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Effect of sunflower oil supplementation on nutrient utilization and growth performances of crossbred calves

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ABSTRACT

The study was conducted to evaluate efficiency of dietary supplementation of sunflower-oil twice in a week, to reduce rumen protozoal population and its effect on nutrients utilization and growth performance of growing crossbred calves. Growing Jersey male crossbred calves (15) were randomly divided into 3 equal groups (G1, G2 and G3) and fed individually under stall feeding on a mixed ration containing 50% maize fodder and 50% concentrate mixture for 120 days. Sunflower oil was supplemented along with concentrate mixture at 0 (control), 2 and 4% of the daily DM intake for consecutive 2 days in every week to the calves of G1, G2 and G3 group, respectively during the entire experimental period. Daily dry matter intake, apparent nutrient digestibility, nutritive value of experimental ration and plane of nutrition were similar among the sunflower oil supplemented and non supplemented calves. Lowest rumen protozoal number was observed in calves of G3 group followed by G2 and G1 group. Average finishing body weight, daily body weight gain, feed conversion efficiency and blood glucose level were higher in sunflower oil fed calves (G2 and G3) than non-supplemented calves (G1). However, average daily body weight gain and feed conversion efficiency of the calves in G2 and G3 groups were similar. Our results indicated that dietary supplementation of sunflower oil for consecutive 2 days in every week, drastically reduced rumen protozoal population and improved average daily body weight gain, finishing body weight and feed conversion efficiency in growing male crossbred calves.

Key words: Body weight gain, Calves, Feed conversion efficiency, Nutrient digestibility, Plane of nutrition, Sunflower oil

Rumen protozoa possess strong proteolytic capacity and contribute to intra-ruminal recycling of microbial nitrogen (Jouany 1996). The recycling of bacterial nitrogen in rumen is higher in presence of ciliate protozoa (Hristova *et al.* 2001). Rumen ciliate protozoa are predators of rumen bacteria and decrease the intestinal flow of amino acids, mainly those of bacterial origin by 20–30% (Ivan *et al.* 2000). Such effects of rumen protozoa contribute to inefficient utilization of nitrogen, which sometimes necessitates dietary supplementation with protein to satisfy protien requirement of animals (Ivan *et al*. 2004). Rumen ciliate protozoa contribute significantly to ruminal production of methane and the associated loss of dietary energy (Blaxter and Claperton 1965). Methanogens associated with ciliate protozoa are responsible for 9–25% off methanogenesis in the rumen (Newbold *et al.* 1995). Therefore, defaunation of protozoa from the rumen is desirable for efficient utilization of dietary protein and energy (Jouany and Ushida 1999). Defaunation results in an increased microbial protein synthesis (Jouany 1996), reduced ruminal methanogenesis and improved growth rate of young ruminants (Bird and Leng 1984, Santra and Karim 2000). Defaunation is presently not practical due to unavailability of a suitable defaunating agent commercially (Ivan *et al*. 2004). Further, it is very difficult to maintain defaunating animal for a long period as rumen protozoa re-appear after 16 days of defaunation under routine farm management practices in Indian condition (Santra and Karim 1999). However, a considerable reduction in rumen protozoal population may also be beneficial as it increased milk yield and the protein: fat ratio in dairy cows (Moate 1989) and growth rate of young ruminants (Ivan *et al*. 2004). Fatty acids present in plant oil reduce ruminal methane production (Jalc and Ceresnakova 2002) and some are also toxic to rumen protozoa (Hristov *et al*. 2005). Plant oils rich in unsaturated C16 and C18 fatty acids inhibit ruminal protozoal growth *in vitro* and *in vivo* (Hristov *et al.* 2004). Sunflower seed-oil rich in linoleic acid decreased ruminal ciliate protozoal population and increased average daily body weight gain in sheep (Ivan *et al*. 2004). Dietary supplementation of sunflower oil also reduced the ruminal methane production in beef cattle (Mc Ginn *et al.* 2004).

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Therefore, the present experiment was conducted to study the efficiency of dietary supplementation of linoleic acid rich sunflower oil twice in a week, to reduce the rumen protozoal population and to measure the effect on nutrient utilization, plane of nutrition and growth performances of growing crossbred calves.

MATERIALS AND METHODS

Experimental animals and feeding trial: Jersey male crossbred calves (15), 118 ± 4.5 days-old and weighing 51.3 ± 1.14 kg were randomly divided into 3 equal groups (G1, G2 and G3) on the basis of body weight so that average body weight of the all group become similar. These calves were fed individually under stall feeding for 120 days on conventional feeding system (grasses and concentrate mixture separately). Concentrate mixture (commercial concentrate mixture purchased from EPIC, Kalyani, West Bengal, India) was offered to the experimental calves once daily at 9:00 AM after discarding previous day's residue if any. Measured quantity of green maize fodder was offered separately twice daily at 10.00 AM and 18.00 PM for an excess of 10% after discarding residue. Record of daily feed intake was maintained throughout the experimental period. Sunflower oil was supplemented along with concentrate mixture at 0, 2 and 4% of the daily dry matter intake for consecutive 2 days in every week to the calves of G1, G2 and G3 group, respectively. Deworming was done at the beginning of the experiment.

Digestibility trial: A digestion trail for 10 days (i.e. 3 days adaptation followed by 7 days sample collection) was conducted on all the 15 experimental crossbred calves after 90 days of experimental feeding. During digestion trial, daily faeces voided, feed offered and residue left were recorded. Fresh samples of fodder and concentrate mixture offer, residues left, and faeces voided were collected daily in the morning after thorough mixing so as to obtain homogeneous and representative samples. The samples were dried, and stored in clean, labeled polyethylene bags. Dried samples for each day of the 7 days collection were pooled, ground to pass a 1 mm screen and preserved for chemical analysis.

Collection of rumen liquor samples and counting of rumen protozoa: Rumen liquor was collected from all experimental calves on 01, 03, 07, 15, 30, 45, 60, 75, 90, 105 and 120 days of experimental feeding at 0 h post feeding (before offering feed and water) by stomach tube for counting the rumen protozoal numbers. After collection of rumen liquor, the samples were processed immediately for counting of rumen protozoa (Santra and Karim 2002). Ciliates were identified according to Hungate (1996) and counted as per Veira *et al*. (1983).

Growth trial: The growth trial lasted for 120 days during which feed intake were recorded daily for each calves. Calves body weight were recorded for 2 consecutive days every in 15 days immediately before offering feed and water and these values were used to determine body weight gain. Patterns of growth were calculated on the basis of the 7 days period.

Chemical analysis of biological samples: The feed offer, residue left and feces voided were analyzed for dry matter by drying at 100 °C for 24 h, OM by ashing at 550 °C for 4 h and crude protein (CP) by Kjeldahl technique (AOAC 1995). NDF, ADF and ADL were estimated as per Van Soest *et al*. (1991). Cellulose content was calculated by subtracting ADL from ADF. GE value of the samples was determined using Ballistic Bomb calorimeter.

Statistical analysis: The data generated in the experiment were subjected to analysis of variance using SPSS-10 package. The significant group differences were compared using Duncan's multiple range test (Duncan 1955). Fortnightly body weights changes of each calve during the study were charted by fitting polynomial equations wherein the third degree was found to be best fit and the generated constants were subjected to analysis of variance to assess treatment differences. The pooled constants for the each experimental group are presented graphically (Fig. 2).

RESULTS AND DISCUSSION

Feed intake and nutrient digestibility: The chemical composition of concentrate mixture and green fodder is presented in Table 1. The offered concentrate mixture and maize fodder contained 18.6 and 10.8% CP on DM basis, respectively. Daily dry matter intake in terms of per kg body weight as well as per kg metabolic body size was similar among the calves of all experimental groups (Table 2) indicating different levels (at 2 and 4% of daily DM intake) of dietary supplementation of sunflower oil did not have any effect on voluntary feed intake as was also observed earlier (Zinn *et al.* 2000, Duckett *et al.* 2002, Sackmann *et al*. 2003, Hervas *et al.* 2008). Kathirvelan and Tyagi (2009) reported that dietary supplementation of mustard oil at 2% level, mixed with contrite mixture had no effect in daily dry matter in take in lactating buffalo. However, supplementation of diet with vegetable oils rich in unsaturated fatty acids often results in a reduction of dry matter intake (Shingfield *et al.* 2006), which is mainly related to potential detrimental effects

Table 1. Chemical composition of experimental feed and fodder (on % DM basis)

Attribute	Concentrate mixture	Maize fodder
Organic matter (OM)	85.2	92.4
Crude protein (CP)	18.6	10.8
Neutral detergent fibre (NDF)	39.3	63.2
Acid detergent fibre (ADF)	17.5	38.7
Hemicellulose	21.9	24.5
Cellulose	12.7	31.8
Acid detergent lignin (ADL)	4.6	6.9
Gross energy (kcal/g DM)	4.3	4.1

Table 2. Effect of dietary sunflower-oil supplementation on nutrient utilization and plane of nutrition in growing crossbred calves

Attributes	Level (%) of sunflower-oil supplementation			SEM	Level of significance
	0(G1)	2.0(G2)	4.0 (G3)		
Dry matter intake					
Roughage (g/d)	1711	1760	1805	57.25	NS
Concentrate (g/d)	1702	1751	1748	63.89	NS
Total (g/day)	3413	3511	3553	110.3	NS
Roughage : concentrate ration	50: 50	50:50	51.49	1.35	NS
Dry matter intake (g)/kg body weight/d	35.2	34.8	34.5	0.93	NS
Dry matter intake (g)/kg $^{0.75}$/d	110.7	109.7	110.2	7.13	NS
Nutrient digestibility					
Dry matter (DM)					
Intake (kg/d)	3.4	3.5	3.6	0.11	NS
Digestibility (%)	61.7	61.1	60.8	0.51	NS
Organic matter (OM)					
Intake (kg/d)	3.1	3.2	3.1	0.15	NS
Digestibility (%)	63.7	63.6	63.2	0.58	NS
Crude protein (CP)					
Intake (g/d)	512.3	521.5	523.1	17.5	NS
Digestibility (%)	67.1	67.5	68.3	0.41	NS
Neutral detergent fibre (NDF)					
Intake (g/d)	1765.9	1801.3	1821.4	9.47	NS
Digestibility (%)	53.8	53.3	52.9	0.78	NS
Acid detergent fibre (ADF)					
Intake (g/d)	798.7	802.1	811.4	8.17	NS
Digestibility (%)	43.2	42.5	41.9	0.83	NS
Cellulose					
Intake (g/d)	691.3	708.5	711.2	9.13	NS
Digestibility (%)	45.8	44.6	43.9	0.97	NS
Gross energy (GE)					
Intake (Mcal/d)	14.4	14.8	14.9	0.98	NS
Digestibility (%)	59.5	59.3	58.7	0.57	NS
Nutritive value of ration					
DCP (on% DM)	9.8	9.9	10.1	0.11	NS
DE (Mcal/kg DM)	2.4	2.5	2.5	0.07	NS
Plane of nutrition					
DCP intake					
g/d	332.7	350.8	356.2	18.3	NS
g/kg body weight/d	3.4	3.4	3.5	0.08	NS
g/kg $W^{0.75}$/d	10.8	10.9	11.1	1.07	NS
DE intake					
Mcal/d	8.5	8.8	8.7	0.65	NS
kcal/kg body weight/d	88.5	86.8	85.4	1.35	NS
kcal/kg $W^{0.75}$/d	276.8	273.7	272.1	4.19	NS

NS, Nonsignificant; SEM, standard error of mean.

on ruminal fermentation (Jenkins 1993). On an average the calves of G1, G2 and G3 group consumed 110.2 g DM per kg $W^{0.75}$/day. Sharma *et al*. (2010) also reported that crossbred calves consumed 103.1 g DM/kg $W^{0.75}$/day under conventional feeding maintained on green fodder and concentrate based diet.

Apparent nutrients (DM, OM, CP, NDF, ADF and cellulose) digestibility did not differ due to dietary supplementation of sunflower oil as well as level of sunflower-oil which was similar to the observations reported by Sackmann *et al.* (2003). Similarly, Hervas *et al*. (2008) reported no change in ruminal DM and fibre degradation in lactating dairy ewes supplemented with 6% sunflower oil. Nutritive value of ration (DCP and DE content) was similar in G1, G2 and G3 group. On an average experimental ration contained 9.9% DCP and 2.5 Mcal DE/kg DM. Plane of nutrition, e.g. DCP and DE intake also similar in G1, G2 and G3 groups. Calves of G1, G2 and G3 group consumed 10.8,

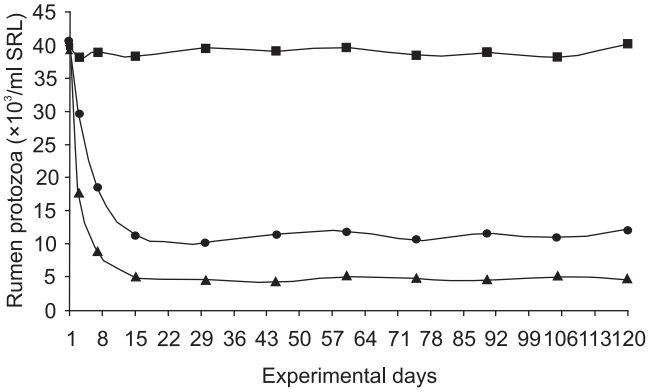

Fig. 1. Rumen protozoal population in the experimental calves at 0h post feeding during the experimental period (G1: ■, at 0% sunflower oil supplementation; G2: ●, at 2% sunflower oil supplementation; G3: ▲, at 4% sunflower oil supplementation).

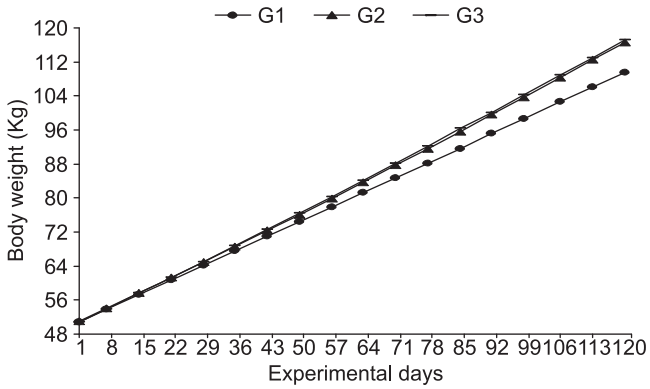

Fig. 2. Body weight changes of growing crossbred calves during the experiment.
G1 (Control: at 0% sunflower oil supplementation) = 50.43 + $0.4851X_1 + 0.00007X_1^2$ ($R_1^2 = 0.974$);
G2 (at 2% sunflower oil supplementation) = 50.59 + $0.5011X_2 + 0.00041X_2^2$ (R_2^2=0.987);
G3 (at 4% sunflower oil supplementation) = 50.30 + $0.5714X_3 + 0.00033\ X_3^2$ (R_3^2=0.988)

10.9 and 11.1 g DCP and 276.8, 273.7 and 272.1 kcal DE per kg metabolic body size, respectively. Similar nutritive value of experimental ration and plane of nutrition of the 3 treatment groups e.g., G1, G2 and G3 in the present experiment was due to similar daily dry mater intake and apparent digestibility of nutrients among the experimental calves of all the 3 groups. DCP intake by the calves per kg metabolic body size per day in the present experiment is also similar to the finding of Sharma *et al.* (2010).

Rumen ciliate protozoal population: The protozoa present in the rumen of experimental calves in all the experimental groups was B type population due to presence of *Epidinium* sp, and the absence of *Polyplastron multivesiculatum* (Coleman 1980). Number of total rumen protozoa was lower (P<0.01) in the calves of G2 and G3 than G1 group. Rumen protozoal number decreased drastically up to 15 days of experimental feeding in the calves of G2 and G3 group due to dietary supplementation of sunflower oil and thereafter the number of rumen protozoa remains almost static during rest of the experimental period (Fig. 1). There were about 70 and 88% reduction in total rumen protozoal number due to dietary supplementation of sunflower oil at 2 and 4% of daily dry matter intake for consecutive 2 days in every week in the calves of G2 and G3 groups, respectively. This is probably due to linoleic acid, which is present in relatively high concentration in sunflower-oil and very much toxic to the rumen protozoa (Hristov *et al*. 2005). Further, we also observed that dietary supplementation of sunflower oil for consecutive 2 days in every week e.g., at 7 days interval is essential to maintain reduced number of ciliate protozoa in the rumen of calves under routine farm management practices.

Blood profile, body weight changes and feed conversion efficiency: Blood glucose level was higher in the sunflower-oil fed calves (G2 and G3). However, it was similar among the calves fed sunflower oil at 2 or 4% of daily DM intake (G2 and G3). Dietary supplementation of sunflower oil had no influence on plasma urea, serum total protein and serum albumin concentration (Table 3). Higher blood glucose level in sunflower-oil fed calves might be due to higher ruminal propionate production (McGinn *et al.* 2004). The level of plasma glucose, urea and protein in the present experiment were ranging from 63.1 to 66.1 mg, 18.2 to 18.6 mg and 7.8 to 8.2 g and all the values were within the normal range as reported earlier (Pachuri *et al.* 1999, Mahanta *et al.* 2001) in crossbred calves.

Final body weight, average daily body weight gain and feed conversion efficiency were higher (P<0.01) for the calves supplemented with sunflower oil (G2 and G3) than the non supplemented calves (G1). Better growth rate and feed conversion efficiency in the sunflower-oil fed calves might be due to lower rumen protozoal population resulting in better utilization of dietary protein and energy, leading to better body weight gain and feed conversion efficiency. Ivan *et al.* (2004) also reported higher growth rate and feed conversion efficiency in the sunflower oil supplemented lambs. However, final body weight, average daily body weight gain and feed conversion efficiency in terms of DM, DCP and DE intake per kg body weight gain was similar among the calves fed sunflower oil at 2 and 4% of daily DM intake (G2 and G3). The calves of G1, G2 and G3 group consumed 110.7, 109.7 and 110.2 g DM, 10.8, 10.9 and 11.1 g DCP, 276.8, 273.3 and 272.1 kcal DE/kg metabolic body size and had an average daily gain of 485.8, 544.6 and 551.6 g, respectively. The trends in body weight gain of the experimental calves fed sunflower oil in G2 and G3 group was almost similar through out the experimental period (Fig. 2).

Our result showed that dietary supplementation of sunflower-oil at 2 and 4% of daily dry matter intake for

Table 3. Effect of dietary sunflower oil supplementation on growth performance and feed conversion efficiency in growing crossbred calves

Attributes	Level (%) of sunflower-oil supplementation			SEM	Level of significance
	0(G1)	2.0(G2)	4.0 (G3)		
Blood profile					
Plasma glucose (mg/dl)	63.1 [a]	65.3 [b]	66.1 [b]	0.71	P < 0.01
Plasma urea (mg/dl)	18.2	18.6	18.5	0.40	NS
Serum total protein (g/dl)	7.8	8.2	8.1	0.13	NS
Serum albumin (g/dl)	3.6	3.7	3.8	0.11	NS
Growth performances					
Initial body weight (kg)	51.2	51.4	51.1	1.96	NS
Final body weight (kg)	109.5 [a]	116.8 [b]	117.3 [b]	2.01	P < 0.01
Total body weight gain (kg)	58.3 [a]	65.4 [b]	66.2 [b]	0.97	P < 0.01
Body weight gain (g/d)	485.8 [a]	544.6 [b]	551.6 [b]	19.17	P < 0.01
Nutrient intake during total experimental period					
Total DM intake (kg)	398.4	386.5	388.9	19.12	NS
Total DCP intake (kg)	37.9	38.3	39.1	1.62	NS
Total DE intake (Mcal)	956.9	961.7	972.6	5.65	NS
Feed conversion efficiency					
DM intake (kg) per kg body weight gain	6.7 [b]	5.9 [a]	5.9 [a]	0.18	P < 0.01
DCP intake (kg) per kg body weight gain	654.1 [b]	585.6 [a]	591.1 [a]	16.15	P < 0.01
DE intake (Mcal) per kg body weight gain	16.4 [b]	14.7 [a]	14.8 [a]	0.39	P < 0.01

[abc] means with different superscript in a row are significantly different; NS, nonsignificant, SEM, standard error of mean.

consecutive 2 days in every week was effective in decreasing rumen protozoal population as well as to maintain lower rumen protozoal population under routine farm management practices and improved body weight gain and feed conversion efficiency in growing male crossbred calves. However, supplementation of sunflower oil at 4% level had no added advantage over supplementation at 2% level in terms of body weight gain and feed conversion efficiency in growing crossbred calves.

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