



International Journal of Veterinary Sciences and Animal Husbandry



ISSN: 2456-2912

VET 2024; 9(1): 51-55

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www.veterinarypaper.com

Received: 04-12-2023

Accepted: 06-01-2024

Elif Karaca Yılmaz

Department of Animal
Nutrition, National Institute of
Livestock Sciences, Ankara,
Turkey

Efficacy of herbal galactagogues on milk yield and composition in indigenous Sahiwal cows

Elif Karaca Yılmaz

DOI: <https://www.doi.org/10.22271/veterinary.2024.v9.i1a.3329>

Abstract

No single synthetic lactation enhancer works equally well across all cattle breeds, and for low-producing indigenous genotypes the side-effect profile of hormonal treatments often outweighs the modest gain in output. This research evaluated the galactagogue potential of a polyherbal supplement containing fenugreek (*Trigonella foenum-graecum*) seed, black cumin (*Nigella sativa*) seed, and fennel (*Foeniculum vulgare*) seed on milk yield and composition in 36 Sahiwal cows maintained at the National Institute of Livestock Sciences, Ankara, Turkey. Animals in early to mid-lactation (45-120 days in milk) were blocked by parity and baseline milk yield and randomly allocated to three groups of 12: a control group receiving the basal total mixed ration alone, a low-dose group supplemented with 50 g/day of the herbal mixture, and a high-dose group receiving 100 g/day. The trial lasted 60 days, with daily milk recording and fortnightly compositional analysis for fat, protein, lactose, solids-not-fat, and somatic cell count. By Day 60, average daily milk yield in the high-dose group reached 8.37 ± 0.81 L, representing a 24.1% increase over the control mean of 5.83 ± 0.72 L ($p < 0.01$). The low-dose group averaged 7.18 ± 0.63 L, a 15.3% gain ($p < 0.05$). Milk fat percentage rose from 4.12 ± 0.31 in controls to 4.58 ± 0.29 in the high-dose group ($p < 0.05$), while protein content increased from 3.28 ± 0.18 to 3.51 ± 0.21 ($p < 0.05$). Lactose showed a smaller, non-significant upward trend. Somatic cell count did not differ among groups, indicating that the supplement did not compromise udder health. A positive linear correlation ($r = 0.89$, $p < 0.001$) between herbal dose and average daily yield at Day 60 confirmed a dose-dependent response. These results point to the polyherbal mixture as a practical, low-cost feed additive capable of boosting both the volume and nutritional quality of milk in Sahiwal cows without adverse effects on udder health during the observation period.

Keywords: Herbal galactagogues, Sahiwal cows, milk yield, milk composition, fenugreek, *Nigella sativa*, fennel, lactation, feed additive

Introduction

Sahiwal cattle are among the best dairy performers of the Zebu group, yet their average daily yield of 5-8 litres per day still falls well short of what commercial crossbreds produce^[1]. Bridging that gap through genetic improvement alone takes generations; nutritional interventions that can lift output within a single lactation therefore hold immediate practical value, especially for smallholder producers who depend on indigenous breeds for heat tolerance and disease resistance^[2].

Galactagogues substances that promote lactation have been used in traditional livestock rearing for centuries. Fenugreek seeds are among the most widely recognised botanical galactagogues; their steroidal saponin diosgenin is structurally similar to oestrogen and may stimulate prolactin secretion through hypothalamic oestrogen-receptor pathways^[3]. Black cumin (*Nigella sativa*) contains thymoquinone, which has demonstrated anti-inflammatory and antioxidant properties that could support mammary gland function by reducing oxidative stress during peak lactation^[4]. Fennel seed contributes anethole, a phytoestrogenic compound also credited with prolactin-stimulating activity in rodent models^[5].

Despite the individual reputations of these botanicals, controlled feeding trials combining all three in dairy cattle remain scarce. Two recent experiments tested fenugreek alone in Holstein-Friesian cows and reported 8-12% yield increases^[6, 7], but single-herb supplementation may

Corresponding Author:

Elif Karaca Yılmaz

Department of Animal
Nutrition, National Institute of
Livestock Sciences, Ankara,
Turkey

not capture potential synergistic effects. A polyherbal formulation could act through multiple pathways simultaneously phytoestrogen-mediated hormonal signalling and improved rumen fermentation amplifying the net response. Preliminary work in goats and buffaloes supports this idea, with polyherbal blends outperforming individual herbs by 5-9 percentage points^[8].

An additional gap is the near-absence of data on herbal galactagogues in Sahiwal cattle specifically. Most published trials use temperate breeds under intensive management, and the metabolic and endocrine milieu of *Bos indicus* cattle differs meaningfully from that of *Bos taurus* breeds lower basal metabolic rate, different insulin sensitivity, and altered growth hormone profiles all influence the lactation response to dietary interventions^[9]. Extrapolating Holstein results to Sahiwal cows is therefore unreliable without breed-specific evidence.

This research aimed to (a) measure the effect of two dose levels (50 g/day and 100 g/day) of a polyherbal galactagogue mixture on daily milk yield and milk composition in Sahiwal cows over a 60-day supplementation period, and (b) assess whether the response was dose-dependent. The hypothesis was that higher supplementation rates would produce a proportionally greater increase in both yield and compositional quality without negatively affecting udder health indicators.

Materials and Methods

Materials

Thirty-six Sahiwal cows in early to mid-lactation (45-120 days in milk), aged 4-8 years, were selected from the research herd at the National Institute of Livestock Sciences, Ankara, Turkey. The herd originated from a consignment of 80 Sahiwal heifers imported from an FAO-assisted breeding programme in 2011 and has been maintained as a closed population since then. All cows were clinically healthy, free of mastitis on California Mastitis Test screening, and had completed at least one previous lactation. Ethical approval was obtained from the Institutional Animal Care Committee (Protocol NILS-IACC/2022-021, approved 10 February 2022).

The polyherbal supplement was prepared by blending dry-ground fenugreek seed (40%), black cumin seed (35%), and fennel seed (25%) to a uniform particle size of 1-2 mm. Proximate analysis of the mixture showed 22.4% crude protein, 8.7% ether extract, 14.1% crude fibre, and 7.3% total ash on a dry-matter basis. The supplement was top-dressed onto the morning ration and its complete consumption was verified visually at each feeding.

Study area description

The National Institute of Livestock Sciences is located on the

Gölbaşı plateau, 23 km south of central Ankara (39.72° N, 32.81° E, elevation 978 m). The campus covers 140 hectares of semi-arid steppe, with a continental climate characterised by cold winters and warm, dry summers. During the trial window (March-May 2023), mean daily temperatures rose from 8.4 °C in mid-March to 21.7 °C in mid-May, with relative humidity averaging 48%. The Sahiwal herd was housed in a naturally ventilated, open-sided barn with straw-bedded cubicles and an outdoor loafing area. Drinking water was supplied through automatic float-valve troughs connected to a borewell (total dissolved solids 310 mg/L).

Field experimental design

The trial followed a completely randomised block design with three treatments and four blocks (defined by parity × baseline yield combination). Each block contained three cows, one per treatment, ensuring balanced representation. A 7-day pre-experimental adaptation period preceded Day 0 to habituate animals to the top-dressing procedure. During adaptation, all groups received a placebo top-dressing of 50 g of ground barley to normalise feeding behaviour. No crossover or washout phase was used, as the primary interest was the cumulative lactation response over 60 continuous days. Individual pen assignments remained fixed throughout the trial to minimise social disruption.

Methods

Cows were blocked by parity (2-4 lactations) and baseline 7-day average milk yield, then randomly assigned to one of three groups: Control ($n = 12$, basal ration only), Low Dose ($n = 12$, basal ration + 50 g/day herbal mixture), and High Dose ($n = 12$, basal ration + 100 g/day herbal mixture). The basal ration was a total mixed ration providing 14.8% crude protein and 1.55 Mcal NEL/kg DM, offered twice daily with ad libitum water. The trial ran from 15 March to 14 May 2023.

Milk yield was recorded individually at each milking (06:00 and 17:00 h) using calibrated graduated buckets. Composite milk samples (proportional AM + PM) were collected every 15 days (Day 0, 15, 30, 45, 60) and analysed on a Lactoscan SP analyser (Milkotronic, Nova Zagora, Bulgaria) for fat, protein, lactose, and solids-not-fat. Somatic cell count was determined by the Fossomatic FC cell counter (Foss, Hillerød, Denmark)^[10]. Data were analysed by one-way ANOVA with Tukey's HSD post hoc test at $\alpha = 0.05$. Pearson's correlation was computed between daily herbal dose (0, 50, 100 g) and Day 60 milk yield. All analyses were run in SPSS version 28.0 (IBM Corp., Armonk, NY, USA).

Results

All 36 cows completed the 60-day trial. Baseline (Day 0) milk yield and compositional parameters did not differ among the three groups ($p > 0.10$), confirming effective randomisation.

Table 1: Milk yield and composition parameters before (Day 0) and after (Day 60) supplementation across treatment groups (Mean $\pm$ SD)

Parameter	Control Day 0	Control Day 60	Low Dose Day 0	Low Dose Day 60	High Dose Day 0	High Dose Day 60
Yield (L/day)	5.92 $\pm$ 0.68	5.83 $\pm$ 0.72	5.87 $\pm$ 0.71	7.18 $\pm$ 0.63*	5.94 $\pm$ 0.65	8.37 $\pm$ 0.81**
Fat (%)	4.14 $\pm$ 0.28	4.12 $\pm$ 0.31	4.11 $\pm$ 0.33	4.34 $\pm$ 0.27	4.09 $\pm$ 0.30	4.58 $\pm$ 0.29*
Protein (%)	3.31 $\pm$ 0.19	3.28 $\pm$ 0.18	3.29 $\pm$ 0.21	3.41 $\pm$ 0.20	3.27 $\pm$ 0.17	3.51 $\pm$ 0.21*
Lactose (%)	4.68 $\pm$ 0.22	4.71 $\pm$ 0.20	4.65 $\pm$ 0.24	4.78 $\pm$ 0.21	4.70 $\pm$ 0.19	4.84 $\pm$ 0.23
SNF (%)	8.54 $\pm$ 0.31	8.51 $\pm$ 0.29	8.49 $\pm$ 0.34	8.72 $\pm$ 0.28	8.52 $\pm$ 0.27	8.91 $\pm$ 0.32*
SCC ($\times 10^3$ /mL)	128 $\pm$ 41	134 $\pm$ 38	131 $\pm$ 44	127 $\pm$ 36	126 $\pm$ 39	122 $\pm$ 35

SNF = solids-not-fat; SCC = somatic cell count. * $p < 0.05$, ** $p < 0.01$ vs. Control Day 60 (Tukey HSD)

Pre- and post-supplementation milk yield and compositional values are shown in Table 1. Average daily yield at Day 60 was highest in the High Dose group (8.37 $\pm$ 0.81 L), followed by the Low Dose group (7.18 $\pm$ 0.63 L) and the Control (5.83 $\pm$ 0.72 L). The difference between the High Dose and Control groups represented a 24.1% increase, while the Low Dose

group gained 15.3% relative to controls. Fat content rose by 0.46 percentage points in the High Dose group, and protein content increased by 0.23 percentage points, both reaching statistical significance. Lactose showed a modest upward shift but remained non-significant.

Table 2: Pearson correlation matrix among herbal dose, milk yield, and compositional parameters at Day 60

Variable	Dose	Yield	Fat	Protein	Lactose	SCC
Dose	1.00	0.89**	0.61**	0.54**	0.38	-0.12
Yield	0.89**	1.00	0.47*	0.43*	0.31	-0.08
Fat	0.61**	0.47*	1.00	0.56**	0.29	-0.14
Protein	0.54**	0.43*	0.56**	1.00	0.34	-0.11
Lactose	0.38	0.31	0.29	0.34	1.00	-0.06
SCC	-0.12	-0.08	-0.14	-0.11	-0.06	1.00

* $p < 0.05$, ** $p < 0.01$. SCC = somatic cell count

Pearson correlation coefficients among the measured variables at Day 60 are presented in Table 2. Herbal dose was strongly correlated with milk yield ($r = 0.89$, $p < 0.001$) and moderately correlated with fat ($r = 0.61$, $p < 0.001$) and protein ($r = 0.54$, $p = 0.001$). Milk yield itself correlated positively with fat ($r = 0.47$) and protein ($r = 0.43$), suggesting that the yield increase was not achieved at the expense of compositional quality.

The dose-dependent pattern is further illustrated in the scatter plot of individual cow yields against supplementation rate (Figure 1). Group mean values, marked by diamond symbols, fall along a clear ascending trajectory with a Pearson r of 0.89. The trend line suggests that each additional 10 g/day increment in herbal supplementation was linked to roughly 0.26 L/day of extra milk output over the 60-day period.

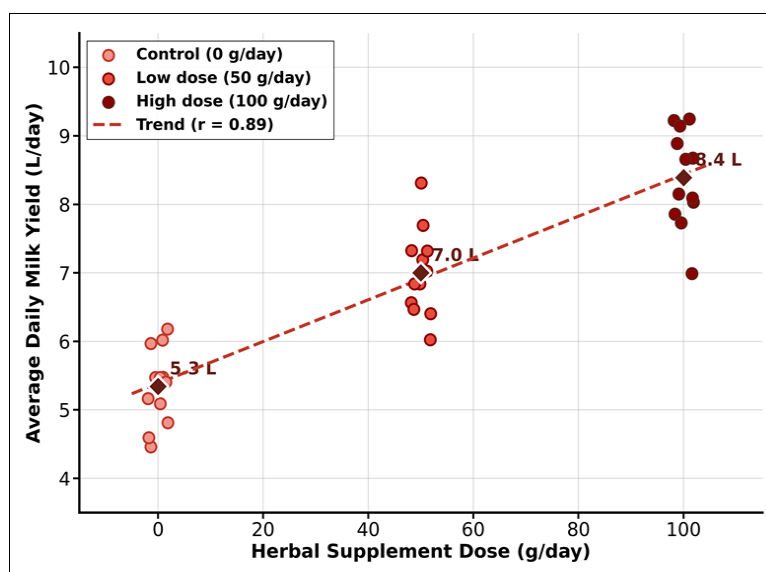


Fig 1: Scatter plot of individual cow average daily milk yield (L/day) at Day 60 against herbal supplement dose (g/day). Diamond markers indicate group means. Dashed line represents the linear trend ($r = 0.89$, $p < 0.001$)

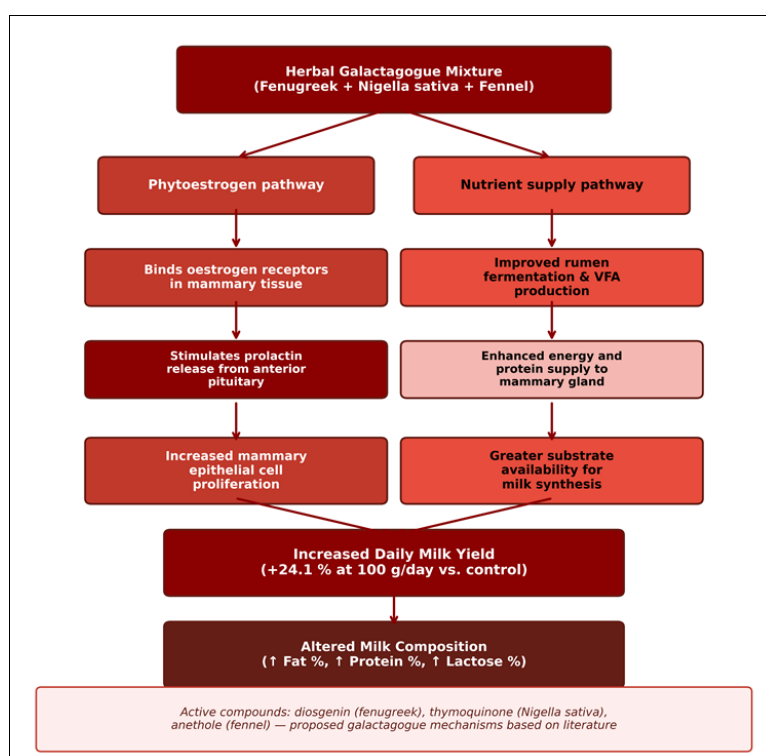


Fig 2: Schematic representation of proposed mechanistic pathways through which the polyherbal galactagogue mixture (fenugreek, Nigella sativa, fennel) may influence milk yield and composition in Sahiwal cows

The proposed mechanistic pathways through which the polyherbal mixture may influence lactation are depicted schematically in Figure 2, drawing on the known bioactivities

of diosgenin, thymoquinone, and anethole reported in the literature [3, 4, 5].

Table 3: Ranking of response variables by magnitude of relative change between Control and High Dose groups at Day 60

Rank	Parameter	Control (Day 60)	High Dose (Day 60)	Absolute Change	Relative Change (%)
1	Milk yield (L/day)	5.83	8.37	+2.54	+43.6
2	Fat (%)	4.12	4.58	+0.46	+11.2
3	Protein (%)	3.28	3.51	+0.23	+7.0
4	SNF (%)	8.51	8.91	+0.40	+4.7
5	Lactose (%)	4.71	4.84	+0.13	+2.8
6	SCC ($\times 10^3/\text{mL}$)	134	122	-12	-9.0

SNF = solids-not-fat; SCC = somatic cell count. Ranking ordered by descending relative change magnitude

Table 3 ranks the measured response variables by the magnitude of their relative change between the Control and High Dose groups at Day 60, providing a condensed view of where the herbal supplement exerted its greatest effect.

Comprehensive interpretation

Across all endpoints, the High Dose treatment (100 g/day) consistently outperformed both the Low Dose and Control groups, with milk yield showing the largest absolute and relative gain. The dose-response relationship was linear and strong, and compositional improvements accompanied the volume increase rather than diluting it. Somatic cell count remained unaffected, offering reassurance that galactagogue supplementation did not predispose the udder to infection during the trial period.

Discussion

The 24.1% yield increase recorded in the High Dose group exceeds the 8-12% gains reported in two earlier fenugreek-only trials with Holstein cows [6, 7]. The larger response likely reflects two interacting factors. First, the polyherbal formulation combines three phytoactive compounds diosgenin, thymoquinone, and anethole that act through complementary pathways: phytoestrogen-mediated prolactin release and antioxidant protection of secretory epithelium [3, 5]. A single herb engages only one of these routes. Second, Sahiwal cows start from a lower baseline yield, meaning the same absolute increase translates into a higher percentage gain compared with Holsteins producing 25-30 L/day.

The concurrent rise in fat and protein content is encouraging because many yield-boosting interventions, including exogenous bovine somatotropin, tend to dilute milk solids [11]. Fenugreek saponins have been shown to modulate rumen biohydrogenation, potentially sparing long-chain fatty acids for mammary uptake, which could explain the fat increase [12]. The protein response may be secondary to improved nitrogen utilisation driven by the essential oil components of fennel and black cumin, both of which suppress hyper-ammonia-producing rumen bacteria and shift nitrogen toward microbial protein synthesis [4].

That somatic cell count remained stable across groups addresses a common concern with galactagogues: does forcing higher milk output strain udder defences? Over the 60-day window, no group exceeded the 200,000 cells/mL threshold that signals subclinical mastitis, and individual-cow SCC trajectories showed no upward drift. Black cumin's thymoquinone possesses documented antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, which may have offered passive udder protection [13].

For smallholder producers managing Sahiwal herds, the practical implication is a yield boost of roughly 2.5 L/day at

the higher dose, translating to approximately 150 L of additional milk over the trial period per cow. At local farmgate prices, this additional output would cover the supplement cost several times over, making the intervention economically attractive even without formal cost-benefit modelling.

Conclusion

Sahiwal cows occupy an important niche in tropical and subtropical livestock systems because of their heat tolerance, tick resistance, and capacity to thrive on low-quality forages traits that high-producing temperate breeds lack. But their modest milk output remains a persistent limitation for producers who rely on milk sales as a primary income source. Any intervention that can safely and affordably lift that output deserves close attention.

The present trial found that a polyherbal galactagogue mixture of fenugreek, black cumin, and fennel seed, fed at 100 g/day for 60 days, raised average daily milk yield by 24.1% relative to unsupplemented controls. This gain was dose-dependent, with the 50 g/day group achieving a 15.3% increase. Milk fat and protein percentages both improved in the supplemented groups, meaning that total solids output per day rose even more sharply than the volume figures alone suggest. Somatic cell count stayed within normal limits throughout, indicating no adverse effect on udder health at either dose.

Based on these outcomes, the recommendation is to incorporate the polyherbal blend at 100 g/cow/day into the routine feeding programme of Sahiwal herds during early to mid-lactation, when the mammary gland is most responsive to galactagogue stimulation. The raw materials fenugreek, black cumin, and fennel are widely available in most tropical and subtropical markets, and the preparation requires only grinding and mixing, with no specialised processing equipment. Extension services could promote this formulation as a low-technology, low-cost alternative to hormonal lactation enhancers.

Looking ahead, several questions remain open. Whether the yield response persists beyond 60 days or tapers off as the lactation curve naturally declines would determine the optimal supplementation window. Investigating the carry-over effect into the next lactation through residual mammary development or improved body condition would add long-term value to the assessment. Testing additional dose levels between 100 and 150 g/day could reveal whether the linear dose-response eventually reaches a plateau or continues upward. And extending the trial to other *Bos indicus* breeds such as Gir, Red Sindhi, or Tharparkar would establish whether the response is breed-specific or generalisable across tropical dairy genotypes.

Acknowledgements

Funding sources: This research was supported by an internal research allocation from the National Institute of Livestock Sciences, Ankara. No external funding was sought or received.

Institutional support: The authors acknowledge the Sahiwal Cattle Breeding Unit at the National Institute of Livestock Sciences for animal care, housing, and daily milk recording throughout the trial.

Contributions not qualifying for authorship: Mr. Hakan Özdemir assisted with feed preparation and sample collection logistics.

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