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THE INFLUENCE OF THE ADDITION OF OIL SEEDS IN THE DAIRY COW RATION ON CO_2 EMISSIONS

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Abstract

The aim of the research undertaken was to highlight that emission reductions can be made available to producers in the steer farming sector and the adoption of current best practices and technologies for the rearing and health of animals, feed rations can be a tool that would help the dragline sector reduce greenhouse gases, and was realized on the Moara Domneasca farm on a flock of 29 dairy cows at different stages of Montbeliarde's lactation between January 2021 and September 2021. Daily milk production was established per lactation cycle, within the lactation cycle of 3 distinct stages and the establishment of two seasons, summer and winter. The influence of feed strategies applied on milk production, manure chemical composition and CH_4 and CO_2 emissions were analyzed. The milk production of cows was not influenced by the addition of vegetable oils, ranging between 22.04 l / head in the ascending phase of lactation, 19.86-20.96 l / head in the plateau phase and 19.45 l / head in the descending phase of lactation. The methane emission from enteric fermentation shows the highest values for variants 4 and 3, when 0.2 l/head/day of rapeseed oil were administered in each variant, and in version 4, 0.1 l/head/day of sunflower oil was also administered (methane emissions are 1.41 kg CH_4/year and 1.39 kg CH_4/year, respectively). The lowest emissions are recorded for nutrition variant 5 (in which equal doses, sunflower oil and rapeseed oil were administered: 0.1 l l/head/day). Also, the trend of CO_2 equivalent emissions closely follows the line of CH_4 emissions from enteric fermentation, being directly dependent.

Key words*: emissions, enteric fermentation, manure, milk production.*

INTRODUCTION

Greenhouse gas (GHG) emissions from human activities are likely to contribute to climate change. Climate change has been associated with rising sea levels, extreme weather conditions, air pollution and biodiversity loss. Such effects can harm ecosystems and human health. In order to monitor GHG emissions from human activities, initiatives to calculate and report on GHG emissions from human activities have increased. Cattle are responsible for about 30% of global GHG emissions from the livestock sector (Gerber et al., 2013). The stages along the dairy production chain include processes related to feed production (upstream), processes related to milk production on the farm (on the farm) and processes related to milk transport and processing (downstream). Significant GHG emissions from dairy production are carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O).

The main sources of GHG emissions from dairy production are enteric fermentation (CH_4), feed production (mainly CO_2 and N_2O) and manure management (CH_4 and N_2O).

Enteric fermentation and feed production each contribute about 30% to total emissions, while manure management contributes about 20%.

In this regard, various strategies have been proposed to reduce GHG emissions from activities within the traceability chain of dairy production (De Boer et al., 2011). Most strategies apply to upstream and on-farm processes (i.e. including the three main sources of GHG emissions), such as animal feed, plant or animal husbandry, or manure processing technology (Ellis et al., 2008); Wall et al., 2010; De Vries et al., 2012). From an animal husbandry research point of view, important areas of interest for reducing GHG emissions per kg of milk are feeding strategies to reduce emissions from enteric fermentation and feed production, as well as breeding strategies to improve animal productivity.

One way to reduce CH_4 emissions is to add oils to the ration of animals, which has generally been used to increase the energy content of rations in order to meet the energy demand of cows with high milk production. The mechanism by which oils reduce the production of CH_4 is to reduce the fermentation of organic matter, by directly inhibiting methanogens in the rumen by hydrogenating unsaturated fatty acids. The greatest reduction is caused by unsaturated fatty acids, which act on the hydrogen in the rumen by dehydrogenation (Boadi et al., 2004).

Grainger and Beauchemin (2011) also reported that supplementation with fat rations often reduces carbohydrate fermentation due to the effects of fats on cellulolytic bacteria and protozoa, while starch fermentation remains unaffected.

Also, cows that received flaxseed oil in a percentage of 6% reduced their methane emissions by 27 to 37% (Md Najmul, 2018).

The aim of the research was to evaluate in a dairy farm the effectiveness of the application of nutritional strategies based on the addition of vegetable oils (sunflower oil and rapeseed oil) to obtain accurate data to calculate greenhouse gas emissions. greenhouse effect (CH_4, CO_2).

MATERIALS AND METHODS

The research was carried out at the Moara Domnească didactic farm of the University of Agronomic Sciences and Veterinary Medicine in Bucharest, on a herd of 29 dairy cows in different stages of lactation of the Montbeliarde breed between January and September 2021.

The rations included fibrous fodder (alfalfa hay), pickled fodder (corn), fodder beet, concentrated fodder and minerals, vegetable by-products (beer brewery) for a judicious use of local fodder resources (Table 1).

Table 1. Rations administered to dairy cows during the experimental period

Lactation phase	Upward phase		Plateau phase								Down phase	
Experimental variant	V1		V2		V3		V4		V5		V6	
Fodder	Fodder quantity (kg)	Fodder quantity (%)	Fodder quantity (kg)	Fodder quantity (%)	Fodder quantity (kg)	Fodder quantity (%)	Fodder quantity (kg)	Fodder quantity (%)	Fodder quantity (kg)	Fodder quantity (%)	Fodder quantity (kg)	Fodder quantity (%)
Lucerne hay	3.00	7.63	3.00	7.88	3.00	7.97	3.00	7.88	3.00	7.82	3.00	7.31
Corn soiled	25.00	63.65	25.00	65.67	25.00	66.40	25.00	65.64	25.00	65.17	25.00	60.91
Fodder beet	0	0	0	0	0	0	0	0	0.50	1.30	4.00	9.74
Beer brewery	3.00	7.64	3.00	7.88	3.00	7.97	3.00	7.88	3.00	7.83	3.00	7.31
Corn grains	2.30	5.86	1.50	3.94	1.20	3.19	1.30	3.41	1.40	3.65	1.50	3.65
Barley grains	2.10	5.35	2.00	5.25	2.00	5.31	2.00	5.25	2.00	5.21	2.00	4.87
Wheat bran	1.50	3.82	1.50	3.94	1.50	3.98	1.40	3.67	1.20	3.13	1.30	3.17
Sunflower meal	2.00	5.09	1.80	4.73	1.70	4.51	2.00	5.25	2.00	5.21	1.20	2.92
Sunflower oil	0.20	0.51	0.20	0.52	0	0	0.10	0.26	0.10	0.26	0	0
Rapeseed oil	0.10	0.25	0	0	0.20	0.53	0.20	0.52	0.10	0.26	0	0
Calcium carbonate	0.07	0.18	0.07	0.19	0.04	0.11	0.06	0.16	0.03	0.08	0.04	0.10
Dicalcium phosphate	0.01	0.02	0	0	0.01	0.03	0.03	0.08	0.03	0.08	0.01	0.02
Total	39.27	100.00	38.07	100.00	37.65	100.00	38.09	100.00	38.36	100.00	41.05	100.00
Ration contribution												
DM (kg)	17.07		15.99		15.62		16.02		15.88		15.61	
NE (Mj)	101		91		91		92		90		88	
PDIN (g)	1601		1491		1447		1512		1501		1348	
PDIE (g)	1494		1374		1330		1368		1367		1325	
Ca (g)	106.34		103		93.34		106.82		95.51		93.92	
P (g)	70.07		64.05		64.16		69.99		68.37		59.05	

where: DM – dry matter; NE – net energy for milk production; PDIN - true protein absorbable in the small intestine when N is limiting in the rumen; PDIE - protein digested in the small intestine when rumen-fermentable energy is limiting; Ca – calcium; P – phosphorus.

From the point of view of milk production, the existing cows on the farms have average productions of about 5920 l of milk / lactation / year, with a duration of lactation of 295.17 days.

In this research, the influence of the addition of vegetable oils, respectively sunflower oil and rapeseed oil, in 5 variants of rations intended for dairy cows was tested. In the 6th experimental variant of the ration, which corresponded to the descending phase of lactation, no oil was administered, but 4 kg of fodder beet was used, because there are researches that indicate the action of this fodder with effect to reduce the greenhouse gas emissions.

RESULTS AND DISCUSSIONS

The influence of feed strategies applied on milk production.

The monitoring of milk quantity and quality (Table 2) was carried out with the DairyPlan C21 system, which made it possible to identify the animals in the milking parlor, to monitor reproduction and ruminating.

The milk production of cows was not influenced by the addition of vegetable oils, ranging between 22.04 l/head in the ascending phase of lactation, 19.86-20.96 l/head in the plateau phase and 19.45 l/head in the descending phase of lactation. The protein content of milk varied between 3.17-3.23% in the ascending phase of lactation, 3.27-3.39% (3.30% being registered in the summer ration variant) in the plateau phase and 3.08% in the descending phase.

The acidity of the milk was between 6.48 and 6.52, and all the milk samples complied with the recommendations regarding the maximum limit of the total number of germs (10 x 104 NTG/ml), the average being 8.6 x 104 NTG/ml.

Although milk production was expected to increase in response to dietary lipid supplementation after peak lactation (Wu and Huber, 1994), no such increase was found in the current study. This is consistent with other studies (Bell et al., 2006; Roy et al., 2006; Chilliard et al., 2009; Benchaar et al., 2015).

The lack of effect of vegetable oils on milk fat concentration is not consistent with some studies (Chelikani et al., 2004; Bell et al., 2006), which reported a lower milk fat content without changes in milk production and other constituents due to high levels of ration oils.

The lack of effect of vegetable oils on milk fat can be attributed to the lack of changes in rumen fermentation in diets based on pickled fodder.

The influence of feed strategies applied on manure chemical composition

Regarding the chemical composition of the manure (Table 3), 3 samples were analyzed for each variant of ration and it was noted that in the case of using rations with fodder beet the proportion of water in manure determined by drying in the oven at 105^0C was 78.44%, while in the case of other rations the water content was 73.09-75.98%.

The ash content determined by calcination at a temperature of 550^0 C varied between 8.12% for the fodder beet variant in the ration and 10.11% for the ration variant administered in the ascending phase of the lactation curve.

The nitrogen content determined by the Kjeldahl method was lower in the ratio of ratio 5 (0.37%), and in the other variants the nitrogen values were between 0.40-0.67%.

The influence of feed strategies applied on shelter's methan emissions

Methane emission from enteric fermentation were estimated using IPCC method 2. The calculation of the methane emission shall be carried out on the basis of equations 10.19, 10.20, 10.21 from *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2006:*

$$Emisions = EF_{(T)} * \frac{N_{(T)}}{10^6}$$

where:

Emisions = methane emission from enteric fermentation (kg CH_4/year);

$EF_{(T)}$ = emissions factor for dairy cow (kg CH_4/head/year);

$N_{(T)}$ = the herd of animals of the species / category T;

T = category of animal

$$\text{Total } CH_{4\ ENTERIC} = \sum_i E_i$$

where:

Total $CH_{4Enteric}$= total methane emissions from enteric fermentation (kg CH_4/year)

E_i = emissions from animal categories

$$EF = \left[\frac{EB * \left(\frac{Ym}{100}\right) * 365}{55.65}\right]$$

where:

EF= emission factor (kg CH_4/head/year)

EB = gross energy (MJ /head/year)

Ym= methane conversion factor, which is the percentage of raw energy in the administered feed converted to methane

55.65 (MJ/kg CH_4) = energy content of CH_4

Gross energy (GE)

Using the calority of the gross energy of each ration: 1 g crude protein (PB) = 5.72 kcal;1 g raw fat (GB) = 9.5 kcal,1 g crude fiber (CelB) = 4.79 kcal, 1 g SEN (non-nitrogenous extractive substances) = 4.17 kcal, the formula for calculating GE was:

GE (kcal/kg) = 5.72·PB + 9.5·GB + 4.79·CelB + 4.17·SEN

where:

GE = gross energy intake (kcal/kg);

PB = crude protein (%);

GB = raw fat (%);

CelB = crude fiber (%);

SEN = non-nitrogenous extractive substances (%).

The values of gross energy and digestible energy for feed constituents of the rations and the total energy value of the rations delivered to the dairy cows expressed in GE and DE are given in Table 4. Digestible energy (DE) was calculated by applying the three simple rule according to the relationship: ED % = (ED/EB)·x 100.

The following equation shall be used to calculate the values of Ym: Ym = -0.0038 x (ED%)2 + 0.3501 x ED% – 0.811 (Cambra-Lopez equation, 2008) The equation for calculating the enthic CO_2 emission shall be (Users' guide for estimating carbon dioxide, methane, and nitrous oxide emissions from agriculture using the State inventory tool, 2019):

CO_2 enteric (kg/year) = (Emission CH_4 x 25 GWP) / 1,000,000,000

The values obtained for the methane emission from enteric fermentation and the CO_2 equivalent are given in Table 5, figures 1 and 2, respectively.

Table 2. The quantitative, qualitative and microbiological parameters of milk production

Exp. variant	Lactation phase	Milk production (l)	Milk protein (%)	Milk fat (%)	pH	Total number of germs (NTG/ml x 10^4)
V1	The upward phase	22.04±0.46	3.25±0.06	3.48±0.43	6.51±0.03	8.7±0.09
V2	The upward phase	20.34±0.98	3.17±0.11	3.51±0.35	6.48±0.02	8.5±0.08
V3	Plateau phase	19.86±0.77	3.09±0.08	3.53±0.55	6.48±0.04	8.6±0.08
V4	Plateau phase	20.88±0.85	3.18±0.10	3.57±0.73	6.50±0.03	8.5±0.10
V5	Plateau phase	20.96±1.01	3.21±0.09	3.56±0.52	6.52±0.04	8.7±0.09
V6	Down phase	19.45±0.67	3.02±0.08	3.49±0.41	6.49±0.03	8.6±0.08

Table 3. Chemical composition of manure obtained in experimental period

Feed variant	Water (%)	Ash (%)	N (%)
V1	73.09	10.11	0.67
V2	75.35	8.74	0.40
V3	75.98	9.06	0.55
V4	73.26	9.97	0.61
V5	75.22	8.46	0.37
V6	78.44	8.12	0.45

Table 4. Value of gross energy (GE) and digestible energy (DE) of the component feeding stuffs and rations delivered to cows during the experimental period

Feed	GE (Mj/kg)	DE (Mj/kg)	Total ration GE (Mj)	Total ration DE (Mj)	Ration variant
Lucerne hay	16.25	8.26	322.95	212.88	V1
Fodder beet	2.37	1.87	301.16	194.45	V2
Beer Brewery	3.78	2.35	293.70	188.37	V3
Corn soiled	4.78	2.78	302.76	196.03	V4
Maize	16.57	14.20	298.94	192.99	V5
Barley	16.14	13.05	289.20	185.18	V6
Sunflower rot	17.88	12.56			
Soybean rot	17.87	16.05			
Wheat bran	16.57	10.69			
Sunflower oil	36.98	35.39			
Soybean oil	33.47	32.58			

Table 5. CH_4 emission from enteric fermentation

Experimental variant	GE (Mj/zi)	DE (Mj/zi)	DE(%)	Ym	EF	Head number	CH_4 emissions (kg/year)	CO_2 x 10^{-9} Emissions (t/year)
1	322.95	212.88	65.917	5.755	121.91	10	1.219	30,477
2	301.16	194.45	64.567	5.952	117.57	10	1.176	29,392
3	293.7	188.33	64.123	6.014	115.84	12	1.390	34,753
4	302.76	196.03	64.748	5.927	117.69	12	1.412	35,306
5	298.94	192.99	64.558	5.953	116.73	10	1.167	29,182
6	289.20	185.18	64.032	6.026	114.31	12	1.372	34,292
							7.736	**193.403**

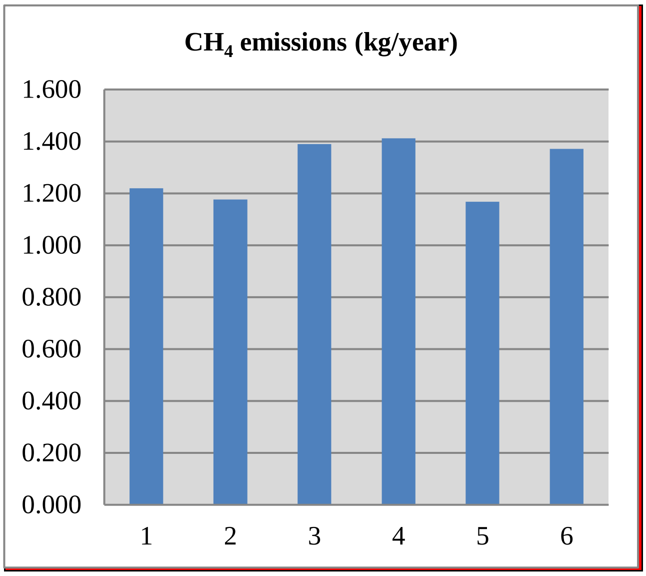

Figure 1. Methane emissions from enteric fermentation in the 6 variants

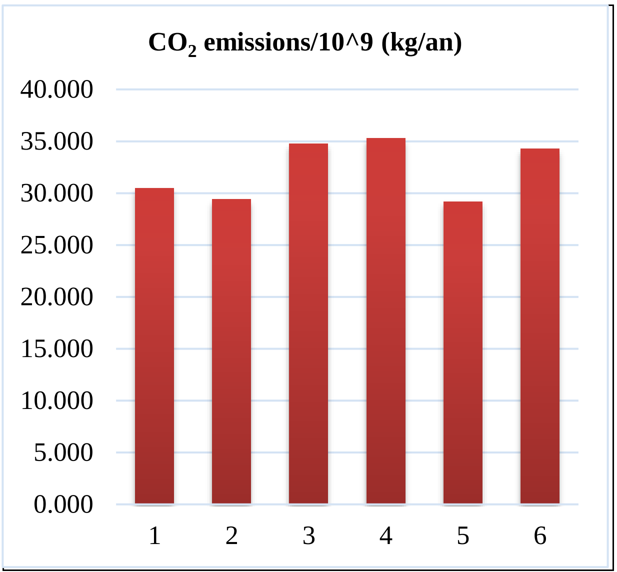

Figure 2. CO_2 equivalent emissions in the 6 variants

Table 6. Dynamics of methane emissions from enteric fermentation in the 2 experimental variants

Experimental variant	CH_4 emissions (kg/year) Experimental Faze 2 (2020)	CH_4 emissions (kg/year) Experimental Faze 3 (2021)	CH_4 emission reduce (%)
1	1.112	1.219	9.62
2	1.294	1.176	-9.12
3	1.453	1.39	-4.34
4	1.538	1.412	-8.19
5	1.229	1.167	-5.04
6	1.536	1.372	-10.68
Total	**8.163**	**7.736**	**-5.23**

From the analysis of the data presented in table 5 it can be seen that the methane emission from enteric fermentation shows the highest values for variants 4 and 3, when 0.2 l/head/day of rapeseed oil were administered in each variant, and in version 4, 0.1 l/head/day of sunflower oil was also administered (methane emissions are 1.41 kg CH_4/year and 1.39 kg CH_4/year, respectively). The lowest emissions are recorded for nutrition variant 5 (in which equal doses, sunflower oil and rapeseed oil were administered: 0.1 l l/head/day). Also, the trend of CO_2 equivalent emissions closely follows the line of CH_4 emissions from enteric fermentation, being directly dependent.

Compared to the methane emissions from enteric fermentation in Experimental Stage 2 (2020), when oils were not used in rations, the methane emissions from enteric fermentation decreased (Table 6). Rations supplementing to dairy cows with vegetable fats reduced daily CH_4 production, which is consistent with research by Odongo et al. (2007), Martin et al. (2010), Grainger and Beauchemin (2011).

CONCLUSIONS

The strategies based on feed solutions are the most effective in the dairy farming sector, the benefit being twofold, respectively limiting the greenhouse effect and improving animal production. Milk production has evolved upwards, respecting the lactation curve, the addition of oils not quantitatively or qualitatively influencing milk production.

The lowest emissions are recorded for nutrition variant in which equal doses, sunflower oil and rapeseed oil were administered (0.1 l l/head/day). Also, the trend of CO_2 equivalent emissions closely follows the line of CH_4 emissions from enteric fermentation, being directly dependent.

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