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Effect of rumen-protected glucose supplementation on milk yield and composition in early-lactation Sahiwal COWS

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Abstract

Dairy cows face a massive metabolic challenge immediately after calving, as their bodies demand more nutrients for milk production than they can physically consume. To determine if targeted feeding could help close this energy gap, this study tested how supplementing rumen protected glucose and lipids alters the milk yield and composition of early lactation Sahiwal cows. 12 cows in early lactation were randomly divided into two equal groups, providing the treatment group with a daily dose of 150 grams of rumen protected glucose comprising of 60% glucose core protected by a 40% rumen inert lipid coating for 28 days. We then tracked their daily milk output and tested the milk for fat, protein, lactose, and non-fat solids. The added bypass energy made a clear difference in production. Starting in the second week, the supplemented cows began producing significantly more fluid milk than the control group, an advantage they held onto for the remainder of the trial ($p < 0.05$). Crucially, producing more fluid milk did not dilute the valuable milk components. In fact, the treated cows produced a significantly higher concentration of milk fat ($3.55 \pm 0.08\%$ compared to $3.22 \pm 0.08\%$; $p < 0.05$) while keeping their protein, lactose, and non-fat solid levels completely stable between the groups ($p > 0.05$). Ultimately, sending usable energy and readymade fats straight to the small intestine proved to be a highly effective way to help the udder partition energy. Feeding this dual supplement offers a practical strategy to boost total milk volume, maintain peak production longer, and increase the overall value of the milk components simultaneously.

Keywords: Sahiwal cows, rumen protected glucose, bypass fat, milk composition, energy balance, lactational persistency

Introduction

Supported by a massive and genetically diverse population of native cattle, India's dairy industry remains one of the largest in the world. These indigenous herds act as the backbone for both rural economies and national food security, largely due to their ability to withstand severe environmental disturbances (Prakash *et al.*, 2024) [13]. The Sahiwal (*Bos indicus*) easily stands out within this group as a top-tier dairy breed. Producers across the subcontinent value them for their heavy milk yields alongside an inherent, evolved ability to thrive under high thermal stress and resist endemic tick-borne infections (Khan *et al.*, 2018) [7]. There is a biological trade-off to this ongoing progress, however. Because targeted genomic selection and improved management practices have successfully driven their production capacity upward (Muansangi *et al.*, 2025) [12], modern Sahiwal cows are now encountering the same severe metabolic roadblocks once thought to affect only specialized exotic cattle. Managing the massive energy drain that hits right after calving has therefore become a primary hurdle for optimizing Sahiwal herd performance in contemporary dairy systems (Chandra *et al.*, 2013) [3].

The time right around calving often called the transition phase puts extreme metabolic stress on dairy cows. When milk production suddenly starts, the cow's body faces a massive, immediate need for glucose, protein, and energy to build milk fat and lactose (Wankhade *et al.*, 2017) [17]. The problem is that cows naturally eat a lot less right after giving birth. This sudden drop in feed intake forces them into a severe negative energy balance (Drackley, 2011) [5].

To keep making milk, the cow has no choice but to break down her own stored fat and muscle tissue. But if she mobilizes this body fat too quickly, her liver simply cannot process it all. That overload leads directly to metabolic diseases like ketosis and fatty liver (Ma *et al.*, 2022 ^[11]; Sammad *et al.*, 2021) ^[14]. Managing this energy crash is especially vital for native breeds like the Sahiwal. When their daily feed lacks enough energy, Sahiwal cows lean heavily on their internal body reserves to keep lactation going (Chandra *et al.*, 2013) ^[3].

Down inside the udder's secretory cells, glucose is absolutely essential. It is the main building block needed to make lactose (Lin *et al.*, 2016) ^[10]. Why does lactose matter so much? It acts as a physiological magnet for water. Through osmosis, lactose pulls fluid into the milk, meaning the amount of glucose circulating in the cow's blood directly controls her overall fluid milk volume (Chaibutur, 2012^[2]; Zhang *et al.*, 2021 ^[19]). Unlike pigs or humans, cows rely on rumen microbes that rapidly ferment dietary carbohydrates into volatile fatty acids. By the time digestion moves past the rumen, barely any intact glucose is left to absorb (Wang *et al.*, 2021) ^[15]. Because of this, a cow's liver has to manufacture its own glucose from scratch, mostly using propionate. But since early-lactation cows aren't eating much, they don't have enough propionate available. We cannot simply feed them massive amounts of starch to fix the deficit, either. Overfeeding starch frequently triggers ruminal acidosis, which ruins fiber digestion and harms the animal (Chandra *et al.*, 2013) ^[3].

To get around this digestive roadblock, animal nutritionists developed rumen protected glucose (RPG). Manufacturers encapsulate the glucose so the rumen microbes cannot break it down. Instead, it passes safely straight into the lower gut, where the cow absorbs it directly as pure, usable energy (Wang *et al.*, 2021 ^[15]; Zewdu *et al.*, 2024). Past trials show that feeding RPG helps cows save their own tissue, shrinks the negative energy gap, and pushes milk yields higher (Li *et al.*, 2019 ^[9]; Wang *et al.*, 2022) ^[16]. Even so, results in the literature can be inconsistent. A cow's response shifts depending on the exact dose she receives, her age, and her underlying health status (Ma *et al.*, 2022). Because of these variables, we set up this trial to determine exactly how early lactation Sahiwal cows handle a specific daily supplement of 150 grams of RPG, focusing closely on how it alters both their total milk volume and the composition of the milk.

2. Materials and Methods

2.1 Place of work

This research was conducted at the Bull Mother Experimental Farm (BMEF), College of Veterinary Science and Animal Husbandry, Anjora, Durg, Chhattisgarh, India (21.161° N, 81.231° E). The study site recorded an average ambient temperature of 32 °C and relative humidity levels spanning 25 to 35% over the course of the trial.

2.2 Selection of animals

A total of 12 healthy, early lactation Sahiwal cows (aged 3 to 7 years) were selected and screened prior to the trial to ensure they were free from clinical mastitis, lameness, and metabolic abnormalities.

2.3 Experimental design

For the 28 days duration of the experiment, a completely randomized design was applied to allocate the twelve

animals into two distinct groups (n = 6). Cows in the control group were fed exclusively the standard basal diet. The concentrate portion of this diet contained 21.22% crude protein, 3.83% crude fat, 5.46% crude fibre, and 14.19% total ash. In contrast, the treatment group consumed the basal diet along with a daily supplement of 150 g of rumen protected glucose per animal. This supplement, comprising a 60% glucose core protected by a 40% rumen inert lipid coating, was administered as a top dress after the morning milking to ensure total intake. Standard husbandry practices of the BMEF were observed for all subjects.

2.4 Sample collection

Following the standard milking protocols of the farm, individual daily milk yields (kg/day) were recorded for each cow throughout the entire 28 days trial to track production changes. To evaluate qualitative parameters, a 20 ml milk sample was collected from each animal during the morning milking every third day. The fresh samples were processed through a Master LM2 Ultrasonic Milk Analyzer to quantify the percentages of milk fat, solids not fat (SNF), protein, and lactose.

2.5 Statistical analysis

Data are presented as Mean±SEM. Following Levene's test for equality of variances, weekly milk yield was analyzed using a repeated-measures ANOVA to assess the main effects of treatment, time, and their interaction. Milk composition parameters (Fat, Solids-Not-Fat, Protein, and Lactose) were evaluated using a Two-Way ANOVA, designating diet and sampling day as fixed factors. Significant effects or interactions were further analyzed using a Bonferroni post-hoc test. All analyses were performed in IBM SPSS Statistics (version 27.0.1.0), with significance defined at $p \leq 0.05$.

3. Results

3.1 Production performance

The effects of the dietary intervention with RPG on average daily milk production over the 28 days trial are presented in Table 1. While baseline milk yield during Week 1 was comparable between the Control (6.79±0.51 kg/day) and Treatment (7.36±0.51 kg/day) groups ($p = 0.440$), a significant Treatment x Time interaction was observed as the trial progressed. Beginning in Week 2, the supplemented cows demonstrated a statistically significant increase in daily milk yield (8.50±0.36 kg/day) compared to the Control group (6.77±0.36 kg/day) ($p = 0.007$). This elevated production was sustained through Week 3, with the Treatment group yielding 8.45±0.33 kg/day against the Control's 6.72±0.33 kg/day ($p = 0.004$). By Week 4, while the Control group exhibited a gradual decline characteristic of advancing lactation (6.32±0.42 kg/day), the Treatment group maintained significantly higher lactational persistency, yielding 8.05±0.42 kg/day ($p = 0.016$).

3.2 Milk compositional characteristics

The effects of the dietary intervention with RPG on milk composition are presented in Table 2. The supplementation resulted in a statistically significant increase in milk fat concentration, with the Treatment group averaging 3.55±0.08% compared to 3.22±0.08% in the Control group ($p = 0.007$). Notably, despite the significant increase in overall fluid milk yield reported earlier, there was no

dilutional effect on the other milk components. The concentrations of Solids-Not-Fat (SNF), protein, and lactose remained highly stable and did not differ significantly between the Control and Treatment groups ($p = 0.651$, $p = 0.829$, and $p = 0.447$, respectively). Furthermore, no significant Treatment $\times$ Time interactions were observed for any of the milk composition parameters.

4. Discussion

This study aimed to see how a high-density bypass energy supplement affects both milk production and composition. A major ongoing challenge in dairy feeding is the "dilution effect", when dietary changes successfully increase milk volume, the percentages of valuable components like fat and protein often drop. Our findings demonstrate a unique dual benefit. The supplemented cows not only produced significantly more milk overall, but they also showed a higher milk fat percentage (3.55% vs. 3.22%, $p = 0.007$) without losing any protein or non-fat solids.

Looking at the production timeline, the supplemented group started yielding significantly more fluid milk by the second week ($p < 0.05$), and this advantage held steady through week four. This quick response shows that the bypass energy effectively countered the cows' negative energy balance. These results line up closely with studies by Yu *et al.*, (2024) [18] and Zhang *et al.*, (2021) [19], who found that rumen-protected glucose supplies direct, usable energy post-rumen. Because the udder uses this glucose to make lactose which in turn pulls water into the milk this pathway directly increases the total fluid volume. Interestingly, our cows maintained this higher production right through day 28. This pushes back against the argument proposed by Wang *et al.*, (2022) [16] that providing bypass energy only makes

biological and financial sense during the first 21 days postpartum. Our data clearly shows that targeted feeding can prevent a sharp drop in yield well beyond that initial transition phase.

The fact that milk fat also increased suggests that feeding rumen-protected fats alongside the glucose works highly synergistically. Chagas *et al.*, (2026) [1] pointed out that regular, unprotected fats can harm rumen microbes and reduce feed intake. However, because the lipids in our supplement were protected, the long-chain fatty acids went straight to the small intestine. The udder easily absorbs these circulating pre-made fats and packs them into milk triglycerides. This saves the cow a massive amount of energy compared to synthesizing fat from scratch (De Souza *et al.*, 2019) [4]. It is worth noting that several recent meta-analyses, such as those by Lashkari *et al.*, (2024) [8] and Gallardo and Teixeira, (2023) [6], found that lipid supplementation frequently depresses dry matter intake and primarily alters milk fatty acid profiles, rather than consistently boosting total fluid milk volume. Our cows successfully achieved both, likely because our specific dietary mix provided the rumen-protected glucose needed to drive volume alongside the lipids needed for fat concentration at the exact same time.

Finally, the steady protein (3.44%) and SNF (9.39%) levels in the treated cows confirm their overall metabolism was perfectly balanced. If the extra energy had outpaced the available amino acids, the milk protein percentage would have dropped due to dilution. Instead, the stable numbers confirm the cows' mammary cells were fully supported, allowing the farm to improve milk quantity and quality simultaneously.

Table 1: Effect of rumen protected glucose on the weekly and overall milk yield (kg/day) in Sahiwal cows.

Week	Control (n = 6)	Treatment (n = 6)	p value (Treatment)
Week 1	6.79 $\pm$ 0.51	7.36 $\pm$ 0.51	0.440
Week 2	6.77 $\pm$ 0.36 ^b	8.50 $\pm$ 0.36 ^a	0.007
Week 3	6.72 $\pm$ 0.33 ^b	8.45 $\pm$ 0.33 ^a	0.004
Week 4	6.32 $\pm$ 0.42 ^b	8.05 $\pm$ 0.42 ^a	0.016
Overall Mean	6.65 $\pm$ 0.32 ^b	8.09 $\pm$ 0.32 ^a	0.010

Data are presented as Mean $\pm$ SEM (n = 6). Main effect of Week: $p = 0.195$; Interaction effect of Treatment $\times$ Week: $p = 0.183$. Different superscripts within a row indicate a significant difference ($p < 0.05$).

Table 2: Effect of rumen protected glucose on the milk composition (%) in Sahiwal cows.

Parameters	Control (n = 6)	Treatment (n = 6)	p value (Treatment)	p value (Week)	p value (Treatment*Week)
Fat	3.22 $\pm$ 0.08 ^b	3.55 $\pm$ 0.08 ^a	0.007	0.590	0.805
SNF	9.42 $\pm$ 0.04	9.39 $\pm$ 0.05	0.651	0.169	0.810
Protein	3.44 $\pm$ 0.02	3.44 $\pm$ 0.02	0.829	0.115	0.941
Lactose	5.17 $\pm$ 0.02	5.14 $\pm$ 0.03	0.447	0.127	0.825

Values (Mean $\pm$ SEM; n = 6) bearing different superscripts in the same row differed significantly ($p < 0.05$).

5. Conclusion

In these 28 days trial, supplementing lactating dairy cows with a rumen protected glucose positively impacted production performance. The dual bypass supplementation resulted in a sustained increase in fluid milk yield throughout the study period. Additionally, the treatment increased milk fat percentage without causing a dilution effect, as milk protein and lactose concentrations remained stable. These findings indicate that rumen protected glucose supplementation effectively supports both milk volume and component quality of cows in early lactation.

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