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Effect of cold process monensin enriched urea molasses mineral blocks on performance of crossbred calves fed a wheat straw based diet

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Abstract

Twenty male crossbred calves were divided into four equal groups. Calves in groups I and II were fed wheat straw ad libitum with a concentrate mixture with or without monensin (30 mg per day per animal). Calves in groups III and IV were fed wheat straw ad libitum with 70% of the allocated concentrate mixture and had free access to urea molasses mineral block (UMMB) with or without monensin (100 ppm). Wheat straw intake was higher ($P < 0.05$) in UMMB supplemented groups, but total dry matter (DM) and crude protein (CP) intake did not differ. ME (Mcal per day) intake was higher ($P < 0.05$) in UMMB supplemented groups. Digestibility of DM, OM, EE, and NDF did not differ due to UMMB or monensin supplementation, although ADF digestibility was increased ($P < 0.01$) with UMMB supplementation. Although the N balance was similar among the groups, the Ca and P balances were higher in UMMB supplemented groups. Blood glucose level was increased ($P < 0.05$) due to monensin treatment but plasma urea N level did not differ. Average body weight gain, feed conversion efficiency, protein utilisation efficiency, and energy utilisation efficiency were higher ($P > 0.05$) in monensin treated groups without any change in body composition. Replacing 30% of a concentrate mixture with a cold process UMMB increased the proportional contribution of wheat straw to DM intake but had no effect on animal performance. However, supplementation with monensin increased the blood glucose level, protein and energy deposition, as well as body weight gain and feed efficiency, but with no change in the wheat straw and total DM consumption.

Keywords: Cold process; Urea molasses mineral block; Monensin; Ionophore; Wheat straw; Growth; Calves

Abbreviations: ADF, acid detergent fibre; BV, biological value; BW, body weight; Ca, calcium; CP, crude protein; DM, dry matter; DMI, dry matter intake; EE, ether extract; ME, metabolisable energy; N, nitrogen; NDF, neutral detergent fibre; NPU, net protein utilisation; OM, organic matter; P, phosphorous; UMMB, urea molasses mineral block

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1. Introduction

Digestion in the rumen is dependent on activity of micro-organisms, which require energy (ATP), N (as ammonia, peptide and/or amino acids), minerals and a medium with an appropriate pH (Moss, 1994). Poor quality forages, such as cereal straws, have insufficient N, sugar, starch and minerals to meet microbial requirements and so supplements are required to optimise rumen microbial growth. One of the most efficient ways of increasing digestion of poor quality forages is supplementation of N and minerals in the form of urea molasses mineral blocks (UMMB; Garg and Gupta, 1993).

Feeding a high forage ration often induces an increase in production of acetic acid and methane (Singh et al., 1995). If energy lost as methane can be reduced, and diverted for productive uses, performance of the animals will generally be improved. Monensin, a carboxylic polyether antibiotic, increases propionic acid production and reduces methane production (Goodrich et al., 1984; Andrae et al., 1995; De, 1998).

Objectives of this study were to study effects of partial replacement of a concentrate mixture by cold process UMMB, and effects of monensin enriched cold process UMMB, on feed utilisation and growth performance of crossbred beef calves.

2. Materials and methods

2.1. Preparation of UMMB

Urea molasses mineral blocks were prepared from Molasses (380 g/kg), urea (100 g/kg), salt (50 g/kg), mineral premix (60 g/kg), sodium bentonite (40 g/kg), calcium oxide (80 g/kg), de-oiled rice bran (190 g/kg) and cotton seed cake (100 g/kg). In the monensin enriched UMMB, 100 mg monensin was added per kg of block. The 10 kg blocks were prepared by adding molasses to a large plastic container, followed by monensin in the case of the monensin enriched UMMB, and mixing thoroughly. Urea and salt were added and mixed manually until dissolved. In a separate container, the mineral premix (Ca 300 g/kg, P 82.5 g/kg, Cu 0.312 g/kg, Co 0.045 g/kg, Mg 2.114 g/kg, Fe 0.979 g/kg, Zn 2.13 g/kg and I 0.156 g/kg), bentonite and calcium oxide were mixed together and poured into the urea molasses mixture and mixed thoroughly to create a homogeneous slurry. In another container, de-oiled rice bran and cotton seed cake were mixed and added to the urea molasses mixture and mixed manually to avoid lumps in the semi-solid mixture. The mixed material was finally poured into a plastic mould and allowed to solidify for 48 h.

2.2. Animal, feeding and management

Twenty crossbred (Sahiwal × Holstein Friesian) calves (9.7 ± 0.4 months old, 117.7 ± 8.2 kg body weight (BW)) were blocked by BW and divided into four equal groups. Calves were kept individually in a well-ventilated facility, and treated with butox 0.5% (v/v) and fed albandazole (0.5 mg/kg BW) prior to the start of the study.

Calves of group I (without '−') were fed on concentrate mixture comprised of maize grain (320 g/kg), groundnut cake (350 g/kg), wheat bran (300 g/kg), the same mineral mixture as

used in UMMB (25 g/kg) and salt (5 g/kg) with ad libitum access to wheat straw. Calves of group II (without '+') were fed a monensin (30 mg per day per calf) enriched concentrate mixture (as previous group) with ad libitum access to wheat straw. Calves of groups III (with '−') and IV (with '+') were fed only 70% of the allocated concentrate mixture with ad libitum access to either the UMMB or the monensin enriched UMMB (UMMMB). Wheat straw was available ad libitum to both groups. The quantity of monensin (i.e. 30 mg per day per head) for animals in the group "without '+'" was calculated from the consumption of monensin from UMMMB by calves of group "with '+'" to equalise monensin consumption between groups. All feed was offered once daily at 9:00 a.m. Blocks were placed in the mangers when all concentrate mixture had been consumed by the calves and left for the balance of the day. Blocks were provided in a plastic container at a slanted angle to avoid biting by the calves. Rations for individual animals were calculated every 14 days based upon the previous BW gain of the calf. A Vitamin A and D mixture was fed once a week to all animals (4240 and 660 IU per day, respectively). Drinking water was available to all calves at all times.

2.3. Feed intake and live weight gain

The growth trial was conducted for a period of 120 days. Voluntary feed intake was measured and recorded for 5 consecutive days in each 14-day period. The amount of block consumed by each calf was measured daily for 120 days. Samples of wheat straw, concentrate mixtures, blocks, and feed refusals were collected for 5 consecutive days in each 14-day period and analysed for determination of actual intake. All animals were weighed on 2 consecutive days at 14-day intervals, before feed and water was offered.

2.4. Metabolism trial

A metabolism trial of 5-day duration was conducted at the end of the growth trial. Calves were kept in metabolism stalls with provision for separate collection of faeces and urine. Calves were placed in the metabolism stalls 5 days before the start of sample collection to acclimatise. Weighed amounts of feeds were offered daily and samples of individual feeds offered and feed refusals were collected for analysis. Amounts of faeces and urine voided by experimental animals during the 24 h period was recorded for 5 days. Faeces were mixed thoroughly in a plastic trough and representative samples were taken to the laboratory for sub-sampling and further analysis. Similarly, the 24 h collection of urine was mixed thoroughly before sampling into a clean dry plastic bottle and brought to the laboratory each day for sub-sampling.

2.5. Chemical analysis

Wheat straw, UMMB, concentrate mixtures and their residues, and faeces were analysed for DM, N and EE and urine was analysed for N (AOAC, 1984; ID No. 7.003 for DM; N by 7.034, 7.035, 7.036, 7.037; EE by 7.062). Analysis of Ca (Talapatra et al., 1940) and P (Ward and Johnston, 1962) in feed, water, faeces and urine were completed. The NDF and ADF of feed and faeces were determined (Van Soest et al., 1991), and NDF was assayed with sodium sulphite and without alpha amylase and expressed with residual ash.

2.6. Estimation of body composition

After the metabolism trial, body composition was determined following antipyrine dilution techniques (Wellington et al., 1956). Calves were deprived of feed and water for 18 h prior to administration of antipyrine.

2.7. Gross energetic efficiency and protein retention efficiency

These values were calculated according to Singh and Gupta (1985) as:

$$\text{gross energetic efficiency (\%)} = \frac{\text{body energy retained (Mcal per day)}}{\text{ME intake (Mcal per day)}} \times 100$$

$$\text{protein retention efficiency (\%)} = \frac{\text{body protein deposited (g per day)}}{\text{body protein retained (g per day)}} \times 100$$

Body protein deposited (g per day) was calculated from body composition data, and protein retention (g per day) was calculated by multiplying N retained (g per day) by 6.25.

ME intake was calculated from total digestible nutrients (TDN) intake using a calorie value of 1 kg TDN as 3.56 Mcal ME (Blaxter, 1967). TDN intake was estimated as:

$$\text{TDN} = \%\text{DCP} + \%\text{DCF} + \%\text{DNFE} + \%\text{DEE} \times 2.25$$

Total energy retained was calculated using the energy values of 5.62 Mcal/kg of protein and 9.36 Mcal/kg of fat (Blaxter, 1967).

2.8. Blood glucose and plasma urea

Blood was collected at the start of the experiment, at the 8th week, and at the 16th week by jugular puncture before offering feed and water. Blood samples were collected in 30 ml tubes containing a heparin solution (0.2 mg/ml). Immediately after collection, tubes were mixed uniformly and 1.0 ml of blood was deproteinised for glucose estimation (Nelson, 1944). Remaining blood was centrifuged to separate plasma for subsequent plasma urea estimation (Rahmatullah and Boyde, 1980).

2.9. Statistical analysis

Data were analysed statistically in 2 × 2 factorial design (Snedecor and Cochran, 1986).

3. Results

3.1. Chemical composition of feeds

The DM, OM, EE, NDF and ADF content of UMMB was lower than that of the concentrate mixture (Table 1). However, the CP, Ca and P content of the block was higher.

Table 1
Chemical composition of feeds[a] (% of DM)

	Concentrate mixture[b]	Wheat straw	UMMB[c] block
Dry matter (%)	89.62	87.15	84.91
Organic matter	92.93	90.45	71.13
Crude protein	20.10	3.44	38.38
Ether extract	5.38	0.68	0.39
Neutral detergent fibre	50.2	80.1	17.6
Acid detergent fibre	16.2	49.7	7.5
Ca	0.73	0.14	3.95
P	0.59	0.09	1.62

[a] Values represent hexaplicate assays of each material.
[b] Ingredient composition of concentrate mixture: maize grain 320 g/kg, groundnut cake 350 g/kg, wheat bran 300 g/kg, mineral mixture 25 g/kg and salt 5 g/kg.
[c] Composition of urea molasses mineral block (UMMB): molasses 380 g/kg, urea 100 g/kg, salt 50 g/kg, mineral mixture 60 g/kg, sodium bentonite 40 g/kg, calcium oxide 80 g/kg, de-oiled rice bran 190 g/kg and cotton seed cake 100 g/kg.

3.2. Feed consumption and nutrient intake

Wheat straw intake by UMMB supplemented calves was higher ($P < 0.05$) than those without UMMB (Table 2), but did not differ due to monensin supplementation. Total DM intake, in kg per day or kg/100 kg BW or g/kg $BW^{0.75}$, was not influenced by block or monensin supplementation. Although CP (g per day) intake did not differ due to block or monensin supplementation, ME (Mcal per day) intake was higher ($P < 0.05$) in block supplemented groups.

3.3. Digestibility of nutrients

Digestibility of DM, OM, CP, EE and NDF did not differ due to block or monensin supplementation (Table 3). However, ADF digestibility was higher ($P < 0.01$) with UMMB feeding.

3.4. Nitrogen, calcium and phosphorus balances

Total N intake and excretion were not affected by block or monensin supplementation (Table 4). However, the biological value (BV; i.e. N retained/N absorbed) tended ($P = 0.06$) to be lower with block supplementation (Table 4). Total Ca intake, excretion and retention were higher ($P < 0.01$ or $P < 0.05$) when UMMB was fed. Total P intake and retention was higher ($P < 0.01$) with block supplementation.

3.5. Body composition, protein retention and energy utilisation efficiency

Body water, fat, protein and ash percent did not differ due to block or monensin supplementation (Table 5). Protein deposition (g per day) and total energy deposition (kcal per day) tended ($P = 0.06$) to be increased due to monensin supplementation.

Table 2
Effect of UMMB block and monensin supplementation on DM and nutrient intake in growing calves

	Without		With		S.E.M.	Probability		
	−	+	−	+		Block (B)	Monensin (M)	B × M
DM intake (kg per day)								
Wheat straw	1.51	1.54	1.89	1.85	0.10	<0.01	NS	NS
Concentrate	2.03	2.03	1.46	1.48	0.03	<0.01	NS	NS
UMMB	–	–	0.36	0.24	0.06	–	<0.05	–
Total DMI	3.53	3.57	3.71	3.57	0.13	NS	NS	NS
DMI (kg/100 kg BW)	2.42	2.36	2.54	2.40	0.08	NS	0.20	NS
DMI (g/kg $BW^{0.75}$)	81.82	83.52	87.63	82.82	1.94	NS	NS	0.12
CP intake (g per day)	459	461	497	453	12.0	NS	0.12	0.09
ME intake (Mcal per day)	6.98	7.11	7.90	7.53	0.26	<0.05	NS	NS

Without, without supplemented UMMB block; with, with supplemented UMMB block; −, without monensin; +, with monensin. NS ($P > 0.20$).

3.6. Body weight gain and feed conversion efficiency

Daily live weight gain (kg per day) was not influenced by block or monensin supplementation (Table 6), but DM intake per kg BW gain was numerically ($P = 0.13$) lower when monensin was fed.

3.7. Blood glucose and plasma urea

There were no differences in blood glucose concentrations among the groups at the start of the study (Table 7). By the 8th week, blood glucose levels tended ($P = 0.12$) to be higher in monensin supplemented groups and by the 16th week, blood glucose level were higher ($P < 0.05$) due to monensin supplementation. There were no differences in plasma urea N concentrations among treatments at any point in the experiment.

Table 3
Effect of UMMB block and monensin supplementation on apparent whole tract digestibility (%) of nutrients in growing calves

	Without		With		S.E.M.	Probability		
	−	+	−	+		Block (B)	Monensin (M)	B × M
Dry matter	56.94	56.61	59.80	57.45	1.85	NS	NS	NS
Organic matter	58.68	58.52	62.38	59.93	1.79	0.19	NS	NS
Crude protein	67.56	63.85	67.21	65.24	5.95	NS	NS	NS
Ether extract	79.54	79.36	77.99	79.65	2.68	NS	NS	NS
Neutral detergent fibre	51.89	51.73	56.41	53.45	2.14	0.18	NS	NS
Acid detergent fibre	35.21	35.66	47.86	43.52	1.75	<0.01	NS	0.20

Without, without supplemented UMMB block; with, with supplemented UMMB block; −, without monensin; +, with monensin. NS ($P > 0.20$).

Table 4
Effect of UMMB block supplementation and monensin on N, Ca and P balances in growing calves

	Without		With		S.E.M.	Probability		
	−	+	−	+		Block (B)	Monensin (M)	B × M
N balance (g per day)								
Intake	82.1	82.7	85.9	85.5	3.3	NS	NS	NS
Excreted	46.9	46.6	51.1	51.1	3.1	0.19	NS	NS
Absorbed	56.0	53.9	58.4	57.8	5.9	NS	NS	NS
Retained	35.2	36.1	34.8	34.4	4.5	NS	NS	NS
Absorbed (% of intake)	69.0	65.3	68.6	66.3	5.8	NS	NS	NS
NPU[a] (%)	43.96	43.88	41.16	39.39	3.89	NS	NS	NS
BV[b] (%)	62.77	66.62	59.64	59.12	2.37	0.06	NS	NS
Ca balance (g per day)								
Intake	19.13	19.22	30.19	28.66	1.42	<0.01	NS	NS
Excreted	14.58	14.33	22.83	22.43	1.33	<0.01	NS	NS
Retained	4.55	4.89	7.36	6.23	0.66	<0.05	NS	NS
P balance (g per day)								
Intake	14.90	15.01	17.49	17.18	0.69	<0.01	NS	NS
Excreted	11.50	11.32	11.77	11.24	0.69	NS	NS	NS
Retained	3.40	3.69	5.72	5.94	0.34	<0.01	NS	NS

Without, without supplemented UMMB block; with, with supplemented UMMB block; −, without monensin; +, with monensin. NS ($P > 0.20$).

[a] NPU, net protein utilisation.

[b] BV, biological value.

4. Discussion

No interactions between monensin and block supplementation occurred for any parameter. Therefore, results are discussed by main effects.

4.1. UMMB supplementation

The increase in straw intake with UMMB supplementation could have been due to availability of more rapidly fermentable N and energy sources, as well as macro and micro minerals, which in turn increased rumen microbial activity and fermentation. This would be consistent with the increase in ADF digestibility (Campling et al., 1962). However, since UMMB supplemented calves were offered about 30% less concentrate than those not supplemented, the increased straw consumption was at least partly a substitution effect. The higher ME intake in UMMB supplemented calves was partly due to higher DM intake and partly due to higher digestibility of ADF in those groups, either due to the change in ingredients consumed, or an increase in their digestibility per se. Replacing up to 30% concentrate with UMMB did not affect net protein utilisation (NPU; i.e. N retained/N intake) indicating that N utilisation efficiency was similar in all the groups.

Higher Ca and P balance in block supplemented calves was primarily due to higher Ca and P intake which after compensating for the greater loss through faeces and urine, resulted in a higher retention of Ca and P.

Table 5
Effect of UMMB block and monensin supplementation on body composition, energy utilisation efficiency and protein retention efficiency in growing calves

	Without		With		S.E.M.	Probability		
	−	+	−	+		Block (B)	Monensin (M)	B × M
Body composition (%)								
Water	64.23	64.28	64.20	64.03	0.26	NS	NS	NS
Fat	11.94	11.88	11.98	12.15	0.27	NS	NS	NS
Protein	18.17	18.19	18.17	18.11	0.07	NS	NS	NS
Ash	5.66	5.65	5.66	5.72	0.07	NS	NS	NS
Protein retained (g per day)	220	226	218	215	28	NS	NS	NS
Daily BW gain (g per day)	497	552	476	574	35	NS	0.06	NS
Protein deposited (g per day)	90.4	100.4	86.6	103.8	6.4	NS	0.06	NS
Protein utilisation efficiency (%)	41.9	46.3	40.9	52.3	5.8	NS	0.20	NS
Energy deposited (kcal per day) as								
Fat	555	614	530	655	41	NS	0.06	NS
Protein	508	564	487	583	36	NS	0.06	NS
Total	1063	1178	1016	1239	75	NS	0.06	NS
Energy intake (Mcal ME per day)	7.29	7.62	7.60	8.11	0.34	NS	NS	NS
Energy utilisation efficiency (%)	14.94	15.60	13.34	15.53	0.99	NS	0.18	NS

Without, without supplemented UMMB block; with, with supplemented UMMB block; −, without monensin; +, with monensin. NS ($P > 0.20$).

4.2. *Monensin supplementation*

Monensin did not affect DM intake, digestibility of nutrients, N, Ca and P balances, consistent with reports by others (Thornton and Owens, 1981; Ricke et al., 1984; Beever et al., 1987; Haimoud et al., 1995, 1996; Toharmat et al., 1997). However, monensin tended to increase protein deposition which might be due to decreased microbial degradation of

Table 6
Effect of UMMB block supplementation and monensin on growth rate and feed conversion efficiency in growing calves

	Without		With		S.E.M.	Probability		
	−	+	−	+		Block (B)	Monensin (M)	B × M
Initial body weight (kg)	117.7	118.2	117.5	117.6	4.9	NS	NS	NS
Final body weight (kg)	178.1	180.1	172.5	180.9	6.8	NS	NS	NS
Body weight gain (kg)	60.4	61.9	55.0	63.3	4.1	NS	NS	NS
Daily gain (kg per day)	0.50	0.52	0.46	0.53	0.04	NS	NS	NS
Total DM intake (kg)	424	428	445	428	15	NS	NS	NS
Feed conversion ratio (feed:gain)	7.12	6.93	8.27	6.75	0.52	NS	0.13	NS

Without, without supplemented UMMB block; with, with supplemented UMMB block; −, without monensin; +, with monensin. NS ($P > 0.20$).

Table 7
Effect of UMMB block and monensin supplementation on blood glucose and plasma urea N in growing calves

	Without		With		S.E.M.	Probability		
	−	+	−	+		Block (B)	Monensin (M)	B × M
Blood glucose (mg/100 ml)								
At the start	58.46	57.35	58.67	58.60	2.43	NS	NS	NS
At 8th week	63.34	73.38	55.73	61.47	5.63	0.12	0.20	NS
At 16th week	67.64	73.17	65.92	70.84	1.66	NS	<0.05	NS
Plasma urea N (mg/100 ml)								
At the start	16.36	17.36	14.57	14.70	2.28	NS	NS	NS
At 8th week	16.08	18.36	19.16	15.85	1.81	NS	NS	0.16
At 16th week	14.40	12.74	14.29	11.46	1.99	NS	NS	NS

Without, without supplemented UMMB block; with, with supplemented UMMB block; −, without monensin; +, with monensin. NS ($P > 0.20$).

protein in rumen and increased availability of feed N in the duodenum (Haimoud et al., 1995). Similarly, energy deposited as fat and protein tended to be higher in the monensin supplemented groups. This improvement might be due to energy saving from the lower heat increment of propionate (Blaxter, 1962), the proportion of which increases with monensin treatment (De, 1998; Davis and Erhat, 1976; Raun et al., 1976; Boling et al., 1977; Ricke et al., 1984; Bogaert et al., 1991; Haimoud et al., 1995; Badawy et al., 1996). The increased blood glucose level would be consistent with increased rumen propionate. Increased daily gain in monensin supplemented calves reflects the better energy and protein utilisation efficiency, which resulted in a better feed conversion ratio (Perry et al., 1976; Raun et al., 1976; Boling et al., 1977; Faulkner et al., 1985; Delfino et al., 1988; Patil and Honmode, 1994).

5. Conclusions

Replacing 30% of a concentrate mixture with cold process urea molasses mineral block (UMMB) did not affect the growth performance of calves fed a straw based diet, although straw intake was increased. UMMB supplementation is an effective strategy to increase the proportion of DM intake as straw, while maintaining animal performance. In contrast, supplementation with monensin has no impact on straw and total DM intake but did increase protein and energy deposition and tended to increase average daily gain and feed efficiency. Monensin supplementation is an effective strategy to increase animal performance and feed efficiency, but does not increase the proportional contribution of wheat straw to DM intake.

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