Dietary supplementation of Shatavari Root Powder alleviates Negative Energy Balance and Improves Productive & Reproductive Performance in Transition Sahiwal Cows

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Abstract

The present study was aimed at evaluating the effects of dietary supplementation of shatavari (*Asparagus racemosus*) root powder on metabolic status, productive performance and postpartum health in transition Sahiwal cows. Twenty healthy pregnant Sahiwal cows between the 2nd – 5th parities were randomly divided into two groups, comprising 10 animals in each group. In the treatment group, shatavari root powder was supplemented with the normal diet at the rate of 150 mg/kg body weight during the last 60 days prepartum and 300 mg/kg body weight during the first 90 days postpartum. Blood samples collected from 4 weeks prepartum to 12 weeks postpartum were analyzed for blood metabolites [non-esterified fatty acids (NEFA), β-hydroxybutyrate (β-HBA), glucose and blood urea nitrogen (BUN)] and hormones (growth hormone and cortisol). Dry matter intake (DMI), body condition score (BCS), body weight, milk production, milk composition, reproductive performance and postpartum health were also recorded. Shatavari supplementation significantly ($P < 0.05$) increased plasma GH, glucose, DMI, BCS, body weight gain, and milk yield while significantly reducing ($P < 0.05$) cortisol, BUN, NEFA, and β-HBA. Milk fat percentage was significantly lower ($P < 0.05$) in the supplemented group, whereas protein and lactose did not differ significantly between groups. Reproductive parameters, including first postpartum estrus, days to first service, open period, and services per conception, showed numerical improvement, as well as a significantly higher ($P < 0.05$) conception rate observed in the supplemented group. Our findings suggest that dietary supplementation of Shatavari root powder improves metabolic adaptation, enhances productive performance and supports postpartum health in Sahiwal cows.

INTRODUCTION

The livestock sector plays a monumental role in India's agricultural economy, accounting for 30.87% of the agricultural Gross Value Added (GVA) and contributing 5.5% to the national GDP at current prices as of 2023–24 (DAHD, 2025, GoI). This sector also plays a vital role in improving the socioeconomic status of small and marginal farmers by generating employment and boosting rural household incomes.

Milk is an important source of nutrients, and nutrient-rich foods such as milk are anticipated to remain cornerstone components of food security and human nutrition (Smith et al. 2022).India is the global leader in terms of milk production, ranking first worldwide. Milk production grew steadily at a Compound Annual Growth Rate (CAGR) of 5.41% between 2014–15 and 2024–25, culminating in a record of 247.87 million tonnes during 2024–25 in India (DAHD, 2025). The per-capita availability of milk in India stands at 485 grams per day (BAHS, 2025, GoI).

Despite this remarkable growth, the dairy sector continues to face multiple challenges such as underfeeding, malnutrition, heat stress and management-related stress that threaten the long-term productivity and profitability of dairy farming, especially for small and marginal farmers (Gautam et al. 2025). Further, undernutrition during the transition period adversely affects milk production, postpartum reproductive health and overall performance of dairy cows, leading to substantial economic losses for farmers (Mekuriaw 2023; Sahu et al. 2026).

The transition period is critical for a dairy cow (Horst et al. 2021).During this period, the energy demand for initiating the next lactation is four times higher than the maintenance level of a high-yielding dairy cow (VandeHaar et al. 2016). Despite possessing a homeostatic mechanism to maintain the basal metabolism, dairy cows often experience negative energy balance (NEB) due to the combined effects of reduced feed intake and increased milk production during early lactation (Reksen et al. 2001; Islam et al. 2022). The inability of dairy cows to cope with metabolic demands, coupled with hormonal alterations (Mili et al. 2015a) and impaired immune functions (Mili et al. 2015b; Aleri et al. 2016), makes them susceptible to infections and metabolic diseases (Esposito et al. 2014; Mili & Pandita 2021). Therefore, improving nutrition and feeding strategies is essential for ensuring both successful lactation and postpartum reproductive health in dairy cows (Duffield et al. 2009; Borchardt et al. 2024).

In this context, the development and adoption of indigenous herbal feed supplements, which are economical, effective and generally safe when used at appropriate doses, have emerged as promising strategies for improving the productive and reproductive performance of dairy animals (Mallick and Prakash 2011). Herbal supplements are increasingly recognized as eco-friendly alternatives in modern animal nutrition due to their beneficial effects on the secretion of digestive enzymes, thereby improving nutrient utilization efficiency (Bakshi and Wadhwa 2000; Tiwari et al. 2014). Among various phytogenic feed additives, herbs with galactagogue properties have gained considerable attention because of their potential to stimulate mammary gland activity, enhance milk secretion, and improve reproductive efficiency in dairy animals (Bakshi et al. 2004).

One such important medicinal herb is shatavari (*Asparagus racemosus*). The beneficial effects of shatavari on feed intake, milk production, growth performance and reproductive traits have been reported in dairy cattle and buffaloes (Kumar et al. 2012; Bhinda et al. 2020; Muwal et al. 2023; Boopathi et al. 2025). However, information regarding its role in improving metabolic adaptation during the transition period remains limited. Moreover, studies simultaneously evaluating metabolic biomarkers, endocrine responses, productive performance, reproductive efficiency and postpartum health following its supplementation are limited. While many studies have focused on crossbred cattle, recent research has increasingly evaluated the effects of these supplements in indigenous dairy breeds such as Tharparkar and Sahiwal cows.

Therefore, the present study was undertaken to evaluate the effects of dietary supplementation of shatavari *(Asparagus racemosus)* root powder during the transition period on metabolic and endocrine profiles, milk production, reproductive performance, and postpartum health in Sahiwal cows. To our knowledge, this is the first study to comprehensively evaluate the effects of *Asparagus racemosus* supplementation during the transition period on metabolic biomarkers (BCS, DMI, NEFA, β-HBA, glucose, and BUN), endocrine responses (Growth hormone and cortisol), milk yield and milk composition, reproductive performance and postpartum health in indigenous Sahiwal cows.

MATERIALS AND METHODS

Animals and Experimental Design

A total of twenty dry, pregnant Sahiwal cows (n = 20) in their second to fifth parity (60 days pre-partum) were selected from the institute's Livestock Research Centre. These animals were randomly allocated into two groups (Control and treatment) comprising 10 animal in each group (n = 10). All these animals were maintained under standard management practices, similar to the rest of the herd. The ethical committee for animal experiments (ECAE) of the ICAR-National Dairy Research Institute approved the animal use protocol, management practices and the experimental design for this study.

All experimental animals were fed as per standards practice (NRC 2001). Clean and fresh water was provided adlibitum. The chemical composition of fodder, concentrate mixture is presented in Table 1.The chemical compositions of the green fodder were analyzed as per standard procedures (AOAC 1995). All treatment group animals were supplemented with shatavari (*Asparagus racemosus*) powder from 60 days pre-partum to 90 days post-partum, at doses of 150 mg/kg body weight (BW) pre-partum and 300 mg/kg BW post-partum. DMI of the cow was recorded at fortnightly intervals. Body condition Score (BCS) was recorded at fortnight intervals in a 5-point scale Edmonson et al (1989). Shatavari root (*Asparagus racemosus*) powder were purchase from Raj and Company, Madhya Pradesh, India.

Estimation of body weight changes fortnightly

The body weights of the animals were recorded at fortnightly intervals early in the morning (between 7:30 A.M. and 8:30 A.M.) using an electronic weighing machine, prior to offering feed or water. The absolute rate of body weight change in the calves was estimated using the following formula (Brody and Lardy, 1945).

Blood Sampling and Processing

Blood samples were collected into heparinised tube at fortnightly intervals. Immediately after collection, blood plasma was separated by centrifuged at 3000 rpm for 20 minutes. The separated plasma samples were stored in 2mL cryovials at -20°C till the assay for hormones and blood metabolites was conducted.

Quantification of plasma of Hormones

Bovine Growth hormone ELISA test kit purchased from endocrine technologies, inc. USA and Endocrine Technologies, 35325 Fircrest Street, USA, respectively. and cortisol concentrations in the blood plasma of Sahiwal cows was quantified using commercial enzyme-linked immunosorbent assay (ELISA) kits, strictly following the manufacturers' instructions.

Quantification of plasma metabolites

The NEFA and β-hydroxy butyrate kit was purchased from Cayman Chemical Company, Ann Arbor, USA. Plasma glucose, BUN and albumin were quantified by kits purchased from Span Diagnostic *Ltd.*, India.

Recording of milk yield and Analysis of milk composition

Daily milk yields (kg) were recorded for each animal, using hand-milking for the first five days postpartum followed by machine milking three times daily. For composition analysis, 100 mL milk samples were collected from each animal on three consecutive days at fortnightly intervals and stored at 4°C. Prior to analysis, samples were thoroughly mixed and pre-warmed to 37–39°C in a water bath. A 50 mL aliquot was then analyzed for fat, protein, lactose, and solids-not-fat (SNF) using a Lacto Scan-BULGARIA milk analyzer.

Recording of Reproductive Traits and Disorders

Reproductive traits and disorders were monitored and recorded systematically for all animals. The recorded reproductive traits included first postpartum estrus interval, days to first service, open period (days open), and services per conception. Concurrently, the incidence of clinical reproductive and periparturient disorders—specifically stillbirth, cystic ovaries and cervicitis were recorded. Periparturient conditions and diseases, including dystocia, retained placenta (RP), endometritis and mastitis were diagnosed by theinstitute's herd veterinary officer based on symptoms (Sheldon et al. 2006).Clinical endometritis was diagnosed by the presence of purulent (> 50% pus) or mucopurulent (approximately 50% pus, 50% mucus) uterine exudates in the vagina, 21 days or more postpartum. Clinical mastitis was diagnosed by an elevated somatic cell count in milk and visual signs of inflammation such as clumpy, watery, bloody, or yellowish milk. The cows that did not shed the fetal membrane within 24 hours of parturition were considered as cases of RP. Further, postpartum postpartum anestrus was diagnosed based on the absence of estrus expression (estrous signs), despite efficient estrus detection (Peter et al. 2009).The incidence rate was calculated as follows:

Number of animals affected from particular disorder during the period

$$\text{Incidence (\%)} = \frac{\text{Number of animals affected from particular disorder during the period}}{\text{Number of cows in the group during the period}}$$

Statistical analysis

The data were analyzed using a three-way analysis of variance (ANOVA) in SAS software, with treatment, stage (prepartum vs. postpartum) and period (fortnightly intervals). Differences were considered statistically significant at $P \leq 0.05$. Reproductive performance and postpartum health parameters were compared between groups using the Student's t-test. The least squares method (LSM) used for the analysis of daily milk yield and reproductive performance is presented below:

$Y_{ij} = \mu + A_i + e_{ij}$

Where

Y_{ij} = k^{th} observation of milk yield, reproduction, or growth parameter measured at j^{th} time given i^{th} treatment.

μ = overall mean.

A_i = effect of i^{th} treatment, (i = 1, 2)

B_j = effect of j^{th} time, (j = 1, 2, 3, ..., for fortnightly data)

e_{ijk} = random error associated with the observation Y_{ijk} which is assumed to be normally and independently distributed with mean zero and constant variance.

RESULTS

Body Condition Score, Dry Matter Intake and Body Weight Changes

The effects of dietary supplementation of shatavari (*Asparagus racemosus*) on BCS, DMI and body weight of Sahiwal cows are presented in Table 2. Body condition score did not differ significantly ($P > 0.05$) between the groups during the first fortnight. However, from the second fortnight onwards, BCS was significantly higher ($P < 0.05$) in the treatment group than in the control group. Dry matter intake was significantly higher ($P < 0.05$) in the treatment group throughout the experimental period. In the control group, DMI declined from 8.06 ± 0.20 to 7.89 ± 0.19 kg/day, whereas in the treatment group it increased from 8.14 ± 0.40 to 9.83 ± 0.42 kg/day. The overall mean body weight was significantly higher ($P < 0.05$) in the treatment group (418.61 ± 11.35 kg) than in the control group (391.35 ± 9.10 kg). Significant differences ($P < 0.05$) in body weight were observed both between treatment groups and across fortnights.

Plasma Metabolites

The effects of dietary supplementation of shatavari (*Asparagus racemosus*) on plasma metabolites in Sahiwal cows are presented in Fig. 3.3a–3.3d. Plasma NEFA concentrations did not differ significantly ($P > 0.05$) between the control and treatment groups throughout the experimental period (Fig. 3.3a). However, plasma β-HBA concentrations were significantly lower ($P < 0.05$) in the treatment group (0.112 ± 0.017 mM) than in the control group (0.150 ± 0.020 mM) (Fig. 3.3b). In both groups, plasma β-HBA concentrations increased progressively before calving, reached peak values at parturition, and declined thereafter.

Plasma glucose concentrations were significantly higher ($P < 0.05$), whereas BUN concentrations were significantly lower ($P < 0.05$) in the treatment group than in the control group (Fig. 3.3c and Fig. 3.3d). Plasma glucose concentrations increased toward parturition, attained their highest values at calving, and remained elevated during the early lactation period. In contrast, BUN concentrations remained consistently lower in the treatment group compared with the control group throughout the study period.

Plasma hormone profiles

The effects of dietary supplementation with shatavari (*Asparagus racemosus*) on plasma GH and cortisol concentrations in Sahiwal cows are presented in Fig. 4a and Fig. 4b, respectively. The overall mean plasma GH concentration was significantly ($P < 0.05$) higher in the treatment group (4.10 ± 0.93 ng/mL) compared to the control group (2.53 ± 0.57 ng/mL). In contrast, the overall mean plasma cortisol concentration was significantly ($P < 0.05$) lower in the treatment group (3.72 ± 0.12 ng/mL) compared to the control group (4.008 ± 0.10 ng/mL). Plasma GH concentrations increased toward parturition in both groups and reached their highest values at calving, with significantly higher concentrations observed in the treatment group (10.93 ± 3.30 ng/mL) than in the control group (6.45 ± 2.89 ng/mL). On the other hand, plasma cortisol concentrations also peaked around parturition but remained significantly ($P < 0.05$) lower in the treatment group (4.31 ± 0.12 ng/mL) than in the control group (4.53 ± 0.10 ng/mL).

Performance of Milk Yield and Milk Composition

The effects of dietary supplementation with shatavari (*Asparagus racemosus*) on milk yield and milk composition of Sahiwal cows are presented in Table 3. Dietary supplementation with shatavari significantly ($P < 0.05$) increased milk yield compared with the control group. The average milk yield was 8.80 ± 1.23 kg/day in the treatment group and 6.74 ± 1.10 kg/day in the control group. The average milk fat percentage during the experimental period was significantly ($P < 0.05$) higher in the control group (5.760 ± 0.74%) than in the treatment group (4.568 ± 0.52%). The average milk protein percentage was 3.129 ± 0.08% in the control group and 3.026 ± 0.11% in the treatment group, with no significant difference ($P > 0.05$) between the groups. Similarly, lactose content did not differ significantly ($P > 0.05$) between the control and treatment groups. However, the SNF content was significantly ($P < 0.05$) higher in the control group than in the treatment group.

Reproductive performance

The effect of dietary supplementation of shatavari (*Asparagus racemosus*) on the reproductive performance of Sahiwal cows is presented in Table 4. Dietary supplementation with shatavari root powder improved several reproductive parameters in the treated cows. The interval to the onset of first postpartum estrus was shorter in the treatment group (46.56 ± 11.76 days) than in the control group (68.87 ± 14.56 days). Similarly, the number of days to first service was significantly lower ($P < 0.05$) in the treatment group (83.33 ± 15.30 days) compared with the control group (147.10 ± 15.78 days). In addition, cows receiving shatavari supplementation exhibited a shorter open period (95.50 ± 13.00 vs. 113.20 ± 18.78 days), fewer services per conception (1.66 ± 0.33 vs. 2.75 ± 1.03), and a higher conception rate (70% vs. 40%) than the control cows. These findings indicate that dietary supplementation with shatavari positively influenced postpartum reproductive performance in Sahiwal cows.

Postpartum reproductive health

The effects of dietary supplementation of shatavari (*Asparagus racemosus*) on the incidence of postpartum reproductive and health disorders in Sahiwal cows are presented in Table 5. The incidence of dystocia (20%), abortion (10%), RP (10%), cystic ovaries (20%), pyometra (10%), anestrus (20%), endometritis (40%), and mastitis (30%) was higher in the control group than in the shatavari-supplemented group. Overall, dietary supplementation of shatavari exhibited a lower incidence of postpartum reproductive and health disorders, indicating improved postpartum health status compared with the control group.

DISCUSSION

The transition from pregnancy to lactation is characterized by numerous physiological changes in dairy cows (Borchardt et al. 2024). During this period, cows typically experience a reduction in DMI, which leads to a state of NEB (Mili et al. 2014; Mondal et al. 2026), insulin resistance (Mili et al. 2015a; Aleri et al. 2016) and impaired immune function (Mili et al. 2015b;Esposito et al. 2014). Hormonal shifts in the somatotropic axis—specifically the GH-insulin-IGF-1-glucose signaling pathway—help maintain energy homeostasis during this period (Mili et al. 2015a). During transition period, alteration in humoral and cellular immune responses coupled with low antioxidant defense system towards the day of parturition in dairy cows reflected a physiological phenomenon; however it could eventually lead to reduced immunity (Mili et al. 2015b). This impaired immune system during transition period resulting in an increased susceptibility to infectious diseases early postpartum in dairy cows (Esposito et al. 2014; Borchardt et al. 2024). Hence, proper management is required to ensure both successful lactation and postpartum reproductive health in dairy cows (Borchardt et al. 2024). Therefore, the present investigation was undertaken to evaluate the effects of dietary supplementation of shatavari (Asparagus racemosus) in transition Sahiwal cows with the aim of improving productivity and postpartum health.

In the present study, dietary supplementation with shatavari (*Asparagus racemosus*) powder significantly improved ($P < 0.05$) in DMI, BCS, and body weight in Sahiwal cows, indicating a favorable metabolic status. The higher DMI observed in the supplemented group may have increased nutrient availability and reduced the severity of NEB, thereby minimizing the mobilization of adipose tissue and body protein reserves. These findings are consistent with previous reports demonstrating that nutritional interventions during the transition period improve energy balance and productive performance in dairy cows (Mili et al. 2014; Borchardt et al. 2024). Earlier studies have also shown that shatavari (*Asparagus racemosus*) supplementation increases appetite and DMI (Berhane et al. 2002; Boopathi et al. 2025). In another study suggested that shatavari (*Asparagus racemosus*) alleviates metabolic stress through modulation of the somatotropic axis and improved nutrient utilization (Kumar et al. 2009). Similar improvements in body weight have been reported in Murrah buffalo heifers supplemented with shatavari (*Asparagus racemosus*) root powder (Boopathi et al. 2025). Hence, these findings suggest that the improved BCS and body weight observed in the present study were primarily driven by enhanced feed intake and nutrient utilization, resulting in a more favorable energy balance during the periparturient period.

The beneficial effects of shatavari (*Asparagus racemosus*) supplementation were further reflected in the metabolic profile of the treated sahiwal cows. Plasma NEFA concentrations is acted as indicators of adipose tissue mobilization and the extent of NEB (Aeberhard et al. 2002). Our results revealed the not significant difference in plasma NEFA concentration ($P > 0.05$) between the groups. However, the significantly lower plasma β-HBA ($P < 0.05$) concentrations together with higher glucose ($P < 0.05$) and lower BUN concentrations ($P < 0.05$) in the supplemented cows indicate a more efficient metabolic adaptation to the transition period. It is well established that the energy demand for initiating a new lactation is four times higher than the maintenance level of a high-yielding dairy cow (VandeHaar et al. 2016). This surge in energy requirement often exceeds the energy intake, resulting in lipid mobilization, accelerated hepatic gluconeogenesis, ATP production through the beta-oxidation of NEFA and the subsequent production of ketone bodies such as β-HBA, acetone, and acetoacetate (McGarry et al. 1975; Aeberhard et al. 2002; Mili et al. 2014).The metabolic profile of the control group was characterized by lower glucose and higher β-HBA concentrations, which was suggestive of a greater degree of subclinical ketosis. In contrast, the lower β-HBA concentrations in the shatavari (*Asparagus racemosus*)-supplemented cows indicate reduced ketogenesis and improved hepatic energy metabolism. Further, the lower BUN concentrations suggest more efficient dietary nitrogen utilization and reduced metabolic burden on the liver. Therefore, the combined response of lower β-HBA and BUN concentrations along with higher glucose levels demonstrates that shatavari supplementation effectively alleviated periparturient metabolic stress and improved nutrient utilization efficiency in Sahiwal cows.

The endocrine responses observed in the present study provide additional evidence of improved metabolic adaptation in the supplemented animals. The somatotropic axis plays a pivotal role in regulating nutrient partitioning and maintaining energy homeostasis during the transition period (Mili et al. 2015b), whereas cortisol is a major indicator of physiological stress. The significantly higher plasma GH concentrations ($P < 0.05$) and lower cortisol concentrations ($P < 0.05$) in the treatment group suggest that shatavari (*Asparagus racemosus*) supplementation positively modulated endocrine function during the transition from late pregnancy to early lactation. Growth hormone promotes nutrient partitioning toward milk synthesis and supports glucose homeostasis by stimulating gluconeogenesis and lipid mobilization, thereby enabling cows to adapt to the increased metabolic demands of lactation. The elevated GH concentrations observed in the supplemented cows may therefore have contributed to the improved DMI, body weight, and metabolic profile recorded in the present study. These findings are consistent with previous reports. Previous studies have reported improved nutrient digestibility and body weight gain in animals receiving polyherbal formulations containing Cryptolepis buchanani and shatavari (*Asparagus racemosus*) Gupta et al. (2004). In contrast, the lower cortisol concentrations observed in the treatment group indicate a reduced physiological stress response. This effect is likely attributable to the well-documented adaptogenic properties of shatavari (*Asparagus racemosus*), whose steroidal saponins and antioxidant compounds have been shown to modulate adrenal activity and attenuate stress-induced endocrine responses (Wiboonpun et al. 2004; Alok et al. 2013). Thus, the combined improvement in metabolic and endocrine parameters suggests that dietary supplementation with shatavari (*Asparagus racemosus*) improved the ability of transition Sahiwal cows to cope with the physiological challenges of early lactation, thereby promoting better metabolic homeostasis and productive performance.

The significant increase in milk yield ($P < 0.05$) observed in shatavari (*Asparagus racemosus*) supplemented Sahiwal cows indicates an improvement in nutrient availability and metabolic adaptation during the transition period. Early lactation is characterized by a substantial increase in nutrient demand for milk synthesis, and the ability of a cow to maintain adequate feed intake and energy balance is a key determinant of milk production (VandeHaar et al. 2016). In the present study, the higher milk yield in the treatment group may be attributed to the increased DMI, improved nutrient utilization, and metabolic profile characterized by higher plasma glucose and lower β-HBA concentrations. These findings demonstrate a more efficient partitioning of nutrients toward productive functions, particularly milk synthesis. The present findings are in agreement with earlier reports demonstrating the galactopoietic potential of shatavari (*Asparagus racemosus*) supplementation in dairy animals (Bhinda et al. 2020; Muwal et al. 2023; Chavan et al. 2023; Kumar et al. 2024). The increased milk production may also be associated with the endocrine-modulating properties of shatavari. Bioactive constituents of shatavari have been reported to stimulate the hypothalamic-pituitary axis, resulting in enhanced prolactin secretion, which plays a central role in mammary gland development, lactogenesis, and maintenance of milk secretion (Singh et al. 2012). Further, the estrogenic activity of shatavari may promote proliferation and differentiation of mammary alveolar epithelial cells, thereby supporting greater secretory activity and sustained milk production (Pandey et al. 2005).

Although milk yield increased significantly, milk fat and SNF percentages were lower in the supplemented cows, whereas milk protein and lactose contents remained unaffected ($P > 0.05$). These findings differ from earlier studies in crossbred cows, where shatavari supplementation increased both milk yield and milk constituents, including fat, SNF, total solids and protein percentages (Chavan et al. 2022; Kumar et al. 2024). The reduction in milk fat and SNF percentages observed in the present study may be explained by a dilution effect associated with higher milk volume, whereby the increased secretion of milk reduces the concentration of certain constituents without necessarily decreasing their total daily output. In addition, differences in breed characteristics, nutrient partitioning patterns and mammary metabolic responses may have contributed to the variation between studies. Unlike previous investigations conducted primarily in crossbred cattle, the present study involved indigenous Sahiwal cows, which possess distinct genetic and physiological characteristics influencing milk synthesis and composition. Therefore, while shatavari (shatavari (*Asparagus racemosus*) supplementation consistently enhances milk production across breeds, its effects on milk constituents may vary depending on genetic background, production level and nutritional status of the animals.

In present study, we found the improved reproductive performance observed in the shatavari-supplemented cows indicates a beneficial effect of shatavari (*Asparagus racemosus*) on the restoration of postpartum ovarian activity and fertility. Early resumption of estrous cyclicity following calving is a critical determinant of reproductive efficiency in dairy cows and is closely associated with nutritional status and metabolic adaptation during the transition period. In the present study, the reduced interval to first postpartum estrus, fewer days to first service, shorter open period, lower number of services per conception, and higher conception rate suggest that shatavari (*Asparagus racemosus*) supplementation improved reproductive recovery following parturition. These findings are consistent with previous reports demonstrating improved reproductive performance in dairy animals supplemented with shatavari (*Asparagus racemosus*) root powders (Kumar et al. 2012; Kumar et al. 2024).

The mechanisms underlying these improvements are likely multifactorial, involving both direct endocrine effects and indirect metabolic influences. Shatavari (*Asparagus racemosus*) possesses phytoestrogenic compounds that have been reported to stimulate ovarian activity and reproductive function through estrogen-like actions (Pandey et al. 2005; Frawley et al. 2006). In addition, the higher DMI, improved metabolic profile, and greater glucose availability observed in the supplemented cows may have contributed to the earlier restoration of ovarian cyclicity. Negative energy balance during early lactation suppresses follicular growth, delays ovulation, and prolongs the postpartum anestrous period, whereas improved energy status promotes reproductive recovery (Kaewlamun et al. 2020). Recent evidence suggests that glucose availability directly regulates ovarian follicular development through activation of the mTOR/AKT signaling pathway, which stimulates granulosa cell proliferation and steroidogenic activity (Wang et al. 2023). Therefore, the higher plasma glucose concentrations and improved nutrient utilization observed in the present study may have enhanced follicular development and ovarian function, resulting in earlier estrus expression, improved conception rates, and overall better reproductive efficiency in the shatavari-supplemented Sahiwal cows.During transition period, inability of dairy cows to cope with metabolic demands, hormonal milieu coupled with impaired immune functions make them susceptible to infectious diseases (metritis, endometritis, mastitis, RP, etc.), and thereby production performance of the dairy animal is seriously affected in terms of economic loss to farmers (Mili et al. 2015b; Mili and Pandita, 2021). In this study, a reduced incidence of postpartum reproductive and health disorders observed in the shatavari (*Asparagus racemosus*) supplemented cows indicates an overall improvement in physiological adaptation during the transition period. The occurrence of conditions such as RFM, endometritis, pyometra, anestrus, cystic ovaries, mastitis and dystocia is closely associated with metabolic stress, impaired immune function, and delayed reproductive recovery following parturition. The lower prevalence of these disorders in the treatment group suggests that dietary supplementation with shatavari (*Asparagus racemosus*) powders enhanced postpartum health and reproductive resilience. These findings are in agreement previous reports (Kumar et al. 2009). They have reported a lower incidence of postpartum disorders in shatavari-supplemented animals. Likewise, in another experiments revealed that improved postpartum reproductive health and reduced occurrence of reproductive disorders following shatavari supplementation in dairy animals (Kumar et al. 2012; Kumar et al. 2024).

The beneficial effects of shatavari on postpartum health may be attributed to its ability to improve both metabolic status and immune function during the transition period. Negative energy balance is a major predisposing factor for postpartum reproductive disorders, impaired uterine involution, and reduced fertility in dairy cows (Bekuma & Galmessa, 2019). Higher plasma NEFA and β-HBA concentrations have been associated with an increased risk of metritis, endometritis, mastitis, and RP due to their detrimental effects on immune cell function and tissue repair mechanisms (Mili et al. 2016; Overton et al. 2017; Horst et al. 2021).

In the present study, shatavari supplementation resulted in lower β-HBA concentrations and improved energy status, suggesting a reduction in metabolic stress and a lower susceptibility to disease. Further, the transition period is characterized by a physiological suppression of both humoral and cellular immunity, accompanied by reduced antioxidant defenses, lower concentrations of IgG, IL-6 and nitric oxide, and diminished total antioxidant activity around parturition (Mili et al. 2015b). This transient immunosuppression increases the vulnerability of dairy cows to postpartum infections and reproductive disorders. Shatavari has been reported to possess potent immunomodulatory properties that enhance the phagocytic and bactericidal activities of neutrophils and macrophages, thereby strengthening innate immune responses (Gautam et al. 2009; Rekhate et al. 2010). Therefore, the combined effects of improved metabolic adaptation, reduced ketotic stress, and enhanced immune competence likely contributed to the lower incidence of RP, endometritis, mastitis and other postpartum disorders observed in the supplemented Sahiwal cows.

CONCLUSION

In conclusion, dietary supplementation of shatavari (*Asparagus racemosus*) root powder during the transition period positively influenced the metabolic, endocrine, productive, and reproductive performance and postpartum health of Sahiwal cows. Shatavari supplementation also modulated endocrine responses by increasing growth hormone and reducing cortisol concentrations, thereby supporting metabolic homeostasis during the periparturient period. Therefore, dietary supplementation of shatavari (*Asparagus racemosus*) root powder at the rate of 150 mg/kg body weight pre-partum and 300 mg/kg body weight post-partum could be an effective nutritional strategy for alleviating transition stress, improving postpartum health, and enhancing overall productivity in sahiwal cows.

DECLARATIONS

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript

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TABLES

Table 01

Chemical composition of concentrate and feed stuffs (% DM basis)

Details	Maize	Jowar	Oats	Berseem
DM	17.32 ± 0.43	22.27 ± 0.19	15.14 ± 0.44	14.92 ± 0.23
CP	8.81 ± 0.05	7.90 ± 0.08	10.26 ± 0.09	17.69 ± 0.08
EE	2.42 ± 0.32	1.79 ± 0.06	1.81 ± 0.09	2.57 ± 0.07
TA	9.43 ± 0.20	9.32 ± 0.02	13.00 ± 0.17	12.73 ± 0.09
CF	35.62 ± 1.90	31.39 ± 0.80	26.29 ± 0.82	26.96 ± 0.40
NFE	43.72 ± 2.31	49.6 ± 0.77	48.64 ± 0.78	43.05 ± 0.29
NDF	57.31 ± 0.09	68.37 ± 0.11	47.84 ± 0.16	48.89 ± 0.04
ADF	37.62 ± 0.76	38.47 ± 0.10	29.65 ± 0.18	37.89 ± 0.27

Table 02
Effect of Shatavari (Asparagus racemosus) supplementation on body weight, body condition score and dry matter intake in Sahiwal cows

Fortnights	Body weight (Kg)		Dry Matter Intake (Kg)		Body condition Score	
	Control	Treatment	Control	Treatment	Control	Treatment
-4	$395.70^{x} \pm 6.79$	$399.70^{x} \pm 8.67$	$8.06^{x} \pm 0.20$	$8.14^{x} \pm 0.40$	$3.17^{x} \pm 0.17$	$3.20^{x} \pm 0.08$
-3	$400.00^{x} \pm 6.94$	$413.90^{y} \pm 14.66$	$7.26^{x} \pm 0.11$	$7.83^{y} \pm 0.49$	$3.25^{x} \pm 0.24$	$3.65^{y} \pm 0.05$
-2	$394.30^{x} \pm 6.80$	$411.10^{y} \pm 15.27$	$7.98^{x} \pm 0.19$	$8.52^{y} \pm 0.16$	$3.65^{x} \pm 0.16$	$4.00^{y} \pm 0.07$
-1	$399.50^{x} \pm 7.43$	$426.40^{y} \pm 10.15$	$7.89^{x} \pm 0.19$	$9.83^{y} \pm 0.42$	$4.025^{x} \pm 0.18$	$4.40^{y} \pm 0.12$
0	$374.3^{x} \pm 8.80$	$403.90^{y} \pm 8.80$	$6.21^{x} \pm 0.41$	$8.35^{y} \pm 0.28$	$3.70^{x} \pm 0.16$	$3.92^{y} \pm 0.13$
1	$377.30^{x} \pm 9.72$	$408.80^{y} \pm 11.77$	$7.92^{x} \pm 0.12$	$9.49^{y} \pm 0.23$	$4.03^{x} \pm 0.22$	$4.05^{y} \pm 0.16$
2	$380.50^{x} \pm 9.05$	$415.40^{y} \pm 11.77$	$8.36^{x} \pm 0.20$	$9.50^{y} \pm 0.13$	$4.07^{x} \pm 0.24$	$4.36^{y} \pm 0.12$
3	$388.10^{x} \pm 9.72$	$424.70^{y} \pm 11.45$	$8.59^{x} \pm 0.28$	$9.99^{y} \pm 0.08$	$3.87^{x} \pm 0.27$	$4.12^{y} \pm 0.21$
4	$396.20^{x} \pm 10.56$	$426.10^{y} \pm 9.98$	$8.59^{x} \pm 0.43$	$10.67^{y} \pm 0.11$	$4.10^{x} \pm 0.19$	$4.21^{y} \pm 0.16$
5	$398.64^{x} \pm 7.43$	$431.80^{y} \pm 11.12$	$9.61^{x} \pm 0.14$	$10.78^{y} \pm 0.10$	$4.00^{x} \pm 0.19$	$4.13^{y} \pm 0.29$
6	$400.02^{x} \pm 11.10$	$439.50^{y} \pm 11.24$	$9.29^{x} \pm 0.24$	$10.67^{y} \pm 0.15$	$4.06^{x} \pm 0.14$	$4.34^{y} \pm 0.14$
Overall mean ± SEM	$391.35^{x} \pm 9.10$	$418.61^{y} \pm 11.35$	$8.07^{x} \pm 0.31$	$9.43^{y} \pm 0.18$	$3.85^{x} \pm 0.21$	$3.99^{y} \pm 0.14$

Values with different subscripts $^{x, y}$ in a row differs significantly ($P < 0.05$).

Table 03
Effect of Shatavari (Asparagus racemosus) supplementation on Milk Yield and Milk Composition of Sahiwal Cows

Fortnights	Milk yield (Kg)		Fat (%)		Protein (%)		Lactose (%)		SNF (%)	
	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
1	$5.51^{x} \pm 0.98$	$7.72^{y} \pm 0.70$	$7.09^{x} \pm 0.82$	$6.28^{y} \pm 0.75$	3.22 ± 0.08	2.97 ± 0.08	4.83 ± 0.16	4.37 ± 0.15	$9.79^{x} \pm 0.24$	$9.14^{y} \pm 0.28$
2	$6.79^{x} \pm 1.11$	$8.91^{y} \pm 1.08$	$6.45^{x} \pm 0.64$	$5.52^{y} \pm 0.73$	3.34 ± 0.08	2.87 ± 0.13	5.09 ± 0.13	4.23 ± 0.15	$10.04^{x} \pm 0.15$	$8.79^{y} \pm 0.25$
3	$7.37^{x} \pm 1.10$	$9.26^{y} \pm 1.50$	$5.45^{x} \pm 0.94$	$3.76^{y} \pm 0.52$	3.02 ± 0.11	3.14 ± 0.09	4.50 ± 0.21	4.70 ± 0.15	$9.14^{x} \pm 0.22$	$9.22^{x} \pm 0.27$
4	$7.18^{x} \pm 1.28$	$9.35^{y} \pm 1.46$	$4.93^{x} \pm 0.78$	$3.46^{y} \pm 0.41$	2.98 ± 0.09	2.97 ± 0.15	4.49 ± 0.17	4.32 ± 0.19	$8.97^{x} \pm 0.24$	$8.41^{y} \pm 0.27$
5	$7.01^{x} \pm 1.18$	$8.96^{y} \pm 1.30$	$5.17^{x} \pm 0.60$	$4.30^{y} \pm 0.31$	3.20 ± 0.04	3.10 ± 0.15	4.82 ± 0.10	4.59 ± 0.17	$9.53^{x} \pm 0.13$	$8.83^{y} \pm 0.23$
6	$6.59^{x} \pm 0.94$	$8.62^{y} \pm 1.34$	$6.45^{x} \pm 0.67$	$4.07^{y} \pm 0.37$	2.99 ± 0.10	3.09 ± 0.08	4.64 ± 0.19	4.66 ± 0.12	$9.32^{x} \pm 0.24$	$9.05^{x} \pm 0.24$
Overall mean ± SEM	$6.74^{x} \pm 1.10$	$8.80^{y} \pm 1.23$	$5.76^{x} \pm 0.74$	$4.56^{y} \pm 0.52$	3.12 ± 0.08	3.02 ± 0.11	4.73 ± 0.16	4.48 ± 0.15	$9.46^{x} \pm 0.20$	$8.90^{y} \pm 0.25$

Mean values with different subscripts $^{x, y}$ in a row differs ($P < 0.05$)

Table 04
Effect of Shatavari (Asparagus racemosus) supplementation on post partum reproduction performance in Sahiwal cows.

Sl.No	Parameters	Groups	
		Control	Treatment
1	First post partum estrus (days)	$68.87^{x} \pm 14.56$	$46.56^{x} \pm 11.76$
2	Day to first service	$147.1^{x} \pm 15.78$	$83.33^{y} \pm 15.30$
3	Open period (days)	$113.2^{x} \pm 18.78$	$95.50^{x} \pm 13.0$
4	Service per conception	$2.75^{x} \pm 1.03$	$1.66^{x} \pm 0.33$
5	Conception rate (%)	40^{x}	70^{x}
6	Time taken to expel placenta (hr)	$7.12^{x} \pm 1.50$	$4.20^{y} \pm 0.50$
7	Birth weight of Sahiwal calves (kg)	$17.66^{x} \pm 0.50$	$20.55^{y} \pm 0.51$
Mean values with different subscripts $^{x, y}$ in a row differs significantly ($P < 0.05$)			

Table 05
Effect of Shatavari (Asparagus racemosus) supplementation on reproductive disorders in Sahiwal cows

Sl. No	Reproductive disorders	Groups	
		Control (n = 10)	Treatment (n = 10)
1	Dystocia (%)	20^{x}	10^{y}
2	Abortion (%)	10^{x}	0^{y}
3	RFM (%)	10^{x}	0^{y}
4	Cystic ovaries (%)	20^{x}	0^{y}
5	Pyometra (%)	30^{x}	20^{y}
6	Endometritis (%)	60^{x}	20^{y}
7	Mastitis (%)	40^{x}	10^{y}
Mean values with different subscripts $^{x, y}$ in a row differs significantly ($P < 0.05$)			

Figures

Plasma Metabolites

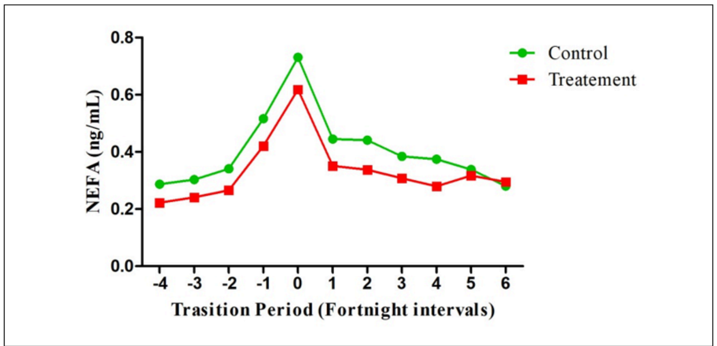
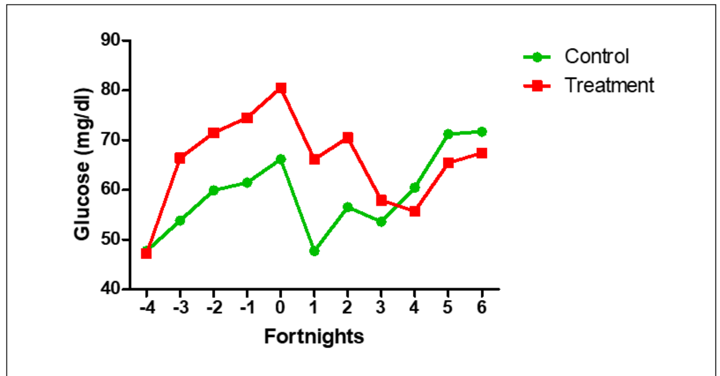


Fig 3.a: NEFA (ng/mL)



3.c: Plasma Glucose

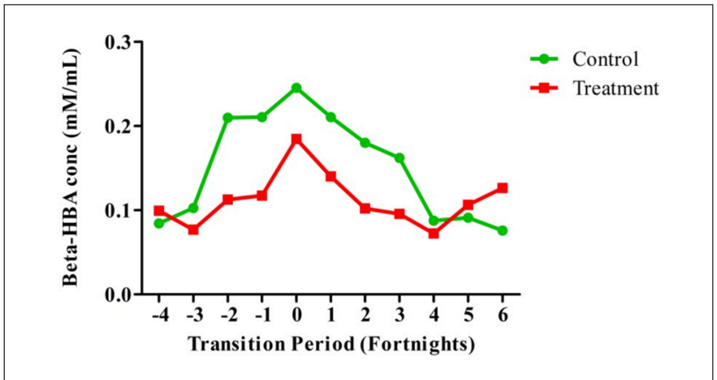


Fig 3.b2β-HBA (mM/mL)

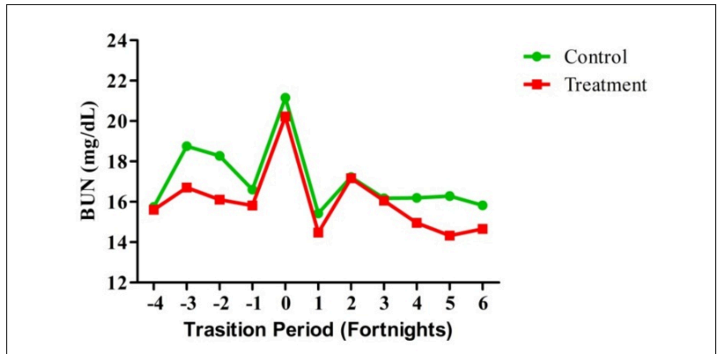


Fig 3.d: BUN (mg/dl)

Figure 1

3: Effect of Shatavari (*Asparagus racemosus*) supplementation on plasma metabolites profiles in Sahiwal cows. 3.a. Plasma NEFA, 3.b: β-HBA (mM/mL), 3.c: Plasma Glucose and Fig 3.d: BUN

Plasma hormone profiles

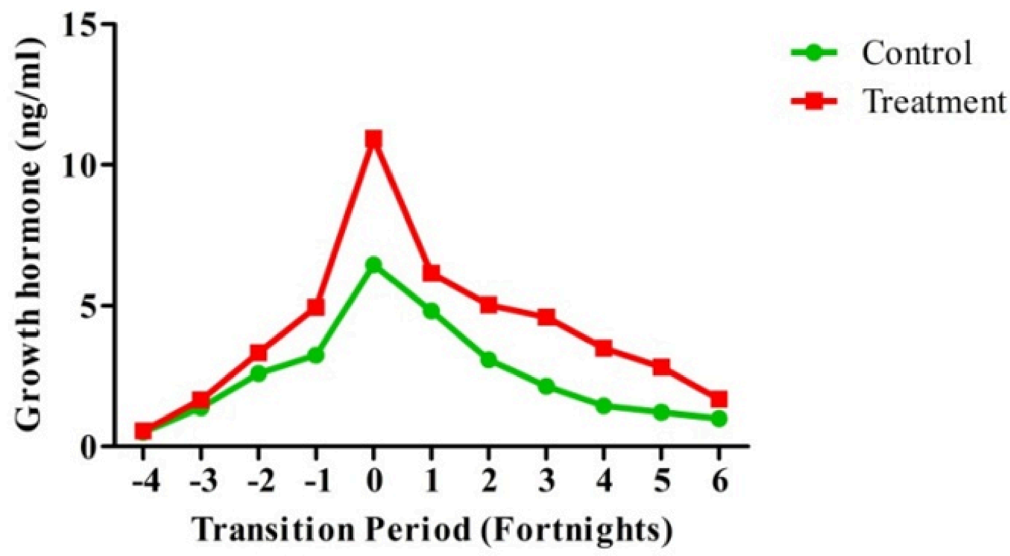


Fig 4.a. Growth hormone (ng/ml)

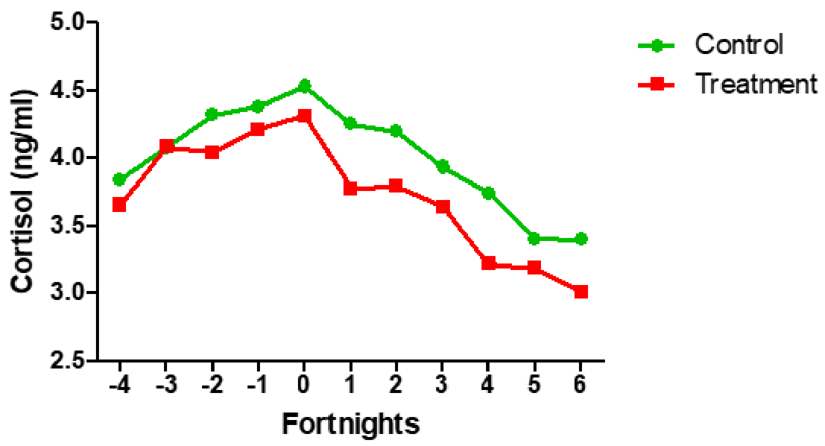


Fig 4.b. Cortisol

Figure 2

4: Effect of Shatavari (*Asparagus racemosus*) supplementation on Plasma hormonal profiles in Sahiwal cows. 4.a. Plasma GH, 4.b: Cortisol.