METHANE EMISSIONS FROM HOLSTEIN HEIFERS GRAZING CONTRASTING PASTURES IN URUGUAY[1]

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Abstract
A trial was carried out with the objective of monitoring and studying the effects of two contrasting pastures, with and without supplement, on methane production of Holstein heifers. Two Holsteins heifers (17 months old, with an average weight of 456 kg) were alternatively assigned to one of the following treatments (1) Improved pasture (tall fescue, white clover and birdsfoot trefoil); (2) Range (mainly warm season species); (3) Range + 0.5 % BW as ground corn. All pastures were offered to the animals at a daily 4% of body weight. The routine included 14-day adaptation period to the diet and a 5-day period for sampling and measurement. Methane emissions were measured by using a sulfur hexafluoride (SF_6) tracer technique, developed at Washington State University (Johnson et al., 1994). During the sampling period, yokes were changed every 12 hours during 5 days. Methane emissions per day and per kilogram of FDN intake per 100 kg of live weight did not differ for treatments that were not supplemented. Therefore an equal emission with a higher intake was achieved for heifers grazing improved pastures.

1. Introduction

Uruguay, a temperate country, is located between 30 and 35° South latitude in South America spanning over 176,215 km^2. Livestock raising is a major economic activity in the country, based on a national herd of 10.5 million cattle heads and 11 million sheep heads. Almost all cattle is raised on pasture, either range (75 % of the country) or improved pasture.

Under the United Nations Framework Convention on Climate Change, Uruguay must adopt measures for combating climate change. Greenhouse gas emissions in Uruguay -expressed, as global warming potential of all gases combined- is about 3 t CO_2-C/person/year. Methane emitted by cattle is the single most important source of atmospheric warming potential, equivalent to more than 60 % of total emissions. The main source of methane emission in Uruguay is the agriculture sector (90%), with ruminant enteric fermentation being responsible for 95 % of total agricultural methane emissions. Per capita emissions are high due to a combination of a large herd and a low human population (3 million).

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Methane is produced during the digestive process of ruminants. The amount produced and excreted depends on animal and nutritional factors. Diet is the main factor governing the amount of methane emissions. Also, emissions tend to increase with animal age and size. Management of these factors may allow achieving a progressive decline in Uruguay's contribution to climate change in the future.

National greenhouse gas inventories should be based on emission factors reflecting reality as much as possible. Currently, there are no locally developed emission factors for non-CO_2 greenhouse gases from agriculture in Uruguay, and the Government has to use adapted factors for producing national inventory reports on greenhouse gases. There is a need to quantify those emission factors for the particular conditions of agro-ecosystems of Uruguay.

This paper reports preliminary findings of a study on the effects of pasture quality and use of supplement on methane emissions by heifers. These data constitute the first set of measurements of ruminant methane emissions ever performed in Uruguay.

2. Objectives

The main objective of this experiment was to evaluate the differences in methane emissions between Holstein heifers grazing on two different pasture qualities: improved pasture with relatively good quality and natural pasture with a lower quality, with and without supplement.

3. Materials and Methods

The experiment was developed at the Intensive Beef Production Unit, at INIA La Estanzuela Research Station, located in Colonia, SW Uruguay (34º 20' S, 57º41' W). The laboratory is located at 3 km from the experiment site.

Two Holstein heifers, 17 months old, and initially weighting 456 kg (in average) were randomly assigned to different plots of the same pasture and after an adaptation period of 17 days and then assign to the treatments. Treatments were: (1) Improved pasture (tall fescue, white clover and birdsfoot trefoil); (2) Range (mainly warm season species); (3) Range + 0.5 % BW as ground corn. The pastures were offered to the animals at a daily 4% of body weight. The routine included a 15-day adaptation period to the diet and a 5-day period for sampling and measurement. From the five days, the four that gave closest values were selected for the analyses. The experiment was conducted over the summer and fall of 2003. Treatments allocated to each heifer and sampling treatment are shown in table 1. These treatments represent three typical situations of heifer raising in Uruguay.

Table 1. Sample treatments

Heifer	I	II	III
1031	R	IP	R + GC
1040	R	IP	R + GC

I, II, III: Treatments; **R**: Range; **IP**: Improved Pasture; **GC**: Ground Corn

3.1 Gas Analysis

Methane emissions were measured using the sulfur hexafluoride (SF_6) tracer technique, developed at Washington State University (Johnson et al., 1994).

SF_6-filled permeation tubes were designed to last for a period of at least six months. During the sampling period, yokes were changed every 12 hours during 5 days. Samples were analyzed for methane and sulfur hexafluoride by a Hewlett Packard 5890 gas chromatograph. Sulfur hexafluoride is measured with an electron capture detector (ECD), operating at a temperature of 300ºC, and methane with a flame ionization detector (FID), operating at a temperature of 280ºC.

3.2 Diet Quality and Intake Estimation

Average offered-feed quality parameters for the different treatments are presented in Table 2. Improved pasture was better in quality than range for all parameters, and range quality was not good enough as for allowing weight gain.

Table 2. Corn and pasture quality for different parameters that compose the diet of the three treatments (as percentage on dry matter basis).

	CP	IVOMD	ADF	NDF	Ash
GC	9.81	91.5	3.10	9.20	1.60
IP	15.31	65.64	37.73	53.28	13.96
R	9.69	43.87	51.32	71.09	8.87

GC = Ground Corn; **IP** = Improved Pastures; **R** = Range.
CP, crude protein; **IVOMD**, in vitro organic matter digestibility; **ADF**, acid detergent fiber; **NDF**, neutral detergent fiber

Chromium oxide (15 g/day/heifer) was given from day 8, and for 11 consecutive days, as an external marker to estimate intake . Animal fecal samples were collected every morning at the same time, during the five sampling days. The samples were analyzed for chromium by atomic absorption spectrophotometry and the result (% Cr), was utilized to determine intake.

At the same time, two cannulated heifers were rumen-emptied on day 17 and grazed in each plot for two hours in order to determine pasture selectivity. Intake was estimated by using chromium concentration in feces analyzed and *in vitro* organic matter digestibility of emptied-rumen contents according to the procedure explained by Galyean (1997).

These samples were later analyzed for in vitro organic matter digestibility (IVOMD, Tilley and Terry, 1967), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and ash (AOAC, 1990).

Data was analyzed using GLM procedure of the Statistical Analyses System (SAS, 1999). The initial model contained pasture treatment, heifer and pasture treatment by heifer. Statistic design was an incomplete latin square. Analysis of variance was performed and means were separated by using least square means

4. Results and Discussion

4.1 Diet components and Intake

Pasture quality results for emptied rumen and ground corn for the three treatments, and their contribution to the diet are presented in table 3.

As rumen emptied forage quality did not differ between cannulated heifers, they were averaged.

Table 3. Diet composition for the three treatments.

Treatment	Components	PC (%)	In Vitro OMD (%)	ADF (%)	NDF (%)	Ash (%)
R	Range	9.69	43.76	50.37	79.20	9.00
R + S	Ground Corn	9.81	91.50	3.10	9.20	1.60
	Range	7.87	43.92	52.22	79.81	9.95
	Total Intake	8.57	61.30	34.26	54.00	6.91
IP	Improved pasture	13.84	61.24	44.70	67.56	13.31

Diet components are expressed as percentage on dry matter basis.

Forage intake estimated by chromium concentration in feces and corn intake are reported in Table 4. Intake for improved pasture was, on average, 12 % higher than that for range, and 25% higher than forage consumed by the animals that were supplemented. However, total intake of treatment R+S was higher than that of treatment IP. Even though forage intake of R+S was lower than R in average (4.31 kg/d vs. 4.81 kg/d), when supplement was added, R+S was higher by about 40%. It is clear that energy supplement decreased range forage intake, but total intake increased. The data did not provide information about digestibility of forage when diet was supplemented.

Table 4. Partial and total intake in kg for the three treatments

Treatment	R	R+S			IP
Heifer	**Total**	**Ground Corn**	**Range**	**Total**	**Total**
1031	5.10	2.66	4.78	7.44	5.93
1040	4.52	2.28	3.83	6.11	4.86
Average	4.81	2.47	4.31	6.78	5.41

4.2 Methane Emissions

Methane emissions per day, per kilogram of intake, per kg per 100 kg of live weight and per kg of FDN intake per 100 kg of live weight and their standard deviation for the three treatments and two heifers are presented in table 5.

Table 5. Least square means and standard deviation for methane emissions by treatment and heifer for the four variables analyzed.

Treatment/ Heifer	g/d	SD	g/d/Kg	SD	g/d/Kg/ 100KgLW	SD	g/d/ KgNDFI/ 100KgLW	SD
IP	92.8a	22.1	17.3[a]	4.4	75.8 a	20.3	101.8[a]	25.0
R	117.a	17.5	24.4ab	3.6	109.9ab	15.9	138.8a	20.5
R+S	223.0b	174.4	37.0b	29.7	170.7b	134.2	323.9b	237.7
1031	98.00a	24.1	16.8[a]	16.8	76.2a	28.6	114.6a	22.4
1040	197.4b	148.5	35.7b	22.2	161.4b	102.3	261.7b	212.0

R: Range; **IP**: Improved Pasture; R+S: range plus supplement
[1] Mean values for four sampling days

As the analyses of variance show that there were significant differences not only within treatments and heifers but also in the interaction term (treatment by heifer), means for the three treatments and two heifers were compared by least square means and their error probabilities are shown for the four variables analyzed (Table 6).

Table 6. Least square means of three treatments and two heifers for the four variables.

Treatment	Heifer	g/d[1]	g/d/KgI	g/d/KgI/ 100KgLW	g/d/KgNDFI/ 100KgLW
IP	1031	95.3 a	16.1 ab	67.9 a	97.0 a
IP	1040	90.3 a	18.5 ac	83.6 ab	106.5 a
R	1031	123.0 a	24.1 bc	111.1 b	136.9 a
R	1040	111.8 a	24.8 c	108.7 b	140.6 a
R+S	1031	75.8 a	10.2 a	49.5 a	109.7 a
R+S	1040	390.3 b	63.9 d	292.0 c	538.1 b

Different letters within variable differ significantly ($p<0.05$).

Methane emissions in grams per day and in grams per day per kilogram of NDF intake by 100 kilograms of live weight did not differ for the first five treatments. A significant difference was detected between heifer 1040 grazing range and supplemented and all the other combinations. Under grazing conditions, FDN is one of the most important forage quality parameters that are related with intake (Mertens 1997). Intake is highly correlated with neutral fiber in the diet, which in turn is correlated with gas emissions. As NDF content for improved pasture was about 15% lower than that for range (Table 3) intake was increased by the same percentage for heifers grazing improved pasture (Table 7). Therefore gas emission per day was the same for heifers grazing IP or R. Total NDF intake for the three treatments were very similar. Similar results were obtained when comparing treatments for ADF intake (Table 7). All variables differed significantly for heifer 1040 grazing range and supplemented with corn when compared with the other treatments. This was probably due to gas measurement problems and not to the treatment that was applied to the heifer. Looking at diet quality and NDF and ADF intake values, similar results are expected if we relate gas emission with ADF instead of NDF.

For the other two variables, (g/d/KgI and g/d/KgI/100KgLW), heifers grazing improved pastures tended to have higher emissions than those grazing native pastures. Data obtained in this work suggest that gas emission was highly correlated with pasture quality. Even though the experiment was not designed to measure weight changes, it can be estimated, from forage quality information, that heifers grazing improved pasture gained weight, whereas those grazing range lost weight. This would explain the estimated lower emission per kilogram of weight gain in IP. This implies that gas emission to reach a target as slaughter weight or weight at calving will be less when heifers are fed improved pastures than when they are feed native pastures.

Table 7. Total, ADF and NDF kilograms intake for the three treatments

Treatment	R	R+S			IP
Estimated diet Consumption (Kg DM basis)	Total	Ground Corn	Range	Total	Total
Intake	4.81	2.47	4.31	6.78	5.41
ADF	2.43	.008	2.18	2.26	2.42
NDF	3.80	0.23	3.40	3.63	3.66

Parameters are expressed on dry matter basis

5. Final Considerations

This paper reports on preliminary results obtained as part of a long-term effort to understand methane emissions by cattle in Uruguay. Following is a list of facts, lessons learned and primary conclusions derived from this early phase of our work:

- There was a high degree of variability in methane determinations, particularly among heifers grazing range, either alone or supplemented. A good part of this variability was attributed to experimental errors related with gas sampling and measurement occurred mainly during the first sampling periods. As experience was gained, many of these sources of error were increasingly controlled.

- There was good consistency of measurements among sampling period means for both range and improved pasture. Inconsistencies were detected in R+S and in standard deviations among heifers.

- IPCC default value for methane emission by 450-kg heifers, gaining 50 kg of body weight/year, grazing on a pasture with 65% digestibility (similar to improved pasture in our experiment) is 160 g CH_4/day. The default value for the same heifers grazing on pasture with 44.4% digestibility (similar to range in this experiment) is 242 g CH_4/day. Our measurements were lower than these values, particularly for range treatment, suggesting that IPCC default factors may not be adequate for Uruguay conditions.

- Allowance in this experiment was fixed in 4% of body weight, value that seems to be limiting intake

- Forage intake is determined by forage quality (FDN) which in turn is correlated with gas emission. As FDN intake seems to have been of the same order independently of diet quality, live weight gain will depend of total intake (the lower the FDN the higher the intake). Therefore, live weight gain will be higher as FDN is lower, due to a higher consumption and better diet quality. As gain is related to energy and protein intake (mainly), when methane emissions were expressed relative to kilogram of live weight gain, lower levels were obtained in improved pasture than in lower-quality range.

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