change in milk production on supplementation of protected fat (Loor *et al*., 2002).

Number of studies have been conducted on feeding of naturally occurring bypass protein like cottonseed cake and maize gluten meal to lactating ruminants to evaluate their effect on milk yield and most of these experiments have given positive results (Walli, 2005).

No literature was available with regard to impact of feeding these three nutrients viz. propylene glycol, bypass fat and bypass protein in a single study. Hence, the present work was designed to study the impact of feeding these three nutrients on milk yield in early lactating cows.

2. Materials and Methods

The study was conducted utilizing Holstein Friesian crossbred dairy cows of different parities, varying from two to seven, maintained at Military Dairy Farm, Bangalore. The animals were dried at the completion of 7^{th} month of pregnancy, shifted to individual calving pens at least 15 days prior to the expected date of calving and closely monitored for the onset of calving. During the experimental period all the cows were fed a basal standard diet (concentrates) based on the quantity of milk produced. In addition, the cows were fed on pasture, guinea grass, Punjab-18 variety hybrid Napier and subabul.

A total of twenty eight animals which had no difficulty and no disease diagnosed at the time of parturition or seven days postpartum and considered normal (Morrow *et al*.,1969) were randomly allotted to four groups with seven animals in each group. The T^0 animals which served as control were managed and received basal herd ration routinely practiced in the farm. The T^1animals received propylene glycol once daily as a drench at the rate of 300 ml (Grummer *et al*., 1994) per head in addition to the standard feeding and management received by the T^0 animals. The propylene glycol was drenched to these animals 90 minutes after concentrate feeding in the morning hours. The T^2 animals in addition to standard management and feeding routinely practiced, also received once daily 100 g of commercially available bypass fat (NUTRI JOULE, M/s Vetcare Ltd., Bangalore) with routinely fed concentrates at the time of morning milking. The T^3 cows in addition to routine management and feeding also received once daily 200 g of commercially available bypass protein (NUTRI PRO, M/s Vetcare Ltd., Bangalore) with routinely fed concentrates at the time of morning milking. The T^1 animals received propylene glycol for a period of 35 days during day 7 and 42 postpartum whereas, T^2 and T^3 animals received bypass fat and bypass protein respectively for a period of 60 days starting from day 7 postpartum. The calves were weaned a day after birth and all the cows were hand milked twice daily at 5.30 AM and 5.30 PM and the amount of milk produced by each cow was recorded. The data on average daily milk yield recorded at weekly interval was statistically (SAS-16.50 version, 2011) analyzed to assess stage variation within a group and between the groups to ascertain the effect of supplementation on milk yield.

3. Results and Discussion

In cows, which received supplementation of propylene glycol (T^1), the mean daily milk yield recorded at weekly interval showed a linear increase from day of supplementation till the end of experimental period. The increase in milk yield was significant ($P \le 0.05$) on day 35 compared to earlier stages recorded. The increased yield obtained between day 7 and 28 did not show significant variation between the stages. Further, the milk yield tended to increase linearly to reach highest average on day 63 postpartum (Table 1; Fig. 1).

The pooled mean daily milk yield recorded in propylene glycol supplemented (T^1) cows was significantly ($P \le 0.05$) higher than the mean daily milk yield recorded in control cows (T^0). The current findings are in close conformity with the reports of Lomander *et al*. (2012) who documented significant increase in mean milk production on propylene glycol supplementation in early lactating cows. Contrary to this, Rizos *et al*. (2008) and Bors *et al*. (2014) reported non-significant effect in early lactating and Cozzi *et al*. (1996) in mid lactating cows. Similarly, Rukkwamsuk and Panneum (2010) did not find significant increase in mean milk yield on propylene glycol supplementation in transition period compared to control cows.

In cows which received supplementation of bypass fat (T^2), the mean daily milk yield recorded at weekly interval showed linear increase from day of supplementation till the end of supplementation period. The increase in milk yield was significant ($P \le 0.05$) on day 35 compared to earlier stages recorded. The increase in mean milk yield recorded between day 7 and 28 did not show significant variation between the stages. Further, it increased linearly to reach highest average on day 63 post-calving (Table 1; Fig. 1).

The pooled mean daily milk yield recorded in bypass fat supplemented (T^2) cows was significantly higher than the mean daily milk yield recorded in control cows (T^0). The current findings are comparable with the reports of McNamara *et al*. (2003) and Tyagi *et al*. (2010) in cows and Tyagi *et al*. (2009a) in buffaloes who documented significant ($P \le 0.05$) increase in mean yield on supplementation of bypass fat. On the contrary, Loor *et al*. (2002) noticed reduction in milk yield on feeding calcium salts of long chain fatty acids. While, non-significant increase in mean milk yield on supplementation of bypass fat was reported by West and Hill (1990). Whereas, Jenkins (1998) reported no effect of rumen inert fat supplementation on milk yield in lactating cows.

In T^3 cows, which received supplementation of bypass protein, the average daily milk yield per day recorded at weekly interval increased linearly from day 7 to 63 postpartum. The increase in milk yield from day 7 to 28 was not statistically significant. The average milk yield recorded on day 35 was significantly ($P \le 0.05$) high compared to earlier stages and further increased linearly to reach highest average on day 63 post-calving (Table 1; Fig. 1). Compared with the control group, the pooled mean daily milk yield recorded in bypass protein supplemented (T^3) cows was significantly high ($P \le 0.05$). The current findings are in close conformity with the earlier reports (Walli and Sirohi, 2004; Yadav and Chaudhary, 2004). On the contrary, Arias *et al*. (2013) found no significant difference in the mean milk yield on supplementation of rumen undegradable protein of 45% compared to 30% rumen undegradable protein treated group.

The mean daily milk yield recorded at weekly interval showed non-significant stage variation between propylene glycol, bypass fat and bypass protein supplemented groups at all stages from 7 days post-calving till the end of the experimental period. In addition, the pooled daily mean milk yield recorded in T^1, T^2 and T^3 animals did not differ significantly (P≤ 0.05) among themselves (Table 1; Fig. 1).

4. Conclusion

In all experimental groups, the average daily milk yield showed increase from stage to stage and the increase was significant after one month of lactation. There was no stage variation between treatment groups and the control group. However, the milk yield was apparently more after one month of lactation in all the treatment groups compared to control group. The pooled mean daily milk yield recorded in all the supplemented groups was significantly higher than that of control with no significant difference among themselves. The results have indicated that, the supplementation of propylene glycol, bypass-fat and protein resulted in favourable effect on milk yield.

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Table 1: Effect of supplementation of propylene glycol, bypass fat and bypass protein on milk yield in dairy cows

Days relative to calving	Average milk yield (kg/day) (Least square mean ± SE)			
	T^0	T^1	T^2	T^3
7	12.31 ± 0.04^{a}	12.92 ± 0.07^{a}	13.00 ± 0.02^{a}	12.83 ± 0.06^{a}
14	12.47 ± 0.07^{a}	14.16 ± 0.24^{a}	13.91 ± 0.16^{a}	14.11 ± 0.26^{a}
21	13.85 ± 0.03^{a}	14.90 ± 0.05^{a}	14.79 ± 0.11^{ab}	14.70 ± 0.14^{a}
28	14.05 ± 0.07^{a}	15.24 ± 0.11^{a}	15.06 ± 0.04^{abc}	15.34 ± 0.05^{a}
35	14.77 ± 0.03^{ab}	15.90 ± 0.03^{bc}	15.89 ± 0.03^{bc}	15.88 ± 0.02^{bc}
42	15.21 ± 0.03^{b}	16.35 ± 0.07^{bc}	16.32 ± 0.05^{b}	16.42 ± 0.04^{b}
49	15.53 ± 0.06^{b}	17.37 ± 0.04^{bcd}	17.43 ± 0.05^{ab}	17.48 ± 0.04^{b}
56	16.04 ± 0.05^{bcd}	18.43 ± 0.18^{bc}	18.27 ± 0.17^{b}	18.42 ± 0.18^{b}
63	16.49 ± 0.11^{acd}	18.84 ± 0.16^{abc}	18.58 ± 0.13^{bc}	18.83 ± 0.18^{ab}
Pooled mean	**14.52 ± 0.18^{a}**	**16.01 ± 0.24^{bc}**	**15.92 ± 0.23^{bc}**	**16.00 ± 0.24^{bc}**
P-value	**0.42**	**0.022^{*}**	**0.014^{*}**	**0.001^{**}**

Means bearing different superscripts between rows/columns differ significantly ($P\leq0.05$)
* → Significant at 5% level, ** →Significant at 1% level
Note: T^0 is control and T^1, T^2& T^3 are propylene glycol, bypass fat and bypass protein supplemented cows respectively