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METABOLIC EFFECTS OF FEEDING SUPPLEMENTAL TALLOW TO LACTATING NILI-RAVI BUFFALO

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ABSTRACT

Four early lactating Nili-Ravi buffaloes were fed four experimental diets containing 0, 2, 4 and 6% tallow in an experiment conducted in a 4x4 Latin Square design to study the effect of feeding different levels of tallow on nutrient intake, digestibility, rumen fermentation and blood metabolites. The intakes of DM, OM, CP, ADF and NDF decreased ($P<0.01$) but intakes of EE ($P<0.01$) increased with increasing level of tallow in the diets. The intakes of NE_L and DE did not decrease with the reduction of DM intake. Digestibility of DM, OM, ADF and NDF improved in buffaloes fed diets containing 2 and 4% tallow but beyond 4% it tended to decline significantly. Digestion coefficients of CP did not differ, while that of EE improved ($P<0.01$) from 68.2 to 74.5%. Rumen pH did not differ significantly ($P>0.05$) but acetate content decreased significantly ($P<0.01$) as the level of dietary tallow increased, whereas, propionate molar percentages increased ($P<0.01$) with increasing level of tallow in the diets. However, butyrate contents were not statistically different among different treatment groups. Acetate to propionate ratio decreased linearly ($P<0.05$) with increasing level of tallow in the diets. Blood pH and concentration of glucose did not vary significantly but cholesterol, triglycerides and total lipids increased ($P<0.01$) as the level of tallow increased in the diets. These results suggest that tallow up to 4% of diet dry matter is a suitable fat supplement as an energy source for lactating Pakistani Nili-Ravi buffaloes.

Keywords: Tallow levels, nutrient intake, digestibility, rumen fermentation, blood metabolites

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INTRODUCTION

The dairy industry in Pakistan is buffalo oriented. Pakistan inhabits 29.3 million buffaloes. Buffaloes in milk contribute 65% of the total milk produced in the country (Anonymous, 2011). Research studies on different aspects of buffalo production have been going on for the last several years. 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 (Fahimuddin,1989). 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. 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 (Markus et al., 1996). Shaver (1990) also reported that many high producing commercial dairy herds successfully utilized tallow and oil seeds in their diets. Annual production of tallow in Pakistan is 0.47 million tons (Anonymous, 2006). However, the optimal amounts of tallow to feed to lactating buffaloes to enhance lactational performance without causing negative effect on nutrient intake, digestibility, ruminal fermentation and blood metabolites have not been determined. It was thus imperative to study the comparative feeding value of different levels of tallow in lactating buffaloes. A study was, therefore, conducted to determine the effect of feeding different levels of tallow on nutrient intake, digestibility, rumen fermentation and blood metabolites in lactating Nili-Ravi buffaloes.

MATERIALS AND METHODS

An experiment was conducted in a 4x4 Latin Square design at Raja Muhammad Akram, Animal Nutrition Research Centre, University of Agriculture, Faisalabad, Pakistan to determine the metabolic effects of feeding supplemental tallow 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 as 2, 4 and 6% of diet dry matter were formulated and fed as complete mixed diet according to nutrients 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. The feed offered and refused were recorded daily and proportionate samples were taken during the last 7 days of each trial. 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. Faecal "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^{o}C for 48 hours. Composited dried samples were ground through a 1 mm screen in a Willey mill and were stored at -20^{o}C until analysed for dry matter(AOAC, 1990; method 934.01), organic matter (AOAC, 1990; method 9420.5), ash (AOAC, 1990; method 9420.5), crude protein as kjeldahl nitrogen (AOAC, 1995; method 920.03), ether extract (AOAC, 1990; method 9920.39), acid detergent fibre and neutral detergent fibre content (Van Soest and Robertson, 1985). The ground fecal samples were also analyzed for chromium by atomic absorption spectrophotometer (Williams et al., 1962) to determine digestibility as described by 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% sulphuric acid (H_2SO_4), centrifuged at 30,000 x g for 10 minutes and the supernatant was collected and stored at -20^{o}C until analysed for volatile fatty acids by gas chromatography (Erwin et al., 1961) utilising 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^{o}C until analysed for glucose, total cholesterol, triglyceride and total blood lipids. The data were subjected to analysis of variance using a 4 x 4 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 δ^2 i.e. $e_{ijk} \cap N (0, \delta^2)$. Comparison of mean difference was made by Duncan's Multiple Range Test as described by Steel et al (1997).

RESULTS AND DISCUSSION

The average daily intakes of dry matter (DM), DM as percentage of body weight (BW), organic matter (OM), crude protein (CP), ether extract (EE), acid detergent fibre (ADF), neutral detergent fibre (NDF), ash, net energy for lactation (NE_L) and digestible energy (DE) are presented in Table 2. Total DM intake as well as that of percentage of BW decreased ($P < 0.05$) with increasing levels of tallow in the diets. Intakes of OM, CP, ADF and NDF varied with differences in DM intake, whereas, intake of EE increased ($P < 0.01$) with increasing quantities of tallow in the diets. These results supported the findings of Ruppert et al. (2003) and Onetti et al. (2002) who observed that tallow supplementation in the diets linearly decreased DM intake in lactating cows versus those fed the control diet. However, Sarwar et al. (2003) observed no effect of increasing levels of supplemental fat on the DM intake in cross bred lactating cows. The chemo-static mechanisms might have been responsible for control of DM intake. This might be due to the effect that DE contents of the diets increased with increasing levels of tallow in the diets, therefore, decreased DM intake did not decrease DE intake in buffaloes. Gagliostro and Chilliard (1991) found that when fat supplementation decreased DM intake, energy intake did not decrease. The intakes of both NE_L and DE did not decrease with the reduction of DM intake in animals fed varying levels of supplemental tallow as compared to control.

Table 1. Percent ingredient and nutrient composition of the experimental diets (% DM basis)

Ingredients	A Control	B (2%)	C (4%)	D (6%)
Berseem (Egyptian clover)	39.46	36.59	35.73	33.76
Wheat straw	21.99	21.19	18.39	16.93
Cottonseed cake	11.72	12.22	12.73	13.16
Maize oil cake	11.92	12.44	12.95	13.39
Wheat bran	14.18	14.80	15.41	15.93
Tallow	-	2.00	4.00	6.00
Dicalcium phosphate	0.73	0.76	0.79	0.83
Total	**100**	**100**	**100**	**100**
Dry matter (g/kg)	303.0	319.5	324.7	340.1
Organic matter(g/kg DM)	913.6	915.3	916.5	918.1
Crude protein (g/kg DM)	121.0	126.0	127.0	126.0
Ether extract (g/kg DM)	40.0	59.0	79.0	99.0
ADF (g/kg DM)	268.9	261.3	249.3	238.7
NDF (g/kg DM)	477.3	466.0	454.7	445.4
DE MJ/kg DM	8.99	9.71	10.46	11.05
NE_L MJ/kg DM	5.98	6.15	6.44	6.61
Calcium (g/kg DM)	5.8	5.7	5.8	5.8
Phosphorus (g/kg DM)	4.4	4.5	4.6	4.6

Table 2. Effect of feeding of different levels of tallow on nutrient intake, digestibility, rumen fermentation and blood metabolites in lactating Nili-Ravi buffaloes

			Nutrient intake		
Item	A (control)	B (2%)	C (4%)	D (6%)	SEM
DM (kg)	14.4^{a}	13.1^{b}	12.7^{b}	12.6^{b}	0.310
DM (%BW)	3.39^{a}	3.08^{b}	3.00^{b}	2.91^{b}	0.071
OM (kg)	13.2^{a}	12.0^{b}	11.7^{b}	11.6^{b}	0.286
CP (kg)	1.83^{a}	1.65^{b}	1.61^{b}	1.60^{b}	0.039
EE (kg)	0.58^{d}	0.77^{c}	1.00^{b}	1.25^{a}	0.023
ADF (kg)	3.87^{a}	3.41^{b}	3.23^{bc}	3.02^{c}	0.091
NDF (kg)	6.86^{a}	6.09^{b}	5.82^{b}	5.63^{b}	0.150
NE_L (MJ/day)	86.21^{a}	80.35^{a}	81.61^{a}	83.7^{a}	1.946
DE (MJ/day)	129.32^{ab}	126.39^{b}	133.08^{ab}	139.78^{a}	3.181
			Nutrient digestibility coefficients		
DM	66.4^{b}	67.9^{b}	70.6^{a}	67.4^{b}	0.790
OM	63.4^{bc}	64.9^{b}	67.2^{a}	62.7^{c}	0.528
CP	63.5^{a}	63.9^{a}	63.0^{a}	62.7^{a}	0.271
EE	68.2^{c}	69.3^{c}	72.6^{b}	74.5^{a}	0.446
ADF	34.6^{bc}	35.5^{b}	37.4^{a}	33.6^{c}	0.316
NDF	36.6^{c}	38.8^{b}	41.8^{a}	35.8^{c}	0.318
			Rumen pH and volatile fatty acids		
Rumen pH	7.14^{a}	7.10^{a}	6.96^{a}	6.89^{a}	0.074
Acetate (mol/100 mol)	64.9^{a}	64.0^{ab}	63.2^{bc}	62.08^{c}	0.416
Propionate (mol/100 mol)	20.0^{c}	21.5^{bc}	22.8^{ab}	23.3^{a}	0.460
Butyrate (mol/100mol)	9.8^{a}	10.2^{a}	10.4^{a}	10.6^{a}	0.210
Acetate to propionate ratio	3.24^{a}	2.98^{ab}	2.78^{bc}	2.66^{c}	0.077
			Blood metabolites		
Blood pH	7.57^{a}	7.53^{a}	7.69^{a}	7.64^{a}	0.105
Glucose (mg/dl)	71.1^{a}	74.3^{a}	78.7^{a}	81.3^{a}	3.576
Total cholesterol (mg/dl)	89.7^{b}	113.6^{b}	152.8^{a}	169.0^{a}	7.465
Triglyceride (mg/dl)	21.3^{b}	29.9^{ab}	42.7^{a}	39.3^{a}	3.639
Total blood lipids (mg/dl)	215.8^{b}	248.3^{b}	317.6^{a}	339.6^{a}	12.360

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

The average digestibility coefficients for DM, OM, CP, EE, ADF and NDF are given in Table 2. Significantly, higher ($P < 0.05$) digestibility of DM was noted in buffaloes fed 4% supplemental tallow and there were no significant ($P > 0.05$) differences in animals fed diets containing 2 or 6% supplemental tallow and those fed the control diet. The results noted for buffaloes fed 4% supplemental tallow appeared to be in line with those of Simas (1995) who observed higher digestibility of DM due to feeding added fat to dairy cows. The results noted on 2 or 6% supplemental tallow supported the work of Drackley and Elliott (1993) who reported that supplemental dietary tallow did not affect digestibility of DM.

Digestibility coefficient of OM was the highest ($P < 0.01$) in buffaloes fed diet containing 4% supplemental tallow, which is attributable to higher digestibility of EE, ADF and NDF. These results were in line with those of Simas et al. (1995) who reported higher digestibility of OM in early lactating cows fed dietary fat. However, the results were not supported by Avila et al. (2000) who found that OM digestibility tended to decrease ($P < 0.05$) with increasing quantities of tallow in the diets of lactating dairy cows. Digestibility of CP did not differ ($P > 0.05$) among treatment groups; however, it followed a linear decreasing ($P < 0.05$) trend due to supplemental tallow. Pantoja et al. (1996) also reported that digestibility of N was not affected by tallow supplementation in the diets of dairy cows. These findings were also not in accordance with those of Sarwar et al. (2003) who found that CP digestibility decreased with increasing levels tallow in the diets of cross bred lactating cows.

Digestibility of EE followed a linear increasing ($P < 0.01$) trend due to increasing level of tallow in the diets. The results were in agreement with those of Simas et al. (1995) who found that fat supplementation increased digestibility of EE. However the findings of this study were not in accordance with those of Elliott et al. (1993) who observed lower digestibility of EE in lactating dairy cows when tallow was added to diets containing high oil corn. Improvement in the digestion coefficients of ADF and NDF was noted in buffaloes fed 2 and 4% supplemental tallow but beyond 4%, the digestibility of ADF and NDF tended to decline significantly.The results noted in animals fed 2 or 6% added tallow were in agreement with those of Drackley and Elliott (1993) who observed that apparent digestibility of ADF did not differ from their control group due to feeding added tallow. However, James et al. (1993) reported decreased digestibility of ADF and NDF in lactating cows with fat supplementation did not support the results of the present study.

The average values for rumen fluid pH and volatile fatty acids are presented in Table 2. Rumen liquor pH did not differ ($P>0.05$) among treatment groups, however, it followed a linear decreasing trend ($P<0.05$) due to addition of tallow in the diets.These results were in agreement with those of Onetti et al. (2001) who observed that ruminal pH was unaffected by feeding supplemental tallow to lactating dairy cows. The reason for reduction in ruminal pH due to supplemental tallow is probably that tallow is hydrolysed into fatty acids and when concentration of fatty acids increases, rumen pH tends to decrease.

Acetate molar percentage decreased linearly ($P < 0.05$) as the level of tallow increased in the diets of buffaloes. The results were in line with those of Onetti et al. (2001) who reported that acetate concentration in the rumen decreased with fat supplementation in the diets of lactating dairy cows. However, Pantoja et al.(1995) reported unaffected acetate concentration in the rumen liquor of lactating dairy cows fed partially hydrogenated tallow. Average molar percentages of propionate were significantly ($P < 0.01$) higher in groups fed diets containing 4 and 6% tallow than those fed the control diet. However, no significant differences ($P > 0.05$) in propionate molar percentages were noted between control and those fed diet containing 2% tallow. Similar findings were reported by Tackett et al. (1996) who fed supplemental fat to lactating cows. The acetate to propionate ratio decreased ($P < 0.01$) linearly with increasing levels of supplemental tallow in the diets. However, Harrison et al. (1995) observed that whole cottonseeds or whole cottonseeds plus Ca-salts of long chain fatty acids supplementation caused no change in ruminal acetate to propionate ratio versus their respective control. Butyrate concentrations were not significantly different ($P > 0.05$) in buffaloes fed the control diet versus those assigned to varying levels of supplemental tallow. These findings were supported by Drackley and Elliott (1993) who observed that butyrate concentration was unaffected in lactating dairy cows fed supplemental tallow. However, the findings were not supported by Avila et al.(2000) who observed that butyrate molar percentage decreased in lactating cows fed diets containing supplemental fat.

Average values for blood pH and concentrations of glucose, total cholesterol, triglyceride and total blood lipids are presented in Table 2. Blood pH and glucose concentrations were not significantly different ($P > 0.05$) in buffaloes fed different levels of tallow, however, the concentration of glucose in blood tended to be greater for buffaloes fed supplemented tallow. Dietary fat might have spared glucose from oxidation in mammary glands which could increase glucose levels in blood. The results of present study were in accordance with those of Grummer and Carroll (1991) who did not find any effect of fat feeding on blood glucose concentrations. However, the results were different from those of Erickson et al. (1992) who observed decreased glucose in lactating dairy cows with fat supplementation.

A linear increasing ($P < 0.01$) trend in total cholesterol was observed from 2 to 6% dietary tallow, giving an idea that blood cholesterol increased with increasing the levels of supplemental tallow, which is a response often observed because increased cholesterol is required for absorption and transport of dietary long-chain fatty acids. The results were in agreement with those of Son et al., (1996) who reported that total cholesterol concentrations in blood were greater for cows fed high tallow diets than for cows fed low tallow diets. Average values for triglycerides ($P < 0.05$) and total lipids ($P < 0.01$) were higher in buffaloes fed diets containing 4 and 6% tallow. Overall, a linear increasing ($P < 0.01$) trend in triglycerides and total blood lipids was noted from 2 to 6% dietary tallow. Palmquist and Mattos (1978) reported that increased uptake of fatty acids from the intestine would be expected to increase triglyceride concentration in blood. Supplemental fat increased the concentrations of free cholesterol, cholesterol esters, triglycerides and phospholipids that might increase the level of total lipids in blood.

Conclusion: The results of the study suggest that tallow up to 4% of diet dry matter appears to be a suitable fat supplement as an energy source for lactating buffaloes.

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