METHANE EMISSION FROM GRAZING DAIRY CATTLE IN TROPICAL BRAZIL: MITIGATION BY IMPROVING PRODUCTION

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ABSTRACT

Experiments were carried out on tropical grass pasture, in summer 2002, to find out possible mitigation options to reduce methane emission using different categories of grazing dairy cattle breeds. Methane emission was measured using the SF_6 tracer technique. Experimental design was a block distribution in time, along four consecutive weeks, five days a week, at 12-hour intervals, employing four animal categories - lactating and dry cows on pastures with nitrogen fertilization and heifers on pastures with and without fertilization - of pure Holstein and 3/4 breeds *(B. taurus x B. indicus)*: lactating Hostein cows in 1 of 33 resting days rotated grazing fertilized *Panicum maximum* with 15% crude protein (CP), 64% neutral detergent fiber (NDF) and 54% "in vitro" organic matter digestibility (IVOMD) plus 1 kg concentrate with 20% CP for each three liter milk surplus above 10 liters; dry cows and heifers of both breeds grazing N-fertilized grass *P. maximum*, lactating Zebu crosbred on N-fertilized *Brachiaria decumbens*, and heifers of both breeds grazing unfertilized *B. decumbens* extensively managed, with 6.5% CP, 72% NDF and 37% IVOMD, similar to the most representative cattle production systems in Brazil. These experiments were carried out in summer (rainy season) with offer of good quality grass forage.
Data indicate that methane emission rates of cattle on tropical grass pastures are higher than those on temperate forages, perhaps due to higher fiber content. Data also suggest that improvement of production potential of dairy cattle may reduce methane emission per product unit in Brazilian summer grazing conditions. Concentrate use equal or lower than 40% of dry matter intake did increase methane emission per animal but reduce per unit of production.

INTRODUCTION

Ruminants are an important source of emission of methane to the atmosphere, improving the greenhouse effect. They contribute, however, only with around 22% of the total anthropic sources in the world, or 80 Tg/year (USEPA, 2000). Methane production results from the digestive process of herbivore ruminants in the rumen, during anaerobic fermentation of soluble and structural carbohydrates, mainly of grass forage, and corresponds to an energy loss of around 6% of gross energy intake, in temperate climate (USEPA, 1990). In Brazil, with the main cattle heard, of around 160 million animals in 1995 (IBGE, 1998), grazing tropical C4-metabolism grasses, estimated methane emission is of about 9.2 Tg/year (Lima, 2002), based on reference data proposed by IPCC (1996), being the main Brazilian anthropic methane source. Some authors, such as Kurihara et al. (1999) and Lassey et al. (2002), estimate that methane emission in tropical areas could be greater than that of cattle feeding C3-metabolism forages in temperate climate or ingesting a greater corn-based diet. Studies did show influence of type of production systems and manner of animal management on methane emission. So, animals ingesting grasses will produce more methane than when fed legumes (Woodward et al., 2001) or grains (Holter and Joung, 1992; Kurihara et al., 1999), and this seems to be mainly related to the percentage of available digestible energy intake to meet daily animal requirements for maintenance and milk or meat production. With the main goal to quantify ruminal methane emission by grazing dairy cattle breeds and animal categories in tropical Brazil, and also to find out some potential mitigation practices, field measurements were performed in summer, on cattle fed tropical grass forages and concentrate supplementation depending on breed or category.

MATERIAL AND METHODS

Experiments were carried out on tropical grass pasture, *Panicum maximum* cv. Tobiata and *Brachiaria decumbens*, in February (summer) 2002, at Sao Carlos, Sao Paulo State, Brazil, under altitude tropical climate, at 860 m above sea level, at latitude 22°01′ S and longitude 47°54′ W. Methane emission was measured using the SF_6 tracer technique, according to Johnson and Johnson (1995). Experimental design was a randomized block distribution in time, along four consecutive weeks, five days a week, at 12-hour intervals, employing four animal categories of pure Holstein and Zebu crosbred (3/4 breeds: *B. taurus* x *B. indicus*). Table 1 shows feed quality and Table 2, animal characteristics.

Table 1. Chemical characteristics of feed, summer 2002.

Characteristics	*P. maximum* fertilized	*B. decumbens* fertilized	*B. decumbens* unfertilized	Concentrate 20%CP	Concentrate 18%CP
OM, g/kg DM	899 a	911 a	920 a	941	875
NDF, g/kg DM	642 c	686 b	719 a	133	280
ADF, g/kg DM	342 a	346 a	362 a	45	153
Cellulose, g/kg DM	329 a	323 a	335 a	45	111
Hcellulose, g/kg DM	300 b	340 a	357 a	88	127
Lignin, g/kg DM	13 b	24 a	28 a	0	42
CP, g/kg DM	154 a	73 b	65 b	271	216
IVDOM, %	54.4 a	47.3 b	37.2 a	82.3	54.7

DM = dry matter; OM = organic matter; NDF and ADF = neutral and acid detergent fiber; CP = crude protein; Hcellulose = hemicellulose; IVDOM = "in vitro" digestibility of organic matter. Mean values in same line not sharing a common letter were significantly different, P<0.05 (Tukey).

Holstein lactating cows, dry cows of both breeds and intensively managed heifers of both breeds were fed fertilized *P. maximum*; Zebu crosbred lactating cows were fed fertilized *B. decumbens*, and extensively managed heifers of both breeds were fed unfertilized *B. decumbens*.

Table 2. Amount and quality of ingested feed, per animal category and breed, summer 2002.

Characteristics	Lactating cows	Dry cows	Heifers intensive	Heifers extensive
		Black and White Holstein		
Live weight (LW), kg	572 abA	605 a A	502 bcA	459 a A
Milk production, L/d	22,7	-	-	-
DM, kg/d	16 a A	12 b A	10 b A	9 b A
OM, kg/d	15 a A	11 b A	9 b A	8 b A
DDM, kg/d	10 a A	6 b A	5 bcA	3 c A
NDF, kg/d	6.9 a A	7.5 a A	5.7 a A	5.5 a A
ADF, kg/d	3.4 a A	4.0 a A	3.0 a A	2.8 a A
CP, kg/d	3.2 a A	1.9 b A	1.6 b A	0.9 b A
CE, Mcal/d	65 a A	48 b A	39 b A	35 b A
DE, Mcal/d	44 a A	26 b A	22 bcA	15 c A
Concentrate, kg/d	6.5 a A	1.0 b A	2.0 b A	0
Concentrate, % DM	40 a A	8 b A	20 b A	0
DM, % LW	2.8 a A	2.0 b A	2.0 b A	1.9 b A
		Brazilian dairy Zebu Crosbred		
Live weight (LW), kg	435 a B	480 a A	365 a B	374 a A
Milk production, L/d	13.3	-	-	-
DM, kg/d	11 a B	11 a A	8 b A	8 b A
OM, kg/d	10 a B	10 a A	7 a A	7 a A
DDM, kg/d	5 a B	5 a A	4 bcA	3 c A
NDF, kg/d	6.0 a A	6.2 a A	4.4 a A	4.6 a A
ADF, kg/d	3.0 a A	3.3 a A	2.3 a A	2.4 a A
CP, kg/d	1.3 a B	1.8 a A	1.3 abA	0.8 a A
CE, Mcal/d	42 a B	43 a A	31 a A	31 a A
DE, Mcal/d	21 abB	23 a A	17 bcA	13 c A
Concentrate, kg/d	3.4 a B	2.0 a A	2.0 b A	0
Concentrate, % DM	32 a A	18 b A	26 a A	0
DM, % LW	2.5 a A	2.3 a A	2.2 a A	2.1 a A

DDM = digestible dry matter; CE = gross energy based on ingested organic matter; DE = digestible energy, considering "in vitro" digestibility of ingested organic matter. Mean values in same line not sharing a common letter were significantly different, $P<0.05$ (Tukey). Mean values of animal categories not sharing a common capital letter were significantly different between breeds, $P<0.05$ (F test).

Calculations of different characteristics were done following the methods used by Holter and Young (1992) and Kurihara et al. (1999). Forage dry matter intake was estimated by the Cornell Nutrient Management Planning System (2003), for each animal.

Data were analyzed by GLM procedure (SAS, 1998), and animal category means were compared with Tukey test and breeds, with F-test.

RESULTS AND DISCUSSION

As far as forage quality is concerned (Table 1), unfertilized *Brachiaria decumbens* did show greater NDF and lower CP contents, beside lower IVDOM. The CP levels of *P. maximum* were around optimal for tropical conditions. Extreme values used by Kurihara et al. (1999) were not reached in this study.

An overview of different measurements and calculated data are shown in Table 3. There was a significant difference ($P<0.05$) among lactating cows and other categories for daily or estimated yearly methane emission rate, by both breeds, but not between breeds.

Table 3. Methane emission by animal category and breed, summer 2002, Sao Carlos, SP, Brazil. (mean of 40 measurements in 4 replications)

Methane emission	Lactating cows	Dry cows	Heyfers intensive	Heifers extensive
		Black and White Holstein		
g/h	16.8 a A	11.6 b A	9.3 b A	8.3 b A
g/d	403 a A	278 b A	222 b A	198 b A
g/year (potential)	147 a A	101 b A	81 b A	72 b A
g/kg IDDM	42 a B	46 a A	45 a A	58 a A
g/d/kg LW	0.71 a A	0.46 b A	0.45 b A	0.43 b A
g/d/L milk	18.4	-	-	-
% CE	8.3 a A	7.6 a A	7.5 a A	7.2 a A
% DE	12.7 a B	14.0 a A	13.7 a A	17.7 a A
		Brazilian dairy Zebu Crosbred		
g/h	13.8 a A	12.3 abA	9.5 bcA	7.6 c A
g/d	331 a A	295 abA	227 bcA	181 c A
g/year (potential)	121 a A	107 abA	83 bcA	66 c A
g/kg IDDM	69 a A	56 a A	58 a A	62 a A
g/d/kg LW	0.79 a A	0.62 a A	0.62 a A	0.48 a A
g/d/L milk	25.3	-	-	-
% CE	10.6 a A	9.1 a A	9.6 a A	7.8 a A
% DE	20.9 a A	16.8 a A	17.7 a A	18.6 a A

IDDM = ingested digestible dry matter. Mean values in same line not sharing a common letter were significantly different, $P<0.05$ (Tukey). Mean values of animal categories not sharing a common capital letter were significantly different between breeds, $P<0.05$ (F test).

Estimated yearly CH_4 emission factor for lactating cows was greater than th estimated for American or European conditions, from 81 to 118 kg/animal and ye (IPCC, 1995), although the availability of estimated digestible energy, in this stu was of about 44 Mcal/day for cows with 572 kg live weight and a milk productio 8,521 L in 298 days, against 60 Mcal/day and 550 kg live weight animals, with a production of 4,200 kg/y and dry matter intake of 13.8 kg/d or 2.5% LW in Europe 65 Mcal/day for 600 kg LW animals with a milk production of 6,700 kg/y and matter intake of 16.2 kg/d or 2.7% LW (IPCC, 1996; Johnson & Ward, 1996).

This may result from lower tropical forage quality (Kurihara et al., 1999), mainly due to greater fiber content. Another point to consider for lactating cows is the longer time spent to reach adult weight in the tropics, due to forage quality, which is not able to provide the requested daily energy. This could result in greater dry matter intake for production and growth, mainly when 40% of dry matter is a corn concentrate, which will stimulate intake.

Breed difference occurred only for lactating cows CH_4 emission related to ingested digestible dry matter (DDM) and ingested digestible energy (DE). Methane emission was greater for Zebu crossbred animals, perhaps due to their greater efficiency to digest cellulose. This allows to conclude that the emission factor per unit of milk is also different between breds. Holstein cows, with a greater milk production potential, may dilute CH_4 emission per kilogram of milk. So, one of the strategies to reduce CH_4 emission is to improve milk production per cow, allowing the decrease of the number of milking animals. Another point that may explain the lower CH_4 emission by lactating cows in temperate climate is that they receive more than 50% of dry matter as grain, with lower fiber content and more digestible energy, and therefore dry matter intake to meet the whole daily energy requirements is lower. The percent CH_4 produced due to gross energy intake was estimated between 5.5 and 6.5% (USEPA, 2000), for United States and western Europe, reaching in this study, 8.3% for lactating Holstein and 10.6% for lactating Zebu crosbred animals (Table 3).

Heifers grazing unfertilized *B.decumbens* forage, which can be considered standard condition for Brazil, produced a potential yearly CH_4 emission of about 66 to 73 kg/animal, values greater than those estimated for tropical Africa and Asia (IPCC, 1995) and for Brazil (Crutzen, 1986). This could be due to no consideration of lower forage availability and intake and methane emission in the dry season, in the estimations of the last study. In Japan, Kurihara et al. (1999), comparing C3- and C4-metabolism grass forages and corn rich diet with Zebu heifers, found lower CH_4 emission when grains were fed, or low fiber and richer in digestible energy compared to better grass forage, 0.42 and 0.71 g/d/kg LW, respectively. With the worst quality tropical forage, resulting in lower dry matter intake and weight losses, a CH_4 emission of 0.32 g/d/kg LW was found. Data with better quality feed were similar to those obtained in this study (Table 3), which covered 42% of the yearly Brazilian pasture conditions. These data suggest that perhaps IPCC standards for tropical areas need to be reviewed.

CONCLUSION

1. Methane emission by dairy cattle, without intake restriction of tropical grass forages, was greater than that of temperate grass forages.

2. Lactating Zebu crosbreds generate greater CH_4 emission per unit of digestible energy intake than European cows.

3. Improving milk production per cow will reduce methane emission per unit of product.

4. Considering forage intake restriction in dry season, yearly methane emission factor of heifers will be lower.

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