

Gut Microbiome Modulation as a Strategy to Improve Heat Stress Resilience in Dairy Cattle: A Controlled Field Study

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ABSTRACT:

Heat stress is a major constraint affecting dairy cattle productivity in tropical regions, leading to reduced milk yield, metabolic imbalance, and increased disease susceptibility. This study investigates the role of gut microbiome modulation using a synbiotic formulation in improving heat stress resilience in lactating dairy cows. A total of 40 Holstein-Friesian crossbred cows were divided into control and treatment groups over 60 days during peak summer conditions. Physiological parameters, milk yield, and ruminal microbial diversity were assessed. Results showed significant improvements in rectal temperature regulation, feed intake, and milk production in the treated group. Microbiome analysis revealed increased abundance of beneficial bacteria such as *Lactobacillus* spp. and *Bifidobacterium* spp. The findings suggest that microbiome-targeted interventions can serve as a sustainable strategy to mitigate heat stress in dairy cattle.

KEYWORDS: veterinary microbiology; heat stress; dairy cattle; gut microbiome; synbiotics; animal productivity.

INTRODUCTION

Heat stress is a critical challenge in livestock production, particularly in tropical and subtropical regions. Elevated ambient temperatures disrupt physiological homeostasis, leading to oxidative stress, reduced feed intake, and compromised immune function.

Recent studies highlight the importance of the gut microbiome in regulating host metabolism and stress response. However, limited research exists on microbiome-targeted interventions in large ruminants under field conditions.

This study aims to evaluate the effect of synbiotic supplementation on physiological adaptation, productivity, and gut microbial composition in dairy cattle exposed to heat stress.

2. MATERIALS AND METHODS

i. Study Design

- Location: Coastal Andhra Pradesh, India
- Duration: 60 days (May–June)
- Sample Size: 40 lactating cows

Groups:

- Control (n=20)
- Synbiotic-treated (n=20)

ii. Treatment Protocol

- The treatment group received a daily oral synbiotic supplement containing:
- Probiotics: *Lactobacillus acidophilus*, *Bifidobacterium bifidum*.
- Prebiotics: Fructooligo saccharides.

iii. Data Collection

- Physiological parameters: Rectal temperature, respiration rate
- Production parameters: Daily milk yield
- Microbiome analysis: 16S rRNA sequencing

vi. Statistical Analysis

Data were analyzed using ANOVA with significance set at $p < 0.05$.

3. RESULTS

i. Physiological Response

- Treated cows showed significantly lower rectal temperatures ($p < 0.01$)
- Improved respiration stability observed

ii. Milk Production

- Average milk yield increased by 12.5% in treated group

iii. Microbiome Changes

- Increased beneficial bacteria:
- *Lactobacillus* spp. ↑
- *Bifidobacterium* spp. ↑
- Reduced pathogenic bacterial load.

VI. FIGURES

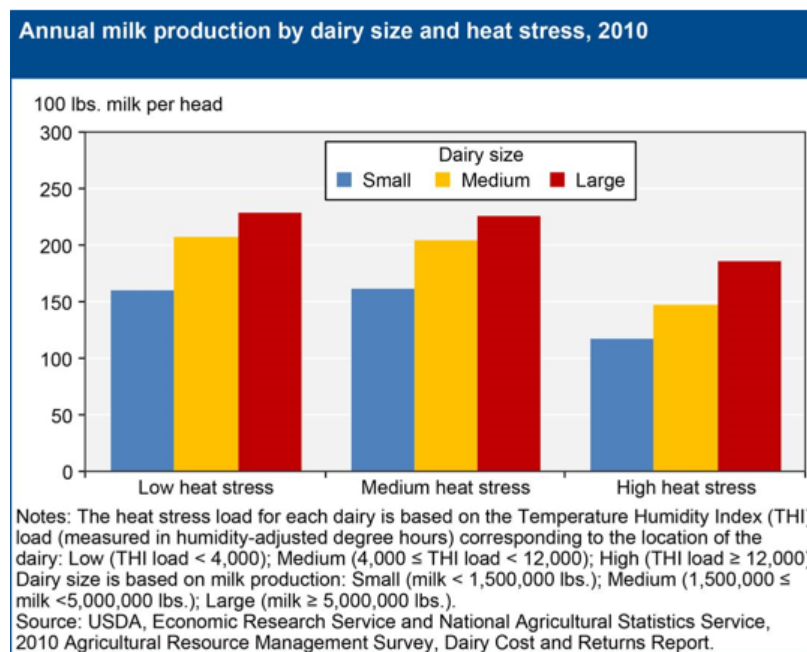


Figure 1: Effect of Synbiotic Treatment on Milk Yield

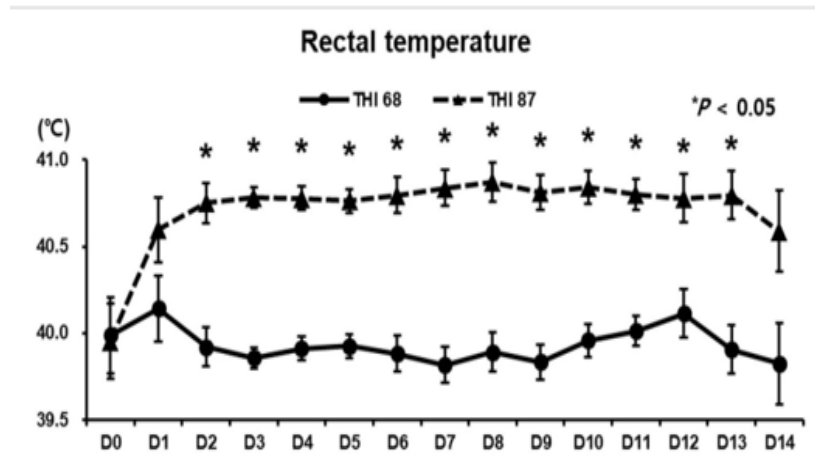


Figure 2: Changes in Rectal Temperature

5. DISCUSSION

The findings demonstrate that synbiotic supplementation significantly enhances thermotolerance in dairy cattle. Improved microbial balance likely contributed to better nutrient absorption and metabolic efficiency. The increase in beneficial bacterial populations supports previous evidence linking gut microbiota to systemic stress responses. Additionally, the improvement in milk yield suggests economic benefits for farmers in hot climates.

However, long-term studies and larger sample sizes are required to validate these findings across different breeds and environments.

6. CONCLUSION

Synbiotic-based microbiome modulation is an effective and sustainable approach to mitigate heat stress in dairy cattle. This strategy can enhance productivity and animal welfare, particularly in regions facing rising temperatures due to climate change.

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