



Association between Chelated Mineral Supplementation on Production and Reproduction Performance of Lactating Cows Receiving Low Green Fodder

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Abstract

To assess the effect of chelated mineral supplementation on cow performance, twenty milking cows at eight days of lactation were allocated based on Randomized Block Design into two groups: control (T0; n = 7) and treatment (T1; n = 13). Cows were fed as per the farmer's practice with concentrate, wheat straw, and green fodder. In addition, cows in the T1 group were supplied with a chelated mineral mixture @ 65 g/day/animal for 188 days, while cows in the T0 group were not provided with a chelated mineral mixture. No significant difference ($P > 0.05$) was observed in the body weight of both groups. Higher ($P < 0.05$) total dry matter intake was observed in the treatment group. Overall mean values of milk yield, fat, fat-corrected milk, total solids, fat yield, and lactose were higher ($P < 0.05$) in the treatment group. Two cows (28.57%) of control and eleven cows (84.61%) of treatment showed postpartum oestrous within the three months. The pregnancy rate in treatment (53.84%) was higher than in control (28.57%). Therefore, it can be concluded that chelated mineral supplementation improves the production and reproduction performance of cows receiving low-green fodder.

Keywords: Fodder, Lactating Cows, Mineral mixture, Production, Reproduction.

Introduction

India leads the world in both animal population and milk production (221.06 million tonnes), and its per-capita milk availability is 444 g/day in 2021–22 (Annual report, DAHD 2022-23). However, the average daily milk production per cow is only 6.64 kg (Annual report, DAHD 2022-23), which is low. This low milk production per cow is primarily caused by dairy animals' poor nutritional status and genetic makeup, which results in various metabolic and reproductive disorders like anestrus, repeat breeding, and infertility (Bach 2019). The primary causes of poor growth, weakened body immunity, low milk production, and other reproductive issues in dairy cows are nutrient deficiencies and insufficient fodder in diet (Bindari *et al.*, 2013, Vipin *et al.*, 2020). Significant studies have been done over the past ten years to determine how supplementation of macro- and micro-minerals and vitamins affects the productivity, reproductive performance, and colostrum quality of dairy animals (Griffiths *et al.*, 2007, Garg *et al.*, 2008, Vipin *et al.*, 2021). When dairy animals are not given enough green fodder and minerals, their growth, milk yield, and reproductive performances may not be as good as they could be (Griffiths *et al.*, 2007). Animals use natural feeds and fodders to fulfill the requirement of minerals, and farmers are also adding inorganic salts to their ration as a mineral mixture supplementation. Due to antagonistic and antinutritional elements in the diet, one of the main drawbacks of utilizing such supplements is that the minerals from such sources are not effectively absorbed. Therefore, the idea of chelated mineral/mineral proteinate emerged to satisfy the rising need for bio-available elements (Spears, 1989). A chelated mineral is a mineral, such as copper, zinc, manganese, cobalt, iron, etc., that is linked to "small proteins", peptides, or amino acids. Therefore, the current study was carried out to determine the effect of chelated mineral mixture supplementation on the reproductive and productive performances of lactating cows on the farm.

Material and Methods

Study Location and Grouping of Animals

Twenty cows at 7 days post-calving were selected and grouped into two groups based on their milk production, parity, and body weights at Korjana, Bikrampur, and Basuhi villages in Begusarai district, Bihar, India. The initial body weight (at 8 days) (410.98 ± 74.35 vs. 416.81 ± 82.19 kg; $P = 0.879$), milk yield (8.49 ± 0.809 vs. 8.10 ± 2.24 kg/d; $P = 0.584$), and parity (2.57 ± 1.27 vs. 2.46 ± 1.26 ; $P = 0.857$) of the control and treatment groups were non-significant ($P > 0.05$).

Experimental Animal Feeding

The selected multiparous cows were individually fed with concentrate at 1.3 % BW, and wheat straw and green fodder (maize) as per the farmer's practice at 3-4, and 10-11 kg/d, respectively, on a fresh basis. The composition of the concentrate mixture fed to cows was wheat bran 24%, chana chunni 5%, mustard oil cake 21%, maize 35%, masoor chunni 5%, soybean cake 9%, and salt 1%. The green fodder was not sufficient to feed the animals due to a scarcity of fodder. The animals were allocated based on Randomized Block Design (RBD) into two groups: control (T_0 ; $n = 7$) and treatment (T_1 ; $n = 13$). In addition, cows in the T_1 group were fed a chelated mineral mixture with concentrate mixture at 65 g/day/animal for 188 days, while the control (T_0) group was not provided the chelated mineral mixture. The composition of the chelated mineral mixture is given in Table 1. The experiment was conducted from June to November 2022 and all cows were reared under similar feeding management.

Body Weight and Feed Intake Recording

Heart girth of animals was measured during field visits, and body weights were calculated as per Shaeffer's formula (Sastry *et al.*, 1982) at fortnightly intervals throughout the study from about 8 days after calving. The dry matter intake of each animal was recorded by feed offered to the animal and collection of feed refusals at monthly intervals after drying in a hot air oven at $100 \pm 1^\circ\text{C}$.

Determination of Milk Composition

Hand milking was used by every farmer during the whole study period. Milk produced from each animal was recorded fortnightly throughout the experimental feeding period using an electronic weighing machine. Representative samples of milk were taken and analyzed for chemical composition: lactose, milk fat, and solids-not

fat, using a pre-calibrated electronic milko tester (MT. SL. NO. 2002 S02, L & D Electronics Industries, Jaipur) just after collection. The fat-corrected milk (FCM, 3.5%) was calculated as per the formula derived by Gaines (1928).

Table 1: Composition of Chelated mineral mixture (per kg)

Nutrients	Quantity
Calcium (g)	200.00
Phosphorus (g)	100.00
Zinc (g)	5.00
Zinc Chelated (g)	5.00
Copper g	0.50
Copper chelated (g)	0.05
Cobalt (g)	0.12
Magnesium (g)	50.00
Sulphur (g)	40.00
Iodine (g)	0.26
Chromium chelated (g)	0.10
Flourine (g)	0.60
Vitamin A (IU)	500000.00
Vitamin D ₃ (IU)	10000.00
Vitamin E (mg)	58.00

kg-kilogram; g-gram; IU-international unit; mg-milligram

Reproductive Performance

Every cow was individually observed between 17 and 25-day intervals for the return of heat for estrous signs such as redness of the vulva, mounting, discharge, etc. Oestrous animals were to undergo artificial insemination, and the number of inseminations was counted and per-rectal examination confirmed pregnancy after 80-90 days of inseminations.

Statistics

All the data were analysed using Statistical Package for Social Science (SPSS version 16 of 2010) software and significantly different means separated using independent t-test. The significance level was considered at $P < 0.05$. All the data were presented as mean \pm SD. A comparison of the first day (8 days) and the last day (188 days) of study was made. The overall mean values were analysed between days 8 and 188 of the trial.

Results and Discussion

Bodyweight and Feed Intake

The average body weight of the two groups at the start of the experiment (8 days) and thereafter at fortnightly intervals till the 188th day of the experiment and their overall mean \pm SD values are depicted in Figure 1. No significant difference ($P > 0.05$) was observed in the values of the two groups at different time intervals, i.e., from day 8 to day 188. The overall mean values of body weight of the two groups were 409.08 ± 75.65 (T₀), and 414.78 ± 74.84 (T₁).

The results of dry matter intake recorded at monthly intervals (expressed as kg/day and kg percent of body weights) during the study are presented in Table 2. The average dry matter (%) of fodder, concentrate, and straw used by farmers to feed the animals was 19.00, 86.49, and 89.36%, respectively. A significant difference ($P < 0.05$) was observed among the groups following the supplementation of the mineral mixture on the total dry matter intake. No significant difference ($P > 0.05$) was observed among the groups following supplementation of the mineral mixture on the percent total dry matter intake of cows. Vipin *et al.* (2023) and Konidiba *et al.* (2022) reports are similar and

contrary, respectively to our results.

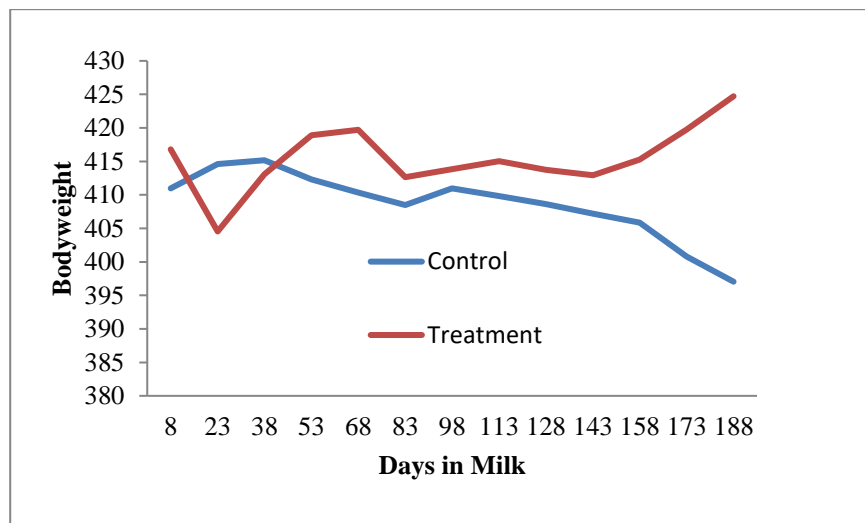


Figure 1: Effect of chelated mineral mixture supplementation on body weight of cows

Table 2: Dry matter intake (mean±SD) of experimental cows

Attributes	Time interval	Control (T ₀ ; N=7)	Treatment (T ₁ ; N=13)	P value
TDMI (kg/d)	First day (8 d)	7.95±0.730	8.02±0.659	NS
	last day (188 d)	9.04±0.860	9.50±0.876	NS
	Overall mean	8.79 ^a ±0.947	9.39 ^b ±1.07	<0.05
TDMI (%)	First day (8 d)	1.98±0.441	2.01±0.396	NS
	last day (188 d)	2.33±0.400	2.88±0.356	NS
	Overall mean	2.20±0.385	2.32±0.469	NS

TDMI-total dry matter intake; d-day; kg/d-kilogram per day; %-percent; NS-non-significant; ^{abc}in different rows differ significantly ($P<0.05$).

Production Performance

No significant difference ($P > 0.05$) was observed among the groups for milk yield, fat, FCM, total solids, and lactose yield on the initial day (at days 8) and last day experiment (at 188 days) values (Table 3). However, overall mean values of all days of experiment for milk yield, fat, FCM, total solids, and lactose yield for the two groups were significantly ($P<0.05$) different (Table 3). Bhosale *et al.* (2021) observed a significant improvement in milk yield and milk fat with the supplementation of chelated minerals. Kantwa *et al.* (2021) indicated that on supplementation with chelated minerals, the average milk production of buffalo was significantly higher ($P<0.01$) than the control group. Similar outcomes were also reported by Riad *et al.* (2018) and Somkuwar *et al.* (2011): an increase in milk yield in dairy animals due to the supplementation with chelated minerals. Singh *et al.* (2020) observed that on supplementing (50g) mineral mixture, average milk production, fat, and solid fat content were enhanced by 6.2, 5.3, and 1.8%, respectively, while milk production was enhanced by 490 mL/day/animal.

No significant difference ($P > 0.05$; Table 3) was observed among the groups for SNF and lactose at different time intervals. Bhosale *et al.* (2021) observed no significant improvement in SNF and lactose content in milk on supplementation with chelated minerals.

No significant difference ($P>0.05$) was observed among the groups for fat yield on day 8, but a significant difference ($P<0.05$) was observed on day 188 of the study (Table 3). The overall mean values of fat yield for the two groups

were significantly ($P<0.05$) different (Table 3).

The current research indicated that adding chelated mineral supplements increased by 14.27 % milk production of cows. This could be due to mineral metabolism by influencing the cells that produce more milk in the udder. The micro and macro elements help memory cells function better and increase their production (Pal *et al.* 2020). Contrary to this, Kedare *et al.* (2021) found no significant improvement in overall milk yields or composition of goats on supplementation with the area-specific mineral mixture.

Table 3: Milk Production and quality performance (mean±SD) of experimental animals

Attributes	Time interval	Control (T ₀ ; N=7)	Treatment (T ₁ ; N=13)	P value
Milk yield (kg/d)	first day (8 d)	8.49±0.809	8.10±2.24	NS
	last day (188 d)	7.06±0.623	9.45±4.40	NS
	Overall mean	8.17 ^a ±1.11	9.53 ^b ±3.19	<0.05
Fat (%)	first day (8 d)	4.01±0.311	4.04±0.313	NS
	last day (188 d)	4.24±0.241	4.43±0.175	NS
	Overall mean	4.11 ^a ±0.283	4.34 ^b ±0.231	<0.05
FCM (3.5%)	first day (8 d)	9.21±1.15	8.79±2.41	NS
	last day (188 d)	7.91±0.682	10.82±4.80	NS
	Overall mean	8.98 ^a ±1.28	10.81 ^b ±3.45	<0.05
SNF (%)	first day (8 d)	8.35±0.390	8.37±0.398	NS
	last day (188 d)	8.57±0.256	8.56±0.209	NS
	Overall mean	8.47±0.373	8.49±0.375	NS
Lactose (g/kg)	first day (8 d)	40.50±3.81	39.69±4.55	NS
	last day (188 d)	46.78±1.34	45.85±2.24	NS
	Overall mean	44.16±2.77	44.23±3.46	NS
Total solids (%)	first day (8 d)	12.38±0.434	12.39±0.558	NS
	last day (188 d)	12.81±0.259	13.00±0.326	NS
	Overall mean	12.58 ^a ±0.408	12.83 ^b ±0.478	<0.05
Fat yield (kg/d)	first day (8 d)	0.34±0.051	0.33±0.090	NS
	last day (188 d)	0.30 ^a ±0.027	0.41 ^b ±0.178	<0.04
	Overall mean	0.34 ^a ±0.052	0.41 ^b ±0.131	<0.05
Lactose yield (kg/d)	first day (8 d)	0.34±0.038	0.33±0.128	NS
	last day (188 d)	0.33±0.031	0.43±0.172	NS
	Overall mean	0.36 ^a ±0.052	0.42 ^b ±0.148	<0.05

FCM- fat corrected milk; SNF- solid not fat; d-day; NS-non-significant; ^{abc} in different rows ($P<0.05$) differ significantly.

Reproductive Performances

A significant difference ($P<0.05$) was observed in the resumption of the first heat after calving (days) among the control and treatment groups (Table 4). Two cows (28.57%) of control and eleven cows (84.61%) of treatment showed heat within three months after calving (Table 4). The pregnancy rate in control and treatment was 28.57% and 53.84%, respectively (Table 4). Kantwa *et al.* (2021) observed that due to the supplementation of chelated minerals, the average time for onset of first estrus after calving was lower (91.30 vs. 115.80 d; $P<0.01$) in the treated group as compared to the control group, respectively. These results are consistent with those reported by Vipin *et al.* (2022), Singh *et al.* (2020), Kumar *et al.* (2020), Tanwar *et al.* (2019), and Gupta *et al.* (2017), who likewise observed reduced time for postpartum estrous in the group receiving a mineral mixture and vitamin supplements compared to the control.

Table 4: Reproductive performances of experimental cows

Attributes	Control (N=7)	Treatment (N=13)	P value
Resumption of first heat after calving (days)	91.42 ^b ±7.180	52.07 ^a ±5.061	<0.05
Monthwise cyclicity (%) of animals			
1 st	0	7.69 (1)	
2 nd	0	53.84 (7)	

3 rd	28.57 (2)	23.07(3)
Total (%)	28.57 (2)	84.61(11)
Average number of AI used for pregnancy	2.0	1.5
Pregnancy (%) within 6 months	28.57 (2)	53.84 (7)

AI-artificial insemination; ^{abc} in different rows ($P<0.05$) differ significantly.

The average number of artificial inseminations used for pregnancy in control and treatment was 2.0 and 1.5, respectively (Table 4). Kantwa *et al.*, (2021) observed that the number of artificial inseminations required per conception was also significantly (1.65 vs. 2.60; $P<0.01$) lower in the supplemented group as compared to the control group. There was a significant difference in the number of artificial insemination/services per conception between the mineral mixture supplemented and non-supplemented groups in dairy animals, as reported by Tanwar *et al.*, (2019), Bhuvanewari (2019), and Gupta *et al.*, (2017).

Conclusion

From the current study, supplementing lactating cows with a chelated mineral mixture improves milk production and quality while also lowering the post-partum estrus period, and the number of inseminations per conception. Therefore, it is necessary to raise awareness among dairy farmers about the necessity to give their animals chelated mineral supplements to increase the production and reproduction performances of dairy animal husbandry.

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Contribution by Authors

Equal contribution. All authors declared that ‘written informed’ consent was obtained from the approved parties for the publication of this article and accompanying images.

Conflict of Interests

There is no conflict of interest.

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