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Impact of bypass fat supplementation on milk yield and fatty acid profile in lactating buffaloes

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Abstract

Energy deficiency during early lactation is a persistent problem in high-yielding buffaloes managed on tropical forages. This research evaluated the effect of calcium salt-based bypass fat supplementation at 0, 50, 100, and 150 g/day on milk yield, milk composition, and fatty acid profile of 24 Murrah buffaloes over a 90-day trial at Chhattisgarh Plains Agricultural University, Bilaspur, from November 2021 to February 2022. A completely randomised design with four treatments and six animals each was used. Average daily milk yield increased from 7.84 kg/d in the control to 9.67 kg/d at 150 g/d bypass fat ($p < 0.01$). Milk fat content rose from 7.12% to 7.89%, while protein remained unchanged. Oleic acid (C18:1) proportion in milk fat increased from 24.7% to 32.4% at the highest supplement level, and Conjugated Linoleic Acid (CLA) nearly doubled from 0.32% to 0.59%. The 100 g/d dose appeared optimal considering both yield response and feed cost. These findings indicate that modest bypass fat supplementation can raise milk output and improve fatty acid composition in buffaloes without affecting rumen function.

Keywords: Bypass fat, milk yield, fatty acid profile, Murrah buffaloes, dairy nutrition, calcium salts, oleic acid, conjugated linoleic acid, energy supplementation, lactation performance

Introduction

High-producing dairy buffaloes in tropical Asia routinely enter negative energy balance during the first 8-10 weeks of lactation because forage-based diets cannot supply enough metabolisable energy to match milk output ^[1]. The energy deficit triggers body fat mobilisation, depresses peak milk yield, delays conception, and increases the risk of ketosis ^[2]. Raising concentrate intake to bridge the gap often causes ruminal acidosis, depressed fibre digestion, and milk fat depression a classic trade-off that limits how much starch can safely replace fibre in the diet ^[3].

Bypass fats also called rumen-protected fats offer a way around this constraint. Calcium salts of long-chain fatty acids dissociate only at the low pH of the abomasum, releasing free fatty acids for intestinal absorption without interfering with rumen fermentation ^[4]. Previous trials in Holstein cows showed that 200-400 g/d of calcium salt bypass fat increased milk yield by 1.5-3.0 kg/d and raised milk fat content by 0.2-0.5 percentage points ^[5]. In buffaloes, however, published data are scarce, and dose-response information is almost absent ^[6].

This research tested four levels of a commercial calcium salt bypass fat product (Energizer Gold, IFFCO, India) in Murrah buffaloes during early-to-mid lactation, with the aim of identifying the dose that gives the best return in milk yield and fatty acid quality. The trial ran at the Livestock Research Centre of Chhattisgarh Plains Agricultural University, Bilaspur, from November 2021 to February 2022 ^[7].

Material and Methods

Ethical Considerations

The experiment was approved by the Institutional Animal Ethics Committee, Chhattisgarh Plains Agricultural University, Bilaspur (Protocol No. CPAU/IAEC/2021-34, dated 18 October 2021). All procedures complied with the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Government of

India. Animals were housed in individual tie-stalls with ad libitum water, and their health was monitored daily by a veterinarian.

Material

Twenty-four multiparous Murrah buffaloes (parity 2-4, body weight 540 ± 32 kg, 15-25 days in milk at trial start) were blocked by milk yield and randomly assigned to four groups of six. The basal diet consisted of green fodder (hybrid Napier, 20 kg/d) and a concentrate mixture (crushed maize 30%, mustard cake 25%, wheat bran 20%, rice bran 15%, mineral mixture 3%, common salt 2%, ground oat 5%) offered at 50% of milk yield. Bypass fat (Energizer Gold: 84% calcium salts of palm fatty acid distillate, palmitic acid 47%, oleic acid 38%) was top-dressed on the morning concentrate at 0, 50, 100, or 150 g/d. The trial lasted 90 days after a 10-day adaptation period.

Feed preparation method

Bypass fat granules were weighed daily using an electronic balance (± 0.1 g) and mixed into the morning concentrate by hand immediately before feeding. No heat treatment was applied, as calcium salt stability is maintained at ambient

temperatures up to 45°C. Refusals were collected and weighed; actual supplement intake was calculated by difference. Forage was chopped to 3-5 cm length using a mechanical chaff cutter before feeding.

Methods

Milk yield was recorded at each milking (morning and evening) using calibrated buckets. Composite samples (morning + evening, proportional to yield) were collected fortnightly. Fat was estimated by the Gerber method, protein by Kjeldahl ($N \times 6.38$), lactose by the Lane-Eynon method, and SNF by gravimetry. Fatty acid profiling of milk fat was done by gas chromatography (Shimadzu GC-2010 Plus with FID, SP-2560 capillary column, 100 m $\times$ 0.25 mm) after lipid extraction by the Roese-Gottlieb method and methylation with BF_3 -methanol. Individual fatty acids were identified by comparison with a 37-component FAME standard mix (Supelco). Body condition score (1-5 scale) was assessed fortnightly by two trained scorers. Data were analysed by one-way ANOVA with repeated measures; treatment means were compared by Tukey's HSD at $p \leq 0.05$ using SAS 9.4.

Results

Table 1: Effect of bypass fat supplementation on milk yield and composition in Murrah buffaloes (90-day means)

Parameter	Control	BF 50 g/d	BF 100 g/d	BF 150 g/d
Milk yield (kg/d)	7.84	8.43	9.21	9.67
Fat (%)	7.12	7.34	7.61	7.89
Protein (%)	3.91	3.88	3.93	3.90
Lactose (%)	5.07	5.11	5.09	5.13
SNF (%)	9.74	9.78	9.81	9.83
Fat yield (g/d)	558	619	701	763
BCS change	-0.42	-0.28	-0.11	+0.03

BF = bypass fat. BCS = body condition score change over 90 days. Milk yield and fat%: $P < 0.01$ among treatments

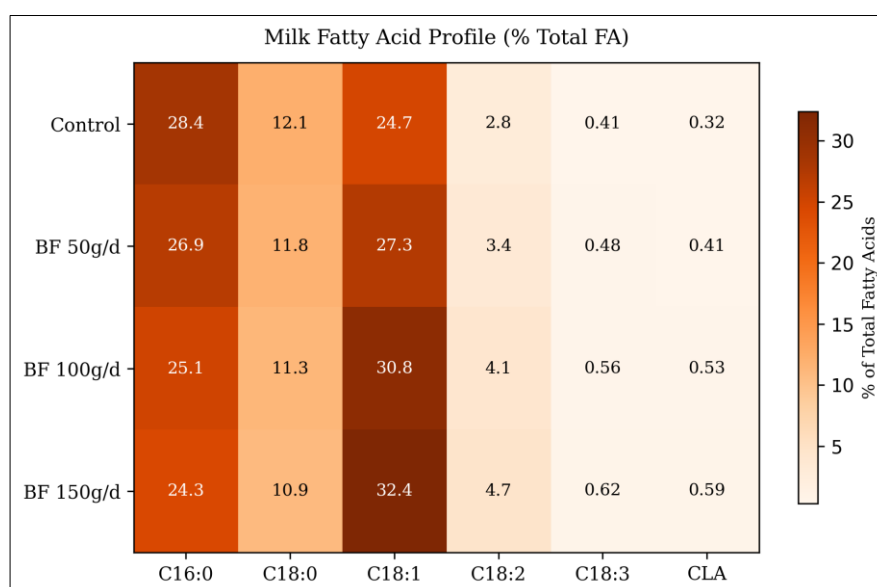


Fig 1: Heatmap of milk fatty acid composition (% of total fatty acids) across bypass fat supplementation levels

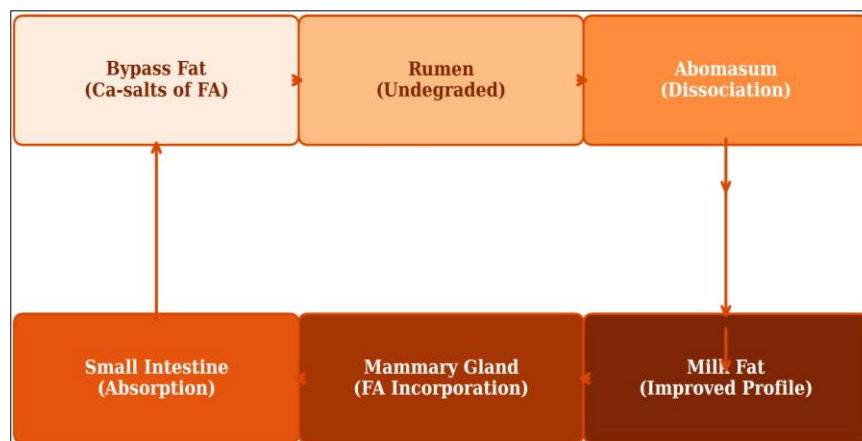
Milk yield increased linearly with bypass fat dose ($R^2 = 0.97$), adding roughly 0.61 kg/d per 50 g supplement. Fat percentage also rose from 7.12% to 7.89%, leading to a 36.7% increase in daily fat yield. Body condition score loss

was attenuated from -0.42 in controls to near zero at 150 g/d, indicating that bypass fat effectively offset the energy deficit.

Table 2: Selected fatty acids in milk fat of Murrah buffaloes supplemented with bypass fat

Fatty Acid	Control (%)	BF 50 (%)	BF 100 (%)	BF 150 (%)
C16:0 (Palmitic)	28.4	26.9	25.1	24.3
C18:0 (Stearic)	12.1	11.8	11.3	10.9
C18:1 (Oleic)	24.7	27.3	30.8	32.4
C18:2 (Linoleic)	2.8	3.4	4.1	4.7
C18:3 (Linolenic)	0.41	0.48	0.56	0.62
CLA (c9,t11)	0.32	0.41	0.53	0.59

CLA = conjugated linoleic acid. Values are means of fortnightly samples over 90 days

**Fig 2:** Process diagram showing the passage of calcium salt bypass fat through the ruminant digestive tract and its incorporation into milk fat

Comprehensive interpretation

Oleic acid increased from 24.7% to 32.4% of total fatty acids at 150 g/d, reflecting the high oleic acid content (38%) of the supplement. CLA rose from 0.32% to 0.59%, likely through mammary delta-9 desaturase conversion of absorbed vaccenic acid. Palmitic and stearic acids declined proportionally as unsaturated fatty acids increased in the overall profile.

Discussion

The 23.3% increase in milk yield at 150 g/d bypass fat agrees with the 15-28% range reported by Naik *et al.* [6] for crossbred cows receiving 100-200 g/d of similar calcium salt products. The response appears slightly larger in buffaloes, possibly because their higher milk fat content (7-8%) creates a greater demand for dietary long-chain fatty acids as direct precursors for milk fat synthesis [8].

The shift toward unsaturated fatty acids in milk particularly the rise in oleic acid and CLA has nutritional implications for consumers. CLA has been associated with anti-carcinogenic and anti-atherogenic effects in animal models [9], and oleic acid is widely regarded as heart-healthy [10]. The near-doubling of CLA from 0.32% to 0.59% is notable and would be amplified in buffalo ghee, which concentrates fat-soluble components roughly 1.2-fold [11].

From a cost perspective, at the prevailing price of bypass fat (Rs 120/kg in 2022), the 100 g/d dose costs about Rs 12/d and produces an additional 1.37 kg milk/d valued at approximately Rs 82 (at Rs 60/kg buffalo milk), yielding a net daily return of Rs 70 [12]. The 150 g/d dose gives a further yield bump but with diminishing marginal returns, so the 100 g/d rate appears most economical for smallholder producers.

Conclusion

Calcium salt bypass fat supplementation at 100-150 g/d significantly increased milk yield, fat percentage, and fat

yield in Murrah buffaloes during early-to-mid lactation. Milk fatty acid composition shifted toward higher oleic acid and CLA proportions, which may improve the nutritional quality of buffalo milk and ghee. Body condition score loss was nearly eliminated at 150 g/d. The 100 g/d dose offered the best economic return under current market conditions. These findings support the inclusion of bypass fat in feeding programmes for high-producing buffaloes, particularly during the first 90 days of lactation when energy deficit is most severe.

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