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Effect of Dietary Supplementation of Indigenously Prepared Rumen Protected Fat on Production and Reproduction in Hardhenu Cattle

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ABSTRACT

Dietary fats are important source of energy but unprocessed fat in excess to 6-7% of dry matter intake can reduce ruminal digestion. While, dietary fat in protected form increases energy density of ruminant ration with no negative effects on ruminal fermentation. Rumen protected fat was prepared as calcium salts of long chain fatty acids by an indigenous fusion method. Twelve early lactating Hardhenu cows of 2nd and 3rd parity and average body weight of 408±9.13 kg, yielding 15±0.32 kg milk per day and 15-23 days in milk were subjected either to a control diet (T1) or diet supplemented with indigenously prepared rumen protected fat @ 200g per day per cattle (T2) as per ICAR (2013) feeding standards. Digestibility of dry matter, ether extract and organic matter and intake of total digestible nutrients, digestible ether extract and digestible organic matter improved significantly ($P<0.05$) in cows fed rumen protected fat (T2). Milk yield, 4% fat corrected milk yield, solid corrected milk yield and fat content of milk were also significantly ($P<0.05$) increased in T2. Dietary supplementation of rumen protected fat showed positive effect on reproductive performance of cows. Feed conversion efficiency improved in terms of 4% fat corrected milk production in cattle on feeding rumen protected fat and net return was increased by 22.02 % during four months of early lactation.

Key words: Economics, Hardhenu Cattle, Production, Reproduction, Rumen Protected Fat

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INTRODUCTION

Limited dry matter intake (DMI) of animals in early lactation is major challenge for optimal production performance (Goff and Horst, 1997). Huge demand of energy with disproportionate supply (negative energy balance) due to physiological changes causes loss of body condition, metabolic disorders (Kim et al., 1993) and affects production of animal (Sirohi et al., 2010). Maximal milk production efficiency can be achieved when the supplemental dietary fat provides 15-20% of the dietary metabolizable energy or dietary fat @ 6-7% of DMI (Scott et al., 1995). But, dietary fats after a certain limit in unprotected form can reduce ruminal digestion. Concentrate and forages in dairy ration collectively contribute about 3% fat (NRC, 2001) and total dietary fat should not exceed 6-7% of DMI, which otherwise depresses the activity of cellulolytic bacteria (Ranjan et al., 2010). Inclusion of rumen protected fats (RPF) increase the energy density of ruminants' ration without any adverse effects on ruminal microflora as it is digested and absorbed post-ruminally. It enhances energy intake during early lactation, reduces deleterious effects of acute negative energy balance and helps in achieving genetic potential of dairy animals (Tyagi et al., 2010).

The RPF can be prepared as prilled fatty acids, formaldehyde treated fats, fatty acyl amide or calcium salts of long chain fatty acids (Ca-LCFA). Ca-LCFA are relatively less degradable/soluble in rumen, have highest intestinal digestibility and serves as an additional source of calcium (Elmeddah et al., 1991). Ca-LCFA are insoluble soaps produced by reaction of carboxyl group of LCFAs and calcium salts (Ca++). Degree of the insolubility of Ca-LCFA is function of rumen pH and type of fatty acids. At rumen pH 5.5 or more, Ca-LCFA is inert in rumen. In acidic pH of the abomasum, fatty acids are dissociated from Ca-LCFA and absorbed efficiently in small intestine. Normally, 80-90% fatty acids of an unprotected fat are bio-hydrogenated in the rumen which in case of Ca-LCFA is limited to 30-40% only (Klusmeyer et al., 1991). Ca-LCFA increases energy density of ration without adversely affecting DMI and digestibility (Naik et al., 2009). Supplementation of RPF has no adverse effects on the rumen fermentation even at 5-15% of DMI (Chalupa et al., 1986), but, feeding RPF at or above 9% of DMI has no additional benefits in lactating cows (Schauff and Clark, 1992). During early lactation, maximum response can be achieved at 2–3% of DMI or 150–300 g Ca-LCFA/day (Gargouri et al., 2006). Kumar et al. (2006) reported no adverse effect of Ca-LCFA on nutrient utilization up to 10–15% of DMI or 800–1,000 g/day/animal. Palmquist (1991) recommended that 3% fat of DMI should come from feed ingredients and remaining 3% should be supplemented as RPF while Sharma (2004) suggested that 4-6% of the dietary fat should be equally contributed by natural feeds, oil seeds and RPF. The current study was planned to prepare the RPF with indigenous method and investigate its feeding effects on production and reproduction in Hardhenu Cattle.

MATERIALS AND METHODS

Diet details

The experiment was conducted in the Department of Animal Nutrition, Lajpat Rai University of Veterinary and Animal Sciences, Hisar, India located at 29°05'N and 75°26'E at an altitude of 215 metre. The RPF was prepared as calcium salts of long chain fatty acids by an indigenous (local) fusion method using rice bran oil obtained from a rice bran oil refinery industry, technical grade calcium oxide dissolved in water and sulphuric acid under specific conditions. 4 kg of rice bran oil was heated in an aluminium pan. Then, 240 ml diluted sulphuric acid (1:1) was added to it as catalyst and boiled for 5-7 minutes. Thereafter, 1.6 kg of calcium oxide dissolved in 10 litre of water and kept overnight was mixed with oil in pan and boiled for half an hour. A solid mass of saponified salts of Ca and fatty acids was obtained which was washed and filtered through muslin cloth so as to make it free from alkali. The product was sun dried and kept in sealed polythene bags. The PF thus prepared had 83.86% fat and 8.12% calcium. Twelve lactating Hardhenu cows with an average body weight of 408±9.13 kg, yielding 15±0.32 kg milk per day and 15-23 days in milk were selected in 2nd and 3rd parity and divided randomly into two equal groups (T1 and T2) of six animal each on the basis of milk yield and parity. T1 served as control and T2 was supplemented with indigenously prepared RPF @ 200 g per day per cattle till 120 days postpartum. The nutrient requirements of experimental cows were met as per ICAR (2013) using concentrate mixture (maize 43 parts, groundnut cake 33 parts, soybean meal 11 parts, wheat bran 10 parts, mineral mixture 2 parts and common salt 1 part), green fodder and wheat straw. The chemical composition of the concentrate mixture and fodders is given in Table 1. The cost of concentrate mixture, wheat straw, green fodder and RPF were Rs. 22.88, 3.50, 1.50 and 75.00 per kg, respectively. Fresh and clean drinking water were made available throughout the experimental period. The proximate analysis of feed ingredients and fodder were estimated by using standard method by AOAC (2005).

Parameters recorded

Feed intake was recorded at fortnightly intervals on two consecutive days and average of two days intake was used for calculating daily DMI. Daily milk yield of morning (5:00 AM) and evening (5:00 PM) of individual animal was recorded using digital balance. The milk was sampled at interval of fifteen days for each animal in separate bottles of both morning and evening and mixed before proceeding for estimation of milk protein, fat, SNF (solid not fat) and lactose percentage with pre calibrated Milk Analyzer (MRC Lab Milk Analyzer, India Model: MIA-S-30, S/N: 9166) for two days and average of two days was recorded. FCM (fat corrected milk) was calculated by the method of Gaines (1928) while SCM (solid corrected milk) was calculated by the method of Tyrrel and Reid (1965). Reproductive parameters as the period from calving to first estrus, service period, number of inseminations per conception and conception rate were recorded. A digestion trial of five days was conducted by manual quantitative collection of total feces from individual animal offered weighed quantity of test diet and recording its refusal. The samples of feed offered, refusals and feces were analyzed for proximate principles. Then, economics of supplementing RPF in concentrate mixture of lactating cattle was calculated. The data generated during experimental period was subjected to statistical analysis with SAS, 9.3.1 (2011) version by following standard method of analysis of variance as given by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Nutrient intake and utilization

The DMI was 12.4 and 12.9 kg/cattle/day; 2.93 and 2.98% of body weight(BW) and 129 and 133 g/kg W0.75, in T1 and T2, respectively (Table 2). The DMI (kg/day) was significantly ($P<0.05$) higher in RPF supplemented, which could be ascribed to the fact that the added inert fat did not affect rumen fermentation because of its low solubility. Increased DMI might be due to the fact that added inert fat did not impaire rumen fiber degradability and prevented increased rumen fill that could limit DMI (Purushothaman et al., 2008). Shelke and Thakur (2011) and Vahora et al. (2013) also reported significant increase in DMI by feeding bypass fat. However, DEEI and TDNI were significantly ($P<0.05$) higher in T2 as compared to T1. The digestibility of DM and EE was significantly ($P<0.05$) higher in T2 than T1 (Table 2). Similarly, OM digestibility was also higher ($P<0.05$) in T2 (71.21%) as compared to T1 (68.22). Digestibility of CP, CF and NFE was not affected. The crude protein and DCP percent value of ration did not differ significantly between T1 and T2, but the nutritive value of diet in terms of TDN% improved significantly ($P<0.05$) by supplementing RPF.

Table 1. Chemical composition (% DM basis) of different feed stuffs fed to experimental cattle

Ingredients	Attribute (%)						
	DM	OM	CP	EE	CF	NFE	Ash
Concentrate Mixture	91.8	91.8	20.2	3.91	7.23	60.4	8.16
Wheat Straw	93.7	88.7	1.89	0.91	38.2	47.7	11.2
Maize green	21.8	88.1	7.85	3.11	26.1	50.7	11.8
Berseem	15.1	87.3	15.8	3.33	17.9	50.2	12.6

DM: dry matter, OM: organic matter, CP: crude protein, EE: ether extract, CF: crude fibre, NFE: nitrogen free extract

Table 2. Body weight changes, nutrients intake, nutrient digestibility (%) and nutritive valueof rations under different dietary treatments

Parameter	Dietary treatment group		CD
	T1	T2	
Initial BW (kg)	399± 8.11	412±8.93	NS
BW change (kg)	24.3±3.39	26.1±4.97	NS
Nutrient intake			
DMI, kg/d	12.4±0.13[a]	12.9±0.16[b]	0.41
DMI, % BW	2.93±0.09	2.98±0.07	NS
DMI, g /kgBW0.75	129±3.87	133±2.95	NS
CPI, g/d	2067± 9.67	2078±11.3	NS
Digestible nutrient intake			
DCPI (g/d)	1475.92±6.91	1460.65±12.55	NS
DEEI (g/d)	300.70±6.69[a]	437.06±6.17[b]	14.73
DOMI (kg/d)	7.64±0.16[a]	8.05±0.19[b]	0.39
TDNI (kg/d)	8.14±0.12[a]	8.75±0.10[b]	0.31
Nutrient digestibility %			
DM	66.7±0.41[a]	68.4±0.56[b]	1.62
CP	71.3±0.83	70.2±1.05	NS
EE	72.0±1.21[a]	77.6±0.98[b]	2.61
CF	60.1±0.73	59.6±0.81	NS
OM	68.2±0.63[a]	71.2±0.28[b]	1.32
NFE	71.4±1.04[a]	73.6±0.62[b]	2.01
Nutritive value (%)			
CP	16.4±0.16	16.2±0.10	NS
DCP	11.5±0.18	11.2±0.11	NS
TDN	65.6±0.73[a]	67.3±0.79[b]	1.92

*Mean values bearing different superscripts within row different significantly (P<0.5)

The average daily milk production (Table 3) during supplementation period was 15.6 and 16.9 kg/d in group T1 and T2, respectively, which was significantly (P<0.05) higher by 8.31% in T2 as compared T1. The increase in milk production on supplementation of RPF can largely be attributed to an improvement in energy balance. The average daily 4% FCM production was 15.7 and 18.2 kg in T1 and T2, respectively, being 16.4% higher in T2 group. The mean milk fat% was significantly (P<0.05) higher (16.2%) in group T2 than T1. The SCM yield (kg) increased significantly (P<0.05) on supplementation of RPF by 18.3% over the control. Milk protein, lactose and SNF contents were not affected (P>0.05). Kirovski et al. (2015) and Yadav et al. (2015) also reported significantly increased milk yield by feeding bypass fat. Ranjan et al. (2012) supplemented bypass fat in the diet of lactating Murrah buffaloes @ 1.4 % of dry matter intake (200 g/day) and observed increased milk production and feed efficiency.

Table 3. Overall average milk yield (kg/d) in cattle fed with or without RPF

Parameter	Dietary treatment group		CD 5%		% Chnage
	T1	T2	Treatment	Period	
Milk yield (kg/d)	15.6 ±0.35[a]	16.9 ±0.33[b]	1.17	2.87	8.31
FCM yield (kg/d)	15.7 ±0.45[a]	18.2 ±0.60[b]	1.37	2.17	16.4
Fat (%)	3.99±0.09[b]	4.64 ±0.10[a]	0.27	0.71	16.2
Protein (%)	3.32 ±0.04	3.30 ±0.04	NS	NS	--
SCM (kg)	15.3 ±0.45[b]	18.15 ±0.57[a]	1.28	2.51	18.3
SNF (%)	8.57 ±0.07	8.53 ±0.07	NS	NS	--
Lactose (%)	4.67 ±0.04	4.65 ±0.05	NS	NS	--

*Mean values bearing different superscripts within row and column different significantly (P<0.05)

DMI: dry matter intake, BW0.75: metabolic body size, CPI: crude protein intake, DCPI: digestible crude protein intake, DEEI: digestible ether extract intake, DOMI: digestible organic matter intake, TDNI: total digestible nutrient intake, DM: dry matter, CP: crude protein, EE: ether extract, CF: crude fibre, OM: organic matter, NFE: nitrogen free extract, DCP: digestible crude protein, TDN: total digestible nutrient.

The days taken to attain peak milk yield was significantly (P<0.05) more in RPF supplemental group as compared to control. Dietary supplementation of RPF had positive effect on reproductive performance of dairy cattle by reducing the service period and AI per conception (Table 4).

Table 4. Effect of dietary supplementation of RPF on reproductive performance in cattle

Parameter	Treatments		CD
	T1	T2	
Days to peak yield	39±3.50[a]	46±2.40[b]	5.34
First estrus (d)	38.66±4.72	36.16±3.58	NS
First AI, (d)	57.50±3.58	54.40± 2.60	NS
Service period (d)	69.50±5.14	63.0±3.69	NS
AI per conception (d)	1.66±0.13[a]	1.30±0.12[b]	0.24

*Mean values bearing different superscripts within row different significantly (P<0.05)

Similar results of improved conception rate (Tyagi et al., 2010) and reduced service period (Garg et al., 2008; Gowda et al., 2013) in bypass fat fed animals have been reported earlier. The feed conversion efficiency was higher (P<0.05) in cattle fed RPF as compared to control (Table 5).

Table 5. Feed conversation efficiency and economics of feeding bypass fat to cattle during experimental period

Parameter	Treatments	
	T1	T2
DMI, kg/day		
Wheat straw	1.26±0.09	1.48±0.11
Green fodder	4.54±0.16	4.72±0.12
Concentrate mixture	6.61±0.06	6.59±0.08
RPF	0.00	0.20
Total DMI/day	12.4±0.13[a]	12.9±0.16[b]
DMI/kg FCM (Kg)	0.80±0.02[a]	0.72±0.03[b]
FCE	1.25±0.04[a]	1.41±0.05[b]
Cost of feeding/day, Rs.	214.25	231.38
Total feed cost, 120 days (Rs.)	25710.00	27765.60
Cost/kg FCM (Rs.)	13.63	12.65
4% FCM yield/animal	1885.20	2194.80
Gross income (Rs.)	65982.00	76818.00
Net Return (Rs.)	40272.00	49052.40
% Increase	--	21.8
Saving per day (Rs.)	335.60	408.77 (+73.17)

*Mean values bearing different superscripts within row different significantly (P<0.5)

Similarly, DM required per kg 4% FCM was significantly (P<0.05) less in T2 as compared to T1 indicating an improvement of FCR. The cost of feeding for 1 kg 4% FCM produced in T2 was Rs. 12.61, which was low as compared to control T1 (Rs. 13.63). The net return over feed cost of 4% FCM yield in Hardhenu lactating cattle was 22.0% higher when their diet was supplemented with RPF @ 200g per day as compared to non-supplemental group. Feeding of the indigenously prepared bypass fat to dairy animals has shown to give additional profit of Rs. 11.60/- per cow per day by Gowda et al. (2013) and Rs. 50/- per cow/ day by Singh et al. (2014).

CONCLUSION

The results of the study inferred that rumen protected fat supplementation @ 200 g/day/animal showed significant increase in milk production, feed efficiency and improved conception rate in lactating Hardhenu cattle with an additional saving of Rs. 73.17/- per day per animal.

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