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Effect of feeding rice bran lyso-phospholipids and rumen protected fat on feed intake, nutrient utilization and milk yield in crossbred cows

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ABSTRACT

In vivo studies were conducted to observe the effect of feeding rice bran lyso-phospholipids (RBLP) and rumen protected fat (RPF) in 18 crossbred lactating Karan Fries (Holstein Friesian × Sahiwal) cows. They were randomly allocated to 3 treatment groups having 6 animals in each group. Group 1 was supplemented with 2.5% mustard oil, group 2 with 6% RBLP and group 3 with 3% RPF in the concentrate mixture. All the 3 diets were isocaloric and isonitrogenous. All the cows were given roughage: concentrate mixture (60: 40) ration and roughage comprised of berseem fodder (30%) and wheat straw (30%) as per requirements. Lactating Karan Fries cows averaging 12±2.5 kg of milk, 100±9 days in milk and 400±15 kg live weight, were stratified for milk yield, days in milk, age, stage of lactation and body weight. The dry matter intake (DMI) averaged 12.14, 11.77 and 11.88 kg/d in groups 1–3, respectively. The intake and digestibility of nutrients were not affected by different treatments, whereas the digestibility of EE increased by the supplementation of RBLP in the diet of cows. Milk yield remained unaltered, while 4% fat corrected milk (FCM) yield increased as a result of adding RBLP and RPF due to significant increase in fat per cent in the milk of groups 2 and 3 cows. The protein, lactose, total solids, and solids-not-fat were not affected by dietary treatments. The proportion of milk total unsaturated fatty acids production was increased in groups 2 and 3. The cost of feeding lactating cows in terms of ₹/kg milk and 4% FCM was 10.24, 8.83, 9.67 and 9.40, 7.88, 8.72 in groups 1, 2 and 3, respectively. Cows fed RBLP were more economical by 15.97 and 9.51% to produce whole milk and 19.30 and 10.70% to produce FCM in comparison to groups 1 and 3 cows, respectively. It was inferred that RBLP can be used @ 6% in the ration of dairy cows without any adverse effect on digestibility of nutrients and milk production and it can also replace the costlier sources of energy i.e. mustard oil and RPF in the diet of lactating animals.

Key words: Crossbred cows, Karan Fries, Rice bran lyso-phospholipids, Rumen protected fat

During refining of rice bran oil in the enzymatic degumming process, large quantities of RBLP is produced as by-product which is a potent source of phospholipids and consists mainly of phosphatidylcholine, phosphatidylethanolamine, phosphatidylinositol and triglycerides. Lecithin has emulsifying property and improves the digestibility of fats and fat-soluble vitamins. Intact phospholipids reach the hindgut and increase lipid absorption in the small intestine which results in favorable changes in milk fatty acid composition. The proportion of mono- and poly-unsaturated fatty acids can be increased relative to saturated fatty acid in milk fat with the inclusion of protected sources of lipids with high concentration of unsaturated fatty acids in the diet. Cows in their early lactation undergo negative energy balance. Energy density of the ration can also be increased by supplementing with phospholipids, which can reduce the negative energy balance in high-yielding cows. As fatty acids are not digested in the rumen, so, less heat is produced in the rumen during digestion of fat-supplemented diets which helps cows to counter heat stress conditions. Therefore, RBLP can have a vast potential in the ruminant's diet to increase the energy density of their rations and to optimize milk production.

RPF is used in the diet of lactating cows to meet their energy requirements and improve fatty acid profile of milk without adversely affecting the feed intake and rumen function. Replacement of Ca soaps of palmoil by soy or canola lecithin and soybean-oil had significant effects on fatty acid digestion and utilization, as well as on the fatty acid profile in milk (Wettstein *et al.* 2001). It is expected that feeding of RBLP might be useful in dairy rations in

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supplying energy. Therefore, this study was conducted to examine the effect of inclusion of RBLP to improve milk production and its composition as well as to see its potential of replacing RPF in crossbred cows.

MATERIALS AND METHODS

Crossbred (Karan Fries) lactating cows (18), in second and fifth lactation, were selected from the Cattle Yard of the Institute, and were distributed into 3 groups of 6 cows in each according to their milk production. The lactation number and days in lactation at the start of the experiment averaged 3.8, 2.8, 3.0 and 106, 105, 101 days in the 3 respective groups. The nutrients requirement of animals were met by feeding roughage: concentrate mixture (60: 40). Roughage comprised berseem fodder (40%) and wheat straw (20%) and concentrate mixture consisted of maize grain 33, groundnut cake 21, mustard cake 12, wheat bran 20, deoiled rice bran 11, mineral mixture 2 and common salt 1 part. The chemical composition of feeds and fodders used in the experiment are presented in Table 1. All the 3 concentrate mixtures used in experiments were isonitrogenous and isocaloric.

These rations were made as per the nutritional requirements (NRC 2001). Group 1 was kept as control. The level of RBPL (6%) selected from *in vitro* studies was incorporated in the concentrate mixture and RPF (3%) of group 2 and 3 cows, respectively. To make all the diets isoenergetic, mustard oil @ 2.5% was added in the concentrate mixture of group 1 cows. DMI was recorded weekly during the experimental period of 90 days. Every fortnightly milk samples were collected for the estimation of milk composition. Buffaloes were milked twice daily at 04:00 and 18:00 h in the milking parlour. Milk yield was recorded at each milking, and representative milk samples were collected fortnightly for 2 consecutive milking. Milk samples were preserved with potassium dichromate and kept at 4°C until shortly analysed for fat, protein and lactose using precalibrated milk analyzer. Fatty acids in feed samples and milk were analysed by GC 5700 (Nucon) equipped with a capillary column (120 m × 0.25 mm × 70 µm). A digestion trial of 7 days period was conducted after 90 days of dietary treatments to determine the nutrients digestibility.

Data Computation and Statistical Analysis: The data generated during digestibility study were subjected to the statistical analysis (Snedecor and Cochran 1994) by one-way analysis of variance (ANOVA) and data of entire experiment were analysed by two-way analysis of variance

Table 1. Chemical composition of feeds used in the experiment (% DM basis)

Parameters	Berseem	Wheat straw	Concentrate mixture		
			Group 1	Group 2	Group 3
Dry matter (%)	12.58	95.60	94.59	94.15	94.62
Organic matter (%)	88.43	90.17	93.56	93.66	93.54
Crude protein (%)	17.25	3.49	21.78	21.90	21.75
Crude fibre (%)	20.04	36.24	4.85	4.80	4.78
Ether extract (%)	2.47	0.94	6.35	6.42	6.26
Ash (%)	12.46	10.28	6.81	6.73	6.83
Neutral detergent fibre (%)	45.12	78.20	45.47	45.32	45.28
Acid detergent fibre (%)	29.63	54.52	11.32	11.70	11.72
Nitrogen free extract (%)	47.78	49.05	60.21	60.15	60.38

The levels of $C_{18:2}$ and $C_{18:3}$ fatty acids in mustard oil and rice bran lyso-phospholipids were 27.16, 33.60 and 8.54, 10.25 (% of total fatty acids), respectively (Table 2). The erucic acid ($C_{22:1}$) content in mustard oil was 14.81% while it was absent in RBPL. The percentages of C18:1, C18:2 and C18:3 fatty acids were 31.18, 29.32, 7.21; 33.74, 36.53, 8.25 and 31.14, 37.91, 9.19 in concentrate mixtures of 3 respective groups.

Table 2. Fatty acid composition of mustard oil, RBPL and concentrate mixtures (% of total fatty acids)

Fatty acid	Mustard oil	RBPL	Concentrate mixture		
			Group 1	Group 2	Group 3
$C_{14:0}$	0.45	0.52	0.42	0.46	0.47
$C_{16:0}$	8.33	10.14	9.51	13.24	12.06
$C_{16:1}$	0.23	0.28	0.26	0.22	0.78
$C_{18:0}$	4.47	4.00	4.85	4.32	4.91
$C_{18:1}$	32.67	35.82	31.18	33.74	31.14
$C_{18:2}$	27.16	33.60	29.32	36.53	37.91
$C_{18:3}$	8.54	10.25	7.21	8.25	9.19
$C_{20:0}$	0.36	0.38	0.42	0.39	0.56
$C_{22:1}$	14.82	0.01	14.62	0.54	0.23

(ANOVA) using SPSS 17.0. Data are presented as mean±SE. Differences were considered to be significant as at P< 0.05.

RESULTS AND DISCUSSION

Feed intake: The average DMI of cows was 12.14, 11.77 and 11.88 kg/d in the 3 respective groups (Table 3). There was non-significant difference ($P<0.05$) in DMI/100 kg body weight among 3 groups. Information is not available on the feeding of RBLP on DMI in animals but no effect of bypass fat feeding on DMI in cows has been reported Rodriguez *et al*. (1997), Chouinard *et al*. (1998) and Tyagi and Thakur (2007). Mishra *et al.* (2005) reported that cows fed on bypass fat supplemented diet consumed significantly higher DM/kg metabolic body weight.

In contrast to present finding, Harvatine and Allen (2006) reported decreased DMI in cows supplemented with saturated and unsaturated fatty acids.

The average CPI/100kg body weight was 0.44, 0.44 and 0.45kg/d in groups 1, 2 and 3, respectively (Table 3) which was higher ($P=0.01$) in group 3 than groups 1 and 2. TDNI/cow/day was similar in all the 3 groups, but when expressed on 100 kg body weight basis (Table 3), TDNI was significantly higher ($P<0.001$) in group 3 than group 1, but was similar to group 2. Efficiency of utilization of DM, CP and TDN for milk production showed that RBPL fed cows could utilize the available nutrients more efficiently towards milk production.

Digestibility of nutrients: The digestibility of all the nutrients was similar among all groups except ether extract which was higher ($P<0.001$) in groups 2 and 3 as compared to group 1 (Table 4).

No effect of feeding RPF on digestibility of DM, OM, CP, CF, NFE was also reported by Mishra *et al.* (2005), Tyagi and Thakur (2007) and Sirohi *et al*. (2007). However, an increase in DM, OM and CP digestibility due to different

Table 3. Feed intake and productive performance of cows fed experimental rations

Parameters	Treatments			SE M	P-value
	Group 1	Group 2	Group 3		
DMI/day (kg)	12.14	11.77	11.88	0.24	0.999
DMI/100kg BW	2.93	2.88	2.90	0.04	0.895
CPI (kg/100kg BW)	0.44[a]	0.44[ab]	0.45[b]	0.04	0.010
TDNI (kg/100 kg BW)	1.97[a]	1.99[ab]	1.99 [b]	0.03	<0.001
Milk yield kg/d	12.54	12.90	12.84	0.52	0.811
4% FCM (kg/d)	13.65[a]	14.47[b]	14.25[b]	1.12	0.042
Milk fat%	4.60[a]	4.81[b]	4.79[b]	0.06	0.014
Milk protein (%)	2.98	2.93	2.92	0.03	0.865
Milk lactose (%)	4.34	4.34	4.36	0.01	1.000
SNF (%)	7.69	7.68	7.71	0.13	1.000
DMI/ milk yield (kg/kg)	0.97[b]	0.91[a]	0.93[a]	0.01	0.010
DMI/ FCM (kg/kg)	0.89[b]	0.81[a]	0.83[a]	0.03	0.010
CPI (g/kg) milk yield	144.66	139.55	142.99	1.58	0.997
CPI (g/kg) FCM	132.81[b]	124.49[a]	128.97[ab]	1.32	<0.001
TDNI (kg/kg) milk yield	0.64	0.62	0.63	0.03	1.000
TDNI (kg/kg) FCM	0.59[b]	0.56[a]	0.57[ab]	0.04	0.012

[a,b] Means having different superscripts in the same row differ significantly ($P<0.05$). SEM, standard error of mean; DMI, dry matter intake; CPI, crude protein intake; TDNI, total digestible nutrient intake; SNF, solids-not-fat; FCM, fat corrected milk.

Table 4. Effect of RBLPL and RPF feeding on nutrients digestibility (%) in Karan Fries (KF) cows

Digestibility (%)	Treatment			SE M	P-value
	Group 1	Group 2	Group 3		
Dry matter	66.98	68.25	67.76	1.16	0.986
Organic matter	75.15	76.59	75.47	1.39	1.000
Crude protein	70.74	70.14	69.01	1.43	0.785
Ether extract	76.86[a]	81.54[b]	80.21[ab]	0.99	<0.001
Crude fibre	57.48	58.65	57.17	1.76	0.897
Neutral detergent fibre	59.55	60.59	58.10	1.89	0.889
Acid detergent fibre	51.00	49.57	52.71	2.11	1.000
Nitrogen free extract	73.04	73.61	73.92	1.43	0.995

[a,b]Means having different superscripts in the same row differ significantly ($P<0.05$).

sources of by pass fat was reported by Canale *et al.* (1990) and Chouinard *et al*. (1998). Similarly, an increased EE digestibility was also observed by Mishra *et al.* (2005), Tyagi and Thakur (2007) and Sirohi *et al*. (2007) in lactating Holstein cows fed rumen protected tallow in ration.

Milk production and milk composition: The daily milk yield of lactating cows in groups 1, 2 and 3 was 12.54, 12.90 and 12.84 kg, respectively (Table 3) showing no significant difference (P>0.05) between all the 3 groups. Cows in all the 3 groups maintained their milk production throughout the experimental period of 90 days even though the experiment was started at about 100 days of lactation which might be due to the inclusion of fat source in one or the other form. Overall mean 4% FCM yield was 13.65, 14.47 and 14.25 kg/d in the 3 respective groups showing significantly higher (P<0.05) milk yield in groups 2 and 3 than group 1, which was due to significant increase in fat % in the milk of this group.

Grummer and Carroll (1988) did not observe any significant effect on milk yield in late lactation cows fed supplemental calcium salts of palm oil fatty acids or prilled fat as they were in positive energy balance. No increase in milk yield in cows supplemented with Ca salts of fatty acids or prilled fatty acids was also recorded by others (Salfer *et al.* 1995, Elliott *et al*. 1996, Chouinard *et al*. 1998). Supplementation of 200 g of acid oil and/or palm oil in Sahiwal cows also did not produce any significant improvement in milk production (Sirohi *et al*. 2007). Contrary to the present finding, an increase of 2.3 kg/d milk yield in cows was reported due to the feeding of supplemental 0.5 kg/cow/day CSFA (Andrew *et al*. 1991). Enhanced milk and 4% FCM yield in cows fed CSFA and free fatty acids or Ca-LCFA was also observed by Moallem *et al*. (1997), Garg and Mehta (1998, and Tyagi and Thakur (2007). The other components of milk i.e. protein, lactose, SNF and total solid content in the 3 groups of cows were similar (Table 3) Similar, no change in SNF or other components in milk due to supplemental fat in the diet of lactating animals were reported by Wu and Huber (1994), and Harrison *et al.* (1995). The average milk fat of lactating cows was 4.60, 4.81 and 4.79% in groups 1, 2 and 3, respectively (Table 3) which was significantly less (P<0.05) in group 1 than groups 2 and 3. Similar increase in milk fat content in lactating Holstein cows was observed by feeding RPF (Mishra *et al*. 2004, DeFrain *et al.* 2005, Mosley *et al*. 2007, Garg *et al*. 2008). In contrast to the present findings, no effect on milk fat percent in cows supplemented with RPF was reported Tyagi and Thakur (2007) and Sirohi *et al*. (2007).

Milk fatty acid profile: The proportion of total unsaturated fatty acid (Table 4) content of milk in groups 2 and 3 was higher (P<0.05) to that of group 1. The $C_{18:2}$ fatty acid in the milk was increased in group 2 as compared to group 1 and was almost similar to group 3 Table 5. The saturated fatty acid content in milk of group 1 was higher in comparison to that of groups 2 and 3 cows. Total long chain fatty acids (TLCFA) in groups 1, 2 and 3 were showing no difference in different treatment groups. Similar results

Table 5. Effect of RBPL and RPF on milk fatty acid profile (% of total fatty acids)

Fatty acid	Treatment			SEM	P-value
	Group 1	Group 2	Group 3		
C8:0	0.91	0.87	0.89	0.01	0.664
C10:0	3.02^{b}	2.47^{a}	2.98^{b}	0.23	0.010
C12:0	3.28	3.09	3.18	0.40	0.563
C14:0	10.86^{b}	8.50^{a}	8.65^{a}	0.54	0.013
C14:1	0.85^{a}	1.18^{b}	1.07^{b}	0.05	0.043
C16:0	26.84	25.96	26.19	1.04	1.000
C16:1	1.43^{a}	1.64^{b}	1.76^{c}	0.02	<0.001
C17:0	0.56^{b}	0.24^{a}	0.24^{a}	0.01	0.046
C18:0	16.48^{b}	12.95^{a}	13.76^{a}	0.89	0.011
C18:1	2.19^{a}	2.78^{b}	2.87^{b}	0.04	0.037
C18:1 C 9	26.88	27.31	27.19	1.54	0.042
C18:2	3.68^{a}	4.48^{b}	4.53^{b}	0.34	0.047
C18:3	0.84^{a}	0.93^{b}	0.92^{b}	0.04	0.010
C20:0	0.38^{a}	0.51^{b}	0.48^{b}	0.02	0.015
Total fatty acid	98.73	92.91	94.69	2.12	1.000
Total unsaturated fatty acid	35.27^{a}	38.32^{b}	38.34^{b}	1.03	<0.001
Total saturated fatty acid	62.90^{c}	54.35^{a}	56.11^{b}	1.43	0.0447
Total long chain fatty acid	77.68	76.80	77.92	1.67	0.0367

were obtained with feeding of PUFA rich protected fat (Sampelayo *et al.* 2004), Ca salts of fatty acids (Fahey *et al*. 2002) and calcium salts of progressively more unsaturated fatty acid of canola, soybean and linseed oil in lactating cows (Chouinard *et al.* 1998). Tyagi *et al.* (2009) reported the supplementation of 2.5% DMI of RPF significantly ($P<0.05$) increased the proportion of unsaturated fatty acid and long chain fatty acid (LCFA) in milk fat. Thakur and Shelke (2010) also reported an increase in the proportions of unsaturated and long LCFA in milk fat on supplementation of bypass fat prepared from soybean acid oil in lactating buffaloes.

Economics of feeding: The cost of feeding lactating cows was ₹ 10.24, 8.83, 9.67/kg milk and ₹ 9.40, 7.88 and 8.72/kg fat-corrected milk in groups 1, 2 and 3, respectively. Cows RBPL and RPFt were 15.97 and 9.51% more economical in producing milk and 19.30 and 10.70% in producing 4% FCM. The cows fed RBPL produced more 4% FCM than the cows fed either mustard oil RPF in the diet. Hence, RBPL can be safely used @ 6% and it can also replace the costlier sources of energy i.e. mustard oil and RPF in the diet of lactating animals.

In conclusion, RBPL is used in the ration of dairy cows without any adverse effect on digestibility of nutrients and milk production and it can also replace the costlier sources of energy and protein i.e. mustard oil and RPF in the diet of lactating animals. Cows fed RBPL were more economical in term of whole milk and 4% FCM production.

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