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Dr. Guru DV Pandiyan
Madras Veterinary College,
TANUVAS, Chennai,
Tamil Nadu, India

V Leela
Madras Veterinary College,
TANUVAS, Chennai,
Tamil Nadu, India

S Eswari
Madras Veterinary College,
TANUVAS, Chennai,
Tamil Nadu, India

M Ramachandran
Veterinary College and
Research Institute,
TANUVAS, Thanjavur,
Tamil Nadu, India

V Ranganathan
Veterinary College and
Research Institute,
TANUVAS, Thanjavur,
Tamil Nadu, India

P Visha
Veterinary College and
Research Institute, Salem,
TANUVAS, Tamil Nadu,
India

Corresponding Author:
Dr. Guru DV Pandiyan
Madras Veterinary College,
TANUVAS, Chennai,
Tamil Nadu, India

Influence of *Asparagus racemosus* on energy metabolism and lipid profile in crossbred dairy cows under summer thermal stress

Guru DV Pandiyan, V Leela, S Eswari, M Ramachandran, V Ranganathan and P Visha

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Abstract

Summer thermal stress is a major constraint to dairy productivity in tropical regions, inducing negative energy balance and dyslipidaemia in lactating crossbred cows. *Asparagus racemosus* Willd. (Shatavari; Family: Asparagaceae, possesses documented antistress, glucogenic, and hypolipidaemic bioactivities attributable to its steroidal saponin content. The present study evaluated the effect of *A. racemosus* root powder supplementation (200 mg/kg body weight/day for four weeks) on plasma energy metabolites and lipid fractions in lactating Jersey crossbred cows during summer thermal stress. Twelve healthy lactating cows were equally divided into control (C) and experimental (E) groups (n = 6 each) matched for parity, body weight, and stage of lactation (3rd-4th month) at the Livestock Farm Complex, VCRI, Orathanadu, TANUVAS. Weekly blood samples were collected from the jugular vein; plasma was analysed for glucose, triglycerides, non-esterified fatty acids (NEFA), total cholesterol, and high-density lipoprotein (HDL) using standard spectrophotometric assays. *Asparagus racemosus* supplementation significantly elevated plasma glucose (Weeks 2 and 4; $p < 0.05$), significantly attenuated NEFA (Week 4; $p < 0.05$), and produced a progressive, statistically significant elevation in HDL (Weeks 2 and 3; $p < 0.05$; Week 4: $p < 0.01$), along with consistent numerical improvements in triglycerides and total cholesterol. These findings demonstrate that *A. racemosus* root powder effectively ameliorates the adverse effects of summer thermal stress on energy metabolism and lipid homeostasis in crossbred dairy cows and may serve as a safe, cost-effective herbal feed additive for tropical dairy management.

Keywords: *Asparagus racemosus*, heat stress, lipid profile, NEFA, HDL, shatavari

Introduction

Heat stress is a pervasive and economically significant constraint to tropical dairy production. When ambient conditions exceed the thermoneutral zone, lactating cows experience reduced dry matter intake (DMI), impaired rumination, and decreased nutrient absorption, while simultaneously facing elevated maintenance energy requirements^[1]. These interacting factors drive heat-stressed cows into a state of negative energy balance (NEB), diminishing the substrate available for milk synthesis^[2, 3]. The Temperature-Humidity Index (THI), is the standard indicator of heat stress intensity; values ≥ 72 are considered physiologically stressful for dairy cattle^[4]. When summer thermal stress coincides with lactation periods, the metabolic disruption is compounded, making supportive nutritional interventions critical^[5, 6]. Synthetic feed additives, hormones, and pharmacological agents used to sustain productivity carry documented risks of residues in milk, adverse health effects, and high cost, motivating a global search for safe herbal alternatives^[7].

Asparagus racemosus Willd. (Shatavari) is classified under the family Asparagaceae, distributed across tropical India, Asia, Australia, and Africa, and grows at low altitudes in shaded, humid conditions. The therapeutic use of *A. racemosus* is officially recorded in both the Indian Pharmacopoeia and the British Pharmacopoeia, lending it a well-established safety profile^[8]. The herb's diverse bioactivities including galactagogue and mammogenic^[9], antioxidant^[10], antistress^[11], and digestive-enhancing properties^[12] are largely attributed to its steroidal saponin constituents. In peri-parturient crossbred cows, shatavari root powder supplementation increased milk yield and improves milk quality traits, while reducing

somatic cell count and subclinical mastitis, further supporting its functional role in dairy cows [13]. Ayurvedic tradition specifically recommends *Asparagus* roots as a cooling agent to counter summer heat [14], a property mechanistically aligned with its antistress and adaptogenic functions [15].

The herb also increases DMI, feed digestibility, and feed conversion efficiency [16, 14], thereby sustaining energy availability under heat stress conditions. Despite these well-characterised properties, systematic investigation of *A. racemosus* supplementation specifically during summer thermal stress in crossbred dairy cattle with focus on energy metabolites and lipid fractions is lacking in published literature. The present study was therefore undertaken to evaluate the influence of *A. racemosus* root powder supplementation on plasma glucose, triglycerides, NEFA, total cholesterol, and HDL in lactating Jersey crossbred cows under summer thermal stress conditions.

Materials and Methods

The experiment was conducted at the Livestock Farm Complex, VCRI, Orathanadu, TANUVAS, situated in the Cauvery delta region of Tamil Nadu, India. The summer trial was conducted during April-May 2020. Ambient temperature ranged from a minimum of 24 °C to a maximum of 41 °C, with relative humidity (RH) of 60-78%. The Temperature-Humidity Index (THI) was calculated using the formula of Mader *et al.* (2006) [14]: $THI = (0.8 \times \text{Ambient Temperature}) + [(\% \text{ Relative Humidity} \div 100) \times (\text{Ambient Temperature} - 14.4)] + 46.4$. THI ranged between 82 and 86 throughout the study (Table 1), consistently exceeding the established critical heat stress threshold of 72 for dairy cattle [17].

Table 1: Weekly mean Temperature-Humidity Index (THI) during the summer study period

S. No.	Week	THI (Mean ± SE)
1	1	84.08±0.29
2	2	84.63±0.29
3	3	84.24±0.32
4	4	84.08±0.35

The present study was conducted as a routine nutritional management trial at the Livestock Farm Complex, Veterinary College and Research Institute, Orathanadu,

Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), India. The supplement was administered as a whole root powder mixed with the routine concentrate ration, without any invasive procedure. All animals were maintained and managed in accordance with institutional farm health protocols and standard animal husbandry practices. All animals were housed in well-ventilated sheds with asbestos roofing and cement concrete flooring, sloped for drainage to prevent dampness. Prophylactic measures against infectious viral and bacterial diseases and endo-and ectoparasites were carried out as prescribed by the institutional health calendar.

Twelve healthy lactating Jersey crossbred cows in the third to fourth month of lactation were randomly selected from the institutional farm herd and allocated to two equal groups. The control group (C; n = 6) had a mean parity of 3.33 and a mean body weight of 332.33 kg, while the experimental group (E; n = 6) had a mean parity of 3.00 and a mean body weight of 334.50 kg. Groups were matched for, parity, and body weight to ensure baseline comparability.

The animals received a standard basal ration in accordance with ICAR (2010) nutrient requirement guidelines [18]. Based on individual milk yield, 4-5 kg of concentrate was provided twice daily prior to milking. Dry roughage at 3-4 kg/day and at 20 kg/day were provided. Total daily dry matter intake was 10-12 kg/cow/day with 650 g digestible crude protein. Clean drinking water was available *ad libitum*. *Asparagus racemosus* root powder was mixed with concentrate and administered at 12:00 noon daily throughout the experimental period.

The experimental group received *A. racemosus* root powder at 200 mg/kg body weight/day mixed with the concentrate ration, based on the effective dose reported by Kumar *et al.* (2010) [19]. The control group received the basal ration without supplementation. The supplementation period was four consecutive weeks during the summer stress phase (Table 2). Fresh *A. racemosus* roots were collected from the Herbal Garden, Ethno Veterinary Herbal Product Research and Development Centre, TANUVAS, Orathanadu, Thanjavur District, Tamil Nadu. The roots were cleaned, shade-dried, and ground into a fine powder. Collection was standardized, maintained batch uniformity and minimise seasonal phytochemical variation.

Table 2: Experimental design and supplementation schedule

Group	Supplement	Dose	Duration	Sample collection
Experimental (E; n = 6)	<i>Asparagus racemosus</i> root powder	200 mg/kg BW/day	4 weeks	Weekly (Weeks 0-4)
Control (C; n = 6)	Basal diet only	—	4 weeks	Weekly (Weeks 0-4)

Blood samples were collected aseptically from the jugular vein at 06:00 am each week (Weeks 0 through 4). Approximately 6 mL of whole blood per animal was collected into EDTA-coated vacutainers (10% ethylene diamine tetra-acetic acid). Plasma was separated by centrifugation at 3, 500 rpm for 20 minutes used for instant sample analysis and remaining stored at -20 °C until further biochemical analysis. Glucose was estimated by GOD-POD endpoint assay using an Eppendorf Biospectrometer at 505 nm with Arkay diagnostic kit (Arkay, India) following the protocol of Kaplan (1984) [20]. Triglycerides were estimated by GPO-PAP endpoint assay using an Eppendorf Biospectrometer at 505 nm with Arkay diagnostic kit

(Arkay, India) following the protocol of Nader *et al.* (1994) [21]. Non-Esterified Fatty Acids (NEFA) were estimated by colorimetric endpoint assay using a semi-automatic biochemistry analyser (Clindia Systems, SA-20) at 505 nm with a Randox NEFA kit (Randox Laboratories Ltd., Antrim, UK) following the protocol of Matsubara *et al.* (1983) [22]. Total cholesterol and HDL were each estimated by CHOD-PAP endpoint assay using an Eppendorf Biospectrometer at 505 nm with Arkay diagnostic kit (Arkay, India) following the protocol of Herbert (1984) [23]. All data were statistically analysed using methods described by Snedecor and Cochran (1994) [24].

Results

Plasma Glucose

The mean plasma glucose concentrations (mg/dL) are presented in Table 3. At baseline (Week 0), both groups were comparable (control: 50.16±1.61; experimental: 50.93±2.45 mg/dL). During Week 1, the increase in the experimental group (51.82±2.47 vs. 49.38±1.76 mg/dL) was non-significant. At Week 2, plasma glucose was significantly higher in the experimental group (54.23±2.24 vs. 47.79±0.99 mg/dL; $p<0.05$). The Week 3 difference was non-significant (52.40±2.55 vs. 48.75±1.77 mg/dL). Week 4 again demonstrated a significant elevation in the experimental group (54.74±1.88 vs. 49.01±1.07 mg/dL; $p<0.05$).

Plasma Triglycerides

Mean plasma triglyceride concentrations are presented in Table 3. Baseline values were comparable (control:

27.95±3.74; experimental: 28.27±5.49 mg/dL). From Week 2 onwards, the experimental group exhibited consistently lower triglyceride values (Week 2: 19.94±2.16 vs. 24.28±3.33; Week 3: 21.72±2.20 vs. 27.00±6.06; Week 4: 20.89±2.58 vs. 26.64±2.12 mg/dL); however, none of these differences attained statistical significance.

Plasma NEFA

Mean plasma NEFA concentrations are presented in Table 3. Baseline values were comparable (control: 0.288±0.04; experimental: 0.277±0.02 mmol/L). Control group NEFA progressively increased from Week 2 (0.294±0.02) to Week 4 (0.395±0.05 mmol/L), reflecting escalating adipose mobilisation. The experimental group maintained consistently low NEFA levels throughout (Week 4: 0.272±0.02 mmol/L), with a significant between-group difference at Week 4 ($p<0.05$).

Table 3: Effect of *Asparagus racemosus* supplementation on plasma glucose, triglycerides, and NEFA in Jersey crossbred cows during summer (Mean ± SE; n = 6)

Week	Glucose (mg/dL) Control	Glucose (mg/dL) Experimental	Triglycerides (mg/dL) Control	Triglycerides (mg/dL) Experimental	NEFA (mmol/L) Control	NEFA (mmol/L) Experimental
0	50.16±1.61	50.93±2.45	27.95±3.74	28.27±5.49	0.288±0.04	0.277±0.02
1	49.38±1.76	51.82±2.47	28.38±3.79	28.08±5.58	0.308±0.05	0.271±0.02
2	47.79±0.99	54.23*±2.24	24.28±3.33	19.94±2.16	0.294±0.02	0.262±0.03
3	48.75±1.77	52.40±2.55	27.00±6.06	21.72±2.20	0.386±0.05	0.270±0.01
4	49.01±1.07	54.74*±1.88	26.64±2.12	20.89±2.58	0.395±0.05	0.272*±0.02

Mean of 6 observations. * Significant between-group difference within the row ($p<0.05$).

Table 4: Effect of *Asparagus racemosus* supplementation on plasma total cholesterol and HDL in Jersey crossbred cows during summer (Mean ± SE; n = 6)

Week	Total Cholesterol (mg/dL) Control	Total Cholesterol (mg/dL) Experimental	HDL (mg/dL) Control	HDL (mg/dL) Experimental
0	137.00±12.22	139.17±8.46	90.60±5.91	97.89±6.51
1	139.00±10.61	145.17±8.43	87.27±6.18	102.89±6.66
2	135.33±11.55	143.33±8.16	85.57±7.27	106.44*±3.75
3	135.00±11.39	143.50±11.47	84.93±9.37	108.42*±8.54
4	142.50±10.93	151.00±9.27	78.91±4.20	107.50**±6.76

Mean of 6 observations. * Significant between-group difference within row ($p<0.05$). ** Significant between-group difference within row ($p<0.01$).

Total Cholesterol

Mean plasma total cholesterol concentrations are presented in Table 4. The experimental group exhibited a consistent numerical elevation across all weeks (Week 4: 151.00±9.27 vs. 142.50±10.93 mg/dL); however, no statistically significant between-group or within-group differences were detected at any time point. Values in both groups remained within the normal reference range.

Plasma HDL

Mean plasma HDL concentrations are presented in Table 4. The control group showed progressive decline throughout the summer period, from 87.27±6.18 mg/dL at Week 1 to 78.91±4.20 mg/dL at Week 4. The experimental group showed a rising trend, reaching a peak of 108.42±8.54 mg/dL at Week 3 and 107.50±6.76 mg/dL at Week 4. Between-group differences were significant from Week 2 ($p<0.05$), Week 3 ($p<0.05$), and Week 4 ($p<0.01$).

Discussion

The weekly mean THI values of 84.08-84.63 recorded throughout the study were consistently above the critical

threshold of 72 for dairy cattle in southern Indian summer conditions ^[17], confirming sustained severe thermal stress. Under such conditions, reduced DMI and consequent negative energy balance are well-documented physiological responses in lactating dairy cows ^[1, 2].

Glucose

Plasma glucose values in both groups were within the normal reference range for lactating dairy cows, consistent with earlier reports ^[25, 26, 27]. The progressive decline in control group glucose concentrations reflects the negative effect of thermal stress on gluconeogenesis, reduced DMI. In contrast, the experimental group maintained significantly higher glucose levels at Weeks 2 and 4 ($p<0.05$). This glucogenic property is not attributable to the herb serving directly as an energy source ^[32] but to its saponins enhancing ruminal propionate production the principal gluconeogenic precursor in ruminants ^[31] as corroborated by Hu *et al.* (2006) ^[29] and Abreu *et al.* (2004) ^[30]. Additionally, *A. racemosus* increases DMI, feed digestibility, and feed conversion efficiency ^[16, 17, 14], providing a greater flux of gluconeogenic substrate to the liver.

Triglycerides

Plasma triglyceride values were within the normal range in both groups, consistent with Piccione *et al.* (2012) [33] and Yehia *et al.* (2021) [34]. The experimental group maintained consistently lower triglyceride levels compared with controls from Week 2 onwards, though between-group differences did not reach statistical significance. The variation in both groups with the nadir at Week 2, aligns with the known effect of peak heat stress on hepatic lipid processing [35]. The numerical attenuation of triglycerides in the supplemented group is best explained by *A. racemosus*-mediated mitigation of the heat stress response, reducing metabolic drive toward tissue lipid breakdown [28].

NEFA

Circulating NEFA concentration is a sensitive indicator of adipose mobilisation and NEB severity; a relatively constant proportion of NEFA is utilised by the liver, making elevated NEFA a reliable biomarker of metabolic stress [36]. The progressive rise in NEFA in the control group (0.308 to 0.395 mmol/L) mirrors escalating energy deficit under sustained summer thermal stress and is consistent with findings of Barletta *et al.* (2017) [37] and Vaidya *et al.* (2017) [27]. High milk production demands combined with reduced feed intake represent the most critical phase for energetic drain, frequently culminating in ketogenesis [38]. The experimental group's significantly lower NEFA at Week 4 ($p < 0.05$) and consistently suppressed values throughout the supplementation period demonstrate that *A. racemosus* effectively attenuated adipose lipolysis, mechanistically explained by saponin-enhanced propionate production [29, 30]. Elevated NEFA during heat stress is strongly associated with postpartum metabolic disease and reproductive failure [38], making this a practically important finding.

Total Cholesterol

The numerically higher but statistically non-significant total cholesterol concentrations in the experimental group across all weeks suggest improved hepatic function, consistent with the glucogenic and DMI-enhancing effects of *A. racemosus*. Values in both groups were within normal range, in agreement with Seifi *et al.* (2007), Piccione *et al.* (2012) [33] and Omur *et al.* (2016) [26]. Summer-induced reduction in DMI limits cholesterol synthesis substrate, and the resulting NEB may impose additional constraints on hepatic cholesterol synthesis in thermally stressed animals [39]. Saponins in *A. racemosus* may further modulate cholesterol metabolism by inhibiting pancreatic lipase activity and delaying intestinal fat absorption [40].

HDL

The most statistically robust finding was the significant and progressive elevation of plasma HDL in the supplemented group, with significance at Weeks 2 and 3 ($p < 0.05$) and at Week 4 ($p < 0.01$) — the strongest statistical outcome across all parameters. The control group exhibited a continuous HDL decline throughout the summer period (87.27 to 78.91 mg/dL), consistent with known adverse effects of thermal and metabolic stress on lipoprotein profiles [41, 42]. The divergent HDL trajectory between groups was attributable to altered metabolic activity during summer stress [43], modulated by *A. racemosus* in the experimental group. This HDL-elevating property is strongly corroborated by

Visavadiya and Narasimhacharya (2005) [11], who demonstrated an 11% increase in HDL-cholesterol with *A. racemosus* supplementation in hypercholesterolaemic rats, accompanied by significant reductions in LDL and VLDL. Elevated HDL facilitates reverse cholesterol transport, protecting hepatic integrity and reducing fatty liver risk in heat-stressed cows [44].

Conclusion

Supplementation of Jersey crossbred dairy cows with *Asparagus racemosus* root powder at 200 mg/kg body weight/day for four weeks during summer thermal stress (THI 82-86) significantly elevated plasma glucose (Weeks 2 and 4; $p < 0.05$), significantly attenuated NEFA concentrations (Week 4; $p < 0.05$), and produced a progressive and statistically significant elevation in HDL (Weeks 2 and 3: $p < 0.05$; Week 4: $p < 0.01$), with consistent numerical improvements in triglycerides and total cholesterol. *Asparagus racemosus* supplementation effectively ameliorated summer thermal stress-induced negative energy balance and dyslipidaemia through its saponin-mediated glucogenic, anti-lipolytic, and hypolipidaemic mechanisms, demonstrating its potential as a safe and effective herbal feed additive for tropical dairy management.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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