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# METABOLIC EFFECTS OF FEEDING DIFFERENT SOURCES OF SUPPLEMENTAL FAT TO LACTATING NILI-RAVI BUFFALOES

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## ABSTRACT

Four early lactating Nili-Ravi buffaloes were fed four diets either contained no added fat or had tallow, poultry fat or mustard oil at 3% of dietary dry matter in an experiment conducted in a 4x4 Latin square design. Intakes of DM, OM, CP, ADF and NDF decreased in buffaloes fed supplemental tallow or poultry fat than those fed control diet or diet containing mustard oil. Intake of EE increased due to supplemental fats and oil. Intakes of $NE_L$ and DE were higher in buffaloes fed mustard oil versus those on control, tallow or poultry fat. Dietary tallow increased DM digestibility than the control diet. Digestibility of EE increased in buffaloes fed diets containing tallow and poultry fat versus those on control or mustard oil. Rumen pH did not differ, whereas, acetate to propionate ratios were lower due to different fat sources than the control diet. Mustard oil supplemented diet increased butyrate content. Blood pH, concentrations of glucose, total cholesterol, triglycerides and total blood lipids did not vary significantly due to feeding different fat sources. It was concluded that fat sources studied can be fed safely at 3% of dietary dry matter to early lactating Nili-Ravi buffaloes.

**Keywords**: Fat sources, buffalo, digestibility, rumen fermentation, blood metabolites

## INTRODUCTION

Water buffalo is an outstanding and extremely valuable to the developing countries of the Far and Near East regions (Nanda and Nakao, 2003). Moreover, of all domestic animals, Asian buffalo holds the greatest promise and potential for production and it is world's second most important milk producing species after cattle (Fahimuddin, 1989). The dairy industry in Pakistan is buffalo oriented. Pakistan inhabits 26.3 million buffaloes. Buffaloes in milk contribute 74.3% of the total milk produced in the country (Anonymous, 2006). Studies have been conducted to compare the efficiency of utilization of different feedstuffs by buffalo. Buffalo is considered superior to cow because it digests feed more efficiently than do cattle, particularly when feed is of poor quality and is high in cellulose; buffalo milk is, therefore, comparatively cheaper to produce. Moreover, buffalo takes less time to adjust to changes in the diet composition as compared to cow (Fahimuddin, 1989).

During early lactation, dairy animals are in negative energy balance for first 8 to 12 weeks because energy intake is insufficient to meet the energy requirement (Pantoja *et al*., 1996).To overcome this negative energy balance, energy density of the diet is to be increased with excessive grain or/and concentrate feeding, however, this often causes undesirable ruminal fermentation and depresses milk fat synthesis. Whereas, supplemental fat tends to increase energy density of the diet without causing negative impact on rumen fermentation associated with excessive grain or/and concentrate feeding (Drackley and Elliott, 1993).They also reported that many high producing commercial dairy herds successfully utilized tallow and oil seeds in their diets. Annual production of vegetable oils and animal fat in Pakistan is 0.81 and 0.47 million tons, respectively (Anonymous, 2006).Since little research had been undertaken on feeding various fat sources to lactating buffaloes to enhance lactational performance without studying effects on nutrient intake, digestibility, ruminal fermentation and blood metabolites. It was thus imperative to study the metabolic effects of feeding different sources of supplemental fat in lactating Nili-Ravi buffaloes.

## MATERIALS AND METHODS

An experiment was conducted in a 4x4 Latin square design at Animal Nutrition Research Centre, University of Agriculture, Faisalabad, Pakistan to determine the metabolic effects of feeding different sources of supplemental fat to lactating Nili-Ravi buffaloes. Four early lactating Nili-Ravi buffaloes of approximately the same age, lactation number, lactation stage, body weight and milk yield were used in the trial. Four experimental diets (Table 1) either contained no added fat or had tallow, poultry fat or mustard oil at 3% of dietary dry matter were formulated and fed as total mixed ration according to nutrient requirement of lactating dairy animals (NRC, 2001). The trial consisted

of four periods of 21 days each. The first 14 days were allowed for adjustment to diet followed by 7 days for sample collection. Buffaloes were individually fed diets ad libitum twice daily i.e. at 05 and 17 h in a tie-stall barn. During the last 7 days buffaloes were fed chromic oxide ($Cr_2O_3$) in the total mixed ration at 0.10% of diet DM to determine digestibility of nutrients (Combs, 1985). The feed offered and refused were recorded daily and proportionate samples were taken during the last 7 days of each trial. Fecal "grab" samples were taken during the last 3 days of the each experimental period directly from the rectum at 6 h intervals. Sample collection times were staggered by 2 h daily to provide a sample at 2 h interval during a 24 h period. From each collection, a 50 g sample was taken. The samples of feed offered and refused and feces were composited to have one sample each per buffalo per period. Dry matter was determined by drying the samples in a forced drought hot air oven at 60°C for 48 hours. Composited dried samples were ground through a 1 mm screen in a Willey mill and were stored at -20°C until analyzed for dry matter (DM), organic matter (OM), ash (600°C for 8h), crude protein (CP), ether extract (EE) (AOAC, 1990), acid detergent fiber (ADF) and neutral detergent fiber (NDF) content (Van Soest and Robertson, 1965). The ground fecal samples were also analyzed for chromium by atomic absorption spectrophotometer to determine digestibility as described by Combs (Combs, 1985).

On day 21 of each period, ruminal fluid was collected from the rumen of each buffalo via stomach tube at 3 h after the morning feeding. Rumen liquor pH was determined immediately after collection. The samples were acidified to pH 2 with 50% sulfuric acid ($H_2SO_4$), centrifuged at 30,000 x g for 10 minutes and the supernatant was collected and stored at -20°C until analyzed for volatile fatty acids (VFA) by gas chromatography utilizing a GLC (Model GC-17A Ver 3, Shimadzu, Japan) using BPI, 0.5 µm film and 0.5 x 0.32 mm ID column.

On day 21 of each period blood samples of each buffalo were collected from the jugular vein at 3 h after the morning feeding. The samples were placed immediately into tubes containing heparin as an anticoagulant and pH was determined. The samples were kept on until centrifuged at 10,000 x g for 5 minutes. Plasma was separated and stored at -20°C until analyzed for glucose, total cholesterol, triglycerides and total blood lipids.

The data were subjected to analysis of variance using a 4x4 Latin square design (Steel *et al*., 1997). Following statistical model was used for this purpose:

$Y_{ijk} = \mu+A_i+P_j+T_k+e_{ijk}$

Where i, j, k, = 1,.....4

and

$Y_{ijk}$ is the observation on the $i^{th}$ animal fed the $k^{th}$ treatment in the $j^{th}$ period.

$A_i$ is the effect of the $i^{th}$ animal

$P_j$ is the effect of the $j^{th}$ period

$T_k$ is the effect of the $k^{th}$ treatment

$e_{ijk}$ is the random error associated with the observation on the $i^{th}$ animal fed the $k^{th}$ treatment in the $j^{th}$ period. It is further assumed that $e_{ijk}$ is normally and independently distributed with a mean 0 and variance $\delta^2$ i.e. $e_{ijk} \cap N(0, \delta^2)$. Comparison of means was made by Duncan's Multiple Range Test as described by Steel *et al*. (1997)

## RESULTS

The effect of feeding different sources of dietary fat on nutrient intake, digestibility, rumen fermentation and blood metabolites in lactating Nili-Ravi buffaloes was investigated. The average daily intakes of DM, DM as percentage of BW, OM, CP, EE, ADF, NDF, $NE_L$ (Mcal/d) and DE (Mcal/d) are given in table 2. Total DM intake and DM as a percentage of BW for buffaloes fed supplemental tallow and poultry fat were significantly lower ($P < 0.01$) from those fed the control diet or the diet containing mustard oil. However, no significant differences ($P > 0.05$) were observed between buffaloes fed the control diet and those fed the diet containing mustard oil. The average daily intakes of OM, CP, ADF and NDF varied with differences in DM intake. Intake of EE increased in buffaloes fed supplemental fats and oil as compared to control. Intakes of $NE_L$ and DE were significantly higher ($P < 0.01$) in buffaloes fed diet containing mustard oil than for those on control or diets containing tallow and poultry fat.

Average digestibility coefficients of DM, OM, CP, EE, ADF and NDF are given in table 3. No significant differences ($P > 0.05$) in DM digestibility were noted in buffaloes fed the diets supplemented with tallow or poultry fat versus those fed the control diet. No significant differences ($P > 0.05$) in DM digestibility were also noted in groups fed the diets contained poultry fat or mustard oil than those fed the control diet. Average digestibility coefficients for OM were significantly higher ($P < 0.01$) in buffaloes fed the diets containing tallow and poultry fat than those fed the control diet or the diet supplemented with mustard oil.

Digestibility coefficients of CP were significantly ($P < 0.05$) lower in buffaloes fed the mustard oil supplemented diet compared with those fed control or diets containing tallow or poultry fat. Differences in CP digestibility were not significant ($P > 0.05$) among the control diet and diets containing poultry fat or tallow. Digestibility coefficients of EE differed significantly ($P < 0.01$) for buffaloes fed the control diet versus those fed diets containing supplemental tallow and poultry fat, but not for those fed the diet containing mustard oil. Means for digestibility of ADF were significantly higher ($P < 0.01$) for buffaloes fed the

control diet or diets supplemented with tallow or poultry fat than from those fed mustard oil. The NDF digestibility was significantly higher ($P < 0.01$) for buffaloes fed diet containing tallow and lower for those fed mustard oil compared to those fed the control diet or the diet containing poultry fat.

The supplemental fat sources did not change rumen pH significantly (Table 4). The acetate concentration was significantly ($P < 0.01$) lower in buffaloes fed fat-supplemented diets than in those fed the control diet (Table 4). However, the percentages of acetate were significantly ($P < 0.01$) higher in buffaloes fed tallow and poultry fat-supplemented diets than in those fed mustard oil. Mustard oil fed group showed significantly ($P < 0.01$) higher concentrations of propionate than those fed tallow or the control diet (Table 4). However, no significant differences in propionate production in the rumen were noted between buffaloes fed diets supplemented with tallow or poultry fat. Acetate to propionate ratios were significantly ($P < 0.01$) lower in buffaloes fed diets supplemented with different sources of fat than those fed the control diet. The acetate to propionate ratio was significantly ($P < 0.05$) lower in buffaloes fed the mustard oil-containing diet than those assigned to diets containing either tallow or poultry fat. The decreased dietary ADF digestibility might have been associated with the negative effect on the ratio of acetate to propionate. Butyrate proportion was significantly ($P < 0.01$) higher in buffaloes fed the mustard oil-containing diet (Table 4). No significant differences ($P > 0.05$) in butyrate content were noted between buffaloes fed diets containing tallow or poultry fat and those fed the control diet.

Average values of blood pH and concentrations of glucose, total cholesterol, triglycerides and total blood lipids are given in table 5. No significant differences ($P > 0.05$) were observed in blood pH and concentrations of glucose, total cholesterol, triglyceride and total lipids in the blood of buffaloes fed the control diet versus those fed diets containing different sources of supplemental fat. However, concentrations of these metabolites tended to be greater for buffaloes fed supplemental fat sources.

## DISCUSSION

Total DM intake and DM as a percentage of BW for buffaloes fed supplemental tallow and poultry fat were significantly lower ($p < 0.01$) from those fed the control diet or the diet containing mustard oil. These results supported the findings of the previous study (Onetti and Grummer, 2004) which reported decreased DM intake in lactating dairy cows fed diets containing tallow, calcium salts of palm fatty acids and selected hydrolyzed tallow fatty acids. These results also supported the findings of other workers (Pantoja, *et al*., 1996) who reported lower intake of DM in lactating cows fed diets containing saturated tallow, tallow or blended animal vegetable fat than those fed the control diet. However, no significant differences ($P > 0.05$) were observed between buffaloes fed the control diet and those fed the diet containing mustard oil supported the findings of an other study (Jenkins and Jenny, 1992) which showed that supplemental canola oil decreased DM intake in lactating dairy cows. These results were similar with the findings of other workers (Zheng *et al*., 2005) who observed relatively constant DM intake in lactating cows fed the control diet and those fed diets either containing cottonseed oil, soybean oil or corn oil. In contrast, some other workers reported that fish oil and sunflower oil diets decreased DM intake in lactating cows (Shingfield et al., 2006). The DM intake response suggested that buffaloes fed tallow and poultry fat might need more time to adjust to diets compared to buffaloes fed the diet containing mustard oil or those on control.

The average daily intakes of OM, CP, ADF and NDF varied with differences in DM intake. Intake of EE increased in buffaloes fed supplemental fats and oil as compared to control, which was attributed to the addition of supplemental fat. Intakes of $NE_L$ and DE were significantly higher ($P < 0.01$) in buffaloes fed diet containing mustard oil than for those on control or diets containing tallow and poultry fat. Significantly higher ($P < 0.01$) intake of energy in buffaloes fed the mustard oil supplemented diet was in agreement with the findings of other study (Steele, 1984) which showed that cows receiving groundnut oil ingested more energy than those receiving tallow supplement. The chemostatic mechanisms might have been responsible for control of DM intake. These observations were in agreement with results of another study (Gagliostro and Chilliard, 1991) which reported that when fat supplementation decreased DM intake, energy intake did not decrease. Noticeably, greater intakes of $NE_L$ and DE in the mustard oil group were primarily due to high DM intake.

No significant differences ($P > 0.05$) in DM digestibility were noted in buffaloes fed the diets supplemented with tallow or poultry fat versus those fed the control diet. No significant differences ($P > 0.05$) in DM digestibility were also noted in buffaloes fed the diets containing poultry fat or mustard oil than those fed the control diet. The results of the present study agreed with the findings of previous study (Drackley and Elliott, 1996) which showed that apparent digestibility of DM was similar in dairy cows assigned to control and supplemental hydrogenated tallow diets. These results supported the findings of another study (Doreau *et al*., 1991) which reported that diets supplemented with mustard oil or tallow had no effect on total DM digestibility. However, the present results did not support the findings of other workers (Simas *et al*., 1995) who reported that addition of fat to the diets of dairy cows increased DM digestibility.

Average digestibility coefficients for OM were higher ($P < 0.01$) in buffaloes fed diets containing tallow and poultry fat than those fed the control diet or the diet supplemented with mustard oil. These findings supported the results of other workers (Simas *et al*., 1995), who reported higher digestibility of OM in early lactating cows due to feeding added dietary fat. The results of other workers (Schauff *et al*., 1992) who reported that OM digestibility significantly decreased due to feeding supplemental fat to lactating dairy cows, were not in accordance with the results obtained from buffaloes fed tallow and poultry fat. However, our findings were different from the results of other workers (Doreau *et al*., 1991) that diets supplemented with either mustard oil or tallow had no influence on digestibility of OM. Digestibility coefficients of CP were significantly ($P < 0.05$) lower in buffaloes fed the mustard oil supplemented diet compared with those fed the control diet or diets containing either tallow or poultry fat. Differences in CP digestibility were not significant ($P > 0.05$) among the control diet and diets containing poultry fat or tallow. The results were in agreement with the findings of previous study (Jenkins, 1990) which reported that protein digestion reduced or not changed by adding fat to the diet of ruminants. Protein metabolism in the rumen is altered when fat supplements interferes with fermentation, therefore, infusion of oil into the rumen of sheep decreased protein digestion (Ikwuegbu and Sutton, 1982). Digestibility coefficients of EE differed significantly ($P < 0.01$) for buffaloes fed the control diet versus those fed diets containing supplemental tallow and poultry fat, but not for those fed the diet containing mustard oil. These results supported the findings of other workers (Simas *et al*., 1995) who found that diets supplemented with saturated fat increased digestibility of EE. However, some studies (Drackley Elliott) found no decrease in digestibility of EE due to feeding supplemental hydrogenated tallow to lactating dairy cows.

Means for digestibility of ADF were significantly higher ($P < 0.01$) for buffaloes fed the control diet or diets supplemented with tallow or poultry fat than from those fed mustard oil. The results on tallow and poultry fat were in agreement with the previous study (Wu *et al*., 1993,) which reported that apparent digestibility of ADF did not differ significantly in dairy cows due to supplemental fat sources. The results obtained from buffaloes fed mustard oil were in agreement with those of other workers (Ikwuegbu and Sutton, 1982) who observed that supplementation of varying amounts of linseed oil in the diets of sheep reduced ruminal digestion of structural carbohydrates. The decrease in digestion is accompanied with reduced production of methane, hydrogen and VFA, including lower acetate to propionate ratio. The results of previous study (Schauff, *et al*., 1992) did not agree with the present findings because they noted that digestibility of ADF decreased due to feeding supplemental fat. Adverse effects of adding yellow grease (DePeters *et al*, 1989), tallow or animal vegetable fat blend (Palmquist and Conrad, 1978) to the diets of lactating dairy cows on total tract ADF digestibilities were observed minimal and these observations supported the results obtained from buffaloes.

The NDF digestibility was significantly higher ($P < 0.01$) for buffaloes fed diet containing tallow and lower for those fed mustard oil compared to those fed the control diet or the diet containing poultry fat. The results noted in buffaloes fed supplemental tallow and poultry fat did not support the findings of previous study (Grummer, 1988) ) which reported that digestibility of NDF in cows decreased due to fat supplementation in their diets; however, these findings supported the results obtained from buffaloes fed mustard oil. The results of other workers (Wu *et al*., 1993), who reported that digestibility of NDF was not affected by supplementation of three fat sources in the diets of lactating cows did not agree with the present findings.

Means for digestibilities of ADF and NDF noted in mustard oil group showed that liquid fats are adsorbed on particulate matter in the rumen and appears to either protect fiber from fermentation or are toxic to cellulolytic organisms. Both effects reduce fiber digestibility in rumen. Therefore, the process of hydrogenation is needed to increase the melting point of oil or fat to decrease its solubility in ruminal fluid. Hydrogenated fats have few negative effects on ruminal fermentation and digestion of nutrients (Jenkins and Jenny, 1989). They further reported that feeding pure vegetable oil reduced fiber digestion. However, such an effect may be less if the oil is encapsulated and introduced into the rumen in small doses as part of total mixed ration.

No differences in ruminal pH were noted between control and treatment groups. These results were in agreement with those of other workers (Grummer, 1988) who reported that ruminal pH was unaffected by feeding supplemental fat to lactating dairy cows. These results also supported the findings of previous study (Doreau *et al*., 1991) which showed that addition of oil in the diets of lactating dairy cows caused no significant differences in rumen pH. The proportion of acetate concentration was significantly ($P < 0.01$) lower in buffaloes fed fat-supplemented diets than in those fed the control diet. However, the percentages of acetate were significantly ($P < 0.01$) higher in buffaloes fed tallow and poultry fat-supplemented diets than in those fed mustard oil. Significantly, ($P < 0.01$) higher concentrations of propionate were found in mustard oil-fed group than in those fed tallow or the control diet. However, no significant differences in propionate production in the rumen were noted between buffaloes fed diets supplemented with tallow or poultry fat. The acetate to propionate ratio was significantly ($P < 0.05$) lower in

buffaloes fed the mustard oil-containing diet than those assigned to diets containing either tallow or poultry fat. The decreased dietary ADF digestibility might have been associated with the negative effect on the ratio of acetate to propionate. The findings that supplemental fat resulted in decreased acetate and increased propionate proportions in the rumen agreed with the report of other workers (Doreau *et al*., 1991) who supplemented rapeseed oil in the diets of lactating dairy cows. The present findings also supported the results of previous study (Ikwuegbu and Sutton, 1982) which showed that supplementation of varying amount of linseed oil in the diets of sheep decreased acetate to propionate ratios. These observations were in line with the findings of another study (Jenkins and Jenny, 1992) which reported that feeding combinations of fat and canola oil decreased acetate, increased propionate and decreased the ratio of acetate to propionate in lactating cows. Butyrate proportion was significantly ($P < 0.01$) higher in buffaloes fed the mustard oil-containing diet. However, no significant differences ($P > 0.05$) in butyrate production in the rumen were noted between animals fed diets containing tallow or poultry fat and those fed the control diet. These findings did not support the results of other study (Avila *et al*., 2000) which reported that butyrate molar percentage decreased in lactating cows fed diets containing supplemental fat.

No significant differences ($P > 0.05$) were observed in blood pH and concentrations of glucose, total cholesterol, triglycerides and total lipids in the blood of buffaloes fed the control diet versus those fed diets containing different sources of supplemental fat. However, concentrations of these metabolites tended to be greater for buffaloes fed supplemental fat. Dietary fat might have spared glucose from oxidation in mammary glands, which might increase glucose concentrations in blood. Other studies with lactating dairy cows fed supplemental fat indicated either decreased (Palmquist and Moser, 1981) or increased blood glucose concentrations (Elliott *et al*., 1993). These results were also in agreement with findings of other study (DePeters *et al*., 1989) which indicated no significant influence on blood glucose concentration due to feeding added fat to lactating dairy cows. Differences in blood cholesterol were non significant, however, an increasing trend in blood total cholesterol from control to added fat sources was noted in early lactating buffaloes giving an indication that higher levels of fat addition might increase total cholesterol concentrations. Buffaloes had greater concentrations of total cholesterol in blood when fed diets containing supplemental fat than when fed the control diet, which is a response often observed because increased cholesterol is required for absorption and transport of dietary long-chain FA. Results obtained from buffaloes fed 3% supplemental fat (low level) were in agreement with the findings of previous study (DePeters *et al*., 1989) which reported increased blood total cholesterol concentrations with high dietary fat level.

**Table 1. Percent Ingredient and Nutrient Composition of the Experimental Diets Containing Tallow, Poultry Fat or Mustard Oil.**

| Ingredients | A<br>Control | B<br>Tallow | C<br>Poultry fat | D<br>Mustard oil |
|---|---|---|---|---|
| Mott grass | 46.82 | 40.60 | 40.42 | 40.42 |
| Wheat straw | 11.72 | 12.42 | 12.39 | 12.39 |
| Cottonseed cake | 13.24 | 14.05 | 14.00 | 14.00 |
| Maize oil cake | 13.47 | 14.29 | 14.25 | 14.25 |
| Wheat bran | 14.04 | 14.88 | 15.17 | 15.17 |
| Tallow | - | 3.00 | - | - |
| Poultry Fat | - | - | 3.00 | - |
| Mustard oil | - | - | - | 3.00 |
| Dicalcium phosphate | 0.72 | 0.76 | 0.77 | 0.77 |
| Total | 100 | 100 | 100 | 100 |
| Dry matter % | 33.62 | 36.70 | 36.77 | 36.78 |
| Organic matter% | 91.17 | 91.39 | 91.39 | 91.39 |
| Crude protein % | 12.50 | 12.50 | 12.50 | 12.50 |
| Ether extract % | 3.50 | 6.50 | 6.50 | 6.50 |
| ADF % | 27.70 | 26.41 | 26.50 | 26.50 |
| NDF % | 47.54 | 45.60 | 45.55 | 45.55 |
| DE Mcal/kg DM | 2.19 | 2.43 | 2.43 | 2.43 |
| $NE_L$ Mcal/kg DM | 1.42 | 1.50 | 1.50 | 1.50 |
| Calcium % | 0.54 | 0.53 | 0.53 | 0.53 |
| Phosphorus % | 0.41 | 0.42 | 0.42 | 0.42 |

**Table 2. Average Daily Nutrients Intake by Buffaloes Fed Diets Containing Different Sources of Supplemental Fat.**

| Item | Diets | | | | SEM |
|---|---|---|---|---|---|
| | A Control | B Tallow | C Poultry fat | D Mustard oil | |
| Dry matter (kg) | 13.8 [a] | 12.7 [b] | 12.9 [b] | 14.2 [a] | 0.200 |
| Dry matter (% BW) | 3.12 [a] | 2.88 [b] | 2.93 [b] | 3.23 [a] | 0.046 |
| Organic matter (kg) | 12.6 [a] | 11.6 [b] | 11.8 [b] | 13.0 [a] | 0.185 |
| Crude protein (kg) | 1.72 [a] | 1.59 [b] | 1.61 [b] | 1.78 [a] | 0.025 |
| Ether extract (kg) | 0.48 [c] | 0.83 [b] | 0.84 [b] | 0.93 [a] | 0.012 |
| ADF (kg) | 3.81 [a] | 3.39 [b] | 3.42 [b] | 3.77 [a] | 0.058 |
| NDF (kg) | 6.55 [a] | 5.79 [b] | 5.88 [b] | 6.48 [a] | 0.092 |
| $NE_L$ (Mcal/day) | 19.6 [b] | 19.0 [b] | 19.4 [b] | 21.4 [a] | 0.298 |
| DE (Mcal/day) | 30.1 [b] | 30.8 [b] | 31.4 [b] | 34.6 [a] | 0.466 |

Means with the same superscript in a row show non-significant difference (P>0.05)
SEM= Standard error of means

**Table 3. Nutrient Digestibility Coefficients in Buffaloes Fed Diets Containing Different Sources of Supplemental Fat.**

| Item | Diets | | | | SEM |
|---|---|---|---|---|---|
| | A Control | B Tallow | C Poultry fat | D Mustard oil | |
| DM | 69.9 [ab] | 71.3 [a] | 70.4 [ab] | 69.0 [b] | 0.492 |
| OM | 68.1 [b] | 69.2 [a] | 69.0 [a] | 66.9 [c] | 0.163 |
| CP | 67.2 [a] | 68.4 [a] | 67.8 [a] | 65.0 [b] | 0.490 |
| EE | 70.2 [c] | 75.9 [a] | 73.8 [b] | 69.4 [c] | 0.314 |
| ADF | 38.2 [a] | 39.4 [a] | 37.9 [a] | 36.0 [b] | 0.429 |
| NDF | 41.3 [c] | 45.3 [a] | 44.1 [b] | 39.9 [d] | 0.284 |

Means with the same superscript in a row show non-significant difference (P>0.05)
SEM= Standard error of means

**Table 4. Blood pH and other Metabolites in Buffaloes Fed Diets Containing Different Sources of Supplemental Fat.**

| Item | Diets | | | | SEM |
|---|---|---|---|---|---|
| | A Control | B Tallow | C Poultry fat | D Mustard oil | |
| Blood pH | 7.59 | 7.45 | 7.38 | 7.50 | 0.062 |
| Glucose (mg/dl) | 67.4 | 71.4 | 69.1 | 68.7 | 3.710 |
| Total cholesterol (mg/dl) | 123.7 | 147.0 | 135.1 | 148.3 | 15.467 |
| Triglyceride (mg/dl) | 21.9 | 24.3 | 23.9 | 22.7 | 2.042 |
| Total blood lipids (mg/dl) | 329.9 | 359.4 | 360.2 | 387.6 | 51.310 |

Means with the same superscript in a row show non-significant difference (P>0.05)
SEM= Standard error of means

The findings that supplemental fat caused a non-significant rise in blood triglycerides concentration of buffaloes agreed with the results of other workers (Palmquist and Mattos, 1978) who reported that increased uptake of FA from the intestine would be expected to increase triglycerides concentration in blood. Fatty acids entering the liver may be oxidized or esterified, mainly to form triglyceride, which can be stored or exported as part of very low-density lipoprotein. The process is thought to occur at a very low rate in ruminants, which would increase triglyceride contents in the blood. The results on buffaloes showed an elevated trend in the concentrations of blood total lipids but the differences from control towards fat supplementation were non-significant. Supplemental fat increases the concentrations of free cholesterol, cholesterol esters, triglyceride and phospholipids, which may increase the level of total lipid in blood. These findings were in agreement with those of

others (Palmquist and Conrad, 1978; Palmquist and Moser, 1981) who found that added fat tended to increase the concentrations of total lipids in blood.

**Table 5. Rumen pH and Volatile Fatty Acids in Buffaloes Fed Diets Containing Different Sources of Supplemental Fat**

| Item | Diets | | | | SEM |
|---|---|---|---|---|---|
| | A Control | B Tallow | C Poultry fat | D Mustard oil | |
| Rumen pH | 7.06 [a] | 6.96 [a] | 6.94 [a] | 6.86 [a] | 0.083 |
| Acetate (mol/100 mol) | 63.0 [a] | 61.0 [b] | 59.4 [c] | 57.5 [d] | 0.405 |
| Propionate (mol/100 mol) | 19.8 [c] | 22.3 [b] | 22.9 [ab] | 24.5 [a] | 0.514 |
| Butyrate (mol/100mol) | 11.2 [b] | 10.2 [b] | 11.5 [b] | 12.9 [a] | 0.358 |
| Acetate to propionate ratio | 3.18 [a] | 2.74 [b] | 2.60 [b] | 2.35 [c] | 0.063 |

Means with the same superscript in a row show non-significant difference (P>0.05)
SEM= Standard error of means

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