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Effect of feeding bypass fat on production, reproduction, feed and economic efficiency of dairy cows

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ABSTRACT

The dairy cows experience negative energy balance during early lactation and feeding bypass fat in ration can produce higher milk yield, improved reproduction with better economics. An experiment was planned to evaluate feeding of total mixed ration (TMR) supplemented with bypass fat @ 100 g/day to dairy animals for -21 to 120 days of calving. Total 16 animals were divided into control and bypass fat group having eight animals in each. The effect on production, reproduction and economics was evaluated for 21 biweekly periods and for 300 days of lactation. The feeding of total mix ration (TMR) supplemented with 100 g/day bypass fat (98%; -21 to 120 days of calving) resulted in daily 1.19 kg higher residual whole milk, 1.21 kg daily higher residual 4% FCM yield whereas improvement in whole milk, 4% fat corrected milk yield and milking days (25 days) was numerical for 1-21 bi-week period. Intake of dry matter and nutrient was non-significant between the groups. The better feed conversion ratio (kg/kg milk) in terms of dry matter (1.581±0.11 vs 2.330±0.39) and total digestible nutrients (0.846±0.06 vs 1.300±0.21 kg), improved reproduction in terms of Artificial insemination (AI)/conception (1.857±0.14 vs 2.286±0.18) and service period (113.13±20.73 vs 177.38±20.92 days) and better feed cost to milk income ratio (1:1.93 vs 1:1.63) in lactating cows during standard lactation. The lower loss of body condition score of bypass fat group cows, after calving, resulted in better milk yield and reproduction of dairy cows.

Keywords: Bypass fat, Dairy cow, Feed economics, Feed efficiency, Milk, Reproduction

The livestock enterprise contributes significantly to rural economy through milk production and contribution to mixed farming systems. To meet future milk demand, India needs improvement in productivity of dairy animals. Feeding dairy cows to meet nutrient requirement according to genetic potential during various physiological phases is key to achieve potential. The majority of livestock in tropical countries feed on hedge grasses, crop residues and agro-industrial byproducts which are higher in lingo-cellulose, and contribute little to achieve genetic potential. Dairy cows produce milk more rapidly during early lactation which drains more nutrients out of the body than intake. The higher demand of energy in milk than intake leads to mobilization of body reserves and weight loss due to negative energy balance (NEB) which adversely affects production, resulting in lower yield (Kim *et al.* 1993). Therefore, dairy cows have a big challenge to fulfill the essential nutrients for meeting metabolic, milk and reproduction requirements. Milk production and optimum reproduction are the important criteria of farm profitability. The negative energy balance is inevitable during early lactation but to minimize the extent and duration could be beneficial for milk production and reproduction of cows (Tyagi *et al*. 2010). NEB during early lactation period predisposes cow to milk fever, subclinical ketosis, retained placenta, metritis, and displaced abomasums, besides increased severity of mastitis, resulting in adverse effects on production, reproduction, farm profitability and animal welfare (Manriquez *et al.* 2019, Shelke *et al.* 2011). The negative effect of NEB on productive performance of early lactating cows can be reduced by supplementation of protected fat in the ration (Remppis *et al.* 2011). The peripartum supplementation of protected fat leads to reproductive performance improvement owing to fatty acids which supply higher energy and act of as a precursor of progesterone synthesis via cholesterol and prostaglandins pathway (Staples *et al.* 1998). Other improvements from added protected fat were improved conception rate (Salem and Bouraoui 2008, Tyagi *et al.* 2010), increased pregnancy rate and reduced service period (Juchem *et al*. 2008, Silvestre *et al.* 2011). Considering the above probable outcomes, feeding of bypass fat from -21 to 120 days of calving to dairy animals was planned to ascertain effect on milk yield, reproduction, feed intake, feed efficiency and feed economics for 1-21 bi-week period/during 300 days of lactation.

MATERIALS AND METHODS

The experiment was started after obtaining permission from Institutional Animal Ethics Committee No. 272/

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LRS/2018 and animals were cared accordingly. Total 16 cows were allotted in two groups having eight cows in each group. Each group had six multi-parous cows [five crossbred (50% HF and 50% Kankrej) and one Kankrej cow], two primi-parous crossbred cows (50% HF and 50% Kankrej). Criteria for allotment of cows were descending order milk of yield of previous standard lactation (kg/day) and lactation numbers. The crossbred heifers were allotted on the basis of first standard lactation yield of dam (kg/day) and number of lactation in descending order, respectively. All crossbred cows, crossbred heifers and Kankrej cows were bred with pure HF bull semen. The milk yield (T1=10.72±1.38 and T2=10.99±1.07 kg/day, respectively) and number of lactation (T1=3.50±0.71 and T2=3.50±1.07, respectively) were non-significant between treatments at initiation of experiment. Cows were housed in well ventilated shed having facility for individual feeding. All animals were ensured to be free from diseases and parasitic load before initiation of experiments and dewormed before starting the experiment. Individual feeding followed at tying place during 21 day precalving to 300 days post calving. Total mixed ration (TMR) was prepared using compounded concentrate mixture-20%, green fodder (Sorghum/Hybrid Napier-Coimbtor-3)-33%, wheat straw-25%, pulse straw (Ground-nut gotar-Straw/pigeon pea gotar-straw)-20%, Mineral mixture-1% and Common salt-1% on dry matter basis to meet nutrient requirement of animals as per ICAR (2013). The nutrient composition of TMR, feeds, fodder, salt and mineral mixture are given in Tables 1 and 2. TMR was offered at tying place in morning (10:00 AM) and afternoon (4:30 PM). The leftover was collected next day early morning (5:00 AM) to arrive at daily feed intake. Rumen protected fat (98%- Burgafat) was supplemented @ 100 g/day/animals, 21 days pre-partum to 120 days post-partum. Milk yield of cows were recorded for standard lactation. Animals were offered clean and wholesome water at noon and at evening at tying place. Animal were let loose for exercise after morning milking (5:30 AM to 9:30 AM). Animals had free access to water during loose time. Cows were milked two times in morning (4:30 to 5:30 AM) and evening (4:30 to 5:30 PM). Milk yield was averaged at bi-weekly period for entire lactation of one to twenty one periods (294 day). Milk samples were collected in morning and evening for analysis. Milk was collected four times and analyzed to arrive at average milk composition using milkoscan as per BIS (1981). The body condition score (BCS) from 1 to 5 point scale was recorded by three scientists individually with incremental of 0.25 point and average was taken as mentioned by Edmonson *et al*. (1989). BCS of experimental cows was taken at 21, 14 and 7 day pre-partum, at calving and 7, 14, 21, 35, 49, 63, 91 and 119 day post-partum. Reproduction parameters like numbers of service required for successful conception and service period were recorded. All data generated were analyzed as per Snedecor and Cochran (1994).

Table 2. Composition of mineral mixture (Bovi Plus-Amul)

Element	Each kg contains	Element	Each kg contains
Calcium	202 g	Iodine	400 mg
Phosphorus	11.8 g	Iron	6000 mg
Magnesium	10 g	Chromium	20 mg
Sodium	5.4 g	Vitamin A	1100000 IU
Sulphur	9 g	Vitamin D_3	220000 IU
Zinc	12760 mg	Vitamin E	2200 mg
Copper	1000 mg	Vitamin B_{12}	8800 mcg
Cobalt	125 mg	Niacin	2750 mg
Manganese	4000 mg	Methionine activity	5000 mg
Selenium	30 mg	Lysine	10000 mg

RESULTS AND DISCUSSION

Feed and nutrient intake: Feeding TMR supplemented with bypass fat @ 100 g/day/head resulted in daily lower intake of 2.43 kg dry matter (DM), 1.57 kg total digestible nutrients (TDN), 0.37 kg crude protein (CP) of bypass fat group of cows (Table 3). The statistical analysis revealed reduction was non-significant. Aguilar-Perez *et al*. (2009) supplemented calcium salt of long chain fatty acids @ 1.8% of dry matter intake of low merit grazing crossbred cows showing reduced dry matter intake. Supplementation of 200 g/cow/day bypass fat to tropical crossbred cows did not (P>0.05) influence the DM intake (Ranaweera *et al*. 2020). Simas *et al.* (1995), Rodriguez *et al.* (1997) and

Table 1. Composition of TMR, feeds and fodder (% on dry matter basis)

Proximate parameter	CP	EE	CF	NFE	TDN	Ash	Silica	Ca	P
TMR	11.04	2.81	26.02	47.85	54.40	10.26	4.22	096	063
Compounded concentrate mixture (Nutri-power; Amul)	27.13	4.91	13.11	46.84	80.00	8.01	2.59	2.56	1.54
Bypass fat pellet (Amul)	19.66	3.41	13.39	49.45	75.00	14.09	4.16	2.25	1.23
Green sorghum	6.16	2.11	35.70	46.91	55.00	9.12	4.15	0.99	0.75
Green hybrid napier-CO3 (Coimbture-3)	9.53	1.56	28.65	45.72	55.00	14.54	4.35	0.43	0.23
Wheat straw	4.02	1.94	30.18	54.24	45.00	9.62	6.25	0.23	0.21
Pigeon pea straw	9.01	3.27	27.34	46.71	45.00	13.58	5.45	069	0.34
Ground nut straw	11.23	4.14	25.05	49.69	45.00	9.89	1.90	1.00	0.72

TMR, Total mixed ration; CP, Crude protein; EE, Ether extract; CF, Crude fibre; NFE, Nitrogen free extract; TDN, Total digestible nutrients; Ca, Calcium; P, Phosphorus.

Pantoja *et al.* (1996) reported decreased DM and nutrients intakes with increasing fat in the diets. Sarwar *et al*. (2003) reported that feeding iso-nitrogenous and iso-energetic diet formulated using 2.5 to 4.5% saturated fat (Bergafat) did not affect intake of cows. This numerical decrease of dry matter and nutrients intake of bypass supplemented cows in present experiment might be due to supplementation of bypass fat above than standard requirement of cows as per ICAR (2013).

Milk and component: The statistically numerical improvement was reported in daily yield of milk (0.25 kg), 4% fat corrected yield-FCM (0.33 kg), 25 days more milking days on supplementation of bypass fat @ 100 g/day/head from 21 days pre-partum to 120 days post-partum in dairy cows (Table 3). Total (1-21 Bi-week) and initial (1-8 Bi-week) milk yield when expressed as whole milk and 4% FCM was statistically non-significant, whereas residual whole milk and 4% FCM was 1.19 kg (p=0.050) and 1.21 kg (p=0.048) higher, respectively. The higher residual milk yield is also reflected in Fig. 2. The milk components like fat, solid not fat (SNF), total solid (TS), lactose and protein were similar in terms of daily yield and per cent basis in dairy cows. Ranaweera *et al.* (2020) reported that bypass fat supplementation @ 200 g/cow/day had no influence (P<0.05) on milk fat, solid non-fat (SNF), protein, and milk urea nitrogen (MUN) contents. Nirwan *et al*. (2018) reported that feeding of diet supplemented with 100 g bypass fat/day from 2 weeks before expected date of calving and continued one week after calving and then increased @ 10 g/litre milk yield until 60 days postpartum limited to 250 g/day maximum had no effect on milk yield and significantly (P<0.05) increased milk fat percentage. Lungariya *et al*. (2016) revealed feeding of bypass fat @100 g/day/cows without considering energy

Table 3. Intake, milk and components yield and feed efficiency of cows

Parameter	T_1 (Control)	T_2 (Bypass fat)	P value
Intake			
DM (kg/day)	16.01±1.09	13.58±0.94	0.139
TDN (kg/day)	9.03±0.73	7.46±0.57	0.140
CP (kg/day)	1.90±0.18	1.53±0.13	0.134
EE (kg/day)	0.46±0.04	0.38±0.03	0.143
Milk yield			
Whole milk kg/day (1-21 biweekly period)	9.71±0.48	9.96±0.34	0.676
Initial whole milk kg/day (1-8 Bi-week)	13.59±0.67	12.29±0.58	0.145
Residual whole milk kg/day (9-21 Bi-week)	7.33±0.53	8.52±0.34	0.050
4% FCM kg/day (1-21 biweekly period)	9.80±0.48	10.13±0.32	0.570
Initial 4% FCM kg/day (1-8 B-week)	13.63±0.66	12.52±0.53	0.195
Residual 4% FCM kg/day (9-21 Bi-week)	7.45±0.54	8.66±0.33	0.048
Milking days	273.25±14.39	298.25±1.15	0.253
Fat yield kg/day	0.394±0.06	0.401±0.05	0.795
SNF yield kg/day	0.843±0.14	0.883±0.11	0.806
TS yield kg/day	1.238±0.20	1.284±0.15	0.803
Lactose yield kg/day	0.466±0.08	0.493±0.06	0.849
Protein yield kg/day	0.306±0.05	0.320±0.04	0.832
Milk components			
Fat%	4.28±0.27	4.19±0.28	0.941
SNF%	8.88±0.14	8.99±0.12	0.703
TS%	13.17±0.39	13.18±0.38	0.966
Lactose%	4.91±0.06	4.99±0.05	0.617
Protein%	3.23±0.06	3.26±0.04	0.811
Feed efficiency			
kg DM/kg milk	2.330±0.39	1.581±0.11	0.048
kg DM/kg FCM	2.198±0.33	1.522±0.08	0.059
kg TDN/kg milk	1.300±0.21	0.861±0.06	0.046
kg TDN/kg FCM	1.202±0.18	0.837±0.05	0.089

Bypass fat, Rumen protected fat; DM, Dry matter; TDN, Total digestible nutrients; CP, Crude protein; EE, Ether extract; FCM, Fat corrected milk; SNF, Solid not fat; TS, Total solid.

intake resulted in higher milk yield and milk fat% during trial of 90 days. Rohila *et al*. (2016) reported significant improvement in milk and 6% FCM yield in Murrah buffalo on 100 g/day supplementation of bypass fat. A non-significant improvement in milk and 4% FCM yield in present experiment might be due to supplementation of bypass fat above the standard requirement of cows as per ICAR (2013) which might have higher nutrient deposited in form of fat in body and improved residual milk yield and body condition score of cows.

Feed conversion efficiency: The conversion efficiency of feed to milk is presented in Table 3. To produce 1 kg of milk and 4% FCM, requirement of dry matter was improved daily by 0.749 kg (P=0.048) and 0.676 kg (P=0.059), respectively in dairy cows fed bypass fat. Similarly, the requirement of TDN to produce each kilogram of whole milk and 4% FCM was improved by 0.439 kg (P=0.046) and 0.363 kg (P=0.089), respectively in cows. Kumari *et al*. (2018) reported improvement (P<0.05) in feed efficiency in terms of dry matter (1.21 vs 1.13 kg DM/kg milk) and total digestible nutrients (0.79 vs 0.68 kg TDN/kg FCM) whereas numerical improvement in DM/kg FCM, CP/kg milk and FCM and TDN/kg milk on feeding 15 g/kg milk to crossbred cows during early to mid lactation period. A numerical improvement in feed efficiency (1.0 vs 0.9 kg milk/kg dry matter) on feeding 200 g/d bypass fat (4% bypass fat in concentrate mixture) to crossbred cows was reported by Purushothaman *et al*. (2008).

Table 4. Reproductive performance and feeding economics of cows

Parameter	T_1 (Control)	T_2 (Bypass fat)	P value
	Reproduction		
AI/conception	2.286±0.18	1.857±0.14	0.008
Service period (days)	177.38±20.92	113.57±20.73	0.015
Calf weight (kg)	29.150±1.91	28.10±1.12	
Female to male ratio	5:3	4:4	
	Feeding economics		
Feed cost (₹/kg milk)	25.228±0.699	18.216±0.253	0.001
Milk value (₹/cow/day)	293.13±51.23	300.87±37.47	0.850
Feed cost (₹/cow/day)	179.63±15.60	156.07±11.81	0.408
Return over feed cost (ROF) (₹/cow/day)	113.50±41.78	144.80±27.45	0.559
Feed cost to milk income ratio	1.00:1.63	1.00:1.93	
ROF over control (₹/cow/day)		+31.30	
% ROF over control		27.58	

Bypass fat, Rumen protected fat; AI, Artificial insemination.

Reproductive performance: The data on reproductive performance and feeding economics is presented in Table 4. The supplementation of bypass fat @ 100 g/day/head in TMR of dairy cows resulted in 0.429 less insemination (P=0.08) to conceive the cow. The cows fed bypass fat required 63.81 day less (P=0.015) to conceive in comparison to control. Garg *et al*. (2008) reported improved reproduction efficiency of cattle fed bypass fat @ 100-150 g/day from 10 days before to 90 days after calving. Tyagi *et al*. (2009) reported significant reduction in the time required for commencement of cyclicity, service period and AI/conception with supplementation of 2.5% bypass fat (on DMI basis) for 40 days prepartum to 90 days postpartum in crossbred cows. Similarly, Shelke *et al*. (2012) revealed enhanced reproductive performance of Murrah buffaloes on feeding of protected fat and protein during early lactation. Rajesh (2013) reported an earlier resumption of estrous cycle, less number of AI per conception and improved conception rate in Karan Fries cows on feeding 75 g/d prilled fat. This improvement in reproductive performance may be due to less negative energy balance which affects production of IGF during early lactation and availability in the oviduct indirectly through changes in specific IGFBP expression due to low circulating IGF-I after calving as well as higher leptin concentrations associated with shorter intervals to first observed estrus indicating a relationship between leptin and expression of estrus as reported by Singh *et al*. (2015).

Economic performance: Milk price in the present experiment was based on milk fat and SNF content as per Anand Milk Producer Co-Operative Union Limited (AMUL), Anand and feed and fodder cost was calculated based on purchasing price and production cost of green fodder. Bypass fat supplementation in dairy cows ration reduced feed cost by ₹ 7.012 (P=0.001) to produce each kilogram of milk. The daily return over feed cost was 31.3 ₹/day/cow higher (P=0.559) in present experiment. The daily return over feed cost was higher by 27.58% on supplementation of bypass fat in dairy cows. Karan Fries cows fed with prilled fat @ 75 g/day for 45 days before calving and 150 g for 70 days after calving resulted in an additional daily income of 94.46 ₹/cow (Yadav *et al.* 2015). Ranaweera *et al*. (2020) demonstrated direct financial benefit on feeding bypass fat to tropical medium producing crossbred cows until 12.7th week of lactation. Rajneesh *et al*. (2020) reviewed several researches on bypass fat feeding and indicated an additional daily profit of ₹ 11.6 to 34.50 in cow and ₹ 39.66 in buffalo using indigenously prepared bypass fat, excluding health and reproduction improvement.

Body conditions score (BCS) and milk yield: BCS of cows (Fig. 1) declined from pre-partum to at calving and trend continued up to 49 day post calving and improvement thereafter. BCS of cows of bypass fat supplemented group showed low variation in comparison to control group and improvement was more. Average daily milk yield (Fig. 2) of cows supplemented with bypass fat showed higher

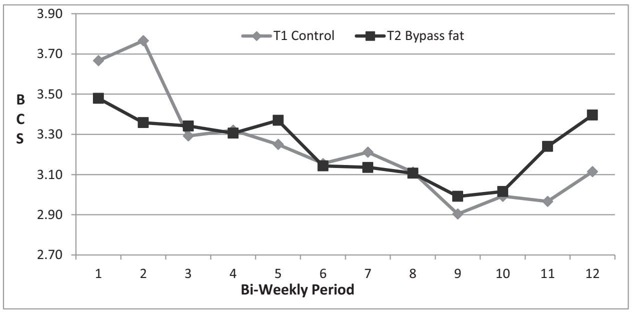

Fig. 1. Body condition score of cows.

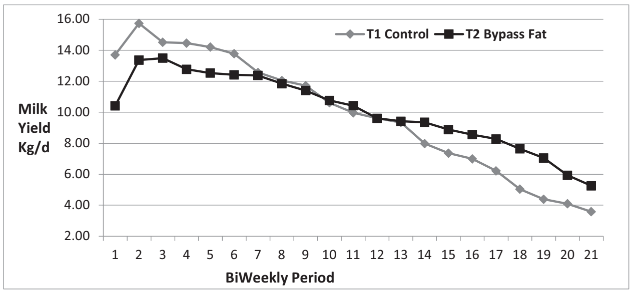

Fig. 2. Bi-Weekly milk yield (kg/day) of cows.

persistency than cows of control group. Residual milk yield after supplemented bypass fat was more in comparison to control group. The supplemented bypass fat allowed fewer decline in BCS, higher persistency of milk yield and might have diverted more energy to reproduction. The loss of BCS has more consequences on reproduction than of the absolute value and loss below one point has modest effect on reproduction (Froment 2007). The higher loss of BCS also results in lower milk production (Souissi and Bouraoi 2019) of dairy cows.

Feeding denser diet having bypass fat have positive impact in dairy cows. Feeding total mixed ration supplemented with bypass fat (100 g/day) from -21 to 120 days of calving resulted in higher residual (9-21 Biweekly period) whole milk (1.19 kg/day) and 4% fat corrected milk (1.21 kg/day) along with better feed conversion ratio (0.749 kg dry matter and 0.454 kg total digestible nutrients less required for each kg milk) and reproduction efficiency (0.429 less insemination/conception and 64.25 days less service period) with better feed cost to milk income ratio during whole lactation in dairy cows. The lower loss of body condition score of bypass fat group cows after calving resulted in better milk yield and reproduction of dairy cows. Feeding bypass fat (100 g/day) to dairy cows from -21 to 120 days of calving is beneficial to improve production, reproduction and farm income and hence advisable for commercial dairy farm.

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