Indian J Dairy Sci 79(3): 241-246
https://doi.org/10.33785/IJDS.2026.v79i03.006

RESEARCH ARTICLE

Effect of inclusion of edible spineless cactus (*Opuntia ficus-indica*) in goat diet on haematology, blood biochemical and physiological responses

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Received: 02 August 2025 / Accepted: 28 November 2025 / Published online: 23 July 2026

Abstract: A study was conducted to investigate the effect of inclusion of spineless cactus (*Opuntia ficus-indica*) cladodes in the rations of male goat haematology, blood biochemical and physiological parameters. For this, 18 Alpine × Beetal male kids were selected from Livestock Research Centre of ICAR-National Dairy Research Institute, Karnal and distributed randomly into 3 groups of 6 animals each based on their body weight and age. In the control group (T_1), maize green fodder and concentrate mixture were supplied in the ratio of 60: 40 (on DM basis) to meet the requirements (ICAR, 2013). In group T_2 and T_3, the maize fodder was replaced by edible spineless cactus accessions No. 1270 and 1280, respectively. Two accessions of spineless cactus *i.e.,* 1270 and 1280 used for animal feeding were provided by ICAR-Centrall Soil Salinity Research Institute, Karnal. Replacement of maize fodder with spineless cactus did not affect haematological parameters like Hb, RBC, WBC and haematocrit concentration in male goats. There was no significant effect on biochemical parameters like glucose, total protein, albumin, globulin and BUN due to inclusion of spineless cactus in place of maize fodder. The activity of plasma aspartate amino transferase, alanine amino transferase and glutathione peroxidase was similar in all the groups, however, SOD activity was higher ($P<0.05$) in cactus fed groups. The concentration of growth hormone and insulin was similar in all 3 groups. The response of inclusion of both accession No. 1270 and 1280 was similar and comparable to maize fodder in male goat kids in terms of blood biochemical and physiological parameters.

Keywords: Blood metabolites, Goat kids, Hematology, Spineless cactus, Physiological parameters

Introduction

Under global climate change scenario, frequent and long droughts land degradation and green fodder scarcity, spineless cactus (*Opuntia ûcus-indica*) can be a promising alternative fodder for livestock due to its sustainability. In India, there is deficit of 44% of concentrate feed ingredients, 35.6% of green fodders and 10.95% dry roughages in India (IGFRI Vision 2050). Under such situation, spineless cactus could be a good alternative fodder source particularly for small ruminants under arid and semi-arid conditions.

Spineless cactus is a fast growing xerophytic plant well adapted to arid conditions. It remains green even during summer and can be used as a feed during scarcity. Cactus belongs to the family Cactaceae assimilating about 130 genera. The spineless cactus is edible (Russell and Felker 1987). It is highly resilient and has high water use efficiency and capability to grow in poor and degraded soils where other plants fail to grow. Cactus pear has the advantage of being a source of water for animals particularly during the dry season. It is tolerant to poor soil conditions and produces high biomass yield with acceptable palatability for animals (Russell and Felker 1987). These and other attributes such as ability to remain succulent during drought and produce forage, fruit and other useful products as well as its capacity in preventing long-term degradation of ecologically weak environments have increased the importance of cactus in arid and semi-arid regions. However, there is very scanty information regarding its utilisation in ruminant diet *vis-a-vis* health aspects (Thakuria et al. 2024). Therefore, an attempt was made to find out its effect of inclusion in the ration of goats on haematology, blood metabolites, enzymes, antioxidant status and hormones.

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Materials and Methods

Study site

The study was conducted in Livestock Research Centre of ICAR-National Dairy Research Institute, Karnal located with an altitude of 250 meter above mean sea level, latitude and longitude position being 29° 42" N and 79° 54" E, respectively. The maximum ambient temperature in summer goes up to 45°C and minimum temperature in winter comes down to about 3.5-4°C with a diurnal variation to the order of 15-20°C. The average annual rainfall is 700 mm, most of which is received from early July to mid-September.

Animals and feeding

Eighteen Alpine x Beetal male kids were selected from Livestock Research Centre of ICAR-National Dairy Research Institute, Karnal and distributed randomly into 3 groups of 6 animals each based on their body weight and age in a randomized block design (RBD). Maize green fodder and concentrate mixture were provided in the ratio of 60: 40 (on DM basis) in group T_1 (Control) to meet nutrient requirements (ICAR 2013). In group T_2 and T_3, maize fodder was completely replaced by edible sineless cactus (*Opuntia ficus-indica*) cladodes of accession No. 1270 and 1280, respectively. The experimental protocol was approved by NDRI-Institutional Animal Ethics Committee (IAEC approval No. 43-IAEC-18-23) governed by Committee for the Purpose of Control and Supervision of Experimentation on Animals (CPCSEA), Govt. of India. Feeding trial was conducted from May to July for 90 days. The partial data on weather parameters were collected from ICAR- Central Soil Salinity Research Institute, Karnal to calculate thermal humidity index (Table 1)) as given below:

THI= 0.72 (Dry Bulb Temp. + Wet Bulb Temp. °C) + 40.6

Chemical composition of feeds

Dry matter, OM, CP, EE and total ash contents in feeds were estimated (AOAC 2005). The fractions of cell wall constituents (NDF and ADF) were also determined (Van Soest et al. 1991). After processing samples, the concentration of minerals (calcium, iron, copper, zinc and manganese) in feeds was estimated by Atomic Absorption Spectrophotometer (Shimadzu AA-7000F). Phosphorus content was estimated using colorimetric method (AOAC 2005).

Collection of blood samples and estimation of blood parameters

Blood samples were collected from each experimental animal on day 0, 45 and 90 of the research trial. Vacutainers containing sodium heparin anticoagulant were used for the collection of blood. Further, the blood samples were centrifuged for separation of plasma and transferred to sterile individual plasma vials. The plasma samples were then stored in -20°C.

Haematological parameters like WBC, RBC and haematocrit were estimated in freshly collected anti-coagulated blood by an auto-hematology cell counter (Nihon kodhen, celltaca, Tokoyo, Japan). The activity of superoxide dismutase; SOD (Madesh and Balasubramanian 1998) and glutathione peroxidise; GPx (Paglia and Valentine 1967) in blood was estimated using blood lysate. The plasma samples were analyzed for levels of various biochemical parameters *viz.*, glucose, total protein, albumin, blood urea nitrogen (BUN), aspartate amino transferse (AST) and alanine amino transferase (ALT) by using diagnostic kit procured from Arkray Healthcare Pvt. Ltd., Surat, India. Growth hormone (GH) was determined in plasma using Goat Growth Hormone ELISA Kit and insulin was determined by using Goat Insulin ELISA Kit, both procured from Bioassay Technology Laboratory, Shanghai, China.

Statistical analysis

Significant difference between the means were analyzed with analysis of variance (two way ANOVA) based on Tukey's HSD test. Experimental data were analyzed with the SPSS version 17 (SPSS 17.0.0, Inc., Chicago, IL, USA) using suitable statistical tools.

Results and Discussion

Chemical composition of feeds offered to the animals

The chemical composition of concentrate mixture, maize fodder, spineless cactus (*Opuntia ficus-indica*) cladodes of accession No. 1270 and 1280 has been given in Table 2. Similar chemical composition of spineless cactus cladodes was reported by Ben et al. (2004) and Kauthale et al. (2017). Batista *et al.* (2003) reported that cactus (*Opuntia sp.*) cladodes were high in water, sugars and ash but they were low in CP and CF. It possessed a high Ca-P ratio and high palatabilty (Nefzaoui and Ben 2001). Compared with conventional feedstuffs, *Opuntia* cladodes have high ash content. Depending on the species and cultivar, the ash content ranged from 10 to 25% of DM. Calcium followed by K was the most abundant mineral in the cladodesbut high content of oxalates and extremely wide Ca: P ratio compromises the Ca availability to rumen microflora and the animal body (Sawyer et al. 2001). The Ca: P ratio was very wide in cactus in this study. The level of Ca was higher in cactus cladodes compared to maize fodder while P content was comparable. Both cactus cladodes and maize fodder were deficient in Zn. (Chander Datt and Aruna Chhabra 2005).

Edible spineless cactus cladodes in goat diets and haematology

The Hb concentration values were found to be 11.49, 10.45 and 11.46 g/dL) in groups T_1, T_2 and T_3, respectively. The values of RBC count (m/mm^3) in male goat kids in different groups were found to be 10.47, 10.49 and 10.56 in groups T_1, T_2 and T_3, respectively. The overall WBC concentration was found to be 7.09, 6.83 and 6.32 m/mm^3 in groups T_1, T_2 and T_3, respectively

with corresponding values of 25.04, 25.02 and 24.67% for haematocrit.

As per the reference values for small ruminant of auto-hematology cell counter (Nihon kodhen, celltaca, Tokoyo, Japan) for small ruminant Hb, RBC, WBC and Hct were reported as 8-12 g/dL, 8-18 m/mm^3, 4-13 m/mm^3 and 22-39%, respectively. The hematological parameters of crossbred kids of 3 groups were found to be in the normal range (Upadhyay and Rao 1985; Phulia et al. 2010).

Blood metabolites and liver enzymes as affected by inclusion of edible spineless cactus cladodes in male goat kids

The overall total plasma protein level was 6.07, 5.95 and 6.06 mg/dL in groups T_1, T_2 and T_3, respectively with corresponding values of 2.71, 2.53 and 2.28 g/dL for plasma albumin. The overall plasma globulin level was 3.36, 3.43 and 3.78 g/dL in groups T_1, T_2 and T_3, respectively. The blood urea nitrogen level was found to be 17.32, 17.20 and 18.47 g/dL in groups T_1, T_2 and T_3, respectively.

The plasma AST activity values across 3 months study were found to be 57.79, 56.38 and 57.14 IU/Lin groups T_1, T_2 and T_3, respectively. Plasma ALT activity was found to be 28.88, 27.89 and 28.28 IU/Lin groups T_1, T_2 and T_3, respectively. The normal levels of blood glucose and BUN were given as 40-80 and 8-20 mg/dL, respectively (Reece and Swenson 2004). Njidda et al. (2013) observed that plasma total protein level was 79.0 mmol/L and globulin level was 24.0 mmol/L in Kano brown doe-kid. The glucose and total protein level in plasma of goats fed with cactus diet were found to be 2.36 mmol/L and 82.5 g/L, respectively (Salem et al. 2019). The blood glucose level in goats fed diet containing 21 and 42% cactus pear silage on DM basis was reported as 77.8 and 65 mg/dL, respectively while the corresponding values for total protein were 6.23 and 6.17 mg/dL, respectively (Albuquerque et al. 2020). Similarly, the plasma albumin level in goats fed diet containing 21% and 42% cactus pear silage on DM basis was reported as 3.28 and 3.06 mg/dL, respectively with corresponding values of 2.94 and 3.11 mg/dL for globulin (Albuquerque et al. 2020).

Arsi-Bale goats had an overall mean (IU/L) of 14.0 for ALT, 43.2 for AST. In this breed, females had higher ($P<0.01$) ALT activity than males. The ALT activity was lower for kids below 6 months of age than older goats. As compared to other seasons ALT level was higher during after long-rainy season (Tibbo et al. 2008).

Antioxidant status

The SOD activity across 3 months study was found to be 8.84, 11.69 and 11.52 U/mg Hb in groups T_1, T_2 and T_3, respectively (Table 5). The overall SOD level in blood was higher ($P<0.05$) in groups T_2 and T_3 compared to control group. The increase in the

Table 1: Weather parameters and THI during the experiment

Month	Average maximum temperature (°C)	Average minimum temperature (°C)	Average relative humidity (%)	Average rain fall (mm/d)	Thermal heat index
May	36.7±0.72	22.0±0.44	40.0±3.09	2.2±0.84	74.46±0.44
June	35.9±0.51	25.7±0.50	59.4±2.18	3.5±1.94	79.40±0.59
July	33.5±0.45	26.3±0.34	76.0±2.09	13.8±5.53	79.53±0.52
Mean	35.4±0.96	27.5±1.34	58.5±10.40	6.5±3.67	77.80±1.67

Table 2: Chemical composition of feeds offered to the animals

Parameter	Concentrate mixture	Maize fodder	Cactus-1270	Cactus-1280
% DM basis				
DM	91.97	17.32	7.80	8.38
OM	92.41	90.09	82.24	84.64
CP	19.80	9.32	6.83	6.26
EE	3.98	2.29	2.63	2.47
NDF	29.25	52.25	34.25	36.75
ADF	16.42	36.67	14.50	13.80
TA	7.59	9.91	17.77	15.37
Ca (%)	0.98	0.25	0.81	0.84
P (%)	0.53	0.22	0.19	0.17
Mg/kg DM (ppm)				
Fe	459.51	341.43	211.62	126.85
Cu	26.55	15.25	7.84	6.85
Zn	52.97	28.38	32.94	29.93
Mn	72.87	33.62	131.46	135.17

Table 3: Replacement of maize fodder with edible spineless cactus in goat diets and haematological parameters

Parameter	Group		
	T_1	T_2	T_3
Hb (g/dL)	11.49±0.04	10.45± 0.07	11.46±0.08
RBC concentration (m/mm3)	10.47±0.38	10.49±0.18	10.56±0.07
WBC concentration (m/mm^3)	7.09±0.04	6.83±0.10	6.32±0.46
Haematocrit level (%)	25.04±0.42	25.02±0.72	24.67±1.30

Table 4: Effect of inclusion of spineless cactus in goat diet on blood plasma metabolites (mg/dL)

Parameter	Group		
	T_1	T_2	T_3
Blood metabolites			
Blood glucose (mg/dL)	65.27±0.08	66.18±0.42	65.05±0.39
Plasma total protein (mg/dL)	6.07±0.01	5.95±0.02	6.06±0.02
Plasma albumin level (mg/dL)	2.71±0.08	2.53±0.14	2.28±0.04
Plasma globulin level (mg/dL)	3.36±0.06	3.43±0.14	3.78±0.07
Blood urea nitrogen (mg/dL)	17.32±0.03	17.20±0.14	18.47±0.22
Plasma liver enzymes			
AST activity (IU/L)	57.79±0.13	56.38±0.25	57.14±0.74
ALT activity (IU/L)	28.88±0.09	27.89±0.22	28.28±0.14

Table 5: Effect of inclusion of edible spineless cactus in goat diet on antioxidant status and plasma hormones

Parameter	Group		
	T_1	T_2	T_3
Plasma antioxidant level			
SOD activity (U/mg Hb)	8.84^a±0.04	11.69^b±0.44	11.52^b±0.37
GPx activity (µmol of H_2O_2 consumed/min/mg Hb)	27.85±0.25	28.37±0.32	28.55±0.27
Plasma hormones			
Growth hormone (ng/mL)	1.20±0.02	1.19±0.02	1.17±0.02
Insulin (ng/mL)	3.31±0.10	3.22±0.06	3.28±0.04

^{a,b} Mean values bearing different superscripts in a row differ significantly ($P<0.05$)

SOD level could be due to increase in Mn balance in the animals fed with spineless cactus cladode diet. Reference values of SOD activity in clinically healthy Iranian native male goats have been reported as 754.06- 1224.56 U/g Hb (Nazifi et al. 2009). The SOD activity in lactating and 8-9 months old Jamunapari goats was reported as 31.63 and 36.92%, respectively in heat stress condition in THI ranging from 85.36- 89.80 (Kaushik et al. 2018). The SOD activity in adult female non-pregnant goats was 3.62 U/mg protein (Mousa et al. 2002).

The overall GPx activity was found to be 27.85, 28.37 and 28.55 µmole of H_2O_2 consumed/min/mg Hb in groups T_1, T_2 and T_3, respectively indicating similar values in all 3 groups. There was no difference in GPx values in all the 3 groups. Reference value of GPx in clinically healthy Iranian native male goats was reported as 276.01- 310.15 U/g Hb (Nazifi et al. 2009). The GPx level in one year old pregnant goats was reported as 730.8 µkat/L (Pavlata et al. 2011).

Plasma hormones

The growth hormone (GH) concentration was similar in all the groups. The overall values across 3 months study were found to be 1.20, 1.19 and 1.17 ng/mL in groups T_1, T_2 and T_3, respectively. The levels of GH in 4 months old native hair goats were given as 1.90 and 1.95 ng/mL in case of male and female, respectively

(Devrim et al. 2015). The concentration of GH in sannen goat during pregnancy as found to 2.5 ng/mL (Hashizume et al. 1999). The GH concentration in growing male sannen goats was reported as 1.9 ng/mL (Hirayama and Katoh, 2004)

The plasma insulin concentration was found to be 3.31, 3.22 and 3.28 ng/mL in groups T_1, T_2 and T_3, respectively. There was no difference in GH values in all the 3 groups. The level of insulin in goat kids was given as 12.32 µU/mL (Khan and Ludri 2002). Meza-Herrera et al (2013) reported that insulin concentration in adult sunnen- alpine goats was 3.8 ng/mL.

Conclusions

The concentration of glucose, total protein, albumin, globulin and blood urea nitrogen was not affected due to inclusion of spineless cactus in place of maize fodder. Plasma AST, ALT and GPx values were similar in all the three groups, however, SOD activity was higher ($P<0.05$) in groups provided with cactus cladodes. The concentration of plasma growth hormone and insulin was similar in all 3 groups. The values of various blood parameters were within the physiological range. Hence, inclusion of spineless cactus in replacement of maize fodder in crossbred male goat kids showed similar response with regards to haematology, blood biochemical and physiological parameters.

Acknowledgements

The authors are grateful to Director ICAR-National Dairy Research Institute, Karnal-132001, Haryana for providing the necessary facilities to carry out this research work. Authors are also grateful to Director, ICAR-Central Soil Salinity Research Institute, Karnal for providing spineless cactus.

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