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Effect of dietary supplementation of rice bran crude lecithin on nutrient metabolism, methanogenesis and metabolic profile of crossbred calves

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ABSTRACT

The present study was conducted to evaluate the effect of rice bran crude lecithin (RBCL) on nutrient digestion and balance, performance, methanogenesis and blood profile in crossbred calves. Crossbred calves (18) were randomly divided into three groups; RBCL-0, RBCL-8 and RBCL-12 and fed wheat straw based diet with concentrate mixture containing 0, 8 and 12% RBCL respectively. The dry matter, organic matter and crude protein intake were comparable but tended to decrease with the RBCL levels. The digestibility of dry matter, organic matter, total carbohydrate and gross energy decreased while crude protein and ether extract digestibility increased with RBCL levels. Fibre fractions (NDF and ADF) digestibility was significantly lower in RBCL supplemented groups in comparison to control group. The body weight gain and average daily gain decreased with increasing level of RBCL. The per cent of nitrogen and calcium retention decreased, while phosphorus retention was significantly lower with inclusion levels of RBCL. Methane production (L/d, L/kg$W^{0.75}$) was significantly lower in RBCL-12 followed by RBCL-8 as compared to RBCL-0 group. The cholesterol and blood urea concentration was significantly higher in RBCL-12 group as compared to control group. It can be concluded that RBCL is helpful in methane mitigation for cleaner production and can be a cheap source of energy in place of corn for ruminants but at present levels (8 and 12%) the average daily gain depression was seen. Further studies in large number of livestock are warranted to explore the potential of RBCL in the ruminant ration.

Keywords: Crossbred calves, Methanogenesis, Nutrient utilization, Rice bran crude lecithin

Although India ranks first in milk production but the productivity of milk per animal is very less in rural areas. The main problem is the chronic shortage of protein (58%) and energy (31%) rich animal feed. It is predictable that India will require 550 million tonnes of dry fodder, 105 million tonnes of concentrate and 1000 million tonnes of green fodder in year 2025 (Ravi Kiran *et al.* 2012). Due to high feedstuff prices and lack of dietary grains, it is required to explore the non-conventional agro-industrial byproducts in improving the availability of dietary energy sources for dairy animals. During refining of rice bran oil in the enzymatic degumming process, rice bran crude lecithin (RBCL) is produced as byproduct, roughly 1.5-2.0% of oil weight (Jala and Prasad 2015). The current RBCL production in India is expected to fluctuate between 9000 and 12000 MT. Using lecithin instead of oil as the only lipid supplement was found to cause a lower ruminal degradation of crude protein due to their high affinity to protein as a result of their amphiphatic properties which are not present in triglycerides and free fatty acids (Jenkins *et al*. 1989). Because they are amphiphatic (having hydrophobic and hydrophilic moieties), phospholipids are readily dispersed in aqueous solutions as micelles, giving surface active properties that enhance their wettability, fat dispersion and their affinity for protein. Sontakke *et al.* (2014b) observed no adverse effect of supplementation of rice bran lysophospholipids (RBLPL) on body weight, dry matter intake and milk production in lactating cows. Recently, several studies have attempted to apply lysophospholipid (LPL) to ruminants, including sheep (Huo *et al.* 2019), beef cattle (Song *et al.* 2015) and dairy cows (Rico *et al.* 2017, Lee *et al*. 2019) but the responses of animal performance to the dietary supplementation of LPL are inconsistent. Therefore present study was planned to investigate the effect of rice bran crude lecithin replacing corn on nutrient utilization, performance, methanogenesis and metabolic profile in crossbred calves.

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MATERIALS AND METHODS

This study was approved by CPCSEA ethical committee, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi, for animal experimentation according to the reference no. 25/2/2020-CPCSEA-DADF, dated 13 April, 2020.

Table 1. Composition of feed and fodder fed to experimental calves

Ingredient	Concentrate mixtures			Wheat straw
	CM1	CM2	CM3	
Ingredient composition (%)				
Maize	42	34	30	
SBM	25	25	25	
Wheat bran	30	30	30	
Mineral mixture	2	2	2	
Salt	1	1	1	
RBCL	0	8	12	
Nutrient composition (%)				
DM	87.15±0.47	87.64±0.23	88.05±0.11	89.62±0.52
OM	94.20±0.32	93.48±0.05	93.40±0.17	91.89±0.08
CP	20.50±0.15	20.04±0.04	19.72±0.15	3.46±0.14
EE	3.02±0.10	7.54±0.15	10.25±0.09	1.30±0.02
TA	5.80±0.32	6.52±0.05	6.60±0.17	8.11±0.08
AIA	3.54±0.17	3.78±0.08	4.05±0.09	6.12±0.21
Total CHO	70.68±0.58	65.90±0.38	63.43±0.73	87.13±0.13
NDF	16.06±0.58	15.76±0.43	15.72±0.40	70.30±0.64
ADF	7.51±0.40	7.37±0.27	6.76±0.43	48.47±0.87
Hemicellulose	8.51±0.29	8.52±0.29	8.96±0.43	21.83±0.46
Ca	1.04±0.02	1.07±0.03	1.11±0.03	0.38±0.03
P	0.58±0.01	0.72±0.01	0.79±0.01	0.10±0.01
GE (kcal/g)	4.26±0.03	4.55±0.02	4.88±0.06	3.69±0.05

Experimental animals and feeding: Eighteen crossbred male calves (*Bos Taurus* × *Bos indicus*) (about 12 months old) were randomly divided into three groups (RBCL-0, RBCL-8 and RBCL-12) six animals each, by completely randomized design. Prior to initiation of the experimental trial, animals were treated for ecto and endo-parasites as per the standard protocol. RBCL-0, RBCL-8 and RBCL-12 group calves were fed wheat straw based diet with three concentrate mixtures i.e. CM1, CM2 and CM3 for 120 days, respectively (Table 1). All the experimental calves were offered daily, a weighed amount of concentrate mixture and wheat straw twice as per Kearl (1985) feeding standards for 500 g daily body weight gain in the morning and evening. The wheat straw was fed *ad lib.* after the concentrate mixture was completely consumed by the calves. Fresh and clean drinking water was made available *ad lib.* twice a day. The body weight of calves was recorded at fortnightly intervals of experiment on the two consecutive days.

Metabolism trial: A metabolism trial of 8 days duration including 2 days adaptation in metabolic cages followed by 6 days collection on all 18 calves in specially designed cages, was conducted to determine nutrient digestibility and balance during experimental feeding.

Indirect respiration chamber study: During experimental feeding, calves were kept in respiration chamber for proper adaptation (2-3 days). The concentration of CH_4, CO_2 and O_2 in the chamber air was measured for three consecutive days using an infrared gas analyzer. The methane, energy and heat production was calculated with the help of Brouwer's equation.

Metabolic profile: Blood from all calves' was collected at 0 and 120 days, early in the morning before feeding, by jugular vein puncture. The serum was separated within 2 h after blood collection and analyzed promptly. Biochemical analysis was performed to determine the glucose, non-esterified free fatty acids (NEFA), total cholesterol, 3-hydroxy butyric acid (βHBA) levels to evaluate energy metabolism; total protein, serum albumin, globulin, A:G ratio and blood urea levels to evaluate protein metabolism; calcium and phosphorus level to evaluate mineral metabolism using commercial diagnostic kits as per manufacturer's recommendations. The growth related hormones, viz. Insulin, IGF-1 and Leptin were analyzed by using commercial available ELISA diagnostic kits.

Chemical and statistical analysis: Analysis of offered feed, residual feed and faeces was done by standard procedure (AOAC 2000). The gross energy of feed offered, faeces and urine was measured by Gallenkamp ballistic bomb calorimeter (Fistreem International Ltd., UK), taking benzoic acid as standard. The data were statistically analyzed by statistical package SPSS version 20.0 in which data were subjected to ANOVA and Duncan's multiple range test (DMRT) was used to determine the significant differences between the means. Comparisons were made at 5% probability level.

RESULTS AND DISCUSSION

Nutrient digestibility, growth performance and methanogenesis: The chemical composition of feeds, nutrient digestibility, growth performance and methanogens in experimental calves under dietary treatments (RBCL-0, RBCL-8 and RBCL-12) is presented in the Table 1 and 2. The DMI and OMI ($g/KgW^{0.75}$) was 1.5 and 8.5% lower in RBCL-8 and RBCL-12 groups compared to control group. TCHOI ($g/KgW^{0.75}$) was significantly ($P<0.01$) lower, while EEI ($g/KgW^{0.75}$) was significantly ($P<0.001$)

Table 2. Effect of various levels of RBCL on nutrient digestibility, growth performance and methanogenesis in crossbred calves

Attribute	Dietary treatments			SEM	P value
	RBCL-0	RBCL-8	RBCL-12		
Metabolic size ($kgW^{0.75}$)	49.97	49.02	47.70	1.31	0.804
Feed DM intake (kg/d)					
Concentrate	2.64	2.74	2.76	0.04	0.634
Roughage	1.74	1.51	1.07	0.12	0.061
Nutrient intake (g/kg $W^{0.75}$)					
DM	87.77	86.56	80.32	1.63	0.128
OM	81.88	80.44	74.69	1.51	0.116
CP	12.12	12.41	12.29	0.27	0.923
EE	2.07[c]	4.64[b]	6.29[a]	0.41	0.001
TCHO	67.66[a]	63.45[a]	56.10[b]	1.70	0.008
NDF	32.79[a]	30.21[ab]	24.55[b]	1.40	0.029
ADF	20.71[a]	18.86[a]	14.54[b]	1.01	0.021
Nutrient digestibility (%)					
DM	63.24	62.04	61.96	0.89	0.296
OM	65.87	64.20	64.02	0.90	0.674
CP	73.62	74.15	74.62	0.83	0.904
EE	81.85[b]	83.36[ab]	85.42[a]	0.59	0.047
TCHO	63.27	60.57	59.48	1.02	0.291
NDF	53.06[a]	47.38[a]	38.59[b]	1.98	0.003
ADF	48.31[a]	40.86[a]	28.94[b]	2.57	0.001
Hemicellulose	60.97	58.15	58.29	1.58	0.745
GE	59.44	58.54	57.24	1.09	0.741
Body weight (kg)					
Initial	128.67	126.83	126.67	4.66	0.983
Final	227.50	220.33	214.67	6.40	0.739
Total Gain	98.83	93.50	88.17	2.70	0.289
ADG (g)	823.67	779.17	734.33	22.47	0.283
Respiration chamber study					
Metabolic size ($kgW^{0.75}$)	59.52	57.74	56.81	1.28	0.711
DMI (kg)	5.03	4.35	4.15	0.19	0.156
CO_2 produced (L/d)	1327.04	1283.14	1160.42	56.17	0.469
O_2 consumed (L/d)	1255.64	1234.48	1109.88	52.17	0.481
RQ	1.06	1.04	1.04	0.01	0.621
CH_4 production (L/d)	114.88[a]	90.68[b]	73.04[c]	5.41	0.001
CH_4 production ($L/kgW^{0.75}$)	1.94[a]	1.57[b]	1.29[b]	0.09	0.001
CH_4 production (L/kg DMI)	23.08	21.06	18.10	0.98	0.095
CH_4 production (L/kg OMI)	24.82	22.89	19.68	1.04	0.111
HP ($kcal/d/W^{0.75}$)	110.34	106.32	97.48	5.25	0.741
CH_4 energy loss ($kcal/d/W^{0.75}$)	18.49[a]	14.95[b]	12.26[b]	0.82	0.001

[abc]Means with different superscripts within a row differ significantly.

higher in RBCL-12 followed by RBCL-8 compared to RBCL-0 group. The NDFI and ADFI was significantly (P<0.05) lower in RBCL-12 group as compared to RBCL-0, while RBCL-8 group had intermediate position between RBCL-0 and RBCL-12 groups. The digestibility of DM, OM, CP, TCHO and GE was comparable among groups. The EE digestibility was significantly (P<0.05) higher in RBCL-12 group as compared to RBCL-0, ps. The NDF and ADF digestibility in RBCL-12 group were significantly (P<0.05) lower than RBCL-0 followed by RBCL-8 group. The body weight gain of RBCL-8 and RBCL-12 group calves was 6 and 11% lower than RBCL-0 group calves. DMI (kg) depression was 13 and 17.5% in RBCL-8 and RBCL-12 groups in comparison to control. The methane production (L/d, $L/kgW^{0.75}$) was significantly (P<0.05) lower in RBCL-12 followed by RBCL-8 as compared to control group. There was 9 and 21% reduction in methane production (L/kg DMI and L/kg OMI) in RBCL-8 and RBCL-12 groups in comparison to control (RBCL-0) group. Total heat production (Mcal/d, $kcal/d/W^{0.75}$) of

RBCL-8 and RBCL-12 group was 2 and 11% lower than RBCL-0 group. Total methane energy loss (kcal/d/$W^{0.75}$) was significantly ($P<0.05$) lower in RBCL-8 and RBCL-12 groups as compared to control (RBCL-0) group with 19 and 33% reduction.

The nutrient digestibility and growth performance of our study are compatible with Jenkins *et al.* (1989), Wettstein *et al.* (2000a), Huo *et al*. (2019), Lee *et al.* (2019) and Sontakke *et al.* (2014b). Contrary to present results, Yoon *et al.* (1986) and Abel-Caines *et al.* (1998) found a higher NDF digestibility with lecithin supplementation. Sabiha (2009) stated that the lysophospholipids (lecithin) enhance the nutrient digestion and absorption by their ability to form comparatively smaller micelles and by increasing

Table 3. Effect of various levels of RBCL on nutrient balance in crossbred calves

Attribute	Dietary treatments			SEM	P value
	RBCL-0	RBCL-8	RBCL-12		
		Nitrogen balance			
N intake and excretion (g/d)					
N intake	96.30	96.32	93.00	1.71	0.576
N faeces	25.47	25.12	23.52	0.98	0.711
N urine	29.83	30.14	31.60	0.94	0.807
N retention	41.00	40.26	38.37	1.71	0.831
% of N excretion					
Faeces	26.39	26.21	25.35	1.02	0.916
Urine	30.83	32.37	33.52	1.15	0.461
% N retention	42.78	41.42	41.13	1.69	0.900
		Energy balance			
Energy intake (Mcal/d)					
Gross energy (GE)	17.78	18.03	17.40	0.52	0.843
Digestible energy (DE)	10.60	10.56	10.07	0.34	0.640
Metabolizable energy (ME)	9.23	9.41	9.05	0.32	0.810
Energy loss (Mcal/d)					
Faecal energy	7.18	7.47	7.33	0.30	0.932
Urinary energy	0.28	0.30	0.33	0.02	0.497
Methane energy	1.09^{a}	0.86^{b}	0.70^{c}	0.05	0.001
Retained energy	6.57	6.74	6.63	0.28	0.924
Energy loss in per cent (%)					
Faecal energy	40.36	41.46	42.76	1.09	0.741
Urinary energy	1.60	1.64	1.87	0.13	0.624
Methane energy	6.14^{a}	4.80^{b}	4.05^{b}	0.25	0.001
Retained energy	36.82	37.30	38.10	1.13	0.865
Energy utilization (Mcal/Mcal)					
DE/GE	0.60	0.59	0.58	0.01	0.238
ME/GE	0.52	0.52	0.52	0.01	0.451
ME/DE	0.87	0.89	0.90	0.01	0.276
		Calcium balance			
Ca intake and excretion (g/d)					
Ca intake	34.11	35.07	34.66	0.76	0.883
Cafaeces	16.66	18.47	19.62	0.52	0.062
Ca urine	4.95	4.22	3.43	0.27	0.074
Ca retention	12.50	12.37	11.61	0.60	0.693
% of Ca excretion					
Faeces	48.74	52.83	57.12	1.15	0.001
Urine	14.64	12.39	10.05	0.94	0.146
% Ca retention	36.62	34.79	33.36	1.19	0.471
		Phosphorus balance			
P intake and excretion (g/d)					
P intake	17.08^{b}	21.25^{a}	22.85^{a}	0.68	0.000
P faeces	10.54^{b}	14.79^{a}	16.44^{a}	0.76	0.000
P urine	0.06	0.06	0.06	0.01	0.754
P retention	6.47	6.41	6.36	0.25	0.641
% of P excretion					
Faeces	61.87^{b}	69.50^{a}	72.03^{a}	1.78	0.007
Urine	0.35	0.29	0.25	0.03	0.162
% P retention	37.78^{a}	30.21^{b}	27.72^{b}	1.78	0.008

[abc]Means with different superscripts within a row differ significantly.

the flux rate of different digested nutrients across the cell membrane by improving permeability. The RBCL contains higher amount of unsaturated fatty acids and it is well established that unsaturated fatty acids are toxic for rumen microbes, therefore decrease the fibre digestion either by coating or direct antimicrobial effects. The inconsistent results of nutrient digestibility and growth performance may be due to the duration of experiments, source of lecithin, method of manufacturing, dose, degradation in the rumen and rumen bypass of lecithin. Lee *et al.* (2019) stated that any improvements in animal performance by LPL, if existent, would come from increased utilization efficiency of feed ingested rather than more nutrients supplied. In the concurrence of present findings, Sontakke *et al*. (2014a) and Wettstein *et al.* (2000b) reported lower methane production with supplementation of RBLPL and soy lecithin. PUFA also has an inhibitory effect on methane production through direct use of hydrogen by saturation in the rumen (Rasmussen and Harrison 2011). The lower reduction of methane release with lecithin than with canola oil indicates that phospholipids were either not hydrolysed to the same extent or slower as triglycerides (Jenkins *et al.* 1989). In current study, the lower methane production may be attributed to lower DMI and presence of PUFAs.

Nutrient balance: The results obtained related to nutrient balance under dietary treatment groups in crossbred calves are presented in the Table 3. The RBCL-12 group had 1% lower faecal N (% of N excretion) and 2.5% higher urinary N (% of N excretion) than control, while RBCL-8 had similar faecal N (% of N excretion) and 1.5% higher urinary N (% of N excretion) than RBCL-0 group. The GE, DE and ME intake (Mcal/d) in RBCL-0, RBCL-8 and RBCL-12 groups were comparable but numerically higher in RBCL-8 and lower in RBCL-12 group. The FE (%) tended to increase, while UE(%) decreased with the increasing level of RBCL. The methane energy (%) was significantly ($P<0.01$) lower in RBCL-12 followed by RBCL-8 as compared to RBCL-0 group. The net energy available for growth and maintenance was only 5% higher in RBCL-8 group and equal in RBCL-12 group in comparison to RBCL-0 group. The energy utilization (DE:GE, ME:GE and ME:DE) was comparable among dietary groups. The Ca intake (g/d) was comparable, while faecal calcium (g/d, %) tended to increase with inclusion level of RBCL. The urinary Ca and Ca retention (g/d, %) tended to decrease with the level of RBCL. P intake (g/d) was significantly ($P<0.01$) higher in RBCL-12 and RBCL-8 as compared to RBCL-0. The faecal P (g/d, %) was comparable among the RBCL-0, RBCL-8 and RBCL-12, however urinary P (%) decreased with RBCL levels. The phosphorus retention was significantly ($P>0.010$) lower in RBCL-12 and RBCL-8 as compared to RBCL-0 group.

The nitrogen and energy balance data were similar to that of Wettstein *et al.* (2000a) and Huo *et al.* (2019), while contrary to Lee *et al.* (2019). In present experiment, the nitrogen utilization efficiency did not improve due to availability of inadequate fermentable energy for rumen microbes. It has been well established that the N utilization

Table 4. Effect of various levels of RBCL on serum biochemical and hormonal profile in crossbred calves

Attribute	Dietary treatments			SEM	Periods		SEM	P value		
	RBCL-0	RBCL-8	RBCL- 12		0 d	120 d		P	T	P*T
Protein metabolism										
Total protein (g/dl)	7.50	7.30	7.39	0.22	6.82^{b}	7.98^{a}	0.18	0.001	0.809	0.836
Abumin (g/dl)	3.90	4.04	4.05	0.16	3.49^{b}	4.5^{a}	0.13	0.001	0.753	0.033
Globulin (g/dl)	3.61	3.27	3.35	0.14	3.34	3.48	0.12	0.397	0.237	0.019
A:G	1.12	1.25	1.22	0.07	1.08^{b}	1.31^{a}	0.06	0.010	0.304	0.003
Blood urea (mg/dl)	30.73	30.11	41.46	0.75	21.64^{b}	46.56^{a}	0.61	0.001	0.001	0.001
Energy metabolism										
Glucose (mg/dl)	62.35	62.40	62.24	2.64	61.17	63.49	2.15	0.290	0.636	0.926
NEFA (μmol/L)	229.31	176.03	198.67	25.34	226.80	175.88	20.69	0.099	0.350	0.829
Cholesterol (mg/dl)	141.17^{b}	141.67^{b}	202.72^{a}	4.63	107.11^{b}	216.59^{a}	3.78	0.001	0.001	0.001
BHBA (nmol/ml)	220.31	194.27	206.66	25.99	263.30^{b}	150.34^{a}	21.22	0.001	0.869	0.714
Mineral metabolism										
Calcium (mg/dl)	9.47	9.47	9.66	0.40	9.16	10.02	0.32	0.124	0.925	0.759
Phosphorus (mg/dl)	6.13	5.98	6.09	0.21	5.39^{b}	6.75^{a}	0.17	0.000	0.860	0.852
Growth related hormonal profile										
Insulin (μIU/ml)	13.78	13.23	13.40	0.479	12.44^{b}	14.50^{a}	0.391	0.001	0.711	0.829
IGF-1 (ng/ml)	149.11	151.49	127.49	41.60	133.38	152.00	33.96	0.703	0.904	0.998
Leptin (ng/ml)	16.79	17.16	16.47	2.93	13.45	20.17	2.39	0.406	0.378	0.856

^{ab}Means with different superscripts within a row differ significantly.

efficiency can be improved through synchronous supply of adequate fermentable energy and N for maximum microbial growth in the rumen and capture ammonia for protein synthesis (Dijkstra *et al.* 2011). In present experiment, the lower methane energy loss in rice bran supplemented groups could be related to lower methane production due to either bio-hydrogenation of unsaturated fatty acids or low acetate production in the rumen. The low HI is associated with lower DMI along with the higher level of RBCL in ration of experimental calves. In the support, Overland *et al.* (1994) noticed that lecithin had no impact on the retention of total P and Ca in pigs while on the contrary Huang *et al*. (2007) observed that lecithin at 2% level significantly improved the Ca and P utilization in broilers. In current study, the higher faecal Ca might be attributed to the formation of insoluble calcium soap by reaction of Ca with free long chain fatty acids (LCFAs) present in RBCL. While RBCL is a good source of phosphorus, the phosphorus absorption is inversely proportional to the intake, which might be possible explanation behind less phosphorus retention. The lower Ca and P retention is also correlated with the reduction in ADG in experimental calves.

Metabolic profile: The data of serum biochemicals related to protein, energy and mineral metabolism and serum hormones is presented in Table 4. The treatment mean of serum total protein, albumin, globulin (g/dl) and A:G ratio was comparable with significant effect of period. The treatment mean of blood urea (mg/dl) was significantly (P<0.01) higher in RBCL-12 group than RBCL-8 and RBCL-0 groups along with period effect. The mean of NEFA (µmol/L) and BHBA (nmol/ml) were quantitatively lower with supplementation and time both. The treatment mean of cholesterol (mg/dl) was significantly (P<0.001) lower in RBCL-12 group as compared to RBCL-0 and 8 groups, while period mean was significantly (P<0.01) lower in 120 d than 0 d. The treatment and period mean of serum Ca was comparable, while treatment mean of serum i-P was comparable and period mean was significantly higher at 120 d than 0 d. The treatment mean of serum insulin (µIU/ml) and IGF-1 (ng/ml) were comparable among groups and tended to decrease with the higher level of RBCL. There was no significant difference in Insulin and IGF-1 among dietary groups due to period treatment interaction. The treatment mean of serum leptin (ng/ml) were comparable among groups, while period mean were significantly (P<0.05) higher at 120 d as compared to 0 d.

In the present study, the higher serum urea and cholesterol level in RBCL-12 group may be attributed to the insufficient utilization of ammonia by ruminal microbes due to lower soluble carbohydrate and supplementation of higher amount of fat in the diet. Plasma glucose, NEFA and BHBA are considered as principle circulating blood metabolites to assess the energy status of the animals (Muwel 2016). The positive balance of Ca and i-P is clearly reflected by the serum levels. The results of our study are in conformity with the finding of Li *et al.* (2016), who observed that soy lecithin in the diet did not affect concentrations of serum glucose, albumin, total protein and calcium while increased the serum concentration of triglyceride, total cholesterol and HDL-cholesterol in steers. Huo *et al.* (2019) found that glucose, total protein, albumin, globulin, blood urea and total cholesterol did not alter with the supplementation of LPL in lambs. Lough *et al.* (1991) showed that feeding soy lecithin to lambs increased cholesterol. Jenkins (1990) reported lecithin had no effects on plasma non-esterified fatty acids and glucose concentrations. Contrary, Jenkins *et al.* (1989) observed that lecithin increased serum NEFA but had no effect on concentrations of glucose, triglyceride or total cholesterol. The results of our study are compatible with those of Yildiz *et al.* (2003) and Cha and Jone (1998), who found that fat feeding increases plasma leptin concentration, however, Becu-Villalobos *et al*. (2007) found lower leptin level in fat supplementation. Researches demonstrated that the plane of nutrition directly influences the circulating level of IGF-1 and IGF-1 along with insulin is reported to indicate the nutritional status of the animals (Ciccioli *et al.* 2003, Lents *et al*. 2005). It has been well established that both dietary energy and protein are the principal nutritional determinants for basal circulating plasma concentration of IGF-1 (Elsasser *et al.* 1989).

It can be concluded that replacing 8% maize of concentrate mixture by RBCL led to low effect on fibre digestibility, while 12% replacement significantly decreased the fibre digestibility against the control. RBCL did not adversely affect the nutrient utilization; blood indices and overall performance of animals while significantly reduced the methane production, so it might be more appropriate as source of energy for growing calves. Further studies in large number of livestock are warranted to explore the potential of RBCL at appropriate level in the ruminant ration. Mechanism studies are needed to explore the effect of RBCL on rumen fermentation and body metabolism.

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REFERENCES

Abel-Caines S F, Grant R J and Morrison M. 1998. Effect of soybean hulls, soy lecithin, and soap-stock mixtures on ruminal fermentation and milk composition in dairy cows. *Journal of Dairy Science* **81**: 462–70.

AOAC. 2000. *Official Methods of Analysis*, 17thed. AOAC International: Arlington, VA, USA.

Becu-Villalobos D, Garcia-Tornadu I and Lacau-Mengido I M. 2007. Effect of fat supplementation on leptin, insulin like growth factor I, growth hormone. *Canadian Journal of Veterinary Research* **71**: 218–25.

Cha M C and Jones P J. 1998. Dietary fat type and energy restriction interactively influence plasma leptin concentration in rats. *Journal of Lipid Research* **39**: 1655–60.

Ciccioli N H, Wettemann R P, Spicer, L J, Lents C A, White

F J andKeisler D H. 2003. Influence of body condition at calving and postpartum nutrition on endocrine function and reproductive performance of primiparous beef cows. *Journal of Animal Science* **81**(12): 3107–20.

Dijkstra J, Oenema O and Bannink A. 2011. Dietary strategies to reducing N excretion from cattle: Implications for methane emissions. *Current Opinion in Environmental Sustainability* **3**: 414–22.

Elsasser T H, Rumsey T S and Hammond A C. 1989. Influence of diet on basal and growth hormone-stimulated plasma concentrations of IGF-I in beef cattle. *Journal of Animal Science* **67**(1): 128–41.

Huang J, Dandan Y and Tian W. 2007. Effect of replacing soy oil with soy lecithin on growth performance, nutrient utilization and serum parameters of broilers fed corn based diets. *Asian-Australasian Journal of Animal Sciences* **20**(12): 1880–86.

Huo Q, Li B, Cheng L, Wu T, You P, Shen S, Li Y, He Y, Tian W and Li R. 2019. Dietary supplementation of lysophospholipids affects feed digestion in lambs. *Animals* **9**: 805.

Jala R C R and Prasad R B N. 2015. Rice bran lecithin: Compositional, nutritional, and functional characteristics. *Polar lipids*. pp. 35-55.

Jenkins T C, Gimenez T and Cross D L. 1989. Influence of phospholipids on ruminal fermentation *in vitro* and on nutrient digestion and serum lipids in sheep. *Journal of Animal Science* **67**: 529–37.

Jenkins T C. 1990. Nutrient digestion, ruminal fermentation, and plasma lipids in steers fed combinations of hydrogenated fat and lecithin. *Journal of Dairy Science* **73**: 2934–39.

Kearl L C. 1982. *Nutrient requirements of ruminants in developing countries*. Int. Feed Stuffs Inst., Utah Agric. Exp. Station, Utah State University, Logan, Utah-84322, USA. pp. 45-81

Lee C, Morris D L, Copelin J E, Hettick J M and Kwon I H. 2019. Effect of lysophospholipids on short term production, nitrogen utilization and rumen fermentation and bacterial population in lactating dairy cows. *Journal of Dairy Science* **102**: 3110–20.

Lents C A, Wettemann R P, White F J, Rubio I, Ciccioli N H, Spicer L J, Keisler D H and Payton M E. 2005. Influence of nutrient intake and body fat on concentrations of insulin-like growth factor-1, insulin, thyroxine, and leptin in plasma of gestating beef cows. *Journal of Animal Science* **83**: 586–96.

Li X Z, Park B K, Hong B C, Ahn J S and Shin J S. 2016. Effect of soy lecithin on total cholesterol content, fatty acid composition and carcass characteristics in the *Longissimus dorsi* of Hanwoo steers (Korean native cattle). *Animal Science Journal* **88**(6): 847–53.

Lough D S, Solomon M B, Rumsey T S, Elsasser T H, Slyter L L, Kahl S and Lynch G P. 1991. Effects of dietary canola seed and soy lecithin in high-forage diets on performance, serum lipids and carcass characteristics of growing ram lambs. *Journal of Animal Science* **69**(8): 3292–98.

Muwel N. 2016. 'Effects of supplementation of area-specific mineral mixture on productive and reproductive performances of crossbred cows during pregnancy to lactational transition phases.' M.V.Sc. Thesis, ICAR-National Dairy Research Institute, Karnal, India.

Overland M, Tokach M D, Cornelius S G, Pettigrew J E and Wilson M E. 1993. Lecithin in swine diets: II. Growing- finishing pigs. *Journal of Animal Science* **71**: 1194–97.

Rasmussen J and Harrison A. 2011. *The Benefits of Supplementary Fat in Feed Rations for Ruminants with Particular Focus on Reducing Levels of Methane Production*. International Scholarly Research Network, Veterinary Science.

Ravi Kiran G, Suresh K P, Sampath K T, Giridhar K and Anandan S. 2012. *Modeling and Forecasting Livestock and Fish Feed Resources: Requirements and Availability in India*. National Institute of Animal Nutrition and Physiology, Bengaluru.

Rico D E, Ying Y and Harvatine K J. 2017. Effects of lysolecithin on milk fat synthesis and milk fatty acid profile of cows fed diets differing in fiber and unsaturated fatty acid concentration. *Journal of Dairy Science* **100**: 9042–47.

Sabiha A. 2009. Lysophospholipids and their role in enhancing digestion and absorption. *Technical Bulletin Avitech Nutrition* pp. 1-6.

Song W S, Yang J, Hwang I H, Cho S and Choi N J. 2015. Effect of dietary lysophospholipid (LIPIDOLTM) supplementation on the improvement of forage usage and growth performance in Hanwoo heifer. *Journal of the Korean Society of Grassland and Forage Science* **35**: 232–37.

Sontakke U B, Kaur H, Tyagi A K, Kumar M and Hossain S A. 2014b. Effect of feeding rice bran lyso-phospholipids and rumen protected fat on feed intake, nutrient utilization and milk yield in crossbred cows. *Indian Journal of Animal Sciences* **84**: 998–1003.

Sontakke U B, Kaur H, TyagiA K, Kumar M, Hossain S A and Prusty S. 2014a. *In vitro* evaluation of rice bran lyso-phospholipids for its use in ruminant ration. *Indian Journal of Animal Nutrition* **31**: 65–68.

Wettstein H R, Quarella Forni M G, Kreuzer M and Sutter F. 2000a. Influence of plant lecithin partly replacing rumen-protected fat on digestion, metabolic traits and performance of dairy cows. *Journal of Animal Physiology and Animal Nutrition* **84**: 165–77.

Wettstein H R, MachmuÈller A and Kreuzer M. 2000b. Effects of raw and modified canola lecithins compared to canola oil, canola seed and soy lecithin on ruminal fermentation measured with rumen simulation technique. *Animal Feed Science and Technology* **85**: 153–69.

Yildiz S, Blache D and Celebi F. 2003. Effects of short- term high carbohydrate or fat intakes on leptin, growth hormone and luteinizing hormone secretions in prepubertal fat-tailed Tuj lambs. *Reproduction in Domestic Animals* **38**: 182–86.

Yoon C S, Jung K K and Bae D H. 1986.Effect of crude soybean lecithin supplementation on the digestibility, rumen and blood fatty acid composition in sheep. *Korean Journal of Animal Science* **28**: 488–99.