CACTUS (*OPUNTIA STRICTA*) AND MESQUITE (*PROSOPIS GLANDULOSA* VAR. *GLANDULOSA*) AS FORAGE RESOURCES FOR GROWING RABBITS IN SEMI-ARID, SUBTROPICAL SOUTH TEXAS

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Abstract - Altex and New Zealand White (NZW) rabbits (n = 64) were used to evaluate cactus and mesquite as forage resources based on growth, feed utilization and carcass trait performances. Two weaning rabbits of each breed were randomly assigned to cages and fed one of four diets: 100% commercial pellets (control) or 50% pellets plus mesquite leaves or cactus pads, or a combination of both forages. There were four cages as replicates per diet treatment group. Individual growth, carcass and pen feeding traits were analyzed using mixed-model procedures. Altex rabbits had better growth trait performances than NZW rabbits ($P<.01$), although dressing percentage was poorer ($P<.05$). Following the 42 d feeding trial period, control rabbits were heavier by 537 g, had reached 1,800 g body weight earlier by 23.2 d, had higher dress-out by 5.6% and had lower gastrointestinal tract weights by 5.2% than forage fed experimental rabbits ($P<.01$). Rabbits fed cactus were 293 g heavier ($P<.01$) than rabbits fed mesquite. Mesquite had low observed palatability compared to cactus. The interaction due to the combination of cactus and mesquite was only important ($P<.05$) for dressing percentage. Gross and pellet feed conversions were improved ($P<.05$ and $P<.01$) in forage fed vs control rabbits, hence feed costs were reduced.

INTRODUCTION

In the U.S., the cost of meat rabbit production is high relative to other livestock enterprises, such as broiler chicken and swine production. In commercial rabbit production systems, feed costs account for over 90% of total operating or variable costs (McNITT et al., 1995).

In order to reduce rabbit production feed costs, one potential solution is to identify and test locally available forage sources that have nutritious properties, reasonable palatability, and yet minimal toxicity problems. There are no literature reports involving use of mesquite (Prosopis spp.), a common leguminous tree in south Texas, for rabbit feeding, although numerous studies (BOHRA, 1980; BOHRA and GUSH, 1980 ; ZELADA, 1986 ; FAGG and STEWART, 1994) involving ruminants (sheep and goats) have been reported. Crude protein ranges between 12-18%, and dry matter digestibility is approx. 90%, although the protein digestibility is very low (range of 3-8%), perhaps attributable to high tannin levels (BOHRA, 1980).

Another promising local forage resource is cactus. Although cacti (Opuntia spp.) are often low in protein, their digestible energy production per unit of rainfall is high. Thus, growth of cactus should be less nitrogen limited than other plants. Cacti should provide a good complement when fed to livestock in combination with semi-arid adapted, nitrogen-fixing, high-protein plants such as leucaena and mesquite (RUSSELL and FELKER, 1987). In general, Opuntia is documented to be high in moisture content (85%), high in *in vitro* dry matter digestibility (75%), but low in protein (6%) (GREGORY and FELKER, 1992). Although there are no known reports of cactus use in rabbit feeding, because of the intense consumption of Opuntia by wild rabbits (*Sylvilagus floridanus*) (FELKER, 1992), it would appear that use of spineless Opuntia in diets of domesticated rabbits might be feasible.

This research project investigated the use of locally available forages: cactus (*Opuntia stricta* var. *stricta*) and mesquite (*Prosopis glandulosa* var. *glandulosa*) for feeding growing rabbits to reduce feed costs under small-scale conditions.

MATERIALS AND METHODS

Population and Experimental Diets

The study was conducted at the Texas A&M University-Kingsville rabbit research and teaching facility. Purebred commercial Altex and New Zealand White (NZW) rabbits were involved for comparative purposes. The Altex is a new sire breed with a breed foundation of ¼Californian x ¼Champagne D'Argent x ½Flemish Giant, and a selection history which emphasized heavy body weight at 70 d of age (LUKEFAHR et al., 1996).

Table 1 : Experimental diet treatments.

100% PELLETS (CONTROL)	MESQUITE + 50% PELLETS
CACTUS + 50% PELLETS	CACTUS + MESQUITE + 50% PELLETS

Two NZW and two Altex rabbits from thirteen litters were randomly assigned to each of four pen replicates for each of four diets for a total of 64 rabbits. Weanling kits were randomly assigned to diets consisting of control (100% commercial pelleted diet) or experimental (free-choice mesquite leaves, cactus pads or mesquite and cactus, in addition to 50% limit feeding of pellets) (Table 1).

All control rabbits were fed (*ad libitum*) a commercial pelleted diet (Cargill-Nutrena Feeds), while water was supplied continuously via an automatic water valve. The limited 50% feeding of pellets to experimental rabbits was determined based on the average feed consumption of control rabbits on the previous day. Forages were harvested at local sites. To avoid contamination and wastage, freshly cut cactus pad strips (approx. 10 cm wide) were presented to rabbits on wire strands tied to the back of the cage, approximately 20 cm from the floor level. Mesquite leaves (harvested from unselected wild trees and wilted for 24 hr) were placed in forage feeders designed for rabbits (Bass Equipment Company). In preliminary trials, *Opuntia stricta* (accession #1270) had higher palatability than *O. ficus-indica or O. cochenillifera.* Accession #1270 has been reported to have superior protein (11.4%, d. m. basis) and phosphorus (.408%) contents compared to seven spineless forage types (GREGORY and FELKER, 1992).

The 42-d feeding trial was initiated with kits that averaged 32.1 d of age. All animals were weighed weekly to determine growth response in relation to diet and breed. The growth phase was completed by d 42 or later until rabbits reached minimum market weight (1,800 g). Animals that did not reach 1,800 g body weight by 42 d were weighed daily until the age at which this market weight was attained could be determined. Individual body weight, pen feed intake and refuse weights and mortality were monitored daily. By d 42 of the growth phase (or later until rabbits reached 1,800 g), rabbits were slaughtered. Carcass traits included: dressing percentage and non-emptied gastrointestinal tract (GIT) percentage of preslaughter weight. Dressing percentage was calculated as total hot carcass weight (head, skin, blood, viscera, heart, lungs, liver, kidneys and abdominal fat not included) divided by the preslaughter weight, times 100. Body weight gains, pellet and forage intakes, and feed conversion by pen were also recorded. The degree of market weight uniformity, calculated on a within-pen basis and separately for breed, was also computed from individual 42-d final weights.

Statistical Analysis

Individual weekly body weight data were subjected to statistical analyses using the General Linear Mixed Models (GLMM) package (BLOUIN and SAXTON, 1990) according to the following mixed- model:

$$Y_{ijklmn} = \mu + D_i + p_{ji} + W_k + B_l + l_{ml} + (DW)_{ik} + (DB)_{il} + (WB)_{kl}$$

$$+ \beta_1(A-\bar{A}) + \beta_2(A-\bar{A})^2 + \varepsilon_{ijklmn}$$

where Y_{ijklmn} = observed value of a given dependent variable; μ = overall mean; D_i = fixed effect of the ith diet; p_{ji} = random effect of the jth pen nested within the ith diet, assumed to be NID $(0, \sigma^2_p)$; W_k = fixed effect of the kth week; B_l = fixed effect of the lth breed; l_{ml} = random effect of the mth litter nested within the lth breed, assumed to be NID $(0, \sigma^2_m)$; $(DW)_{ik}$ = diet x week interaction; $(DB)_{il}$ = diet x breed interaction; $(WB)_{kl}$ = week x breed interaction; β_1 and β_2 = partial linear and quadratic regressions due to age (A) at the beginning of the experiment, and ε_{ijklmn} = the random error, assumed to be NID $(0, \sigma^2_\varepsilon)$. For the analysis of remaining growth and carcass traits, all terms pertaining to weeks (W) were eliminated from the model.

Pen trait data (weight gains, pellet and forage consumption, feed conversion and market weight uniformity) were analyzed using the LSMLMW package (Harvey, 1990) according to the following model:

$$Y_{ij} = \mu + D_i + \varepsilon_{ij}$$

where Y_{ij} = observed value of a given dependent variable; μ = overall mean; D_i = fixed effect of the ith diet, and ε_{ij} = the random error, assumed to be NID (0, σ^2_ε). The market weight uniformity analysis included additional effects of breed and the diet by breed interaction.

From ANOVA, least squares diet means for performance traits were compared using single degree of freedom independent contrasts: 1) control versus experimental diets; 2) cactus versus mesquite (single forage groups), and 3) combined forages (cactus plus mesquite) versus the average of single forage groups (interaction).

RESULTS AND DISCUSSION

Individual Growth and Carcass Traits

Figure 1 : Rabbit growth response due to forage treatment

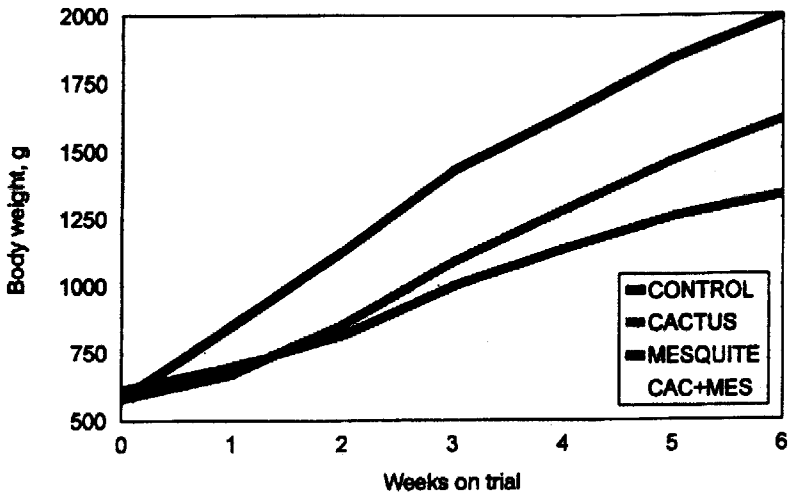
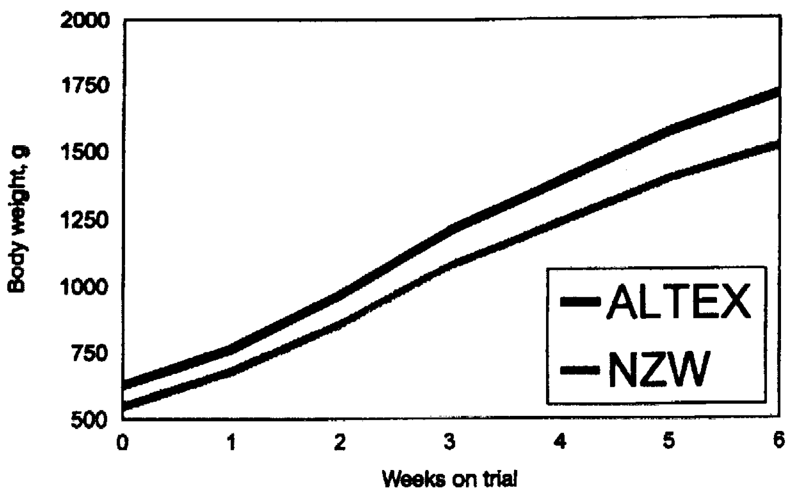


Figure 2 : Rabbit growth response due to breed



In the weekly growth response analysis, breed by week and diet by week interactions were detected (P<.01). Altex rabbits gained weight more rapidly than NZW rabbits throughout the 42-d experimental period (Figure 1). This is in agreement with literature reports in which Californian, Champagne D'Argent, Flemish Giant and NZW crossbreds had better growth rates than NZW purebred rabbits (LUKEFAHR et al., 1983 ; MASOERO et al., 1985 ; OZIMBA and LUKEFAHR, 1991 ; ROBERTS and LUKEFAHR, 1992). Control rabbits had the better growth response, whereas rabbits fed mesquite leaves (single or combined with cactus) had the slowest growth response (Figure 2).

Overall, the main effects of diet or breed were significant for all traits presented in Tables 2 and 3. The diet x breed interaction was never a significant source of variation. No initial body weight differences existed across diet treatments. There was only one mortality case which occurred in the control group during the 42-d trial. Control rabbits reached minimum market weight (1,800 g) 23.2 d earlier (P<.01) than experimental rabbits. However, cactus fed rabbits reached market weight 19.3 d earlier (P<.01) than mesquite fed rabbits. The final weight of control rabbits was 537 g heavier (P<.01) than the average of experimental forage-fed rabbits, but rabbits fed cactus were 293 g heavier (P<.01) than rabbits fed mesquite leaves. In general, rabbits fed mesquite leaves, either alone or in combination with cactus, had the poorest performance. The slower growth rate of rabbits fed mesquite leaves could be due to the presence of tannins, which may reduce intake by decreasing palatability and(or) by negatively affecting protein absorption (REED, 1995). Slow growth rates were reported in sheep consuming *Acacia siberiana* pods and leaves of *A. cyanophyla,* which contained high levels of tannins (REED et al., 1990). In addition, the reduction in growth rate in rabbits fed cactus and mesquite, as compared with rabbits fed only cactus, could be due to the fact that tannins not only precipitate proteins, but also starch and cellulose (HORVATH, 1981 ; REED, 1995), thereby possibly reducing both protein and carbohydrate absorption.

Table 2 : Generalized least squares diet means for growth and carcass traits and selected contrasts.[a]

Item	IW	AGE1800	FW	DP	GIT
Control	593 ± 29	70.2 ± 2.2	2,030 ± 49	51.2 ± .65	16.6 ± .62
Cactus	583 ± 29	84.5 ± 2.1	1,625 ± 40	45.4 ± .64	21.8 ± .57
Mesquite	613 ± 28	103.8 ± 2.1	1,332 ± 40	44.7 ± .60	22.5 ± .56
Cac+Mes	580 ± 28	91.9 ± 2.2	1,520 ± 39	46.6 ± .63	21.0 ± .60
Selected contrasts					
Control-Exp	1	-23.2**	537**	5.6**	-5.2**
Cac-Mes	-31	-19.3**	293**	0.8	-0.8
Interaction	-18	-2.2	42	1.6*	-1.1

[a]Trait abbreviations: IW = initial body weight, g; AGE1800 = age at 1,800 g, d; FW = final weight at the end of 42 d feeding trial, g; DP = dressing percentage; GIT = gastrointestinal tract percentage.
*P<.05, **P<.01.

Dressing percentage was higher (P<.01) in control than in experimental animals (Table 2). Rabbits fed cactus plus mesquite had higher (P<.05) dressing percentage than the average of simple forage groups. One explanation is that cactus intake may have been reduced when mesquite leaves were available (due to palatability problems of the latter), thereby reducing GIT development. Conversely, control animals had 5.2% lower GIT than the average of experimental rabbits (P<.01). These results are in agreement with the findings of MUIR and MASSAETE (1991) who reported a reduction of 5% in dressing percentage in rabbits fed a diet consisting of *Ipomonea batatas* and *Clitoria ternatea*, as compared with a pelleted diet. The same author reported lower digestive tract development in rabbits fed pellets when compared to rabbits fed only forages. POTE et al. (1980) did not find any differences in dressing percentage when rabbits were fed free-choice pellets, 75 g pellets plus greens free-choice, or greens fed free-choice. This could be the result of the forage species involved in their study. As cactus, in general, has a large amount of water (approx. 85%), animals have to increase their total forage intake in order to meet nutrient requirements, thereby stimulating an enlargement of the GIT.

The effect of breed on performance traits is shown in Table 3. Altex rabbits had a heavier final weight by 203 g and reached market weight 12.1 d earlier than NZW rabbits (P<.01). Altex rabbits had numerically lower (but not significant) dressing percentage than NZW rabbits, due, in part, to a larger GIT percentage (P<.05). OZIMBA and LUKEFAHR (1991) reported lower dressing percentage in Flemish Giant crosses, due to higher visceral wastes. However, the larger GIT development of Altex rabbits could explain their better growth performance, because the larger GIT allows the rabbit to consume more feed when fed a low quality, bulky forage diet.

Table 3 : Breed type generalized least squares means for growth and carcass traits

Item	IW	AGE1800	FW	DP	GIT
Altex	633 ± 28	81.5 ± 1.9	1,729 ± 41	46.8 ± .52	21.3±.41
NZW	552 ± 29	93.7 ± 1.9	1,525 ± 43	47.2 ± .53	19.7±.40
Contrast					
Altex-NZW	81	-12.1**	203**	-.5	1.6*

*P<.05, **P<.01.

Pen Traits

Uniformity of body weight within pens at the end of the 42 d experimental period was not statistically different between breeds or among diets. Nevertheless, Altex were numerically more uniform than NZW (CV = 5.7 vs 8.3%). Controls were more uniform (CV = 4.6%), whereas mesquite fed rabbits were least uniform (CV = 9.2%).
Diet results for weight gains, pellet and forage consumption and feed conversion are shown in Table 4. Control pens consisting of four rabbits gained 1.69 kg more total body weight (P<.01) than experimental pens of rabbits. Cactus fed pens gained 1.23 kg more body weight (P<.01) than mesquite fed pens. The same trends for daily gains per pen were observed. The restriction of 50% pellets for experimental rabbits related to control rabbits consuming twice as much feed (P<.01), as expected. Total feed intake (pellets plus forage [moisture content: 94.3 and 39.0 % for cactus and mesquite]) was still higher in control than in experimental rabbits (P<.01). The more limited forage consumption could at least be partially explained by the high moisture content of cactus and the low palatability of mesquite. Cactus fed pens consumed 2.1 kg more forage (P<.01) than mesquite fed pens on a dry matter basis.
Gross feed conversion (total pellet plus forage intake/total pen weight gains) was improved (P<.05) in experimental compared to control pens of rabbits. POTE et al. (1980) also reported improved feed conversion when pellet consumption was restricted (50 g/d per fryer) and supplemented with green forages. Rabbits fed cactus

had better gross feed conversion than rabbits fed mesquite (P<.05). The pellet feed conversion contrasts had the same trends. Control rabbits consumed .79 kg more pellets than experimental rabbits per kg of live weight gains (P<.01). This reduction in pellet consumption per kg of body weight gains could represent important economic savings for small-scale producers.

Table 4 : Generalized least squares diet means for pen traits[a]

Item	TPG	DPG	TPI	TFI	GFC	PFC
Control	5.28	125.9	16.1	16.1	3.07	3.07
Cactus	4.13	98.4	8.0	10.7	2.59	1.94
Mesquite	2.89	69.0	8.0	8.6	2.95	2.76
Cac+Mes	3.74	89.3	8.0	10.6	2.83	2.14
SE	.18	4.4	.3	.3	.07	.07
Contrasts						
Control-Exp	1.69**	40.4**	8.1**	6.1**	.27*	.79**
Cac-Mes	1.23**	29.4**	0.0	2.1**	-.37*-.82**	
Interaction	.23	5.5	0.0	.9	.06	-.21

[a]Trait abbreviations: TPG = total 42 d pen weight gain, kg; DPG = average daily pen gain (TPG/42), g; TPI = total pellet intake, kg; TFI = total feed intake (pellets plus cactus and[or] mesquite), kg; GFC = gross feed conversion (TFI/TPG); PFC = pellet feed conversion (TPI/TPG). Forage intake was based on a dry matter basis.
*P<.05, **P<.01.

Conclusions

1. Altex may be more adaptable than NZW rabbits on high forage diets due to their ability to enlarge gastrointestinal tracts.
2. Cactus is a promising forage resource for rabbit fryer production under small-scale conditions.
3. Rabbit growth performance appeared to be adversely affected by tannins present in mesquite leaves.
4. The reduction in feed costs realized through less commercial pellet usage could stimulate small-scale rabbit production, especially among low income rural people.

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