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Influence of monensin enriched UMMB feeding on *in vivo* methane emission in crossbred calves fed on wheat straw and concentrate based diet

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Monensin, a biologically active compound produced by a strain of *Streptomyces cinnamonensis* (Haney and Hoehn 1968), is commonly used feed additive for feedlot cattle. It improves the efficiency of feed utilization of cattle by altering volatile fatty acid proportion towards more propionate (Dinius *et al.*1976, Richardson *et al.* 1976, Goodrich *et al.*1984, Andrae *et al.*1995, Singh and Mohini 1999, Callaway *et al.* 2003, Packer *et al.* 2011) and thereby reduces methane production (Badawy *et al.* 1996; Mbanzamihigo *et al.*1996). Monensin also depresses feed intake (Walker *et al.* 1980, Faulkner *et al.*1985, Stock *et al.*1995,Ramanzin *et al.* 1997). However, when ruminants were fed diets containing considerable -linked carbohydrate (roughage) ionophore did not depress intake (Bergen and Bares 1984). Supplementation of urea molasses mineral block increase the feed intake and utilization of straw (Garg and Gupta 1993) and reduce the methane production by decreasing methanogenic volatile fatty acids (Preston and Leng 1989, Singh *et al.*1995). The methane production is not only loss of feed energy but it also plays a major role in global warming (Vangardingen 1991, Singh 1997, Martin *et al.* 2008). In the present study an attempt was done to enrich the UMMB with monensin for the mitigation of methane emission from ruminants.

Crossbred (Sahiwal × Holstein Friesian) male calves (4), ~ 1-year-old, body weight 249.25 to 258.5 kg, were used in a switchover design (Table 1) comprising 4 treatments, 4 animals and 4 periods. Each experimental period lasted for 23 days of which 15 days adaptation period followed by 3 days gas collection period and 5 days digestibility trial. The animals were kept in well ventilated byre, where there was provision for keeping UMMB licks separately. Before final collection of gas in canister, animals were trained with canister for 3 days during adaptation period to avoid sudden change in feed intake and to make them feel comfortable with canister and halter.

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Table 1. Chemical composition of feed (%DM)

Parameter	Concentrate mixture	Wheat straw	UMMB
DM	87.89	90.50	82.55
OM	90.82	89.80	70.10
CP	19.10	3.38	38.38
EE	4.42	0.78	0.53
CF	9.47	38.37	6.76
NFE	57.83	47.27	56.43
Total Ash	9.18	10.20	29.90
Ca	0.68	0.16	4.04
P	0.58	0.11	1.72

Concentrate mixture: maize grain (320 g kg^{-1}), groundnut cake (350 g kg^{-1}), wheat bran (300 g kg^{-1}), mineral mixture (25 g kg^{-1}) and salt (5 g kg^{-1})

UMMB: (molasses 380 g kg^{-1}, urea 100 g kg^{-1}, common salt 50 g kg^{-1}, mineral mixture 60 g kg^{-1}, sodium bentonite 40 g kg^{-1}, lime powder 80 g kg^{-1}, deoiled rice bran 190 g kg^{-1} and cotton seed cake 100 g kg^{-1})

The animals of groups 1 and 2 were fed wheat straw *ad lib* and concentrate mixture as per requirement (Kearl 1982). Group 2 was also given monensin (30 mg/d/animal) along with concentrate mixture. Animals in group 3 were fed on wheat straw *ad lib*. plus 70% concentrate mixture of their requirement and the animals also had free access to UMMB. However, the animals under group 4 were fed on similar dietary plan as fed in group 3, except the enrichment of UMMB with monensin (100 ppm) for this group. Quantity of monensin (i.e. 30 mg/animal/d) for animals of group II was based on the consumption of monensin from UMMMB in group 4 to keep the monensin level as close as possible in both the groups. Feed was offered once daily at 9.00 AM. Blocks in group 3 and 4 were placed after the consumption of concentrate mixture in plastic container in a slanting position to avoid biting of blocks by animals.

Methane emission was measured *in vivo* using SF_6 tracer technique (Singh 1996). Using gas chromatograph fitted with an electron capture detector (350°C) to determine SF_6, and a flame ionization detector (250°C) to determine CH_4, the ratio

of CH_4 and SF_6 in the sample was determined. Gas chromatograph was fitted with a 3.3 m molecular sieve column. The column and injector temperature were both 85°C. Nitrogen gas was used as carrier gas at a flow rate of 40 ml/min. The methane emission rate (QCH_4) was calculated from the ratio of CH_4 and SF_6 in collected gas and the known release rate of SF_6 (QSF_6). Background methane level [$(CH_4)_b$] was subtracted from methane concentration in the yoke [$(CH_4)_y$].

$$QCH_4 = QSF_6 \times [(CH_4)_y - (CH_4)_b]/SF_6$$

After 3 successful gas collection, a digestibility trial of 5 days duration was conducted to determine DM and OM digestibility. Wheat straw, UMMB and concentrate mixture were analyzed for proximate principles (Table 2) and faeces was analyzed only for DM and OM content (AOAC 1984). Data obtained were analyzed statistically according to Snedecor and Cochran (1986).

DM, OM, digestible DM (DDM) and digestible OM (DOM) intake did not differ significantly between different treatment groups. DM and OM digestibility also did not differ significantly among the groups (Table 2). Methane production (l/d) in different groups were significantly (P<0.01) different to each other. Methane production was highest in group 1 followed by group 3, 2 and 4. Methane production l/kg DDM intake and l/kg DOM intake were significantly (P<0.01) higher in groups 1 and 3 as compared to that of group 2 which was again significantly (P<0.01) higher than that of group 4. However, no significant difference was observed between group 1 and group 3.

Results of the study indicated that when monensin (30mg/d/animal) was supplemented with concentrate mixture (group 2), methane emission (l/d) was reduced (P<0.01) by 21.57% as compare to that of animal fed concentrate mixture without monensin (group 1). However, a reduction (P<0.01) of 12.38% in methane emission was found when the animals were fed on UMMB based diet (group 3) when compared to those fed on concentrate mixture without monensin (group 1). Enrichment of UMMB with monensin, reduced (P<0.01) methane emission (l/d) by 40.49, 24.12 and 32.08% as compared to group 1, group 2 and group 3, respectively. Reduction in methane emission in group 3 could be due to decrease in methanogenic bacterial population in UMMB fed animals caused by some ingredients (e.g. urea, molasses, calcium oxide,sodium bentonite and cotton seed cake) that were present in UMMB but not in concentrate mixture (De and Singh 2003). When methane emission was calculated on the basis of digestible DM and OM intake it was found that methane emission (l/kg DDMI) was reduced (P<0.01) by 20.72% as compared to that of animal fed concentrate mixture without monensin (group 1). Enrichment of UMMB with monensin, reduced (P<0.01) methane emission (l/kg DDMI) by 33.46, 16.08 and 31.09% as compare to group 1, group 2 and group 3, respectively. Methane emission (l/kg DOMI) was reduced (P<0.01) by 20.80% as compared to that of animal fed concentrate mixture without monensin (group 1). Enrichment of UMMB with monensin, reduced (P<0.01) methane emission (l/kg DDMI) by 32.88, 15.26 and 30.88% as compare to group 1, group2 and group 3, respectively. When monensin was supplemented either with concentrate mixture or with UMMB, methane production was reduced. This reduction in methane emission due to monensin could be because of inhibition of hydrogen and formate producing bacteria and stimulation of succinate and propionate producers which could increase propionate formation by utilizing hydrogen rather than diverting it for methane emission (Chen and Wolin 1979). Reduction in methane emission in monensin treated groups might also be due to reduction in methanogenic bacterial and protozoal population (De and Singh 2003). Greater reduction in methane emission in monensin enriched UMMB fed animals (group 4) as compared to that of group II might be due to greater inhibitory effect of monensin enriched UMMB on methanogenic bacterial and total protozoal population (De and Singh 2003). Inhibitory effect of monensin on methane emission is more pronounced when used with UMMB as compare to when used with nonconcentrate because feeding of UMMB itself resulted reduction in methane emission due to its effect on methanogenic bacterial population (De and Singh 2003) and here action of monensin was additive in nature to further reduce methane emission. Reduction in

Table 2. Effect of monensin enriched UMMB on intake digestibility and *in vivo* methane production

Parameter	Group 1	Group 2	Group 3	Group 4	CD
DM intake (kg/d)	5.35±0.59	5.43±0.35	4.62±0.13	4.60±0.38	NS
DM digestibility (%)	58.87±2.32	56.54±3.16	60.39±4.45	60.00±3.95	NS
Digestible DM intake (kg/d)	3.15±0.31	3.07±0.19	2.79±0.06	2.76±0.14	NS
OM intake (kg/d)	4.880.53	4.96±0.31	4.17±0.11	4.15±0.35	NS
OM digestibility (%)	60.87±3.98	58.47±2.86	62.83±2.90	62.17±3.17	NS
Digestible OM intake (kg/d)	2.97±0.29	2.90±0.18	2.62±0.06	2.58±0.14	NS
Methane production (l/d)	150.07^{d}±6.47	117.70^{b}±4.32	131.49^{c}±6.23	89.31^{a}±2.63	10.98**
Methane production (l/kg DDMI)	48.80^{c}±4.50	38.69^{b}±2.25	47.12^{c}±1.50	32.47^{a}±0.82	5.39**
Methane production (l/kg DOMI)	51.73^{c}±4.74	40.97^{b}±2.38	50.23^{c}±1.49	34.72^{a}±0.87	6.05**

**P<0.01; NS- Nonsignificant; a, b,c and d values bearing different superscripts in a row differ significantly.

methane production might be due to removal of protozoa (Kreuzer *et al.*1986) as ciliate protozoa are symbiotic with methanogenus (Stumn and Zwart 1986, Finlay *et al.*1994). When concentrate mixture was fed to animal, the increase in methane production might be due to an increase in hydrogen transfer between this microorganisms (Krumholz *et al*. 1983).When UMMB was fed, due to partial defaunating properties of UMMB (Garg 1989) acetate and butyrate production was less (De and Singh 2003) and hydrogen might have been utilized towards more propionate production and methane emission was reduced as compare to when animals were fed with concentrate mixture. The principal fermentation products of protozoa are acetate and butyrate (Gutierrez 1955), therefore, the removal of these microorganisms from rumen might shift towards propionate and decrease the formation of methane (Itabashi *et al.*1984). Results revealed that the enrichment of UMMB with monensin is more effective to inhibit methane emission as compared to that of when monensin was supplemented with concentrate mixture. So, from this study it can be concluded that addition of monensin either with urea molasses mineral block or with concentrate mixture can reduce methane production by 10.11 to 16.33 litre/kg DDMI or 10.76 to 17.01 litre/kg DOMI or 32 to 60 litre per day.

SUMMARY

Crossbred (4; Sahiwal × Holstein Friesian) male calves (~1 yr, avg. body weight 249.25 to 258.5 kg) were used in a switchover design to study the effect of monensin addition either in concentrate or enrichment of urea molasses mineral block (UMMB) with monensin on methane emission. In group 1, animals were fed concentrate mixture and wheat straw *ad lib*, group 2 were supplemented with 30 mg monensin/day,group 3 and 4, a deduction of 30% in concentrate was done, which was fulfill through UMMB. In group 4, UMMB was enriched with monensin (100 ppm). Methane emission (l/d) was affected significantly (P<0.01) due to monensin. It was significantly (P<0.01) lower in group 4 (89.31 l/d) followed by group 2 (117.70 l/d), group 3 (131.49 l/d) and group 1 (150.07 l/d). Methane emission (l/kg DDMI and l/kg DOMI) was significantly (P<0.01) lower in groups 2 (38.69, 40.07) and 4 (32.47, 34.72) as compared to groups 1 (48.80, 51.73) and 3 (47.12, 50.23). However, no significant difference was observed between groups 1 and 3 and also between groups 2 and 4. So, monensin enriched UMMB can reduce the methane production significantly.

REFERENCES

Andrae J G, Horn G W, Buchanan D S and Bowen C. 1995. Effect of salt intake in a monensin containing energy supplement on rumen fermentation of steers grazing wheat pasture. *Animal Science Research Report.* Agricultural Experiment Station, Oklahoma State University. pp. 145–50.

AOAC. 1984. *Official Analytical Methods*. 4th edn. Association of Official Analytical Chemists, Washington, D C, USA.

Badawy S A,Younis M, Shalaish M R, Nawito M F, Mansour S A and Rekha G. 1996. Monensin effects on rumen metabolic profile, methane production and protozoal population in buffalo heifers. *Egyptian Journal of Veterinary Science* **30**: 49–56.

Bergen W G and Bates D B. 1984. Ionophores: Their effect on production efficency and mode of action. *Journal of Animal Science* **58**: 1465–83.

Callaway T R, Edrington T S, Rychlik J L, Genovese K J, Poole T L, Jung Y S, Bischoff K M, Anderson R C and Nisbet D J. 2003. Ionophores: Their Use as Ruminant Growth Promotants and Impact on Food Safety. *Current Issues in Intestinal Microbiology* **4**: 43–51.

Chen M and Wolin M J. 1979. Effect of monensin and lasalocid-sodium on the growth of methanogenic and rumen Saccharolytic bacteria. *Applied Environmental Microbiology* **38**: 72–77.

De D and Singh G P. 2003.Effect of ionophore enriched cold processed mineral block supplemented with urea molasses on rumen fermentation and microbial growth in crossbred cattle. *Asian-Australian Journal of Animal Science* **16** (6): 852–62.

Dinius D A, SimpsonM E and Marsh P B.1976. Effect of monensin fed with forage on digestion and the ruminal ecosystem of steers. *Journal of Animal Science* **42**: 229.

Faulkner D B, Klopfenstein T J, Trotter T N and Britton R A. 1985. Monensin effects on digestibility, ruminal protein escape and microbial protein synthesis on high fibre diets. *Journal of Animal Science* **61**: 654–60.

Finlay B J, Esteban G, Clarke K J, Williams A G, Embley T M and Hirt R P. 1994. Some rumen ciliates have endosymbiotic methanogens. *FEMS Microbial Letter* **117**: 157–62.

Garg M R. 1989. 'Effect of supplementation straw based diet with urea molasses mineral block licks on rumen fermentation pattern, nutrient utilization and growth in crossbred cattle.' Ph. D.thesis, Kurukshetra University, Kurukshetra, India.

Garg M R and Gupta B N. 1993. Effect of supplementing urea molasses mineral block lick to wheat straw based on digestibility of nutrients and N balance. *Indian Journal of Dairy Science* **46**: 247–52.

Goodrich R D, Garrette J E, Gast D R, Krick M A, Larson D A and Meiske J C. 1984. Influence of monensin on the performance of cattle. *Journal of Animal Science* **58**: 1484.

Gutierrez J. 1955. Experiment on the culture and physiology of holotrichs from bovine rumen. *Biochemistry Journal* **60**: 516.

Haney M E Jr. and Hoehn. 1968. Monensin, a new biologically active compound. I. Discovery and isolation. *Antimicrobial Agents and Chemother*apy. Pp. 349–52.

Itabashi H, Kobayashi T and Matsumato M. 1984. The effect of rumen ciliate protozoa on energy metabolism and some constituents in rumen fluid and blood plasma of goats. *Japanese Journal of Zootechnical Science* **55**: 248–56.

Kearl C L. 1982. *Nutrients requirement of ruminants in developing countries*. International Feedstuffs Institute. Utah Agricultural Experiment Station, Utah State University, Loyan Utah.

Kreuzer M, Kirchgessner J and Muller H L. 1986. Effect of defaunation on the loss of energy in wethers fed different quantities of cellulose and normal or steam flaked maize starch. *Animal Feed Science and Technology* **16**: 233–41.

Krumholz L R, Forsherg C W and Veira D M. 1983. Association of methanogenic bacteria with rumen protozoa. *Canadian Journal of Microbiology* **29**: 676–80.

Martin S A and Macy J M. 1985. Effect of monensin pyromellitic diimide and 2–bromoethanesulfonic acid on rumen fermentation *in vitro*. *Journal of Animal Science* **60**: 544.

Martin C, Doreau M, Morgavi D P. 2008. Methane mitigation in ruminants: from rumen microbes to the animal. *International Conference on Livestock and Global climate change* 17–20 May, 2008, Hammamet, Tunisia.

Mbanzamihigo L, Van-Nevel C J and Demeyer D I. 1996. Lasting effect of monensin on rumen and caecal fermentation in sheep fed a high grain diet. *Animal Feed Science and Technology* **62** (2/4): 215–18.

Packer E L, Clayton E H and Cusack P M V. 2011. Rumen fermentation and liveweight gain in beef cattle treated with monensin and grazing lush forage. *Australian Veterinary Journal* **89** (9): 338–45.

Preston T R and Leng R A. 1989. The green house effect and its implications for world agriculture. The need for environmentally development. *Livestock Research for Rural Development* **1**: 14–17.

Ramanzin M, Bailoni L, Sachiavon S and Bittante G. 1997. Effect of monensin on milk production and efficiency of dairy cows fed two diets differing in forage to concentrate ratios. *Journal of Dairy Science* **80**: 1136–42.

Richardson L F, Raun A P, Potter E L, Cooley C O and Rathmacher R P. 1976. Effect of monensin on rumen fermentation *in vitro* and *in vivo*. *Journal of Animal Science* **43**: 657–64.

Singh G P, Gupta B N and Madhu Mohini. 1995. Effect of supplementation of UMM licks to straw diet on DM intake, volatile fatty acids and methane production. *Indian Journal of Dairy Science* **48**: 290–94.

Singh G P. 1996. Use of tracer technique in estimation of methane (green house gas) from ruminant. *Isotope and Radiation in Agriculture and Environment Research.* pp. 298–302. (Eds) Scahdeva M S, Sachdeva P and Deb D L.

Singh G P. 1997. Effect of green house gases on climate change and Indian ruminant livestock. *Current Science* **72**: 431–34.

Singh G P and Mohini M. 1999.Effect of different level of rumensin in diet on rumen fermentation, nutrient digestibility and methane production in cattle. *Asian-Australasian Journal of Animal Science* **12**(8):1215–21.

Snedecor G W and Cochran W G. 1986. *Statistical Methods.* Oxford and IBH Publishing Co., Calcutta, India.

Stock R A, Laulert S B, Stroup W W, Larson E M, Parrot J C, Britton R A. 1995. Effect of monensin and monensin and tylosin combination on feed intake variation of feedlot steers. *Journal of Animal Science* **73**: 39–44.

Stumm C K and Zwart K B. 1986. Symbiosis of protozoa with hydrogen utilizing methanogens. *Microbiological Science* **3**: 100–05.

Vangardingen P R. 1991. Green house gas production by ruminants in New Zealand: serious problem or just hot air. *Proceedings of New Zealand Society of Animal Production* **51**: 35.

Walker P M, Weighenthal B A and Cinarik G F. 1980. Efficacy of monensin for beef cows. *Journal of Animal Science* **51**: 533–38.