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Effect of feeding cactus (*Opuntia ficus*) on growth performance of Nellore lambs

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Abstract
A study was conducted for 75 days to assess the incorporation of Spineless Cactus (*Opuntia ficus-indica*) on the growth perforamce of Nellore lambs. Eighteen growing Nellore lambs of uniform body weight (20.5 kg) and age (232 days) were randomly allotted to three groups and fed with one of the three diets namely, basal diet containing super napier (T_0), 20 per cent spineless cactus along with super napier (T_1) and 40 per cent spineless cactus along with super napier (T_2). All the lambs were supplemented with concentrate mixture @ 2 percent of the body weight. The average daily dry matter intake (kg/day) was 0.90 ±0.01,0.87 ±0.01 and 0.86 ±0.01 for T_0, T_1 and T_2 groups, respectively and the differences were statistically significant ($P< 0.05$). Nellore lambs in T_0, T_1 and T_2 group had an average daily gain (g) of 76.00±1.53, 72.22±2.18 and 70.00±1.18 g, respectively during 75 days experimental period and the differences were non-significant. At the end of the growth trial, a five-day digestibility trial was conducted on all the lambs to assess the digestibility of nutrients in experimental diets. Higher ($P< 0.05$) digestibility of DM and OM observed in spineless cactus supplemented group lambs (T_1 and T_2). Water intake was significantly ($P< 0.05$) lower in group T_2 compared to T_0 and T_1 lambs. It was concluded that spineless cactus could be a good unconventional, valuable fodder resource especially in rainfed drylands and could replace other feed stuffs like super Napier.

Keywords: Spineless cactus, super Napier, dry matter intake, average daily gain, digestibility trial, water intake

Introduction
Small ruminant rearing is one of the most sustainable enterprise among different livestock production systems to provide supplementary income and livelihood to small land holders and landless rural holds. The production efficiency of small ruminants in tropics has been low due to low feed resource availability and low plane of nutrition. Ensuring the availability of alternative feed of superior quality in adequate amounts is a priority to keep up the increased demand of growing animals, since continuous drought and variations in global climate affects the grain harvest and increase in prices in the international market (Lins *et al.*, 2017) [16]. Hence, one alternative would be to use cactus pear (*Opuntia ficus indica*), that is easily available as an energy source of low cost. The cactus pear has high water-holding capacity.
rich in nutrients and adapted to the environmental conditions of semiarid areas (Costa *et al*., 2013) [10]. Cactus is gaining importance as an alternate source of livestock feed in arid and semi-arid zones due to its drought resistance, high bio-mass yield, high palatability, low soil fertility, tolerance to salinity (Ben Salem *et al*., 1996; Barbera, 1995) [7, 4]. The succulent cladodes of spineless cactus are palatable to livestock with chemical composition of 10 percent of dry matter (DM), 4 to 10 percent crude protein (CP) and 30 to 40 percent neutral detergent fibre (NDF) (FA0, 2001) [12]. It also provides a major source of water (89.9 per cent), energy (8.4 MJ ME per kg DM), minerals and vitamin A in the diet of small ruminants (Salem *et al*., 2002; Abidi *et al*., 2009, Costa *et al*., 2013) [21, 1, 10]. Earlier experiments have shown that spineless cactus could be replaced in the diet as a source of roughage or concentrate ingredients in the diets of small ruminants. while, the growth performance in lambs has been ambiguous and the cactus inclusion in the diet has not been clearly defined. More over the studies on the nutritive value, digestibility and effect of feeding spineless cactus on haemato-biochemical parameters is rare. Based on these, the objectives of this study was taken up to determine the effect of feeding optimum inclusion of spineless cactus in the diets of lambs.

Material and Methods

The present study was conducted at Animal Experimental Farm, Hayathnagar Research Farm (17°27′N latitude and 78°35′E longitude and about 515 m above sea level), ICAR-CRIDA (ICAR-Central Research Institute for Dryland Agriculture), Hyderabad.

Selection of the experimental animals

Eighteen growing Nellore lambs of uniform body weight (20.5±0.90 kg) and age (232±9.4 days) were selected and randomly allotted to three treatment groups i.e., control T_0, treatment T_1 and treatment T_2 with six lambs in each group, these lambs reared in intensive farming at Animal experimental farm, HRF. The feeding trial was performed for a period of 75 days. The experimental animals were maintained on standard management practices in the farm with following feeding regimen.

The dietary treatments included

T_0 Basal concentrate mixture + chopped super Napier without spineless cactus

T_1 Basal concentrate mixture +chopped super Napier in which 20% of super Napier replaced by spineless cactus.

T_2 Basal concentrate mixture +chopped super Napier in which 40% of super Napier replaced by spineless cactus.

Nutrient digestibility

At the end of the growth trial, a five-day digestibility trial was conducted on all the lambs to assess the digestibility of nutrients in experimental diets. The animals were kept on clean, well aired individual metabolic cages with feeding and watering arrangement.

The animals were kept for adaptation period of 4 days followed by collection period of five days. During this collection period daily feed consumption, left over feed as well as faeces voided were recorded. Dry matter intake and digestibility coefficient (%) for the nutrients were estimated as per the formula.

Proximate analysis

Samples of concentrate mixture, super napier and spineless cactus were collected and dried in a hot air oven at 100±5◦C till constant weight and then grounded in a laboratory Willey mill and preserved in air tight containers for further chemical analysis. The proximate analysis of feeds was performed as per the procedures described by AOAC (2005) [3].

Blood collection

Blood samples were collected fortnightly from the jugular vein of all the experimental animals, prior to the morning feeding with the help of sterilized needles. Each time two blood samples were collected from each animal, one sample of 5 ml in heparinized vacutainer, for haematology and the other 5 ml in the vacutainer coated with clot activator for serum separation. Serum was separated by centrifugation at 2500 rpm for 15 min and transferred to 5 ml eppendorf tubes which were stored at –20 °C till use.

The blood samples were labelled, stored and transported in cooling box maintained at 2-8 °C to CRIDA for further investigation. Haemoglobin concentration (Hb, g/dl), haematocrit value (PCV,%), total erythrocyte count (TEC, $x10^6/mm^3$), total leucocyte count (TLC, $x10^3/mm^3$), leukocyte cell types (%), platelet count and erythrocyte indices *viz*., Mean corpuscular volume (MCV,%), Mean corpuscular haemoglobin (MCH,%) and Mean corpuscular haemoglobin concentration (MCHC,%) were analyzed using Automatic haemoanalyser. (ABX-MICROS-60). Concentration of glucose, total proteins, albumin, triglycerides, SGOT (Aspartate Amino Transferase), SGPT (Alanine Amino Transferase) were estimated in serum.

Statistical analysis

Statistical analysis was performed by using SPSS version 21 software one-way analysis of variance (ANOVA) followed by Duncan's test as post hoc analysis. The value of $P< 0.05$ was considered to be statistically significant.

Results And Discussion

Chemical composition of experimental diets

The chemical composition of spineless cactus (*Opuntia ficus - indica*) fed to the experimental lambs presented in Table 1.The DM content of spineless cactus was low (9.2 per cent) and moisture content was high (90.8 percent), hence it had an advantage of meeting the water requirements of the livestock. Significant decrease in the voluntary intake of water of sheep with increased levels of feeding cactus in their diets (Ben salem *et al*., 1996; Gebremariam *et al*., 2006 and Viera *et al*., 2008) [7, 13]. The CP content of spineless cactus was 5.62 percent. The CP value for spineless cactus obtained in this experiment was almost similar to the report of Ajith *et al*. (2017) [2], but lower than those reported by Salem *et al*. (2002) [21], Tegenge *et al*. (2005) [25], Tien and Beynen (2005) [23], Gebremariam *et al*. (2006) [13] and Misra *et al*. (2006) [17]. Such variation in CP content has been attributed to the fertility of the soil, since De Kock *et al*. (1980) [11] and Karim *et al*. (1996) [7] observed increased CP content in spineless cactus with nitrogen fertilization of soil.

The NDF and ADF content in spineless cactus were 38.7 and 27.2 respectively. Similar values were previously reported by Costa *et al*. (2012), Gebremariam *et al*. (2006) [13], Misra *et al*. (2006) [17] and Viera *et al*. (2008) [27]. A range of 31 to 41 percent NDF has been reported (Costa *et al*., 2016; Misra *et al*., 2006 and Vieira *et al*., 2008) [8, 17, 27], while Tegenge *et al*. (2007) [24] and Ajith *et al*. (2017) [2] reported lower values. Variation in NDF and ADF could be due to the age of the cladode, soil type and season. The TA content of spineless cactus was 29.2 percent. The TA content of spineless cactus was higher than the findings of Batisa *et al*. (2003) [5]. The higher TA content could be due to the age of the cladode (young cladode contain higher TA compared to middle-aged or old cladodes), and the soil content as reported by Retamal *et al*. (1987) [20]. The calcium content of spineless cactus was high 41.4 g/kg DM. Nobel *et al*. (1977) [19] and De Kock (1980) [11] also reported higher calcium content in cactus. In the present study, the spineless cactus contained (g/kg DM) 13.8 magnesium, 16.7 zinc, 34.6 manganese and 87.1 ferrous, all these values being much higher than the earlier findings of Batisa *et al*. (2009) [6]. Variation in mineral content could be due to the age of the cladode, soil type and season.

The chemical composition of DM, OM, CP, NDF and ADF were similar to the values reported by Vikram, (2014) who used the same composition of ingredients in the concentrate mixture in their experiment. The CP, CF and NDF content of super napier values similar to the values reported by Jamsawat (2020) [14] presented in Table 2.

Dry matter intake

Average DMI (g per day) was 905, 879, 861 g per day for T_0, T_1 and T_2 groups, respectively and a significant ($P< 0.05$) difference was observed between the treatment groups (Table 3). The dry matter intake of treatment groups were more than the values reported by Ajith *et al.* (2017) [2] and it could be due to the higher palatability of offered feeds and feed ingredients along with healthy lambs.

The mean daily dry matter intake per day from spineless cactus was 73.6 g in T_1 group that is equivalent to a 0.8 kg of fresh cactus, whereas it was 147.2 g in T_2 group that is equivalent to 1.6 kg of fresh cactus. The intake of spineless cactus depends on age, body weight, dietary regime and adaptation of the animals for feeding spineless cactus (Ben Salem *et al*., 1996) [7].

Body weight gain

The lambs fed diets with control (T_0), 20 per cent (T_1) and 40 per cent (T_2) spineless cactus along with concentrate mixture had an initial average body weight of 20.5± 0.88, 20.5± 1.11 and 20.5± 0.88 kg respectively with no significant difference among the groups, which grew linearly and attained a body weight of 26.2± 0.79, 25.9± 1.02 and 25.8± 0.80 kg, respectively by the end of experiment (Table 4). Statistical analysis of the data revealed that there was no significant difference in the fortnightly body weights of the lambs from 1st to 5th fortnight among three dietary groups. Relatively higher body weight was observed in control (T_0 group) when compare to T_1 (20% cactus) and T_2 (40% cactus) group lambs. Among the spineless cactus fed lambs, T_1 had relatively higher body weight than T_2 group, however the differences were non-significant (Table 4).

Further average daily gain (g) was 76.00, 72.22 and 70.00 for T_0, T_1 and T_2 group lambs respectively and no significant difference was observed among the three treatment group lambs (Table 5). However, lambs in T_0 had relatively higher average daily gain and weight gain when compared to T_1 and T_2. The results of the present study indicating that the incorporation of cactus in the diet will not affect much of average daily gain and body weight gain in lambs as it was nutritionally comparable with any roughages. Similar findings were reported earlier by Venkatesh *et al*. (2014) [26] and Shashi kumar *et al*. (2017) [22] in Mandya lambs. However, Gebremaram *et al*. (2006) [13] observed an increase in body weight gain with increased levels of cactus intake in growing lambs.

Water intake

The mean daily water intake (kg) was 1.50, 1.32 and 0.98 for T_0, T_1 and T_2 group lambs, respectively (Table 6). Water intake was significantly ($P< 0.05$) lower in group T_2 compared to T_0 and T_1. The average intake of water in control group was almost similar to that reported by Tegenge *et al*. (2007) [24]. Significantly ($P< 0.05$) lower intake of water in group T_2 lambs compared to groups T_0 and T_1 lambs indicates that the spineless cactus was a potential source of water to meet the requirements of the sheep.

Nutrient digestibility

Higher ($P< 0.05$) digestibility of DM, OM, CP, CF, NDF and ADF in the spineless cactus supplemented diets of group T_1 and T_2 lambs indicating higher digestibility and availability of nutrients from spineless cactus (Table 7). A similar results reported by Ajith *et al*. (2017) [2]. Costa *et al*. (2012) [9]. They noticed higher digestibility of OM with higher levels of cactus inclusion in the diet of growing Santa lambs, where in, the cactus replaced 50 percent of the corn in the diet.

Haematological parameters

At the end of the experiment all the experimental (T_0, T_1 and T_2) group lambs had normal haematological (RBC, WBC, Hb) values which are with in the physiological range. Similarly, MCH and MCHC values among three experimental group lambs were comparable. The values of all agranulocyte indices were statistically non-significant among the three experimental group lambs at the end of experiment. Granulocyte indices were differed significantly ($P< 0.05$) among three experimental group lambs at the end of experiment and highest Granulocytes were found in T_2 than T_0 and T_1 group lambs, however all are with in normal physiological limits. Small differences in haematological parameter values among the spineless cactus incorporated and non-incorporated lambs may not reflect any pathology or toxicity on blood-forming organs, hence spineless cactus could be useful as safe as other feed stuffs for ruminant livestock. A similar non-significant difference was reported by Morshedy (2020) [18] with RBC, WBC, Hb and all other Haemotological parameters in lambs suckling from ewes fed diets supplemented with prickly pear cactus peels.

Blood biochemical parameters

Statistically non-significant differences were observed in the mean serum glucose (mg/dl), serum albumin (g/dl) and triglycerides (mg/dl) values in lambs among three groups (T_0, T_1 and T_2) both before start of the experiment and at the end of the experiment. However, significantly higher ($P< 0.05$) serum total proteins (g/dl) were observed in T_1 and T_2 group lambs fed with spineless cactus compared to the control lambs fed without cactus. The mean serum triglycerides levels (g/dl) were relatively higher in T_2 group lambs at the end of the experiment. Inclusion of spineless cactus in the diets seems to increase serum total proteins and triglycerides, however liver function tests (SGPT and SGOT concentrations) before start of the experiment and at the end of the experiment were comparable among the three experimental group lambs. All these indicating, spineless cactus does not contain any toxic substances which can harm liver. Morshedy (2020) [18] observed a similar Triglycerides, SGOT and SGPT values, whereas contrary in glucose and total protein concentration when lambs fed diets supplemented with two levels of prickly pear cactus (*Opuntia ficus-indica*) peels.

Table 1: Chemical composition (% DM) of spineless cactus (*Opuntia ficus -indica*) fed to the Nellore lambs

S. No	Chemical composition	Cactus
1	DM	9.2
2	OM	70.8
Proximate composition		
3	CP	5.62

4	EE	1.08
5	CF	10.86
6	TA	29.20
7	NFE	53.24
Van Soest fibre fractions		
8	NDF	38.7
9	ADF	27.2
Mineral composition		
10	Ca	41.4
11	P	0.72
12	Mg	13.8
13	K	51.3
14	Zn	16.7
15	Fe	87.1
16	Cu	1.65
17	Mn	34.6

Table 2: Chemical composition (% DM) of concentrate mixture and super napier fed to the Nellore lambs

S. No	Chemical composition	Concentrate mixture	Super napier
1	DM	89.60	19.40
2	OM	90.15	90.52
Proximate composition			
3	CP	17.88	8.91
4	EE	5.94	1.88
5	CF	9.84	28.20
6	TA	9.85	9.48
7	NFE	56.49	51.53
Van Soest fibre fractions			
8	NDF	34.8	54.8
9	ADF	15.8	38.2

Table 3: Effect of feeding spineless cactus (*Opuntia ficus-indica*) on dry matter intake (DMI) in Nellore lambs

Experimental diets	BW (kg)	DMI (kg/Day)
T_0	26.20±0.79	0.90±0.01[a]
T_1	25.90±1.02	0.87±0.01[ab]
T_2	25.75±0.80	0.86±0.01[b]
N	6	6
SEM	0.479	0.007
P Value	0.935	0.055

[ab] Means with different superscript in a column differ significantly $P< 0.05$
P- value: Probability value; N: Number of animals; SEM: Standard Error Mean;

Table 4: Effect of feeding spineless cactus (*Opuntia ficus-indica*) on body weights (kg) of Nellore lambs

Exp-Diet	Initial body weight (kg)	Fortnight body weights (kg)					Increase in body weight (kg)
		1	2	3	4	5	
T_0	20.50±0.88	21.8±0.81	23.15±0.85	24.12±0.81	25.18±0.74	26.23±0.79	5.73±0.11
T_1	20.52±1.11	21.95±1.06	22.96±0.90	24.00±0.91	25.00±0.94	25.92±1.02	5.41±0.16
T_2	20.54±0.88	21.38±0.86	22.66±0.79	23.93±0.90	24.93±0.82	25.75±0.80	5.25±0.08
N	6	6	6	6	6	6	6
SEM	0.523	0.502	0.466	0.474	0.456	0.479	0.082
P value	1.00	0.904	0.922	0.988	0.977	0.935	0.068

Exp-Diet: Experimental Diet;
P- value: Probability value; N: Number of animals; SEM: Standard Error Mean;

Table 5: Effect of feeding spineless cactus (*Opuntia ficus-indica*) on average daily gain (g) in Nellore lambs

Experimental diet	Average daily gain (g)
T_0	76.00±1.53
T_1	72.22±2.18
T_2	70.00±1.18
N	6
SEM	1.095
P Value	0.068

P- value: Probability value; N: Number of animals; SEM: Standard Error Mean;

Table 6: Effect of feeding spineless cactus (*Opuntia ficus-indica*) on water intake (kg/day) of Nellore lambs

Experimental diet	Water intake (l/d)
T_0	1.50±0.10[a]
T_1	1.32±0.06[a]
T_2	0.98±0.01[b]
N	6
SEM	0.101
P Value	0.027

[ab] Means with different superscript in a column differ significantly $P< 0.05$
P-value: Probability value; N: Number of animals; SEM: Standard Error Mean;

Table 7: Effect of feeding spineless cactus (Opuntia ficus-indica) on nutrient digestibility in Nellore lambs

Acid detergent fibre	43.73±1.64[b]	55.19±0.69[a]	57.06±0.87[a]	6	1.185	0.000
Neutral detergent fibre	50.63±1.59[b]	56.66±0.66[a]	58.51±0.99[a]	6	0.860	0.000
Nitrogen free extract	61.72±1.21[b]	66.71±1.45[a]	67.42±0.49[a]	6	0.765	0.002
Ether extract	70.67±1.04[c]	73.02±1.37[ab]	75.87±0.38[a]	6	0.674	0.004
Crude fibre	64.28±1.01[c]	67.47±1.02[b]	70.42±0.79[a]	6	0.680	0.000
Crude protein	73.87±0.89[c]	76.79±0.66[b]	79.81±0.39[a]	6	0.560	0.000
Organic matter	64.65±1.10[b]	69.03±0.94[a]	71.01±0.45[a]	6	0.667	0.000
Dry matter	63.22±1.15[b]	67.32±0.92[a]	69.01±0.46[a]	6	0.649	0.000
Treatments	T_0	T_1	T_2	N	SEM	P Value

[abc] Means with different superscript in a column differ significantly $P< 0.05$

P- value: Probability value; N: Number of animals; SEM: Standard Error Mean

Conclusions

The present study indicated that spineless cactus could be a source of energy for inclusion in the diet of lambs. Inclusion of cactus in the diets significantly decrease the voluntary intake of water (per unit feed DM intake), thus spineless cactus could also be a good source of water to meet the demands of the body. Cactus also a good source of minerals like calcium, iron and manganese. Considering the overall performance of the animals in terms of feed intake, digestibility and average daily gain, it was concluded that spineless cactus could be a good unconventional, valuable fodder resource especially in rainfed drylands and could replace other feed stuffs like super napier in all the season where super napier shows dormancy in winter season.

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