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Chemical composition and feed intake of *Opuntia* cladodes varieties offered to goats

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1 ABSTRACT

An experiment was conducted to determine chemical composition and feed intake *American giant, Algerian, Cross x, Morado* and *Roedtan* (cactus cultivars) as an alternative feed for goats. *Opuntia* cladodes are regarded as a good cheap feed source that can be used to reduce the cost of raising ruminant production in dry areas. Spineless *Opuntia* has been planted in Mara research station (Limpopo Province) but little is known about its nutritional value. Dry matter, organic matter, crude protein, ether extract, fibre, non-fibre carbohydrates, total digestible nutrients and mineral content were determined from five *Opuntia* cladodes. Intake was measured from five *Opuntia* cladodes fed to goats. *Roedtan* and *Algerian* ranked high in nutritional value and *Morado* and *Roedtan* ranked high in mineral contents as compared to other varieties. *Algerian* followed by *Roedtan* had the highest total digestible nutrients as compared to *American giant*, *Cross x* and *Morado*. Goats ate more *Algerian* and *Morado* as compared to other three varieties. This study concluded that cladodes of *Algerian* and *Morado* are moderately nutritious and more digestible than other *Opuntia* cladodes. However, the cladodes should be corrected for low CP and fibre content. The content of anti-nutritional factors should be determined as they do have a negative effect on animal performance.

2 INTRODUCTION

Opuntia cladodes are regarded as a good inexpensive source of energy, which may reduce the use of concentrated feeds and expensive fodder crops, in dry areas (Rodrigues *et al.*, 2016). *Opuntias* are widely naturalized and located at the edge of roads and paths (Reis *et al.*, 2014). There are drought resistance fodder crops, have high biomass yield, palatability and soil adaptability (Batista *et al.*, 2003). They have on average crude protein (8.91 %DM), acid detergent fibre (16.1 %DM), neutral detergent fibre (18.0 %DM) and fat (1.6 %DM). In addition, *Opuntia* cladodes (on dry matter basis) are rich in calcium (3.0 %), ash (25.7 %) and carbohydrates. *Opuntia* cladodes are low in crude protein and crude fibre (Rodrigues *et al.*, 2016). *Opuntias* were used as supplementary feed to sheep (Rekik *et al.*, 2010; Costa *et al.*, 2012), dairy goats (Costa *et al.*, 2009; Andrade-Montemayor *et al.*, 2011) and dairy cows (Vilela *et al.*, 2010). The availability of nutrients for ruminant animals has not been assessed. To assess the potential value of *Opuntia* cladodes varieties as an emergency forage resource, it is important to know its nutritional value. Nutritional value analyses are used to predict performance of animals. Nutritional value analyses can also be used to identify factors in forages that may be limiting animal performance. Therefore, the main objective of this study was to determine the nutritional value and intake of five

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Opuntia cladodes varieties as alternative feed for ruminant animals.

3 MATERIALS AND METHODS

3.1 Study area: The study area was Molelwane Farm situated 6 km west of the North West University. The area has summer months from August to March with temperatures ranging from 22 to 35° C, and long-term average annual rainfall of 450mm. The province has winter months from May to July, with sunny dry days and chilly nights with average minimum and maximum temperature of 2 and 20° C respectively. Cladodes from five varieties of *Opuntia* (*Morado, Algerian, American giant, Roedtan* and *Cross x)* were collected from ten years old trees established at the experimental site of Mara Research Station, Limpopo Province. Mara ADC is located ± 54 km West of Louis Trichard, Limpopo Province at 23°05'S and 29°25'E, at altitude of 961 m above sea level in the Arid Sweet Bushveld. The average annual minimum and maximum temperature recorded are 12.7 and 25.1°C respectively. The average season rainfall us 441 mm.

3.2 Soil type: Hutton type soil is the predominant soil type on the Mara Research Station. This sandy loam is moderately permeable and well drained having a low water retention and hydraulic conductivity of $2x10^2$ (m/yr)

3.3 Planting and sample collection: Ten plants per variety were planted in a single row in an East/West direction and used for data analysis. The distance between rows was 5m and within rows was 2m. During feeding trial, the cutting length for the plant materials was 20 to 30 mm. For nutritive value, the plant materials were ground to pass through 2 mm screen. The management practices such as pruning and pad thinning of *Opuntia* cladodes were done followed the procedure by Potgieter (1997

3.4 Chemical analyses: The samples were dried at 105^0C for dry matter content, ashed at 600^0C to determine organic matter content (AOAC, 1990). The nitrogen content of *Opuntia* cladodes were analyzed using Kjeldahl procedure (AOAC, 1990). The acid detergent fibre and neutral detergent fibre were determined using the method of Van Soest *et al.* (1991). Ether extract was determined using ANKOM XT10, Extractor 120V. Hemicellulose was determined by differences from NDF – ADF. The sum of NDF, CP, EE and Ash in percentage was subtracted from 1000 to calculate Non-fibre carbohydrates (NFC) (NRC, 2001). The formula used to predict total digestible nutrients (TDN) was 82.38 – (0.7515 x ADF) as described by Bath and Marble (1989. The Ca, Mg, K, Na, Cu, Zn, Fe, Mn, Se and P were determined using the dry – ashing procedure (AOAC 2005).

3.5 Nutrient intake: Tswana goats were randomly allocated to individual pens to evaluate the intake of 5 different *Opuntia* cladodes varieties. The initial total weight varied between 36kg and 38kg for goats. Animals were housed in individual pens. Five feed troughs were placed in each pen for each animal. The troughs were attached to the wire mesh separating the pens to avoid spillage of feed. Each animal was offered all the feeds simultaneously. Adaptation period was two weeks. The collection period was for twelve days. One kilogram of each of the five *Opuntia* cladodes were cut fresh and fed every morning at 09:00 after feed refusals were weighed. Fresh drinking water was available at all time. Unfortunately, water intake was not measured. Nutrient intake was determined by weighing feed offered and refusals on daily basis.

3.6. Hypothesis: The hypothesis was that there is a difference in the nutritive value and the intake of the *Opuntia* cladode varieties.

3.7 Experimental design: The design for the study was completely randomized design.

3.8 Statistical analyses: ANOVA was used to test the effect of *Opuntia* cladode varieties on nutritive value and intake using the General Linear Model (GLM) procedure of the statistical analysis system (SAS, 2008) using completely randomized design. The linear model employed was:

$$Y_{ij} = \mu + S_i + E_{ij},$$

Where Y_{ij} = observation of the dependent variable *ij*, μ = fixed effect of population mean

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for the variable, S_i = effect of *Opuntia* varieties (i = *Morado, Algerian, American giant, Roedtan* and *Cross x*), and E_{ij} = random error associated with observation *ij*. Least square means was used to test the significance of difference between treatment means (P<0.05). Ranking analysis was used to differentiate the five types of *Opuntia* varieties using dry matter, crude protein, acid and neutral detergent fibre, ether extract, calcium, magnesium, phosphorus, zinc, manganese, iron, copper and selenium. Ranks were assigned based on the variety means of each trait, with the value of one assigned to variety adjudged best in a given trait based on the effect on that trait on chemical composition and 5 given to the worst.

3.9 Ethical statement: All animals in this study were treated according to the ethical standards of Department of Agriculture, Mara Research Station, and all animal handlings were approved. The Farm workers (especially small stock) were informed about the purpose and the methods of the study.

4 RESULTS AND DISCUSSION

4.1 Nutritional value*:* There were significant differences in nutritive value (P< 0.05) of different *Opuntia* cladodes varieties (Table 1). According to the results shown in Table 1, the crude protein content of different *Opuntia* cladodes varied between 6.10 to 10.28 %DM. The crude protein content for *Algerian, Morado* and *Roedtan* was higher than the one required for maintaining 40 kg goats (7.7 %) (Guevara *et al.*, 2004). The average crude protein content of the different *Opuntia* cladodes analyzed (8.04 %DM) was higher than that reported by Tegegne *et al.* (2007) (5.06 %DM), Villegas-Diaz *et al.* (2008) (5.90 %DM), Abidi *et al.* (2009) (3.80 %DM) and Rekik *et al.* (2010) (4.40 %DM). Varieties with the lowest CP content were *American giant* and *Cross-x* (6.20 %DM and 6.10 %DM). In order for these varieties to meet maintenance and production requirements, the diet should be balanced with supplementary protein such as non-protein nitrogen (Misra *et al.*, 2006).

Table 1 Mean nutritional value of different O*puntia* varieties on a dry matter basis.

Sample	DM %	OM %	CP %	ADF %	NDF %	Hemicellulose %	EE %	NFC %	TDN %
Algerian	92.53^{c}	77.75^{e}	8.07^{c}	7.64^{e}	13.67^{e}	6.03^{d}	1.34^{c}	62.16^{c}	76.64^{a}
Morado	92.09^{d}	78.84^{d}	9.57^{b}	10.43^{b}	20.88^{a}	10.45^{b}	1.25^{cd}	55.04^{e}	74.54^{c}
American giant	93.63^{a}	83.17^{a}	6.20^{d}	11.25^{a}	18.65^{c}	7.40^{c}	1.54^{b}	63.15^{b}	73.93^{d}
Roedtan	92.66^{b}	79.79^{c}	10.28^{a}	9.15^{d}	19.91^{b}	10.76^{a}	1.24^{d}	55.69^{d}	75.51^{b}
Crossx	92.67^{b}	81.63^{b}	6.10^{d}	9.31^{c}	16.71^{d}	7.40^{c}	1.64^{a}	64.54^{a}	69.83^{e}
s.e	0.018	0.040	0.051	0.039	0.026	0.058	0.024	0.019	0.004

^{a,b,c,d,e,}Mean within the same column with different superscripts differ (P<0.05)

DM – Dry matter, OM – Organic matter, CP – Crude protein, ADF – Acid detergent fibre, NDF – Neutral detergent fibre, EE – Ether extract, NFC – Non fibre carbohydrates, TDN – Total digestible nutrients.

Opuntia cladodes varieties with low organic matter content were *Algerian, Morado* and *Roedtan*. Low organic matter content were also reported for cactus pear by other authors, 74.6 % by Ben Salem *et al.* 2002 and 76.2 % by Ben Salem *et al.* 2004. The average EE content of different *Opuntia* varieties was 1.40 % on a DM basis. Several authors reported values of EE between 2.1 %DM and 2.3 %DM (NRC, 2007; Vilela *et al.*, 2010) which are higher than the current study. The acid detergent fibre content of different *Opuntia* cladodes varieties varied from 7.64 %DM (*Morado)* to 11.25 %DM (*Cross x*). *American giant* was recorded as the variety with the highest acid detergent fibre content. Some authors reported the higher values ranging between 13.7 %DM and 28.7 %DM (Cordova-Torres *et al.*, 2009; Vilela *et al.*, 2010; Andrade-Montemayor *et al.*,

2011; Costa *et al*., 2012). The acid detergent fibre content indicated that *Opuntia* cladodes could not be regarded as a sole source of roughage. From this study, the average NDF content was 17.96 %DM. The neutral detergent fibre content varied significantly (P<0.05) from 13.67 % (*Algerian*) to 20.88 %DM (*Morado*) on a dry matter basis. The average NDF content was lower than the NDF content reported by Tegegne *et al.* (2007), (23.88 %DM), Vilela *et al.* (2010) (31.40 %DM) and Costa *et al.* (2012) (31.20 %DM). The neutral detergent fibre content values from *Opuntia* cladodes varieties indicated that they could not be regarded as a source of roughage. Hemicellulose content of *Opuntia* cladodes varieties varies from 6.03 % (*Algerian*) to 10.8 % (*Roedtan*) on a dry matter basis. The average hemicellulose content was 8.41 %DM that was lower than 13.18 %DM reported by Tegegne *et al.* (2007) and 12.3 %DM reported by Vilela *et al.* (2010). Total digestible nutrients of *Opuntia* cladodes varieties varies significantly (P<0.05) from 69.83 %DM (*Cross x*) to 76.64 %DM (*Algerian*). Whereas *Cross x* had the highest Non-fibre carbohydrates as compared to *Morado.* Ranking of *Opuntia* varieties is shown in Table 2. *Roedtan* had the highest average rank on chemical composition followed by *Algerian* then *Cross-x*. *American giant* and *Morado* had the same average rank, which was lower than the other three varieties on chemical composition.

Table 2 Ranking of varieties based on selected traits of nutritional value parameters

Traits	***Algerian***	***Morado***	***American giant***	***Roedtan***	***Crossx***
DM	4	5	1	2	2
CP	3	2	4	1	4
ADF	1	4	5	3	2
NDF	1	5	3	4	2
EE	3	1	4	1	5
TOTAL	12	17	17	11	15
Average	2.4	3.4	3.4	2.2	3
Average rank	2	4	4	1	3

There were no statistical significant difference (P>0.05) on potassium and sodium (Table 3). The range for phosphorus content from different *Opuntia* cladodes varieties was 0.1 to 0.5 %DM that was reported by Lopez *et al.* (1988). The phosphorus content from different varieties in this study was lower than the 0.2 % (*Opuntia ficus-indica*), 0.33 % (*Opuntia engelmannii*) and 0.55 % (*Opuntia lingheimen*) respectively (Nefzaoui *et al.* 1995). Variation in phosphorus content could be due to plant species, soil fertilization, cladode age, rainfall, irrigation and temperature (Tegegne, 2001 *Opuntia* cladodes varieties in this study contained high levels of calcium than that of requirements of beef, cattle and sheep (0.18 – 0.66 %DM) (NRC 1989. This could be due to high oxalates content in different cladodes varieties of which 40 % is in a soluble form and bound to calcium (Nefzaoui and Ben Salem, 1998). The content of magnesium in this study was lower than 2.5 %DM reported by Retamal *et al.* (1987). Magnesium content is reported to be poorly absorbed from the alimentary canal of ruminants. The results revealed minimal content of micro minerals (Table 3). These findings suggest that the *Opuntia* cladodes might be a complement to daily diet due to their essential micro minerals content. These results are in line with the previous studies, which reported that *Opuntia* cladodes contain the main minerals in carbonates, chlorides, sulfates and phosphate (Frati *et al*., 1991; Granados and Castaneda, 1997).

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Table 3 Mineral content of different *Opuntia* cladodes varieties

Variety	Ca %DM	Mg %DM	P %DM	K %DM	Na %DM	Zn d.p.m	Mn d.p.m	Fe d.p.m	Cu d.p.m	Se d.p.m
Algerian	2.05^{b}	1.95^{a}	0.07^{b}	2.10	0.06	27.5^{c}	485.00^{c}	64.00^{d}	9.05^{a}	0.25^{a}
Morado	2.25^{a}	1.50^{bc}	0.07^{b}	2.50	0.08	26.50^{c}	547.50^{b}	55.00^{e}	5.05^{d}	0.25^{a}
American giant	2.35^{a}	2.05^{a}	0.13^{a}	2.15	0.07	57.50^{a}	455.00	159.00^{a}	7.00^{c}	0.19^{b}
Roedtan	2.05^{b}	1.55^{b}	0.07^{b}	2.30	0.07	20.50^{d}	227.50^{e}	73.00^{c}	7.90^{b}	0.19^{b}
Crossx	1.85^{c}	1.35^{c}	0.07^{b}	2.50	0.07	38.00^{b}	615.00^{a}	118.00^{b}	4.50^{e}	0.25^{a}
s.e	0.050	0.045	0.002	0.304	0.004	0.447	4.183	1.673	0.084	0.005

^{a,b,c,d,e}Means within the same column with different superscripts differ (P<0.05)

Ranking of *Opuntia* varieties is shown in Table 4 for mineral composition. *Morado* had the highest average rank on mineral composition followed by *Roedtan*, *American giant*, *Algerian* and the lowest rank was for *Cross X*.

Table 4 Ranking of varieties based on selected traits of mineral composition

Variety	*Algerian*	*Morado*	*American giant*	*Roedtan*	*Crossx*
Ca	3	1	1	3	5
Mg	1	3	1	3	5
P	2	2	1	2	2
Zn	2	2	5	1	4
Mn	3	4	2	1	5
Fe	2	1	5	3	4
Cu	5	2	3	4	1
Se	2	2	1	1	2
TOTAL	20	17	19	18	28
Average	2.5	2.125	2.375	2.25	3.5
Average rank	4	1	3	2	5

4.1 *Opuntia* cladodes intake: There was a difference in daily intake of goats consuming different types of *Opuntia* cladodes varieties (Figure 2).

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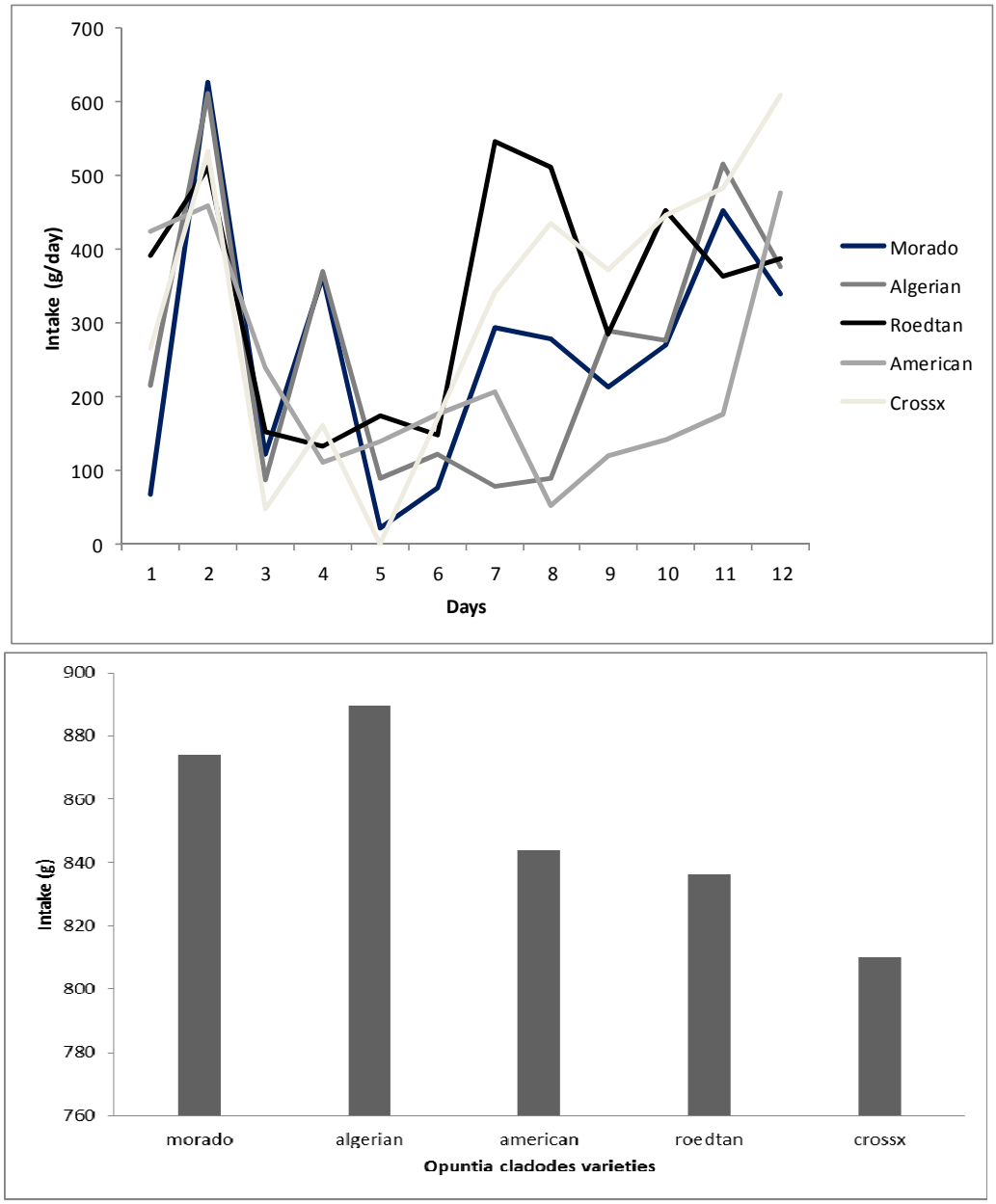

Figure 2: Daily intake of *Opuntia* cladodes varieties fed to goats

The average intake of different *Opuntia* cladode varieties varied between 810.0 g/day to 889.4 g/day for five goats. Intake for *Algerian* and *Morado* was high as compared to other three varieties.

5 CONCLUSION

Significant variations were recorded in the nutritional value and intake between the different types of O*puntia* cladodes. The cladodes of *Algerian* and *Morado* can be used as supplement because of the higher intake, higher total digestible nutrients and higher mineral contents. However they do contain lower level of crude protein and fibre content and therefore need to be corrected for low CP and fibre content as it does not meet the for maintenance of goats.

6 RECOMMENDATION

Opuntia cladodes are low in crude protein, fibre, sodium and phosphorus. It is recommended that in order to meet requirements of animals for maintenance and production, the cladodes should be balanced with supplementary protein. The content of anti-nutritional factors should be determined as they have a negative effect on animal performance.

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