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Effect of Mannan Oligosaccharides Supplementation on Milk Production, Composition, and Udder Health in Crossbred Lactating Cattle

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ABSTRACT: The present study was undertaken to evaluate the effect of Mannan Oligosaccharides (MOS) supplementation on milk production, composition, and quality in crossbred lactating cattle. Twelve mid-lactation crossbred cows (second to fourth parity) were randomly divided into two groups (n=6): T_0, receiving a basal diet (control), and T_1, receiving a basal diet supplemented with MOS at 12 g/cow/day. The trial was conducted for 90 days, with individual milk yield recorded daily and milk samples collected on the 45th and 90th day for analysis of fat, protein, SNF, total solids (TS), lactose, density, freezing point, pH, and somatic cell count (SCC). Results indicated that MOS supplementation significantly (P<0.01) increased milk fat percentage and significantly (P<0.05) improved milk protein and total solids compared to the control. SCC was significantly (P<0.01) reduced in the MOS-supplemented group, indicating improved udder health. However, milk yield, SNF, lactose, density, freezing point, and pH remained statistically non-significant (P>0.05). These findings suggest MOS as a beneficial natural feed additive for crossbred lactating cattle.

Keywords: Crossbred Cattle, Mannan Oligosaccharides, Milk Production, Milk Composition, Somatic Cell Count.

INTRODUCTION

The livestock industry plays a pivotal role in global food security, providing essential animal proteins in the form of milk, meat, and other dairy products. However, the misuse of antibiotics as growth promoters and prophylactic agents in animal production has led to the emergence of antibiotic-resistant bacteria, posing a major threat to both animal and human health (Coimbra *et al*., 2022; Marita *et al*., 2024). This growing concern has prompted the search for natural, safe, and effective alternatives to antibiotics that can enhance productivity and health without compromising food safety. Among such alternatives, *mannan oligosaccharides* (MOS), a prebiotic derived from the outer cell wall of *Saccharomyces cerevisiae*, have gained significant attention for their beneficial effects on gut health, immune modulation, and overall animal performance (Alagawany *et al*., 2023).

MOS functions primarily by modulating the gut microbial ecosystem. It promotes the proliferation of beneficial bacteria such as *Lactobacillus* and *Bifidobacterium* while inhibiting the colonization of pathogenic microorganisms by preventing their adhesion to intestinal epithelial cells (Hady *et al*., 2012; Kandasamy, 2022). This alteration in gut microbiota composition enhances nutrient absorption, stabilizes rumen fermentation, and reduces toxin production—factors crucial for maintaining optimal digestive efficiency in ruminants. Moreover, MOS exhibits immunomodulatory properties by stimulating both humoral and cellular immune responses, thereby improving disease resistance and overall animal health (Silva *et al*., 2012).

In dairy cattle, the supplementation of MOS has been reported to influence several production parameters. Studies have demonstrated that MOS can improve colostrum yield, enhance immune transfer to calves, and modulate immune responses during the transition and dry periods (Franklin *et al*., 2005; Westland *et al*., 2017). Although the effects of MOS on milk yield and composition have been variable, certain studies indicate potential improvements in milk quality attributes such as somatic cell count, fat content, and protein percentage (Bagheri *et al*., 2009). These variations are likely influenced by animal breed, lactation stage, dietary composition, and environmental conditions.

Crossbred cattle, widely reared in tropical regions, are known for their adaptability and productive potential but are often challenged by nutritional and environmental stressors affecting milk production and quality. Hence, evaluating the role of MOS supplementation in improving lactation performance and milk composition under such conditions is of particular importance. Therefore, the present study was undertaken to evaluate the effect of Mannan Oligosaccharides supplementation on milk production, composition, and quality in crossbred lactating cattle.

MATERIALS AND METHODS

The experiment was conducted at the Instructional Dairy Farm (IDF), Nagla, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. All experimental procedures were approved by the Institutional Animal Ethics Committee (IAEC) of G.B. Pant University and the study was conducted in accordance with CPCSEA guidelines.

A total of 12 crossbred lactating cattle (second to fourth parity, mid-lactation stage) were selected and divided into two groups (n=6 per group): T_0: Basal diet (control), T_1: Basal diet + Mannan Oligosaccharides (MOS) @ 12 g/cow/day

Animals were housed in a loose housing system under hygienic conditions and managed uniformly. All cows received ad libitum green and dry fodder, with concentrate feed offered twice daily during milking, adjusted according to milk yield. Clean drinking water was available at all times.

The trial was conducted for 90 days. Individual daily milk yield was recorded and averaged fortnightly. Milk samples were collected on the 45th and 90th day for compositional analysis, including fat, solids-not-fat (SNF), protein, total solids (TS), lactose, density, freezing point, and pH, using a LACTOSCAN milk analyzer. Somatic cell count (SCC) was also determined using the LACTOSCAN SCC module to assess milk quality and udder health.

This experimental design enabled evaluation of the effect of MOS supplementation on milk production, composition, and quality in crossbred lactating cattle.

Statistical analysis

The data was statistically analysed using a two-way ANOVA using SPSS version 21.0 to determine significant differences among treatment groups and sampling days, and to assess the influence of dietary interventions on different parameters. Mean comparisons were conducted using Duncan's multiple range test, with statistical significance considered at $P<0.05$ and $P<0.01$ (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

The results of supplementation of mannan oligosaccharides (MOS) at 12 g/cow/day resulted in a significant ($P<0.01$) increase in milk fat percentage and a significant ($P<0.05$) improvement in total solids and milk protein percentage as compared to the control group (Table 1). However, milk yield, SNF, and lactose percentage remained statistically non-significant ($P>0.05$) between treatments. The findings revealed that supplementation of MOS at 12 g/cow/day effectively improved milk fat, total solids, and protein content, thereby enhancing the overall milk quality of crossbred lactating cows.

Table 1: Effect of supplementation of MOS on milk production and composition of crossbred lactating cattle.

Parameters	T_0	T_1	SEM	T	D	T*D
Milk yield (kg)	8.88	9.18	0.28	0.45	0.22	0.99
Milk fat (%)**	4.12	4.43	0.07	0.00	0.34	0.77
Total solids (%)*	12.81	13.14	0.09	0.02	0.17	0.91
SNF (%)	8.69	8.70	0.07	0.96	0.44	0.96
Milk protein (%)*	3.17	3.26	0.03	0.02	0.01	0.01
Lactose (%)	4.85	4.75	0.05	0.13	0.03	0.70

SNF: Solid not fat; T_0: Basal diet (control); T_1: Basal diet + Mannan Oligosaccharides (MOS) @ 12 g/cow/day; T: Treatment effect; D: Day effect; T×D: Interaction between treatment and day; Means with different superscripts different significantly (*P<0.05, **P < 0.01) across the row

The observed enhancement in milk fat percentage following supplementation with MOS could be associated with their positive influence on rumen microbial dynamics and fatty acid metabolism. Improved milk fat content may be attributed to increased fiber digestibility and elevated acetate production during rumen fermentation. As a prebiotic, MOS supports the proliferation of beneficial rumen microorganisms such as *Lactobacillus* and *Bifidobacterium*, which in turn enhance volatile fatty acid (VFA) production and nutrient digestibility (Sharma *et al*., 2018). Additionally, MOS supplementation contributes to the stabilization of rumen pH, thereby reducing the risk of subacute ruminal acidosis (SARA), a condition often linked to decreased milk fat synthesis (Plaizier *et al*., 2008).

The increase in milk total solids including fat, protein, and lactose, might be due to MOS supplementation modulating the rumen microbial ecosystem. This modulation promotes beneficial microbial populations while suppressing protozoa, leading to improved nutrient utilization and enhanced synthesis of these milk components (Guo *et al*., 2021). However, some earlier reports have indicated that MOS supplementation may not significantly influence milk fat or solid-not-fat (SNF) content but could still exert beneficial effects on gut health and immune function in dairy animals (Westland *et al*., 2017).

The increase in milk protein might be due to these supplements optimizing protein metabolism by improving nitrogen utilization and enhancing microbial protein production in the rumen, which provides essential amino acids for milk protein synthesis (Guasch *et al.*, 2016; Elcoso *et al*., 2019). Additionally, they may support overall cow health and feed efficiency, further contributing to improved milk quality.

Milk somatic cell count and physical properties

Supplementation of MOS at 12 g/cow/day resulted in a significant (P<0.01) reduction in somatic cell count (SCC) in the treatment (T_1) group as compared to the control (T_0) group (Table 2) indicating improved udder health. However, the effects on milk density, freezing point and pH were non-significant. The significant decrease in SCC with MOS supplementation suggests its positive influence on mammary gland health and milk quality, while the overall physical properties of milk remained largely unaffected.

Supplementation with Mannan Oligosaccharides (MOS), derived from yeast cell walls, has been shown to improve milk quality in dairy cows by reducing somatic cell count (SCC), an important indicator of udder health and mastitis risk. MOS binds to pathogenic bacteria such as *E. coli* and *Salmonella*, preventing their attachment to the intestinal lining and reducing systemic inflammation, which indirectly supports udder health (Tewoldebrhan *et al*., 2017). This immunomodulatory effect enhances cows' ability to combat infections, maintaining lower SCC levels and improving milk yield and quality. The use of natural supplements like MOS also aligns with sustainable, antibiotic-reducing dairy practices. Similar studies have been reported by Tewoldebrhan *et al.* (2017), who found that exogenous β-mannanase improved feed conversion efficiency and reduced SCC in dairy cattle. Additionally, Tosun (2024) demonstrated that MOS supplementation improved immune function in dairy cows, leading to lower SCC levels and enhanced milk yield and quality. These findings underscore the potential of MOS as a natural supplement to improve udder health and milk quality in dairy cows.

Table 2: Effect of supplementation of MOS on milk somatic cell count and physical properties of crossbred lactating cattle.

Parameters	T_0	T_1	SEM	T	D	T*D
SCC (×10³ cells/ml)**	190.50	123.17	9.90	0.00	0.86	0.92
Density (kg/m³)	1027.97	1027.83	0.38	0.79	0.06	0.64
Freezing point (ºC)	-0.587	-0.583	0.01	0.74	0.05	0.01
pH	6.78	6.81	0.07	0.71	0.84	0.41

SCC: Somatic cell count; T_0: Basal diet (control); T_1: Basal diet + Mannan Oligosaccharides (MOS) @ 12 g/cow/day; T: Treatment effect; D: Day effect; T×D: Interaction between treatment and day; Means with different superscripts different significantly (**P<0.01) across the row

Supplementation of Mannan Oligosaccharides (MOS) did not cause significant changes in milk density, freezing point, or pH, which might indicate that the fundamental composition and physicochemical properties of milk were largely maintained. Consistent density might suggest stable milk quality and absence of adulteration (Fehér Pindešová *et al*., 2022). The unchanged freezing point might indicate that MOS did not markedly affect osmotic balance or solute concentration, despite potential influences from lactation stage, diet, or udder health (Henno *et al*., 2008). Similarly, stable pH might indicate that microbial activity and protein stability remained unaltered, preserving milk's intrinsic quality and suitability for processing (Aydogdu *et al*., 2023).

CONCLUSIONS

Supplementation of MOS at 12 g/cow/day positively influenced milk composition and udder health in crossbred lactating cows. It significantly increased milk fat, protein, and total solids, thereby enhancing overall milk quality, and reduced SCC, indicating improved mammary gland health. However, MOS supplementation did not significantly affect milk yield, SNF, lactose, density, freezing point, or pH, suggesting that the fundamental physicochemical properties of milk remained stable. Overall, MOS can be considered an effective natural feed additive for improving milk quality and supporting udder health without altering the intrinsic milk characteristics.

FUTURE SCOPE

Future studies could evaluate the effects of different doses of MOS on milk yield, composition, and udder health to determine the optimal supplementation level. Research can also explore long-term impacts and potential synergistic effects when combined with other natural feed additives for enhanced dairy performance.

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