caused the production of wet faeces by the sheep (De Waal *et al*., 2006; 2007). The aim of this study was to determine whether two treatment diets with incremental levels of sun-dried and coarsely ground *Opuntia* cladodes substituting lucerne hay will have the same capacity as the control diet to promote growth in young animals. It was important to establish if feed intake, diet digestibility and especially the performance of young Dorper wethers were affected negatively when these diets are fed over a period of several weeks.

Materials and Methods

The *Opuntia ficus-indica* var. Algerian cladodes used in this study were produced during the growing seasons of 2004/5 and 2005/6 and pruned from the plants in May 2006 on the farm Waterkloof, 20 km West of Bloemfontein in the Free State Province, South Africa. The *Opuntia* cladodes were cut lengthwise by hand with a single-machete (mounted on a flat wooden surface) into strips of approximately 15 to 25 mm and dried in direct sunlight on corrugated roof sheeting. After about 6 to 10 days the *Opuntia* cladode strips were considered sufficiently dried (about 700 to 850 g DM/kg) to be collected and ground in a hammer mill to pass through a 20 mm sieve. Three treatment diets (T0, T24, and T36) were formulated to include incremental inclusion levels of 0, 240, and 360 g/kg sun-dried and coarsely ground *Opuntia* cladodes as partial substitution of coarsely ground lucerne hay (Table 1).

Table 1 Air-dry composition of treatment diets with incremental inclusion levels of sun-dried and coarsely ground *Opuntia* cladodes

Feed ingredients (kg)	Treatment diets*		
	T0	T24	T36
Coarsely ground *Opuntia* cladodes	0	240	360
Coarsely ground lucerne hay	660	410	285
Yellow maize meal	300	300	300
Feed grade urea	0	10	15
Molasses meal (Calori 3000)	40	40	40

*Inclusion levels of coarsely ground *Opuntia* cladodes: T0 – 0%; T24 – 24%; T36 – 36%

Lucerne hay was ground through the same 20 mm sieve as the cladodes. Yellow maize meal, molasses meal (Calori 3000) and feed grade urea were included in the physical form in which these feeds are commercially available (Table 1). As the *Opuntia* cladodes were incrementally increased in the experimental diets, lucerne hay was decreased (Table 1). The crude protein (CP) content of the diets was balanced to be iso-nitrogenous by the inclusion of feed grade urea in the two diets that contained *Opuntia* cladodes, because *Opuntia* contains less CP than lucerne hay (77 compared to 184 g CP/kg DM).

For a period of nine weeks 28 young Dorper wethers (33.9 ± 2.98 kg) were used in the trial that simulated conditions in a feedlot. Prior to being subjected to the treatments, the wethers were treated for internal parasites and vaccinated for pulpy kidney. Treatments were replicated due to limited space in the metabolism cages using a fully randomized block design, with block A starting one week prior to that of block B. Wethers were randomly allocated on average weight within each block between the three treatments (block A: n = 4, 5 and 5 for treatments T0, T24 and T36, respectively; block B: n = 5, 4 and 5 for treatments T0, T24 and T36, respectively). Wethers were housed in an open-sided roofed shed in small pens. The amount of feed offered and refused by the wethers in the different treatment groups was measured in 48-hour cycles, starting every day at noon. The food allocated for the next cycle was then calculated as the feed consumed times a factor of 1.15, as explained in detail by Einkamerer (2008).

At the end of the trial apparent digestibility of the treatment diets was determined by housing the wethers individually in metabolism cages for a period of one week. The metabolism cages are designed to separate and collect the faeces and urine of male sheep with a minimum loss (De Waal, 1979). While in the cages, the wethers were also offered food at a 15% refusal level of intake. However, feed allowance was calculated on a daily basis by using a 3-day moving average of feed intake of the preceding three days. During the trial the wethers were fed twice daily (12:30 and 08:00) and weighed weekly.

Representative samples (treatment diets, feed refused, and faeces) were collected for each wether and dried in a force draught oven at 100 °C for at least 16 hours. After thorough mixing, these samples were ground to pass through a 1 mm sieve and stored in plastic jars with airtight screw tops pending chemical analyses. A composite feed sample from each treatment diet was collected on a daily basis. The DM, organic matter (OM), ash, ether extracts (EE) and gross energy (GE) of samples were determined according to the procedures described by the AOAC (2000). The CP was determined with a Leco Nitrogen analyzer (Leco, 2001). A factor of 6.25 was used to convert the nitrogen (N) content of the samples to CP content. Acid-detergent fibre (ADF) and neutral-detergent fibre (NDF) were determined according to the procedures described by Goering and Van Soest (1970) and Robertson & Van Soest (1981). Sulphite and α-amylase were not used as reagents during NDF determination.

The data of the block model was analyzed and tested for significant differences using the PROC ANOVA procedures of the SAS programme (SAS, 1999). When significant differences were found ($P < 0.05$), further multiple comparisons using Tukey's higher studentized range (HSD) test were used to identify these differences.

Results and Discussion

The OM, ADF, NDF, and GE content of the treatment diets decreased as the inclusion level of *Opuntia* cladodes increased (Table 2) and is ascribed to the lower OM, ADF, NDF, and GE content of *Opuntia* cladodes compared to lucerne hay. These results correspond with the findings of Zeeman (2005). The CP content also decreased as *Opuntia* inclusion increased incrementally as partial substitution of lucerne hay (Table 2) but was corrected by including small quantities of feed grade urea (Table 1). The treatment diets used in this study corresponded to three of the four diets used in the study by Zeeman (2005). The control diet T0 was formulated as a basal diet to ensure moderate growth of sheep. The same objective was set in formulating treatment diets T24 and T36 by partially substituting the coarsely ground lucerne with *Opuntia* and adding small quantities of feed grade urea (Table 1).

Table 2 Chemical composition of the three treatment diets with incremental inclusion levels of sun-dried and coarsely ground *Opuntia* cladodes

Chemical constituents	Treatment diets*		
	T0	T24	T36
Dry matter (g DM/kg)	913	905	902
Organic matter (g OM/kg DM)	900	879	862
Crude protein (g CP/kg DM)	171	177	177
Ether extract (g EE/kg DM)	24	24	22
Acid-detergent fibre (g ADF/kg DM)	214	178	159
Neutral-detergent fibre (g NDF/kg DM)	413	363	313
Gross energy (MJ/kg DM)	17.3	16.7	15.5

*Inclusion levels of sun-dried and coarsely ground *Opuntia* cladodes: T0 – 0%; T24 – 24%; T36 – 36%.

The average daily gain (ADG) of the wethers tended to decrease (P >0.05) (Table 3). Atti *et al*. (2006) found differences in the performance of male goat kids because the energy and fibre content of the treatment diets differed as a result of *Opuntia* inclusion. Nutrient deficiencies may be overcome when *Opuntia*-based diets are supplemented with protein and energy sources (Ben Salem *et al*., 2005). Thus, the body weight gains (Table 3) of the wethers were moderate and acceptable for these diets and could in part be ascribed to the levels of maize meal and urea (Table 1) included in the diets.

Table 3 Mean (± s.e.) daily gain of Dorper wethers, dry matter (DM) and organic matter (OM) intake, apparent digestible DM and OM intake, as well as the apparent digestibility coefficients of three treatment diets with incremental inclusion levels of sun-dried and coarsely ground *Opuntia* cladodes

	Treatment diets*				
	T0	T24	T36	P	CV (%)
Average daily gain (g/day)	118 ± 13.7	116 ± 15.6	96 ± 7.9	0.3219	34.552
DM intake (g/day)	1368 ± 69	1345 ± 46	1317 ± 61	0.9039	13.858
Digestible DM intake (g/day)	977 ± 51	983 ± 29	995 ± 44	0.9414	13.421
OM intake (g/day)	1235 ± 62	1198 ± 41	1152 ± 52	0.7405	13.704
Digestible OM intake (g/day)	907 ± 48	905 ± 28	902 ± 40	0.9934	13.502
DM digestibility coefficients	0.714^{a} ± 0.004	0.732^{a} ± 0.007	0.756^{b} ± 0.004	<0.0001	2.055
OM digestibility coefficients	0.734^{a} ± 0.005	0.757^{b} ± 0.006	0.783^{c} ± 0.003	<0.0001	1.878

[a,b] Means in the same row followed by different superscripts differ significantly (P < 0.05)
*Inclusion levels of sun-dried and coarsely ground *Opuntia* cladodes: T0 – 0%; T24 – 24%; T36 – 36%

No significant differences (P >0.05) were observed between the DM and OM intake of the wethers (Table 3). This is in agreement with the results reported by Zeeman (2005). The apparent DM and OM digestibility increased (P <0.05) with *Opuntia* inclusion (Table 3). This could explain why no effect on ADG was observed between the treatments. Zeeman (2005) also reported increases in apparent digestibility coefficients and ascribed it to the fact that *Opuntia* cladodes contain high levels of easily digestible carbohydrates (Ben Salem *et al*., 1996; 2004).

Conclusions

Dietary treatment had no effect (P >0.05) on feed intake of young Dorper wethers subjected to diets with sun-dried *Opuntia* cladodes included at 24% and 36%.

The study by Zeeman (2005) concluded that *Opuntia*-based diets had no apparent negative effects on the growth of similar young Dorper wethers. However, the trial period of 19 days used by Zeeman (2005) was too short to draw definitive conclusions in this regard. Having been subjected in the current study to *Opuntia*-based diets for a longer period of nine weeks only tended to decrease (P >0.05) live weight gain at the highest level of inclusion (diet T36). Therefore, it can be concluded that sun-dried and coarsely ground *Opuntia* did not affect animal performance negatively at the inclusion levels used in this trial.

The results of the study suggest that *Opuntia* cladodes can be utilised as a partial replacement for lucerne hay in ruminant diets. It is recommended that the focus should now be on the formulation of *Opuntia*-based production diets with a high energy content to be used in feedlots. Supplementing additional protein, and energy feed sources would likely improve animal performance.

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