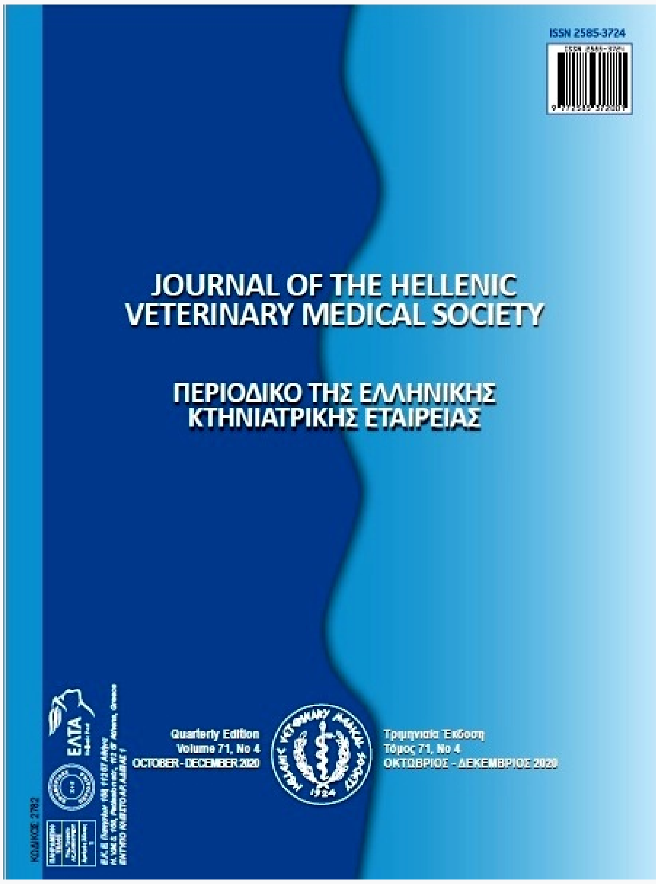
Journal of the Hellenic Veterinary Medical Society

Vol 71, No 4 (2020)



Influence of rumen bypass fat fed with total mixed ration on growth performance in Nili-Ravi buffalo calves

S. AHMED, M. AAMIR, M. N. UL-HAQUE, N. AHMAD, I.B. MARGHAZANI, M. I. KHAN

doi: 10.12681/jhvms.25917

J HELLENIC VET MED SOC 2020, 71(4): 2437-2444
ΠΕΚΕ 2020, 71(4): 2437-2444

Research article
Ερευνητικό άρθρο

Influence of rumen bypass fat fed with total mixed ration on growth performance in Nili-Ravi buffalo calves

S. Ahmed*[1], M. Aamir[1], M.N. Ul-Haque[1], N. Ahmad[2], I.B. Marghazani[3], M.I. Khan[1]

[1]Department of Animal Nutrition, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan

[2]Department of Livestock Production, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan

[3]Department of Animal Nutrition, Faculty of Veterinary and Animals Sciences, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Pakistan

ABSTRACT: This study was conducted to know the influence of rumen bypass fat supplement on growth performance of Nili-Ravi mal buffalo calves. Nili Ravi buffalo male calves (n=12) were randlomly selected and divided into two groups i.e., A and B based on two different levels of age. These groups (A and B) were further divided into two respective subgroups i.e., A1, A2 and B1, B2. Sub groups A1 and BI served as control (without supplement) whilst subgroups A2 and B2 were fed RBF supplement (at the rate of 2.35% of dry matter intake) with basel diet with total mixed ration. Results showed no statistical difference ($P>0.05$) in dry matter intake, body weight gain and body condition score on rumen bypass fat supplementation. In blood metabolites, rumen bypass fat supplementation increased ($P<0.05$) blood triglyceride and cholesterol levels, however, it reduced ($P<0.05$) blood glucose level in Nili-Ravi buffalo male calves. This study suggests that supplementation of rumen bypass fat at the rate of 2.35% per day in TMR possess no impact on growth performance parameters in Nili Ravi buffalo male calves.

***Keywords**:* buffalo calves, rumen bypass fat, growth performance, body condition score, blood metabolites

Corresponding Author:
Saeed Ahmed, Department of Animal Nutrition, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan
E-mail address: saeed.ahmed@uvas.edu.pk

Date of initial submission: 06-04-2019
Date of revised submission: 09-06-2020
Date of acceptance: 17-06-2020

INTRODUCTION

Nutrition plays key role in the maintenance and body development of animals (İmran *et al*., 2018; Nawab *et al*., 2019; Aydogdu *et al*., 2019). The available information on the nutrients requirements of buffalo male calves for growth is limited. Of all nutrients, energy is an important constituent of a ration for beef animals (Basra *et al*., 2003). Traditionally, cereal grains are energy sources which are used for feeding of ruminants, possessing good production potential however, high levels of grains adversely affect feed intake, fermentation characteristics of rumen and consequently digestion (Palmquist and Jenkins, 1982). The growth potential of calves can be fully exploited by incorporating fats in the ration. Rumen bypass fat is vegetable oil which contains 85% palmitic acid and has higher melting point, it bypasses rumen degradation and does not melt in rumen. This undegraded bypass fat degraded by lipase enzyme in small intestine (Singh *et al.,* 2014). Rumen bypass fat remain partly unaffected by process of bio-hydrogenation of rumen microorganisms and hence it supports in leaasening the looming danger of metabolic diseases (Naik *et al.,* 2009). Zinn and Plascencia (1996) stated that consumption of energy by feedlot steers augmented linearly with cumulative nutritional energy density. Moreover, a direct reduction in feed consumption and unfilled body gain is reported due to addition of fat in the diets of steers (Zinn, 1989; Jenkins and Jenny, 1989). In dissimilarity, Palmquist and Jenkins (1982) stated that calcium could get better fiber digestibility in additional fat diets by creating unsolvable soaps, which eliminate fatty acids (FA) from rumen fluid, therefore they are not available for a long time for rumen bacteria. Though, Sutton *et al*. (1983) stated that protected linseed oil caused a large depression in neutral detergent fiber breakdown in the rumen. It was designated that the seeming discrepancy might be due to the extent of defence, and the result fatty acid slowly released in the rumen which permissible hydrogenation of fatty acid to happen, therefore decreased microbial activity**.** Considering varying nature of reported literature due to different species, physiological status of experimental animals, the protection level of rumen bypass fat (RBF), basal diet and many other reasons, this study was designed to know the influence of RBF supplemented with total mixed ration (TMR) on growth perofrmance in Nili-Ravi buffalo male calves.

MATERIALS AND METHODS

This study was carried out in University of Veterinary and Animal Sciences, Ravi campus, Pakistan. For this purpose, Nili Ravi buffalo male calves (n=12) were randomly selected and divided into two groups i.e., A and B based on age. The age of buffalo calves in group A were 21-24 months (average body weight 308±8.8kg) whilst age of buffalo calves in group B were 08-11 months (average body weight 130±7.6kg). These groups (A and B) were further divided into two respective subgroups i.e., A1, A2 and B1, B2. Sub groups A1 and BI served as control (without supplement whilst subgroups A2 and B2 were fed RBF supplement (@ 2.35% of dry matter intake). RBF (in fine flanks, white to pale in color) is commercially available product with different trade names and are prepared by 100% vegetable oil. This product was made by palm oil fatty acids and fractionated by physical method (where in fatty acids of wanted configuration were achieved). It contained 99 % total fat, 85% plametic acid, 20% stearic acid with 29 (MJ/kg) NEL and 56-58^{0}C melting point. This procudt is developed to provide maximum energy from a protected fat with great small intestine digestibility and low rumen solubility.

As basal diet, total mixed ration (Table 1) containing 2.5 Mcal/kg mtabolizabe energy and 12% crude protein fed to all groups at the rate of 3% body weight on dry matter basis. The duration of experiment lasted for 70 days with 10 days adjustment period of calves to their respective diets. Clean and freshwater was given *ad libitum* daily for 24 hours. The refusals were collected and recorded (if any). Nili Ravi Buffalo calves were de-wormed for ecto and endo-parasites during the adjustment period.

Data on daily feed intake was recorded on daily basis. Body weight of individual Nili-Ravi buffalo were taken before the commencement of feeding experiment, subsequent weight of each Nili Ravi calf was recorded after every 14 days using a digital weighing balance. Body weight gain (kg) of each calf was determined by deducting initial body weight from final body weight. Body condition score (BCS) was recorded by using 1 to 9 measurement scale in which different scores were allotted according to the body conditions of animals with 1 being very thin and 9 being extremely obese (Eversole *et al*., 2009). BCS in terms of brisket, ribs, pins, hooks, back and tail head of every male calf was noted before the start of experiment and at the end of feeding trial.

Table 1. Ingredient and chemical composition of TMR fed to experimental calves

Ingredients %	Control group	Supplemented group
Maize grains	25.00	20.00
Soybean meal	05.00	05.00
Canola meal	06.00	06.00
Molasses	06.00	06.00
Oat silage	45.00	47.65
Wheat straw	11.00	11.00
Mineral mixture	02.00	02.00
RBF	0.00	2.35
Total	100	100
Nutrients %		
DM	56.90	56.90
CP	12.00	12.00
ME (Mcal/kg)	2.50	2.50
NDF	28.70	28.70
NFC	38.34	38.34
Calcium	0.98	0.98
Phosphorus	0.40	0.40
Fat	2.08	4.07

TMR Total mixed ration; RBF= Rumen bypass fat; DM= Dry matter CP= Crude protein;
M.E= Metabolizable energy; NDF= Neutral detergent fiber; NFC= Non fiber carbohydrates

Blood samples of Nili-Ravi buffalo male calves were taken at day zero of experiment and then at the completion of experiment by puncturing the jugular vein in 20 ml sterilized disposable syringes and were transferred to EDTA coated tubes for biochemistry analysis. Plasma was collected from the samples of blood by the process of centrifugation at 3000 rpm for five minutes in a centriguge. All samples were labeled carefully and plasma was stored at the temperature of -20 ^{0}C until further analysis (Ashmawy, 2015). The blood glucose, cholesterol and triglyceride levels were measured by standard procedure using Human cat # 10260, 10017 and 12851, respectively.

Collected data on all studied parameters were stayistically analysed (Steel *et al.*, 1997) under 2x2 factorial design using Statistical Analysis System software (SAS, 2004).

RESULTS AND DISCUSSION

Daily average and total dry matter intake (Mean ± S.E) of Nili-Ravi buffalo male calves on experimental diets are given in Table 2. In our findings, feeding additional RBF did not improve average daily matter intake (DMI) and total dry matter intake. Similar response with and without RBF supplementation in DMI may be due to nature of basal diet fulfilling basic nutrient requirement of calves. In our study, TMR was fed as basal diet and it is well established fact that TMR provides all ingredients containg different nutrients in one bolus. Therefore, it is deduced that it may have attributed to the non-interference of RBF with digestibility of nutrients and its relatively stable nature and minimum dissociation in the rumen (Reddy *et al.*, 2003). Findings of this study are inagreement with the earlier findings (Garg *et al.*, 1997) where feed intake was not different on RBF feeding at the rate of 500 gm per day per head in Holstein Friesian cows. Similarly, Raval *et al.* (2017) reported no difference in DMI on RBF feeding in Surti buffaloes. Tyagi *et al.* (2010) also reported statistically same DMI on RBF feeding at the rate of 2.5% in multiparous crossbred cows. However, some studies have shown increased DM intake on RBF feeding. Gajera *et al.* (2013) performed an experiment on growing Jaffrabadi heifers and reported increased ($P<0.05$) DMI. Likewise, Sirohi (2010) reported higher DMI with additional bypass fat supplementation in crossbred cows. The increased DMI in these studies may be due to different physiological stage of animals and nature of basal diet.

Table 2. Daily DMI* and total DMI (Mean± SE) intake in Nili-Ravi male buffalo calves fed experimental diets

Diet	Average DMI* (kg /animal/)	Total DMI (kg)
Control	6.80±0.90	407.86±54.10
RBF**	6.80±1.06	407.82±63.74
Age (months)		
21-24	8.88±0.20[a]	532.90±12.09[a]
8-11	4.71±0.40[b]	282.78±24.23[b]
P-value		
RBF	0.9990	0.9990
Age	<.0001	<.0001

[a-b] different superscript in a column shows significant differences;
*Dry matter intake ;
**RBF Rumen bypass fat

In the present study, as expected, younger age calves (8-11months age) consumed less (average dialy DMI, Total DMI) as compared to older age calves (21-24 months age). These findings explains higher requirement of DMI in comparatively older age and weight calves. These findings are similar with the Kumar *et al.* (2007) who fed RBF to Murrah buffalo calves and found low DM intake in calves of younger age (less than one year) buffalo calves. The lower DMI in younger age calves may be due to the fact that unsaturated long chain fatty acids reaching the small intestine may reduce the gastrointestinal motility and thus DMI (Reidelberger 1994). However, Meshram *et al*. (2017) conducted study on growing crossbred calves having less than one year of age and compared RBF fed group with non RBF fed group.They found significantly higher dry matter intake with feeding RBF diets.

Influence of RBF supplementation with TMR on body weight gain (Mean ± S.E) in Nili-Ravi buffalo male calves is given in Table 3 and Table 4. In our study, RBF supplementation did not show significant body weight gain as compared to claves fed same diet without RBF supplementation. However, age and weight variation influenced body weight gain. Eearlier studies (Wadhwa *et al*., 2012; Long *et al*., 2014; Len *et al*., 2016; Mangrum *et al*., 2016) are in agreement to our findings where weight gain in experimental animals was increased with supplementation of RBF. However, in his studies Vahora *et al*. (2012) found increased ($P<0.05$) body weight gain in growing buffalo calves on RBF feeding. Higher gain on RBF supplementation in some studies may be correlated with nature of basal diet and consequent nutrient digestibility, nitrogen balance and utilization, better rumen environment and higher microbial-nitrogen synthesis. (Bhatti *et al*., 2016).

Table 3. Fortnight body weight (Mean ±SE) in Nili-Ravi buffalo calves fed experimental diets

Diet	**0 day (Kg)**	**14 day (Kg)**	**28 day (Kg)**	**42 day (Kg)**	**60 day (Kg)**
Control	255.67±42.77	261.17±43.06	268.00±43.67	279.33±45.13	295.00±45.77
RBF*	266.33±40.00	277.33±42.95	286.83±43.75	298.67±45.10	311.67±46.21
Age (months)					
8-11	173.50±13.08^{b}	177.67±13.13^{b}	184.00±13.37^{b}	192.67±13.99^{b}	205.50±14.31^{b}
21-24	348.50±14.40^{a}	360.83±14.06^{a}	370.83±13.66^{a}	385.33±14.16^{a}	401.17±14.99^{a}
P-value					
RBF	0.8591	0.7958	0.7668	0.7681	0.8030
Age	<.0001	<.0001	<.0001	<.0001	<.0001

$^{a-b}$ different superscript in a column shows significant differences; *RBF= Rumen bypass fat

Table 4. Weight gain (Mean ±SE) in Nili-Ravi buffalo calves fed experimental diets

Diet	**14 day (Kg)**	**28 day (Kg)**	**42 day (Kg)**	**60 day (Kg)**	**ADG/anim (kg)**	**AGF (Kg)**	**TWG (Kg)**
Control	5.50±1.23	6.83±1.74	11.33±1.58	15.67±1.23	0.66±0.07	9.83±1.05	39.33±4.22
RBF	11.00±3.46	9.50±2.39	11.83±1.74	13.00±1.21	0.76±0.12	11.33±1.73	45.33±6.92
Age (months)							
8-11	4.17±0.79^{b}	6.33±2.01	8.67±1.09^{b}	12.83±1.30	0.53±0.05^{b}	8.00±0.76^{b}	32.00±3.03^{b}
21-24	12.33±3.04^{a}	10.00±2.02	14.50±0.99^{a}	15.83±1.05	0.88±0.07^{a}	13.17±1.04^{a}	52.67±4.17^{a}
P-value							
RBF	0.0427	0.4048	0.7673	0.1133	0.4761	0.2575	0.2575
Age	0.0073	0.2611	0.0073	0.0805	0.0025	0.0030	0.0030

$^{a-b}$ different superscript in a column shows significant differences
ADG = Average daily gain; AGF = Average weight gain on fortnight basis; TWG = Total weight gain

In our study, average daily and total weight gain increased (P<0.05) in older age calves (21-24 months) as compared to younger age (8-11 months) calves which may be due to more weight and age of calves that consequently resulted in increased DMI. In other words, average daily gain was not significantly increased in lower age and weight calves due to less and decreased feed intake (Crystal 2015). Similar to our findings, Gajera *et al*. (2013) reported significant differences (P<0.05) with RBF supplementation on body weight gain in Jaffrabadi buffalo heifers in more than one year age).

Initial and final BCS in terms of brisket, ribs, pins, hooks, back and tail head of Nili-Ravi buffalo calves is given Table 5. RBF supplementation and age difference showed no influence on BCS of buffalo calves. These results explain that iso-caloric and iso-nitrogenous nature of basal diet (TMR) may have fulfilled nutritional requirement of calves according to their respective age and weight, hence additional suuplenetation of RBF may have not further improved BCS. Findings of this study are in accordance with Raval *et al*. (2017) who did not report any change in BCS of Surti buffaloes fed RBF. Likewise, Long *et al*. (2014) reported no difference in BCS of beef heifers fed with different dietary treatments of RBF. On the other hand, an improved BCS in animals with RBF supplementation is reported in litearature. Naik *et al*. (2009) recorded significant differences (P<0.05) in BCS of cows fed RBF as compared to control diet. However, lactating animals may give repsose to RBF supplementation due to high demand of rich energy source in small intestine particularly at early stage of lactation.

Table 5. Body condition score (Mean ±SE) in Nili Ravi male buffalo calves fed experimental diets

Diet	Day zero (BCS)*	Day Final (Day 60) (BCS)
Cnotrol	3.00±0.26	4.33±0.42
RBF**	3.00±0.26	5.00±0.26
Age (months)		
8-11	2.67±0.21	4.33±0.33
21-24	3.33±0.21	5.00±0.37
***P*-value**		
RBF	1.0000	0.2191
Age	0.0805	0.2191

*BCS=Body condition score; 1 emaciated; 2 very thin; 3 thin; 4 moderate thin; 5 moderate ideal; 6 moderate fleshy; 7 fleshy; 8 very fleshy; 9 obese.
** RBF= Bypass fat

Effect of diet and age on blood glucose, cholesterol and triglycerides level (Mean±S.E, mg/dl) of Nili-Ravi buffalo male calves are given in Table 6. RBF feeding to buffalo calves significantly reduced blood glucose level whilst blood cholesterol and triglycerides level were increased. Findings of this study are in line with Hammon *et al.* (2008) who found significantly reduced glucose concentration in RBF fed animals as compared to control group. The decrease in plasma glucose concentration was not associated with decreased post absorptive availability of glucose, because rate of appearance of glucose was not affected by the diet. Therefore, the reduced glucose concentration was likely due to an increased utilization of glucose (Hammon, 2008). On a similar pattern, in our study the reduced glucose concentration was likely due to increased utilization of glucose. This may be due to elevated fat oxidation in the liver, changes in gastrointestinal hormones, or impact on rumen digestion (Benson et al., 2001). Barley and Baghel (2009) fed RBF at the rate of 100gm per day/buffalo and found significantly increased serum triglyceride levels in buffaloes fed RBF as compared to control group. Our findings are also similar with Ranjan *et al*. (2012) who found significantly increased serum cholesterol level with feeding RBF in Murrah buffaloes. Raval *et al.* (2017) also found that supplementation of RBF significantly (P<0.01) increased serum cholesterol and triglyceride levels in Surti buffaloes calves of more than one year age. Increased serum triglycerides and cholesterols levels with the advance in feeding of supplemental RBF might be due to enhanced uptake of dietary fatty acid (Grewal *et al*. 2014). However, contradictory finding were also reported by Tyagi *et al*. (2010) who fed ration 2.5% RBF supplement (on DMI basis) and did not found any effect on cholesterol concentration between groups in cows. In this case, the probable reason might be level of RBF feeding (2.5% of DMI) which was not sufficient to cause increase in serum cholesterol level.

Table 6. Blood level (Mean ±SE, mg/dl) in Nili-Ravi male buffalo calves fed experimental diets

Diet	Glucose		Cholesterol		Triglyceride	
	Initial	Final	Initial	Final	Initial	Final
Control	99.86±8.01	138.42±10.86[a]	214.34±10.95	228.25±15.36[b]	231.94±9.13	264.62±10.19[b]
RBF*	92.01±3.52	109.51±5.52[b]	221.09±15.94	365.07±53.46[a]	205.60±6.18	351.76±44.71[a]
Age (months)						
8-11	95.86±6.36	113.65±9.48	227.89±14.45	251.74±20.38[b]	214.97±10.17	262.85± 11.00[b]
21-24	96.00±6.49	134.29±9.97	207.54±11.33	341.58±61.19[a]	222.57±9.05	353.53±43.81[a]
***P*-value**						
RBF	0.4450	0.0361	0.7371	0.0072	0.0578	0.0074
Age	0.9891	0.1102	0.3248	0.0467	0.5413	0.0060

[a-b] different superscript in a column shows significant differences; *RBF=Rumen bypass fat

Influence of different age groups on blood metabolites in calves, Kumar and Thakur (2007) also reported no influence on blood glucose level in different age groups of Murrah buffalo calves. The researon may be due to more utilization of glucose (high metabolic rate) and other factors (homeostatic mechanism) in ruminants and other animals that limits glucose level (Tyagi and Thakur, 2007). Further, similar to our findings, Sharma *et al.* (2016) reported significantly increased cholesterol level in more than one year old buffalo calves. The higher plasma cholesterol in buffaloes may be due to the positive energy balance of animals associated with prilled fat feeding (Ranjan *et al*., 2012).

CONCLUSION

It is concluded that supplementation of RBF at the rate of 2.35% per kg in total mixed ration did not improve dry matter intake, body weight gain and body condition score. In blood metabolites, RBF supplementation significantely reduced blood glucose level however, it increased blood triglyceride and cholesterol levels in Nili-Ravi buffalo male calves.

CONFLICT OF INTEREST

In this research trial, the authors declare that there is no conflict of interests regarding the publication of this article

REFERENCES

Aydogdu U, Coskun A, Yildiz R, Guzelbektes H, Sen I (2019) Clinical importance of lipid profile in neonatal calves with sepsis. J Hellenic Vet Med Soci 69 (4), 1189-1194.

Barley GG, Baghel RPS (2009) Effect of bypass fat supplementation on milk yield, fat content and serum triglyceride levels of murrah buffaloes. Buffalo Bulletin 28 (4):173175.

Basra MJ, Nisa M, Khan MA, Riaz M, Tuqeer NA and Saeed NM (2003) Nili-Ravi buffalo III energy and protein requirements of 12–15 months old calves. Int J Agri Biol 5(3): 382–383.

Benson JA, Reynolds CK (2001) Effects of abomasal infusion of long-chain fatty acids on splanchnic metabolism of pancreatic and gut hormones in lactating dairy cows. J Dairy Sci 84: 1488-1500.

Bhatti RS, Sahoo A, Karim SA, Gadekar YP (2016). Effects of Saccharomyces cerevisiaeand rumen bypass-fat supplementation on growth, nutrient utilisation, rumen fermentation and carcass traits of lambs. Anim Pro Sci 58(3): 530-538,

Eversole DE, Browne MF, Hall JB, Dietz RE (2009) Body condition scoring beef cows**.** *Virginia Tech.*, p. 400-497.

Fahey J, Mee JF, Murphy JJ, Callaghan DO (2002) Effects of calcium salts of fatty acids and calcium salt of methionine hydroxyl analogue on plasma prostaglandin F2 αmetabolite and milkfatty acid profile in late lactation Holstein–Friesian cows. Theriogenol 58 (8): 1471-1482.

Gajera AP, Dutta KS, Parsana DK, Savsani HH, Odedra MD, Gajbhiye PU, Murthy KS, Chavda JA (2013) Effect of bypass lysine, methionine and fat on growth and nutritional efficiency in growing Jaffrabadi heifers. Vet World 6(10): 766-769.

Garg MR, Metha AK (1997) Effect of feeding bypass fat on feed intake, milk production and body condition of Holstein Friesian cows. Indian J Animal Nutr 15 (4): 242-245.

Grewal RS, Tyagi N, Lamba JS, Ahuja CS, Saijpaul S (2014) Effect of bypass fat and niacin supplementation on the productive performance and blood profile of lactating crossbred cows under field conditions. Animal Nutr Feed Technol 14 (3): 573-581.

Hammon HM, Metges CC, Junghans P, Becker F, Bellmann O, Schneider F, Nurnberg G, Dubreuil P, Lapierre H (2008) Metabolic changes and net portal flux in dairy cows fed a ration containing rumen-protected fat as compared to a control diet. J Dairy Sci 91 (1): 208–217.

Imran M, Ahmed S, Ditta YA, Umar S (2018) Effect of microencapsulated butyric acid supplementation on growth performance, ileal digestibility of protein, duodenal morphology and immunity in broilers. J Hellenic Vet Med. Soc 69 (3):1109-1116.

Jenkins TC, Jenny BF (1989) Effect of hydrogenated fat on feed intake, nutrient digestion, and lactation performance of dairy cows. J Dairy Sci 72: 2316–2323.

Johnson RR, McClure KE (1973) High fat rations for ruminants. II. Effects of fat added to corn plant material prior to ensiling on digestibility and voluntary intake of the silage. J Animal Sci 36: 397–404.

Kumar B, Thakur SS (2007) Effect of supplementing bypass fat on the performance of buffalo calves. Indian J Anim Nutr 24 (4): 233-236.

Kumar R, Sivaiah K, Ekambaram B, Reddy YR, Reddy JJ, Reddy GVN (2004) Influence of dietary rumen inert lipids on growth and carcass characteristics in Deccani sheep. Indian J Animal Nutr 21(4): 217–20.

Len TV, Bilal MA, Sharma AN, Sachin K, Tyagi N, Tyagi AK (2016) Effect of different bypass fat sources on nutrient utilization, blood parameters and growth in male murrah buffalo calves. Indian J Animal Nutr 33(4): 376-382.

Long NM, Burns TA, Duckett SK, Schafer WD (2014) Reproductive performance and serum fatty acid profiles of underdeveloped beef heifers supplemented with saturated or unsaturated rumen bypass fat compared to an isocaloric control. Pro Animal Sci 30 (5): 502–509.

Mangrum KS, Tuttle G, Duckett SK, Sell GS, Krehbiel CR, Long NM (2016) The effect of supplementing rumen undegradable unsaturated fatty acids on marbling in early-weaned steers. J Anim Sci 94(2): 833–844.

Meshram RT, Ramteke BN, Gadegaonkar GM, Sirsat SD (2017) Effect of bypass fat supplementation on performance of Growing crossbred calves. Indian. J Vet Sci and Biotechnol 12(4): 49-52.

Naik PK, Saijpaul S, Sirohi AS, Raquib M (2009). Lactation response of cross bred dairy cows fed on indigenously prepared rumen protected fat-a field trial. Indian J Anim Sci 79(10): 1045-1049.

Nawab A, Liu W, Li G, Ibtisham F, Fox D, Zhao Y, Wo J, Xiao M, Nawab Y (2019)

The Potential Role of Probiotics (nutraceuticals) in Gut Health of Domestic Animals; an Alternative to Antibiotic Growth Promoters. J. Hellenic Vet Med Soc 69(4): 1169-1188.

Palmquist DL, Jenkins TC (1982) Calcium soaps as a fat supplement in dairy cattle feeding. In Proc 12th World Cong Dis Cattle p. 477-481.

Park J 2007. Heat stress and dairy feeding program. In procd. Intern Trop Anim Nutr Conf 1: 4-7.

Peter CW, Corah LR (1993) Effect of rumen-escape lipid on endocrine profiles, lipid metabolites and follicular dynamics during estrus synchronization in primiparous beef heifers. J Anim Sci 71 (Suppl.1): 72-77.

Purushothaman S, Kumar A, Tiwari DP (2008). Effect of feeding calcium salts of palm oil fatty acids on performance of lactating crossbred cows. Asian Aust J Anim Sci 21 (3): 376–85.

Raikwar R, Thakur SS (2004) Bypass nutrient technology for growing and lactating buffaloes, p. 285-297. In Kundu, S.S., P.S. Pathak and A.K. Mishra (eds.) Buffalo Production Under Different Climatic Regions., Intern. Book Distrib. Co. Jhansi.

Ranjan A, Sahoo B, Singh VJ, Srivastava S, Singh SP, Pattanaik AK (2012) Effect of bypass fat supplementation on productive performance and blood biochemical profile in lactating Murrah (Bubalus bubalis) buffaloes. Trop Anim Health Prod 44 (7): 1615–1621.

Raval AP, Sorathiya LM, Kharadi VB, Patel MD, Tyagi KK, Patel VR, Choubey M (2017) Effects of calcium salt of palm fatty acid supplementation on production performance, nutrient utilization and blood metabolites in Surti buffaloes. Indian J Anim Sci 87 (9): 1124–1129.

Reddy YR, Krishna N, Rao ER, Reddy TJ (2003) Influence of dietary protected lipids on intake and digestibility of straw based diets in Deccani sheep. Anim Feed Sci Technol 106 (1-4): 29-38.

Reidelberger RD (1994) Cholecystokinin and control of food intake*. J. Nutr*.124(8): 1327.1333.

SAS (2004). Statistical Analysis Software. Version 90 SAS Institute Inc Cary, North Carolina, USA.

Sharma S, Singh M, Roy AK, Thakur S (2016) Effect of pre-partum prilled fat supplementation on feed intake, energy balance and milk production in Murrah buffaloes. Vet World 9 (3): 256-259.

Shelke SK, Thakur SS, Amrutkar SA (2012) Effect of feeding protected fat and proteins on milk production, composition and nutrient utilization in Murrah buffaloes (*Bubalus bubalis*). Anim Feed SciTechnol 171 (2-4): 98–107.

Singh M, Sehgal JP, Roy AK, Pandita S, Rajesh G (2014) Effect of prill fat supplementation on hormones, milk production and energy metabolites during mid lactation in crossbred cows. Vet World 7(6): 384-388.

Sirohi SK, Walli TK, Mohanta RK (2010) Supplementation effect of bypass fat on production performance of lactating crossbred cows. Indian J Anim Sci 80 (8): 733–736.

Son J, Grant RJ, Larson LL (1996) Effects of tallow and escape protein on lactational and reproductive performance of dairy cows. J Dairy Sci 79 (5): 822-830.

Steel RGD, Torrie JH, Dickey DA (1997) Principles and procedures of statistics. A biochemical approach (3rd ed.) McGraw Hill Book Co.Inc., New York, USA.

Sutton JD, Knight R, McAllan AB, Smith RH (1983) Digestion and synthesis in the rumen of sheep given diets supplemented with free and protected oils. J Anim Sci 49: 419-432.

Tyagi N, Sudarshan S, Thakur SS, Sachin K, Shelke S (2010)Effect of bypass fat supplementation on productive and reproductive performance in crossbred cows. Trop. Anim. Health Prod 42 (8): 1749-1755.

Tyagi N, Thakur SS (2007) Effect of rumen protected fat on lactation performance of crossbred cows. In Bakshi M.P.S. and Wadhwa, M. (eds). Proc Int Trop Anim Nutr Conf Vol II: 5.

Vahora SGS, Parnerkar S, Kore KB (2012) Effect of feeding bypass nutrients to growing buffalo heifers under field conditions. Livestock Res Rural Dev 24(2): 39.

Wadhwa M, Grewal RS, Bakshi MPS, Brar PS (2012) Effect of supplementing bypass fat on the performance of high yielding crossbred cows. *Indian J. Anim. Sci.,* 82: 200- 203.

Zinn RA, Plascencia A (1996) Effect of forage level on the comparative feeding value of supplemental fat in growing-finishing diets for feedlot cattle. J Anim Sci 74:1194-1201.

Zinn RA (1989) Influence of level and source of dietary fat on its comparative feeding value in finishing diets for steers: feedlot cattle growth and performance. J Anim Sci 67: 1029-1037.