Productive response of lambs fed with fresh or dehydrated spineless cactus (*Opuntia ficus–indica* L.)

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Abstract

The objective of this study was to evaluate the effect of cactus (*Opuntia ficus–indica* L.) supplementation on lamb animal performance, during a 11–week period. For this purpose, 27 male lambs of commercial crossbreeds were used, with initial live weight mean of 21.4±3.8 kg. They were distributed homogeneously into three groups of nine each, and then randomly assigned to each of the following treatments: (T1) control diet, (2) diet with 17% (dry matter basis) of dehydrated cactus, and (3) diet with 17% (dry matter basis) of fresh cactus. Digestibility *in situ* of the diet, dry matter intake (DMI), daily gain weight (DGW), feeding conversion (FC) and efficiency (FE), back fat, hot and cold carcass yield, biological hot and cold carcass yield, and carcass pH at slaughtering and 24h *post mortem*, were evaluated. A completely random design using Proc GLM was used, and when statistical differences were observed, a mean comparison was done using the Tukey test. There were significant differences ($P \leq 0.001$) on DM digestibility, with higher value (42.0%) on the control diet during the first 6 hours of incubation, but after 48 hours, the highest digestibility (88.6%) was on the fresh cactus diet. There were not significant differences ($P > 0.05$) between treatments on animal performance, except on back fat, being higher ($P < 0.001$) on dehydrated (4.1 mm) and fresh (3.3 mm) diets, compared to the control one (7.8 mm). The means for hot and cold carcass yield, biological hot and cold carcass yield, and carcass pH at slaughtering and 24h *post mortem* were 50.6%, 47.0%, 55.4%, 49.5%, 6.6% and 5.8%, respectively. Diet including cactus had similar effect on productive parameters than that of the commercial one, which makes it a viable feeding strategy, and from the economical point of view, could be attractive to the farmer, since the cactus is a plant that grows over the year. However, there is a need of doing more research to confirm these results, not only on fattening lambs, but also on the different animal life stages, considering different levels of cactus, and working on different animal breed and species.

Keywords: Cactus, digestibility, yield, meat, carcass.

Introduction

In the arid and semi–arid zones of Mexico, the climatic conditions limit plant growth, especially of agricultural and foraging crops. Despite this, species such as the spineless cactus (*Opuntia* spp.) are very well adapted, and among other uses, it plays an important role in feeding bovines, sheep, and goats, as well as wild fauna (López, 2003), especially during the dry season, when spineless cactus is an excellent source of nutrients and water (Abidi *et al*., 2009; Germano *et al*., 2009). However, it does have the disadvantage of having low protein content, ranging from 5 to 10% (Batista *et al*. 2003), depending on the age of the cladodes, although this can be increased with proper fertilization (Guevara *et al*., 2009). Consequently, its effect on animal response is not very satisfactory, with weight gains between 20 and 60 g day^{-1} in lambs fed solely with fresh spineless cactus (Ben Salem *et al*., 2005; Tegegne *et al*., 2007), and between 90 and 110 g day^{-1} when fed with fresh spineless cactus and supplemented with a concentrate (Atti *et al*., 2006), respectively.

These results are indicative that spineless cactus is used as a survival fodder. Nevertheless, given its availability in conditions not apt for agriculture, it is important to find alternatives to make its use more efficient, framing it within a context of sustainable animal production. In this sense, recent research has shown improvements in the productive parameters, especially when there is a supplementation program (Tien and Beynen, 2005; Atti *et al*., 2006; Aranda *et al*., 2008), where not only is the nutritional value improved but also the consumption of dry matter, and therefore animal production. Moreover, carcass yields of 42.5% (Abidi *et al*., 2009) have also been reported for lambs, and of 48.0% (Atti *et al*., 2006) for goat kids supplemented with spineless cactus.

These results evidence the potential that including spineless cactus in the diet of lambs can have, whether fresh (Ben Salem *et al*., 2005; Tegegne *et al*., 2007) or dehydrated (Gebremariam *et al*., 2006a), complementing it with different energetic and/or protein sources (Degu *et al*., 2009). This alternative would represent a decrease in production costs, a vitally important aspect, especially if one considers that the costs of feeding are high given the high use of grains, particularly maize, whose price has risen considerably in the last few years. Therefore, the objective of this study was to evaluate the productive response of commercial crossbreed lambs fed with fresh or dehydrated spineless cactus.

Materials and methods

Fieldwork of the present study was carried out during 11 weeks, from July to September 2009, in the Ovine Production Module of the Experimental Farm of the Colegio de Postgraduados, Campus Montecillo, located in the State of Mexico, at an altitude of 2240 masl. The climate corresponds to the driest of the template climates, with a mean annual rainfall of 640 mm and preponderant summer rains, and a mean annual temperature of 18 °C (García, 1988).

Twenty–seven male lambs of commercial crossbreeds were used, with a mean initial weight of 21.4±3.8 kg. They were homogeneously distributed (according to their live weight) into three groups of nine animals each. Each group was randomly assigned to one of the three evaluated treatments: (T1) control diet, (T2) diet with 17% (dry matter basis) dehydrated spineless cactus, and (T3) diet with 17% (dry matter basis) of fresh spineless cactus (Table 1). The animals were kept in individual pens, and prior to the experiment, treated for parasites with Ivermectin and Clorsulon (Ivomec–F 0.2 ml kg^{-1} LW) subcutaneously, and received a toxoid bacterine (Exgon 8, 2.5 ml, unique dose), and vitamins A, D, and E (Vigantol ADE).

Table 1.Composition of the experimental diets (%) and proximal analysis.

Ingredients (% dry matter basis)	Treatments Control	Dehydrated cactus	Fresh cactus
Spineless cactus	0.00	17.03	17.03
Broken maize	18.04	16.19	16.19
Ground sorghum	26.70	26.79	26.79
Chicken flour	1.98	2.97	2.97
Soy paste	8.90	8.90	8.90
Wheat bran	15.44	7.12	7.12
Urea	0.60	0.60	0.60
Maize hay	8.20	1.45	1.45
Molasses	5.89	6.00	6.00
Broiler oil	1.80	2.00	2.00
Limestone	–	0.00	0.00
Mineral mix*	0.20	2.20	2.20
<u>Proximal analysis</u>			
Dry matter (%)	73.5	71.9	71.0
Raw protein (%)	15.53	15.73	15.84
FDN (%)	25.71	24.30	25.15
FDA (%)	9.93	9.58	10.62
Ash (%)	4.26	3.98	4.24
EM (Mcal kg^{-1})**	2.76	2.85	2.85
ENg (Mcal kg^{-1})**	1.15	1.09	1.09

BH= wet matter basis; BS= dry matter basis, *Mineral mix: 24, 3, 2, 8, 12, 0.50, 0.50, 0.50 % Ca, P, Mg, Na, Cl, K, S; 5.00, 4000, 2000, 5000, 100, 30, and 60 ppm of Cr, Mn, Fe, Zn, I, Se, and Co; EM (Mcal kg^{-1})=Metabolizeable energy in mega calories per kilogram; ENg (Mcal kg^{-1})=Net gain energy in mega calories per kilogram; **= Calculated from tables.

For the elaboration of the diet with dehydrated spineless cactus, the cactus was cut manually into strips approximately 1 cm wide, and set to dry in the sun on a 10 x 10 m cement slab, with daily turnings to obtain an homogeneous drying. Once dried, the cactus was kept in plastic bags and later ground in a hammer mill, with a 25 mm sieve, and finally mixed with the rest of the ingredients. For the elaboration of the diet with fresh spineless cactus, it was cut daily, three times a day, into 1 cm wide strips. It was offered half and an hour before and separately from the rest of the ingredients that made up the respective diet, with the aim of encouraging its consumption. Once reaching approximately 80% consumption, the rest of the diet was offered. The amount of total fodder offered to the lambs was calculated based on 3.5% of their live weight, later adjusting it according to daily consumption. It was offered at 7:00, 13:00 and 19:00 hours, in order to stimulate consumption. We provided water *ad libitum* to animals, except for the animals fed with the fresh cactus treatment, which had their water limited so not to affect cactus consumption.

Fodder consumption (CDA) was obtained from the difference of the offered and rejected fodder every day. Daily weight gain (GDP) was calculated based on the weight gained during the experimental stage, divided by the number of days that the research lasted. Food conversion (CA) was calculated by dividing the consumption of dry matter by the daily weight gain, and alimentary efficiency (EA) was obtained by dividing the daily weight gain by the daily consumption of dry matter.

At the end of the experimental period, the animals were sacrificed when reaching a mean live weight of 37.70 kg. At the moment of slaughtering, blood, skin, hooves, head, red innards (trachea, lungs, liver, and heart), and green innards (small and large intestines) were weighed. To estimate the empty live weight (PVV), the viscera were weighed full (with intestinal and ruminal content), and empty (emptied and washed with running water). Back fat was measured using a vernier, making an incision between the twelfth and thirteenth ribs. The carcass was weighed hot (PCC) and cold (24 hours *postmortem*) (PCF) in a refrigerating chamber at 4 °C. A register was done of the yield of the hot carcass [(weight of the hot carcass/weight before sacrifice) X 100], yield of cold carcass [(weight of the $cold_{24h}$ carcass/weight before sacrifice) X 100] (Osorio *et al*., 1998a), biological yield of the hot carcass [(weight of the hot carcass/empty live weight) X 100], and biological yield of the cold carcass [(weight of the $cold_{24h}$ carcass/empty live weight) X 100] (Hernández *et al*., 2009).

The temperature and pH of the carcass were measured between the twelfth and thirteenth ribs, directly from the carcass at slaughtering and 24 h *post mortem*, according to the method proposed by Cañeque and Sañudo (2000). For this, a portable potentiometer (HANNA, model HI99163) with a penetration electrode and automatic readings was used.

From each treatment, 100 g samples were taken, homogenized, and ground. The proximal chemical analysis was done in the laboratory of Animal Nutrition of the Livestock Program of the Colegio de Postgraduados. The determined variables were dry matter, protein, and ash (AOAC, 2005), FDN and FDA (Van Soest *et al*., 1991). Digestibility of dry matter was determined *in situ*, being registered at 0, 6, 12, 24, 48, and 72 hours of incubation, using three 1–year old lambs, cannulated in rumen and distributed in a 3x3 Latin Square. For this, bags (3x5 cm) with Japanese lining and 52 ± 10 mm pores were used. The fodder samples were previously ground using a Wiley mill model 4, with a 2 mm sieve. A 3 g sample from each treatment was placed into each bag, with 3 replications per time of incubation, and the bags were fastened to a stainless steel chain and later introduced to the rumen, beginning with the 72 hour samples and finishing with the 0 hour ones, in order to take them out at the same time. Once they were removed, the bags were washed with running water, dried in a forced air stove at 55 °C, and then placed in a drier for 15 minutes and immediately weighed. Digestibility was determined as a percentage of the fodder disappeared in the rumen, initially placed in each bag (Ørskov and McDonald, 1979).

The results were analyzed by taking into account a completely random design using Proc GLM (SAS, 2002), and when statistical differences were observed, a mean comparison was done using the Tukey test (Steel and Torrie, 1989).

Results and discussion

Digestibility of the diets

The mean values of the digestibility of the diets are shown in Table 2. There were significant differences ($P<0.05$) among treatments in all the times of incubation, except for 24 hours. A greater digestibility was observed in the treatment with fresh cactus, followed by the diet with dehydrated cactus, and finally the control diet, whose means were 6.8 to 90.5, 13.9 to 87.5, and 12.3 to 84.1%, respectively, when increasing from 0 to 72 hours incubation. Cürek and Özen (2004), who reported a digestibility of 85.0% at 72 hours incubation with diets that included young spineless cactus cladodes, found similar results. It is important to point out that the digestibility found in the present study at 24 hours in the diets which included cactus was in mean 64.1% lower than the 89.4 and 84.6% reported by Medina *et al*. (2006) when including 33.3 and 10.0% dehydrated cactus flour in diets for cows, respectively. These differences are because these authors included fibrolitic enzymes in the diet, causing an increase of digestibility. This suggests that including this type of additives in diets with spineless cactus could increase its digestibility, and thus the consumption of dry matter, and consequently daily weight gains. In our study, the greatest digestibility of dry matter was found at 72 hours in diets with fresh cactus. This tendency could be due to the energy:protein interaction, where the digestible energy of the cactus is usually greater (2000 Kcal/kg DM) (Nefzaoui and Ben Salem, 2003) than that of other forages, thus favoring a rumen environment adequate for the action of microorganisms, and so increasing the degree of digestibility (Church *et al*., 2007).

Table 2. *In situ* digestibility of dry matter in the rumen of lambs, in diets with dehydrated or fresh spineless cactus.

	Treatments				
Time (Hours)	Control	Dehydrated cactus	Fresh cactus	SD	Significance
0	12.3a	13.9a	6.8 b	4.6	0.0001
6	42.0a	29.8 b	26.9 b	10.9	0.001
12	58.3a	42.8 b	36.9 b	12.8	0.0001
24	71.9	64.2	64.1	12.7	NS
48	80.7ab	80.5 b	86.7a	6.6	0.05
72	84.1 c	87.5 b	90.5a	3.3	0.0001

NS=Not significant; SD=Standard deviation; abc=Different letters in the same line represent statistical differences.

Animal performance

There were no significant differences (P>0.05) among treatments in the animal performance, with mean values for consumption of dry matter, daily weight gain, food conversion, and alimentary efficiency; 1.13 kg day^{-1}, 0.248 g day^{-1}, 4.66, and 0.221, respectively (Table 3).

Table 3. Animal performance of lambs fed with dehydrated or fresh spineless cactus.

	Treatments				
	Control	Dehydrated cactus	Fresh cactus	SD	Significance
Initial weight (kg)	21.28	21.25	21.82	2.18	NS
Final weight (kg)	37.38	37.26	38.37	5.21	NS
CMS (kg day^{-1})	1.16	1.13	1.09	0.11	NS
GDP (g day^{-1})	253.00	260.00	232.00	0.05	NS
Food conversion	4.68	4.58	4.74	0.65	NS
Alimentary efficiency	0.22	0.230	0.22	0.05	NS

CMS= Consumption of dry matter; GDP= Daily weight gain; SD= Standard deviation.

Not having found statistical differences in the consumption of dry matter among treatments was basically due to the similar chemical composition of the diets. Despite the low nutrimental quality of the spineless cactus, it conferred a better digestibility, given the high fermentative capacity of its carbohydrates (Misra *et al*., 2006). This favored the consumption of dry matter, even greater than what is reported in other studies (Gebremariam *et al*., 2006b; Abidi *et al*., 2009). To this regard, Nefzaoui and Ben Salem (2003) reported that the high water content of spineless cactus serves as a vehicle in nutrient transportation, but at the same time, this water is eliminated through urine. This causes a quick emptying of the rumen (McDonald *et al*., 2006) and, therefore, a greater consumption, although not necessarily greater weight gains. Contrarily, Aranda *et al*. (2008) reported that adding spineless cactus to the diet contributes to a quick filling of the rumen, and therefore a lower consumption of dry matter, when adding 30% spineless cactus dry matter. Aranda *et al*. (2008) also reported that the use of spineless cactus leads to a lower consumption of water, which is vitally important in arid and semi–arid zones, where water scarcity is common especially during the dry seasons, when the spineless cactus represents an excellent source of the vital liquid (Gebremariam *et al*., 2006b; Tegegne *et al*., 2007; Germano *et al*., 2009).

The daily weight gains found in this research were 260 and 232 g day^{-1} in the animals with the treatments considering dehydrated and fresh spineless cactus was added, respectively; similar to that of the animals with the control diet (248 g day^{-1}). This performance is especially important if one considers a daily weight gain of 257 g day^{-1}, reported by the NRC (2007) for 40 kg lambs. Thus, the weight gains found in this experiment are within the recommended range and, therefore, considered acceptable even if the genetics of the animals is different. Similar results have been reported by Aranda *et al*. (2008), who proved different levels of spineless cactus dry matter in diets for Corriedale/Criollo sheep.

Although treatments in the present research did not show significant statistical differences at $P \leq 0.05$ for daily weight gains, this result suggests that including spineless cactus at a level of 17% DM in the diet of lambs in the final stage represents benefits to the producers. This is because of the greater weight gains than those observed by Ben Salem *et al*. (2004), Tien and Beynen (2005), and Degu *et al*. (2009), who reported mean gains of 138, 53.7, and 100 g day^{-1} for Barbarine, Vietnamese, and Tigray highland sheep, respectively, with spineless cactus based diets. These results are particularly important in the context of sustainable animal production, which nowadays is a necessity, and where the efficient use of local resources is a priority (Toledo, 2002). This is a situation that is followed in our experiment, because spineless cactus is a plant that grows in adverse conditions, with little rainfall and poor soils (Batista *et al*., 2003), where most foraging crops would not be able to grow. This means that even if spineless cactus is a low quality forage, it can be enriched with other sources of protein or energy, mainly (Tien and Beynen, 2005), which would help to surpass the weight gains here reported. It is pertinent to point out that for the energy:protein relation to be adequate, it is necessary to add an extra protein source, which in our case was soy and chicken flour. These ingredients have the disadvantage of increasing production costs. This leads us to the search for other, cheaper, sources of protein, such as urea and bird excrements (Zapata *et al*., 2004; Ríos *et al*., 2005), which will minimize said costs, and also improve food conversion and alimentary efficiency, indicators of productive efficiency. In our experiment, these last two parameters showed no statistical differences ($P>0.05$) among treatments, with means of 4.6 and 0.221, respectively. These values are lower than those reported by Álvarez *et al*. (2003), who working with Pelibuey sheep fed with parota ear tree (*Enterolobium cyclocarpum*) and chicken droppings found food conversion and alimentary efficiency values of 8.60 and 0.137, respectively. The importance of these results lies in the benefit that it would represent to the producer, by using a lower amount of concentrated fodder to obtain a live weight comparable with other reports, and to a certain degree, would represent economic benefits in the concept of feeding. This will be discussed further on.

Characteristics of the carcass

The characteristics of the carcass were not different ($P>0.05$) among treatments (Table 4), with the exception of back fat, which was lower ($P<0.001$) in carcasses from animals fed with diets including fresh (3.3 mm), and/or dehydrated (4.1 mm) spineless cactus, than in those fed with the control diet (7.8 mm). Atti et al. (2006), who found a decrease of 13.0% in the back fat of goat kids when spineless cactus was included in their diets, reported a similar performance. These differences can be attributed to pectins, gum rubber, and mucilage, main components of spineless cactus, because it has been reported that these encapsulate greases and drag them to the posterior tract, and thus eliminate them (Basurto *et al*., 2006). The same authors report that in the case of humans, including spineless cactus in the diet contributes to reducing cholesterol, triglycerides, and glucose in the bloodstream, which may be what happens in animals. The fact of having obtained carcasses with lower fats deposits when spineless cactus was included in the diet, assumes a better quality of the meat. This brings benefits to human health, since as a consumer, one would be acquiring a low fat food source (Martínez *et al*., 2002), and an aspect that is demanded by the population nowadays, because it decreases the probability of ailing from cardiovascular diseases (Lara *et al*., 2004).

No significant differences (P≤0.05) were observed among treatments in the weight percentage of blood, hooves, skin, head, red innards, green innards, empty or full. Manso et al. (1998) reported similar results for head, blood, hooves, and skin. These authors mentioned that these parts of the body have an early development, and thus represent a greater percentage of the live weight of the animal in its first days of life, and as it grows older the percentage that these part represent decreases while the carcass weight increases, and so carcass yield increases too. This could explain the yield values of the carcass found in this experiment, although there were no significant statistical differences (P≤0.05) among treatments either, but they do lie within the normal range reported by other authors (Osorio *et al*., 1998b).

Table 4. Carcass yield in lambs fed with dehydrated or fresh spineless cactus.

	Treatments				
	Control	Dehydrated cactus	Fresh Cactus	SD	Significance
Live weight (kg)	35.67	35.91	36.89	4.33	NS
Head (%)	6.43	5.94	6.39	0.82	NS
Hooves (%)	2.60	2.61	2.96	0.51	NS
Blood (%)	3.56	4.11	4.0	0.74	NS
Skin (%)	11.58	11.82	11.60	1.17	NS
Red innards (%)	4.34	4.60	4.65	0.57	NS
Full green innards (%)	18.41	16.49	17.47	2.24	NS
Empty green innards (%)	8.89	8.50	12.46	6.07	NS
Gastrointestinal content (%)	8.75	7.99	8.33	2.04	NS
Empty live weight (%)	32.26	33.01	33.76	4.33	NS
Weight of hot carcass (kg)	17.98	18.37	18.51	2.24	NS
Weight of cold carcass 24h (kg)	16.63	17.20	17.18	2.40	NS
Yield of hot carcass (%)	50.39	51.13	50.30	1.74	NS
Yield of cold carcass (%)	46.66	47.84	46.50	1.99	NS
Biological yield warm carcass (%)	55.73	55.61	54.92	2.36	NS
Biological yield cold carcass 24h (%)	51.52	51.26	50.76	9.23	NS
Back fat (mm)	7.80a	4.1b	3.3b	0.22	0.001
pH at sacrifice	6.41	6.45	6.57	0.20	NS
pH 24h *post mortem*	5.88	5.82	5.78	0.25	NS

NS= Not significant at P≤0.05.

The mean yields for hot and cold carcass were 50.7 and 47.0%, respectively, independently of the diet. Previously, Fimbres *et al*. (2002) reported that Pelibuey sheep had a mean yield for cold carcass of 52.70%, when fed with different levels of forage in their diet. These differences might be evidence of the genetic factor, as suggested by Hernández *et al*. (2009), who reported greater carcass yields in hair sheep than in wool sheep, which would justify the carcass yields found in our study. Cabrera *et al*. (2007) also mention that carcass yield is related with the age of the animal, it being greater in older animals than in younger ones, since they have greater fat deposits and bone growth, which are both included in the carcass. Therefore, the values found in this experiment agree with those reported by other authors (Beriain *et al*., 2000; Hernández *et al*., 2009).

The mean pH of the carcasses at the time of sacrifice and 24 hours *postmortem* was 6.4 and 5.8, respectively, within the normal range reported (Bianchi *et al*., 2006; Abidi *et al*., 2009; Torrescano *et al*., 2009). These results suggest good handling before and after the sacrifice, where the animals did not suffer from stress. This is of vital importance if it is considered that pH is a determining factor in the quality of the carcass and the meat (Inmonem *et al*., 2000).

Economic analysis

The economic analysis is shown in Table 5. The diet of the control treatment showed the highest cost ($0.30) per kilogram of fodder, followed by dehydrated ($0.27) and fresh ($0.26) spineless cactus. These differences are because the control diet used wheat bran and corn hay in a greater proportion as a source of fiber, thus raising the cost per kilogram of the fodder. It is important to point out that the use of spineless cactus in sheep feeding comes from the need to decrease feeding costs, and most of all, to make efficient use of the available local resources, contemplated within the demands of a sustainable production.

In view of this, spineless cactus, being a plant that grows year round (Batista *et al*., 2003), can be used as a food source for sheep, especially during the dry seasons, and particularly in small–scale production systems. It offers economic benefits to the producers, who besides growing the spineless cactus for human consumption, could use its waste after pruning for animal fodder and thus obtain an extra source of income.

Table 5. Economic analysis of diets for lambs fed with fresh and dehydrated spineless cactus. Values presented in USA Dollars.

	Treatments		
	Control	Dehydrated cactus	Fresh cactus
Feeding costs			
Duration of the study (days)	72.00	72.00	72.00
Cost/diet ($/kg)	0.30	0.27	0.26
CMS (kg/day/animal)	1.17	1.13	1.09
kg of CMS/day/animal ($)	0.35	0.30	0.29
Total ($)	25.7	22.28	21.13
Returns			
PTG (kg/animal)	16.10	16.01	16.20
Price kg standing ($)	2.40	2.40	2.40
Income from sales of the meat/animal ($)	38.73	38.51	38.97
Net income ($)	12.98	16.23	17.84

$/kg= cost per kilogram of fodder; CMS= Dry matter consumption; PTG= Total gained weight; $= cost per kg of fodder, in dollars; USA$1= 12.47 Mexican pesos.

The economic analysis shows that when feeding the sheep with dehydrated and fresh spineless cactus, net gains increase to $16.23 and $17.84, respectively, while the control was only $12.98. This represents an increase of 25 and 37% in diets with dehydrated and fresh spineless cactus, respectively. These data refer to a single animal during the fattening process, thus benefits would increase depending on the number of animals kept in a determined production system. Moreover, if other cheaper, protein sources are used, the production costs would decrease even more, reflecting in a greater income for the producer. This scenario suggests, therefore, that spineless cactus is an option to improve the economic viability in a small scale, without disregarding medium– and large–scale production systems. However, it is necessary to point out that the economic analysis here presented deals exclusively with feeding and sales of live meat. For a more complete economic analysis it is necessary to consider the costs of ingredients for elaborating a diet, labor, fuel, animals, machinery, installations, and transportation (Ramírez *et al*., 2010), and in any case, the results here reported could vary. Therefore, it is necessary to take into account these considerations to extrapolate the results of the present study to other situations.

Conclusions

Diets including cactus had similar effect on lamb productive parameters than that of the commercial one, which makes it a worth and viable feeding strategy, especially within a sustainable animal production context. From the economical point of view, this could be attractive to the farmer, since the cactus is a plant that grows over the year, and can be used as a herbage resource, particularly in areas where herbage production is limited. However, there is a need of doing more research to confirm the results here reported, not only on fattening lambs, but also on the different animal life stages, taking into consideration different levels of cactus, and working on different animal breed and species.

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