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Performance and nutrient digestion of lambs fed incremental levels of wild cactus (*Opuntia leucotrichia*)

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Abstract

In northern Mexico the cacti *Opuntia leucotrichia* (OL) is abundant and widely distributed. Traditionally, OL cladodes are used as emergency feed for livestock during dry seasons; however, scarce research has been carried out using OL cladodes on high production diets for sheep. The aim of this study was to evaluate growing performance, nutrient digestion and rumen parameters of lambs fed incremental levels of OL. Two simultaneous trials were conducted to evaluate five isoenergetic and isonitrogenous diets containing different levels of OL: 0%, 10%, 20%, 30% or 40%, dry matter basis. In a performance trial one, fifty intact Rambouillet × Dorper male lambs (10 lambs x diet) of 19±2.8 kg of body weight, were randomly assigned to experimental diets. Data was analyzed as complete block design. In trial two, five ruminal cannulated Rambuillet male rams were used in a digestion study. Ruminal pH, and ammonia-N were also estimated. Data were analyzed as a 5 x 5 latin square design. About 25% of immature cladodes of each plant were harvested then were singed-off of spines by burning, chopped in a ¾ HP helicoidal mill and mixed to diets. Dry matter intake of lambs was significantly higher for 0% (1344 g d^{-1}) diet than 10% (1153), 20% (1098), 30% (955) or 40% diet (982). The average daily gain of lambs was also significantly different among diets (329 g d^{-}1, 227, 212, 185 and 253, respectively). Feed efficiency was significantly higher for 20% diet (5.2) followed by 30% (4.5), 10% (4.3), 40% (4.1) and 0% (4.1) diet. As could be expected, water intake (3.8 l d^{-1} 3.3, 2.1, 1.3 and 0.8, respectively) decreased as consumption of OL increased. Digestibility of dry matter, organic matter, cell wall and lingo-cellulose were not significantly different among treatments; however, crude protein was digested higher ($P<0.05$) in lambs fed 40% diet (72%) than other lambs (mean = 69). Ruminal pH (mean = 6.1) and ammonia-N (13.8 mg dl^{-1}) were not significantly different among treatments. Inclusion of OL on feedlot lambs diets is a good option for production systems were this resource is available.

Key words : *Opuntia leucotrichia*, lambs, growing performance, nutrient digestibility, pH and ammonia-N

Introduction

Water scarcity, poor quality soils and inadequate supply of feed are the major constraints of grazing livestock developed in arid and semiarid regions of Mexico. These areas are characterized by droughty conditions, erratic rainfall and soils subject to erosion. However, cacti plants of the generous *Opuntia* are well-adapted to arid regions, because they have developed phenological, physiological and structural adaptations to sustain their progress in these adverse environments (Kueneman and Kudo, 2001). In certain regions of northeastern Mexico, cladodes of *Opuntia* plants are used by domestic livestock and wildlife animals as food and water supply (Reynolds and Arias, 2001).

About 104 species belongs to the generous *Opuntia*. They are abundant and widely distributed in vast stands in dry areas called "nopaleras", of which 60% of them are located in the Chihuahuan desert. The most important species that are used as a forage source are *Opuntia leucotricha, O. streptacantha, O. robusta, O. cantabrigiensis, O. rastrera, O. lindheimeri and O. phaeacantha*. However, *O. leucotricha* (OL) is the most widely distributed and is an extremely drought tolerant, highly productive, and multipurpose succulent plant (Elizondo *et al*., 1987). However, when cactus pear is fed excessively as the sole feed diarrhea and bloat can occur (Tegegne *et al*., 2005).

In Mexico cladodes of OL are traditionally used as emergency feed for livestock, especially during drought periods; however, scarce research has been carried out using OL on high production systems. Thus, the aim of the study was to evaluate growing and digestion responses by feedlot lambs fed diets containing graded levels of cladodes of *Opuntia leucotrichia*.

Materials and Methods.

Two simultaneous trials were conducted to evaluate five isoenergetic and isonitrogenous diets containing different levels of OL cladodes: 0% (control), 10%, 20%, 30% or 40 % dry matter basis. As they were encountered in the range, about 25% of immature cladodes of each healthy plant were harvested, and then were singed-off of spines by burning, chopped in a ¾ HP helicoidal mill and mixed to diets.

In a growing trial one, fifty recently weaned intact male lambs (19±2.8 kg) of the cross Rambouillet × Dorper were randomly allotted to one of five treatment diets (10 lambs per treatment). Previously, lambs were dewormed and vaccinated. For a period of 10 days lambs were adapted to diets; thereafter, animals were fed for an experimental period of 90 d. Diets were offered to lambs twice a day (08:30 y 16:00 h) considering a 5% more than the previous day. Lamb intakes were recorded daily by weighing feed offered and refused. At the beginning of adaptation and experimental periods, individual lamb weights were measured and recorded and subsequently every 15 days. Weight of lambs at the beginning of adaptation period was used as a covariable to adjust average daily gain (ADG).

In a digestion trial two, five ruminal cannulated Rambouillet rams were (80.5±2.3 kg BW) used in a 5 × 5 Latin Square design that lasted 21 d in each period (14 d of adaptation and 7 d for collections). Animals were fed, *ad libitum*, the same experimental diets used in the growing trial.

Table 1. Ingredients of diets with graded levels of *Opuntia leucotrichia* cladodes.

Ingredient g kg^{-1}	Diets, DM				
	0 % OL	10% OL	20% OL	30% OL	40% OL
Opuntia leucotrichia	0.0	100.0	200.0	300.0	400.0
Oat hay	359.3	309.2	219.2	143.1	78.2
Corn grain	349.3	275.4	229.5	186.6	183.6
Poultry litter	109.8	128.7	139.7	135.7	111.8
Cottonseed meal	119.8	124.8	149.7	154.7	126.6
Tallow	49.9	52.9	49.9	53.9	45.9
Fish meal	0.0	0.0	10.0	24.0	47.9
Urea	10.0	7.0	0.0	0.0	4.0
Premix	2.0	2.0	2.0	2.0	2.0

Rams were housed in metabolic crates, and had free access to water during experimental periods. Diets were offered twice daily (0800 and 1600 h). Feed consumption was recorded daily by weighing feeds offered and refused. Diet samples and orts were collected daily and dried at 55°C for 48 h, and then were ground (1-mm screen) in a Wiley mill. Samples were grouped by period and composites were stored for further analyses.

On d 15 of each period, after morning feeding, rumen fluid samples were obtained at 0, 1.5, 3, 6, 9, 12, 15, 18 h. Samples were strained through two layers of cheesecloth. Ruminal fluid pH was measured (Courning pH meter) immediately after sampling, and then samples of 30 ml were acidified with 8 drops of sulphuric acid 97% and stored in a freezer (-4° C). Afterwards, samples were analyzed for ammonia-N following the procedures described by FAO (1986).

Total fecal collections of individual animals were carried out from d 16 to 21. Feces were weighed and mixed daily, and a representative sample (5%) was taken, stored at -4° C, and subsequently thawed. Feces were partially dried at 55° C during 48 h, after that were ground through a 1-mm screen for chemical analysis. Concentrations of dry matter (DM), organic matter (OM), crude protein (CP; (AOAC, 1997), neutral detergent fiber (NDF) and acid detergent fiber (ADF; Van Soest *et al.,* 1991) in diets, orts, and feces were determined. Apparent digestibility coefficients of DM, OM, CP, NDF and ADF were calculated using formulas by Van Soest (1994).

Data of growing performance of lambs were statistically analyzed using a completely block design, and rumen fermentation and digestion data with a replicated 5 x 5 Latin Square design using the General Linear Model (GLM) procedure of SAS (SAS, 2000). The Tukey´s test was used to adjust for multiple comparisons (Steel and Torrie, 1980).

Results and discussion

Final weight of lambs was significantly different among treatments (Table 2). Total gain and ADG showed very similar pattern as final weight. Lambs without OL showed about 40% better performance compared to lambs fed OL. The DM intake was also significantly different across experimental groups; animals consumed less feed as OL was increased in diets. Feed efficiency was also significantly different among treatments. Lambs without OL or with 40% OL required less fed to gain weight (Table 2).

In this study, addition of OL to lamb diets decreased weight gain. Conversely, Ben Salem *et al*. (2004) reported that barley grain can be substituted for *Opuntia ficus indica* pads without effects on growth rate of Barbarine lambs. Moreover, Tegegne *et al.* (2007) also used pears of *Opuntia ficus indica* for pasture hay replacement and found better ADG when hay was replaced at 20, 40 and 60%. In addition Degu *et al.* (2008) reported that oil seed cakes enhance the performance of lambs on cactus diets. Furthermore, Gebremariam *et al.* (2006) when fed lambs with 0, 22.8, 45.7 and 68.5% of *Opuntia ficus indica* on substitution to tef (*Eragrostis tef*) straw, they found that at 45.7% of cactus level, lambs gained more weight (56 g d^{-1}) than tef straw control diet (23 g d^{-1}). Besides, Tien and Beynen (2005) supplemented with 32% of *Opuntia elator* per day to grazing lambs and obtained 137 g d^{-1} in the supplemented groups compared to 98 g d^{-1} of the non-supplemented control group.

Table 2. Growing performance parameters of lambs fed diets with graded levels of *Opuntia leucotrichia* cladodes.

	Percentage in diets, DM						
Item	0	10	20	30	40	SEM	P<
Initial weight, kg	19.2	19.3	19.3	19.2	19.2	0.2	1
Final weight, kg	49 [a]	43 [b]	40 [c]	38 [d]	41 [b]	0.3	0.01
Total gain, kg	29 [a]	24 [b]	21 [d]	19 [e]	22 [c]	0.1	0.01
Average daily gain, g d^{-1}	329 [a]	254 [b]	213 [c]	185 [c]	227 [bc]	14	0.01
Dry matter intake, g day^{-1}	1344 [a]	1153 [b]	1099 [b]	955 [c]	982 [c]	22	0.01
Feed efficiency[a]	4.1 [c]	4.5 [b]	5.2 [a]	5.2 [a]	4.3 [bc]	0.1	0.01

[a]Calculated as dry matter intake/average daily gain.
[abcd]Means in a row with different letter superscripts are significantly different.

It seems that dietary by-pass protein sources may promote better growing animal responses compared to other protein sources. In this study, the unexpectedly growing superiority of lambs consuming 40% OL than lambs on 30% OL diet could be explained by the fact that the former received more fish meal, a by-pass protein (4.8 vs 2.4% of the diet, respectively). Similar responses were recently reported for Aguilera *et al.* (2008) when fed lambs with diets containing fish meal and graded levels of wet brewer grains. In addition, Tien and Beynen (2005) reported that fish sauce inclusion improved ADG (145 g d^{-1}) compared to groundnut (130 g d^{-1}) on lambs supplemented with 32% of *Opuntia elator*. Degu *et al.* (2008) also found that sheep consumed cotton seed cakes showed better performance than noug seed cake added to *Opuntia Ficus indica*-tef straw diet.

In this study, as OL was increased in diets, DMI of lambs was also reduced (Table 3). However, based on sheep DM requirements for maintenance (2–2.5% BW) and growth (4–4.5% BW) (Van Soest, 1994; NRC, 2007), all treatment diets satisfied maintenance requirements for DMI; meanwhile, diets with 0, 10 or 20% OL provided additional nutrients for growth. Conversely, Gebremariam *et al.* (2006), Bisop *et al.* (2007), Tegegne *et al.* (2007) in sheep and

Vieira *et al.* (2008a) in goats reported DMI improvement as cactus level increased. However, in former studies, cacti substituted grass hay or straw, and in this study corn grain and oat hay were replaced by cactus.

In this study, water intake of lambs increased as OL increased in diets (Table 3). These finding was also reported by Tegegne *et al.* (2007) in sheep, Carvalho *et al.* (2005) in lactating cows and Vieira *et al.* (2008b) in goats when fed spineless cactus. It seems that water from cactus food represented an important water supply for body needs. De Kock (2001) reported that wool sheep survived for 500 days on cactus cladodes alone. Thus, OL as a supplemental feed is of paramount importance in arid and semiarid like Central-North part of México where water quality and provision are limited (Aguilera *et al*., 2007).

In this study, ruminal NH_3-N was not significantly different between lambs fed 0, 10 and 20% OL, but were higher than 30 and 40%. Bisop *et al.* (2007) in sheep and Vieira *et al.* (2008a) in goats also reported reduction in ruminal NH_3-N as spineless cactus consumption increased. In this study, ruminal pH did not varied (P>0.05) among treatment diets (Table 3). This finding was also reported Bisop *et al.* (2007).

Table 3. Nutrient Feed intake, ruminal parameters and apparent digestion coefficients of lambs fed diets with graded levels of *Opuntia leucotrichia* cladodes

Item	Diets[a]					SEM	P<
	0	10	20	30	40		
Dry matter intake							
g d^{-1}	3065 [a]	2898 [b]	2655 [c]	2288 [d]	2240 [d]	34	0.01
g kg^{-1} d^{-1}	38 [a]	36 [b]	33 [c]	28 [d]	28 [d]	0.4	0.01
g $kg^{0.75}$ d^{-1}	114 [a]	108 [b]	99 [c]	85 [d]	83 [d]	0.9	0.01
% of BW	3.8 [a]	3.6 [b]	3.3 [c]	2.8 [d]	2.8 [d]	0.1	0.01
Water intake							
L d^{-1}	8 [a]	7 [b]	4 [d]	3 [d]	2 [e]	0.1	0.01
ml kg^{-1} d^{-1}	103 [a]	91 [b]	55 [c]	35 [d]	22 [e]	3	0.01
ml $kg^{0.75}$ d^{-1}	308 [a]	273 [b]	170 [c]	105 [d]	65 [e]	6	0.01
% of BW	10 [a]	9 [b]	6 [c]	4 [d]	2 [e]	0.3	0.01
Rumen parameters							
Ammonia N (mg dl^{-1})	14.8 [a]	14.2 [a]	14.4 [a]	12.9 [b]	13.0 [b]	0.3	0.02
pH	5.9	5.9	6.2	6.3	6.1	0.2	0.4
Digestibility (%)							
Dry matter	65	65	64	64	64	2	0.5
Organic matter	68	67	68	68	67	2	0.7
Crude protein	69 [b]	68 [b]	68 [b]	68 [b]	72 [a]	1	0.03
Neutral detergent fiber	58	61	59	58	61	1	0.3
Acid detergent fiber	47	45	46	46	44	2	0.2

[abcde]Means in a row with different letter superscripts are significantly different.

In this study, lams digested similar (P>0.05) amounts of DM, OM, NDF and ADF. However, CP was digested in higher amounts by lambs fed 40% OL (Table 3). As discussed above higher inclusion of fish meal in the 40% OL diet could have caused that lambs digested more CP. Bispo *et al.* (2007) when added 0, 14, 28, 42 or 56% of *Opuntia ficus indica* in substitution to Elephantgrass hay, reported higher DM and OM digestibility on the diets with cactus, but no differences were found among cactus diets. Tegegne *et al.* (2007) also found similar DM, OM and CP digestibility coefficients in lambs consumed 0, 20, 40 or 60% of spineless cactus (*Opuntia ficus indica*); however, all coefficients decreased with the 80% cactus diet. In the other hand, Gebremariam *et al.* (2006) reported that CP, NDF and ADF digestibility coefficients reduced as cactus level increased but the DM and OM digestibility coefficients were similar.

Conclusion

Inclusion of OL to feedlot lamb diets supported reasonable growing performance and nutrient digestibility. Thus, OL could be considered as good alternative that provides nutrients and water to ruminants in production systems were this resource is available.

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