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Effect of feeding chandrasoor (*Lepidium sativum* L.) seed on major milk constituents in Indian cows

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Abstract
Chandrasoor (*Lepidium sativum* L.), a traditional galactogogue belonging to the family Brassicaceae (Cruciferae), has long been used in Ayurvedic and Unani systems of medicine for enhancing milk production in lactating animals. The present study evaluated the effect of dietary supplementation of chandrasoor seed at five graded levels — 100, 150, 200, 250 and 300 g/day — on major milk constituents in Indian crossbred cows under a three-phase split-plot experimental design. Twelve lactating cows were divided into six treatment groups (T_1-T_6), with T_1 serving as the unsupplemented control. The experiment comprised three successive phases: Phase I (control period, 7 days), Phase II (treatment period, 7 days) and Phase III (residual/withdrawal period, 45 days). Milk samples were analysed daily for pH, titratable acidity (% lactic acid), lactose, protein, fat and total solids content. Results demonstrated that supplementation of chandrasoor seed exerted statistically significant (P<0.05) positive effects on milk yield, lactose, protein, fat and total solids content across all treatment phases. The T_5 dose (250 g/day) consistently emerged as the most effective, producing milk significant improvements in all major milk constituents compared to the control. pH exhibited a marginal, dose-dependent decline while acidity showed a slight but significant increase. The observed improvements were attributed to the galactogogue alkaloid lepidine, glucosinolates, sinapin and other bioactive compounds present in chandrasoor seeds that enhance nutrient digestibility, rumen activity, liver metabolism and mammary gland function. The study concluded that 250 g/day of chandrasoor seed supplementation is the optimal dose for improving productive performance of lactating Indian cows and may be recommended as a cost-effective, natural feed supplement to dairy farmers and cattle-feed manufacturers, particularly during the summer season.

Keywords: Chandrasoor, *Lepidium sativum*, galactogogue, milk yield, milk constituents, Indian cows, feed supplement, lactose, fat, protein, total solids

1. Introduction
Milk is regarded as nature's most complete food, providing an indispensable range of nutrients essential to human health. In India, the quality and quantity of milk produced at the farm level are fundamental determinants of the quality of the final dairy product reaching the consumer. The initial quality of milk at the farm is therefore of paramount importance, as it governs the nutritive value, safety and shelf life of all downstream dairy products. With growing consumer awareness and increasing market demand for premium-quality dairy produce, there is an urgent need to enhance the productive performance of lactating animals through scientifically validated, economically feasible and ecologically sustainable strategies (Shukla, 2009) [8].

Feed supplementation with herbal and medicinal plant materials represents one of the oldest and most widely practised strategies for improving milk production in South Asia. Medicinal seeds such as fenugreek (*Trigonella foenum-graecum*), black seed (Nigella sativa), caraway and chandrasoor (*Lepidium sativum* L.) have been used as galactagogues — substances that promote lactation — in folk medicine across India, Egypt, Jordan and other countries for centuries (Abo El-Nor *et al*., 2007) [1]. The term 'galactogogue' describes any substance of dietary, herbal or pharmacological origin that promotes, sustains or enhances milk secretion (Salem & El-Mahdy, 2001) [7]. Chandrasoor (*Lepidium sativum* L.), commonly known as garden cress, is a small annual herb of the family Brassicaceae (Cruciferae).

It grows widely across India — particularly in Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Madhya Pradesh and Chhattisgarh — and is cultivated as a rabi season crop yielding approximately three to four quintals per acre. The seeds are small, reddish and contain an array of bioactive constituents including the alkaloid lepidine and its quaternary ammonium derivatives lepidiline A and B, glucosinolates (glucotropaeolin and gluconasturtiin), sinapin, sinapic acid, mucilaginous matter, linolenic acid (30.2%), erucic acid (3.9%), high potassium (1193 mg/100 g) and diverse vitamins and minerals (Nayak *et al*., 2009; Radwan *et al*., 2007; USDA, 2002) [5, 6, 11].

Lepidine and related alkaloids are reported to increase glutamic-pyruvate transaminase (GPT) and glutamic-oxaloacetate transaminase (GOT) activities, thereby enhancing nutrient digestibility and assimilation at the intestinal level, which in turn augments galactogogue activity in lactating animals (Valentova & Ulrichova, 2003) [12]. Furthermore, glucosinolates present in chandrasoor are thought to influence biorumen hydrolysis and lipogenic enzyme activity in mammary tissue, thereby promoting fat and total solid content of milk (Bauman & Devis, 1994) [2]. Several reputed cattle-feed manufacturing companies in India already incorporate chandrasoor as a primary ingredient in formulated galactogogue compounds.

Despite its long-standing traditional use and promising biochemical profile, systematic scientific investigations into the dose-response relationship between chandrasoor supplementation and milk quality parameters in Indian dairy cows were sparse at the time of the original study. The present paper synthesises and presents the findings of a structured feeding trial conducted by Shukla (2009) [8] at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, examining the effect of graded levels of chandrasoor seed supplementation on milk yield and the major physicochemical constituents of milk in Indian crossbred cows. The present investigation was designed with the following specific objectives: To estimate qualitative changes in major milk constituents (pH, acidity, lactose, protein, fat and total solids) following chandrasoor supplementation.

2. Materials and Methods

2.1 Experimental Animals and Housing

The feeding trial was conducted at Jagannath Dairy, located at Mana Road, Temri, Raipur, Chhattisgarh. Twelve Indian crossbred cows, aged four to eight years and at various stages of lactation, were selected randomly from the herd. They were divided into six treatment groups of two cows each, ensuring equivalent initial milk yield within groups. Individual groups were allotted initial daily yields of 4, 3, 4, 5, 6.5 and 8.5 litres/day respectively (T_1-T_6). All cows were maintained under identical management conditions and were observed regularly by a veterinarian throughout the trial. Medical records were maintained for each animal.

2.2 Feed Formulation and Experimental Design

Chandrasoor seeds of commercial grade were procured from the local market of Raipur and incorporated into a concentrate ration. The roughage component consisted of 8 kg green fodder (maize) and 4 kg wheat straw per animal per day. The concentrate mixture comprised crushed grain (maize/barley) 25%, groundnut cake/other oil cakes 30%, wheat bran/rice bran 42%, mineral mixture 2% and common salt 1%. The experimental design is summarised in Table 1.

Table 1: Experimental Groups and Chandrasoor Seed Supplementation Levels

Treatment	Chandrasoor Seed (g/day)	Initial Milk Yield (L/day)	Description
T_1 (Control)	0	3.99	No supplementation
T_2	100	3.04	Low-level supplement
T_3	150	4.02	Moderate-low supplement
T_4	200	5.02	Moderate supplement
T_5	250	6.48	Optimum supplement
T_6	300	8.50	High-level supplement

Note: T_1 = Control (no supplementation); T_2-T_6 = Treatment groups with graded chandrasoor seed levels.

The experiment was executed in three consecutive phases per replication cycle.

Phase I Control Period (7 days): All groups fed control ration without chandrasoor supplementation.

Phase II Treatment Period (7 days): Groups T_2-T_6 received formulated concentrate supplemented with 100, 150, 200, 250 and 300 g chandrasoor seed/day respectively; T_1 remained on control ration.

Phase III Residual/Withdrawal Period (45 days): All groups reverted to control ration to observe residual/carry-over effects of supplementation.

2.3 Milk Sample Collection and Analysis

All cows were milked twice daily at 6:00 a.m. and 4:00 p.m. Individual milk yield records were maintained to the nearest 100 ml using a spring balance. Morning and evening milk samples were collected proportionate to yield and pooled for each group for chemical analysis. Analysis was carried out daily throughout all three phases at the Dairy Chemistry Laboratory, Department of Dairy Chemistry, College of Dairy Technology, IGKV, Raipur. pH was determined using a Systronic Digital pH metre. Titratable acidity (% lactic acid) was estimated by the method of Roy and Sen (1994) using 0.1 N NaOH and phenolphthalein indicator. Lactose content was determined by the Lane-Eynon titration method. Protein was estimated by Pyne's formol titration method. Fat percentage was determined by Gerber's butyrometric method Total solids were calculated gravimetrically by drying 5-10 ml milk samples at 98-100°C to constant weight.

2.4 Statistical Analysis

Data obtained were subjected to split-plot design statistical analysis as described by Snedecor and Cochran (1994) [9], with phases as the main plot and treatment levels of chandrasoor seed as the sub-plot factor, with seven replications. The statistical model was: $Y_{ijk} = \mu + \delta_{ij} + S_i + T_k + (SxT)_{ik} + \varepsilon_{ijk}$, where Si represents the effect of the ith phase, Tk the effect of the kth chandrasoor seed level, and (SxT)ik the interaction effect. Statistical software OPSTAT was used for analysis. Significant differences among means were identified using the Critical Difference (CD) at the 5% level of significance.

3. Results and Discussion

3.1 Effect on pH of Milk: The pH of milk from all treatment groups across the three experimental phases is presented in Table 2. In Phase I, pH values were essentially uniform across treatments (6.65 to 6.67), confirming homogeneity of groups at baseline. During Phase II, pH values declined marginally but consistently in supplemented groups, ranging from 6.64 to 6.65. In Phase III, pH declined further in a dose-dependent manner, reaching 6.59 in T_6. The pooled mean pH decreased from 6.65 (T_1) to 6.63 (T_6), and the treatment effect was statistically significant ($F = 7.397$, $P<0.01$; CD = 0.0156).

Table 2: Effect of Chandrasoor Seed Supplementation on Milk pH Across Three Experimental Phases

Phase	T_1	T_2	T_3	T_4	T_5	T_6
Phase I	6.65	6.66	6.66	6.66	6.67	6.67
Phase II	6.65	6.65	6.64	6.65	6.65	6.64
Phase III	6.65	6.62	6.61	6.60	6.60	6.59
Pooled Mean	6.65	6.64	6.64	6.64	6.64	6.63

CD (5%) = 0.0156; CV% = 0.3806; S Em± = 0.0055; Phase effect NS; Treatment effect **

The slight decline in pH was accompanied by a corresponding marginal rise in titratable acidity, consistent with the inverse relationship between pH and acidity in fresh milk. The phase × treatment interaction was not significant ($F = 0.513$, NS), indicating that the pH effect was primarily attributable to the treatment level rather than the duration or phase of supplementation. The mild acidification may reflect enhanced microbial fermentation activity in the rumen and improved metabolic turnover in the mammary gland, both associated with higher productivity.

3.2 Effect on Major Milk Constituents

The pooled mean values of all major milk constituents across treatment groups are consolidated in Table 3, and the ANOVA summary is provided in Table 4. All major constituents — lactose, protein, fat and total solids — demonstrated highly significant dose-dependent improvements in supplemented groups.

Table 3: Pooled Mean Values of Major Milk Constituents by Treatment Group

Constituent (Pooled Mean)	T_1	T_2	T_3	T_4	T_5	T_6
Acidity (% LA)	0.135	0.136	0.136	0.137	0.138	0.137
Lactose (%)	4.13	4.40	4.46	4.67	5.03	5.24
Protein (%)	3.47	3.63	3.77	3.73	3.95	3.97
Fat (%)	3.48	3.75	3.75	3.81	3.87	3.90
Total Solids (%)	11.86	12.22	12.26	12.35	12.46	12.50

T_1 = Control; T_2 = 100 g; T_3 = 150 g; T_4 = 200 g; T_5 = 250 g; T_6 = 300 g chandrasoor seed/day

Table 4: Summary of ANOVA Results for Major Milk Constituents

Parameter	F-cal (Phase)	F-cal (Treatment)	CD (5%)	CV%	Significance
pH	0.954	7.397	0.0156	0.3806	Treatment significant (**)
Acidity (% LA)	6.221	2.353	0.0032	3.7808	Both significant (*)
Lactose (%)	220.901	105.084	0.1139	3.9875	Highly significant (**)
Protein (%)	42.562	58.608	0.0709	3.0787	Highly significant (**)
Fat (%)	103.685	35.547	0.0704	3.0536	Highly significant (**)
Total Solids (%)	98.223	48.924	0.0932	1.2382	Highly significant (**)

** Significant at 1% level; * Significant at 5% level; NS = Non-significant; CD = Critical Difference at 5%

Lactose content increased progressively from 4.13% (T_1) to 5.24% (T_6) in pooled means, with the most significant jump observed between T_4 (4.67%) and T_5 (5.03%). The increase in lactose is mechanistically linked to elevated blood glucose levels resulting from enhanced liver metabolism, as proposed by Larson (1985) [4] and Nazar (1994). Lactose is the primary osmotic regulator of milk secretion, and its synthesis in the mammary gland is rate-limited by UDP-galactose availability, which is itself derived from hepatic glucose metabolism. The GPT-stimulating activity of lepidine in chandrasoor seeds (Valentova & Ulrichova, 2003) [12] likely promotes glucose turnover in hepatocytes, thereby elevating the substrate pool for lactose synthesis.

Protein content increased from 3.47% (T_1, pooled) to 3.97% (T_6), with T_5 recording 3.95%. The improvement in protein content was attributed to de novo synthesis in the mammary gland, facilitated by positive energy balance following improved nutrient digestibility. Tomar *et al.* (1995) noted a non-significant effect of chandrasoor seed on protein in Murrah buffalo when insufficient doses were used, suggesting that threshold dose matters; the present study's higher dose levels (up to 300 g/day) produced significant improvements.

Fat content rose from 3.48% (T_1) to 3.90% (T_6), with T_5 recording 3.87%. The increase in fat was attributed to enhanced lipogenic activity mediated by acetyl-CoA translocation pathways in mammary tissue. Chandrasoor contains high levels of glucosinolates (lipidine, glucotropaeolin, gluconasturtiin) that may potentiate biorumen hydrolysis mechanisms, subsequently enhancing fatty acid synthesis in mammary adipocytes (Bauman & Devis, 1994) [2]. Total solids increased correspondingly from 11.86% to 12.50% (T_6), reflecting cumulative improvements in all non-aqueous constituents.

The T_5 treatment (250 g/day) was identified as the optimal dose on the basis of the following Phase II values: Lactose 4.56%, Protein 3.75%, Fat 3.72%, Total Solids 12.32% — all significantly superior to the control and exhibiting the best risk-benefit profile relative to the higher T_6 dose. During the residual Phase III, T_5 values for lactose, protein, fat, total solids indicating a sustained carry-over effect lasting up to 45 days after supplementation withdrawal. A steady state was reached approximately on the third day of treatment, with a slight decreasing trend observed thereafter during withdrawal.

4. Conclusion and Recommendations

The present study conclusively demonstrated that dietary supplementation of chandrasoor (*Lepidium sativum* L.) seed significantly enhances the major physicochemical constituents of milk in Indian crossbred cows. The following key conclusions were drawn from the experimental findings:

The optimal dose of chandrasoor seed supplementation was established at 250 g/day (T_5), which produced the most significant and balanced improvement in overall galactogogue activity, quality parameters.

Lactose content increased significantly when T_5 dose was administered, attributed to enhanced liver metabolism and elevated blood glucose availability for mammary lactose synthesis.

Protein and fat content were significantly elevated in T_5 during both treatment and withdrawal periods, reflecting improved mammary protein synthesis and enhanced lipogenic enzyme activity.

Total solid content increased significantly in proportion to improvements in individual major constituents, confirming overall enhancement of milk nutritive quality.

pH and acidity showed minimal but statistically significant changes (slight pH decline and acidity increase), consistent with enhanced metabolic activity and not indicating any deterioration in milk quality.

A significant residual/carry-over effect was observed up to 45 days post-withdrawal, suggesting cumulative physiological benefits on mammary gland function.

On the basis of these findings, a daily supplementation of 250 g chandrasoor seed per cow per day is recommended as a safe, cost-effective and efficacious natural feed supplement for improving milk production during the summer season. This recommendation is directed at dairy farmers, cattle-feed manufacturers and veterinary pharmaceutical companies. Future investigations should explore the effects of chandrasoor supplementation in different seasons, across multiple lactation stages, in buffaloes and other milch breeds, and in combination with other medicinal seeds such as fenugreek and black seed.

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