Methane emissions and milk carbon footprint of dairy cows at grazing or fed with a concentrate diet.

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Abstract

In order to compare methane emissions and carbon footprint of milk produced by dairy cows with different feeding strategies, a trial was carried out on two groups of 11 Holstein cows from May to July 2017. One group was grazing day and night with a target sward availability of 17 kg per cow. The other one received a diet composed of dried pellets mixed with straw, molasses and alfalfa hay. In the barn where all the cows had permanent access, an automatic concentrate supplier provided concentrates to complement the ration of both groups. Methane emissions were assessed by predictions based on the mid infra-red spectra of milk samples and by the Guardian® located in the automatic concentrate supplier. Furthermore, ruminal fluid was sampled monthly on five cows of each group to check the ruminal function (pH, redox potential, presence and mobility of protozoa). The aim of this study was to get an holistic overview of the effect of contrasted feeding practices on methane emissions, environmental impact, zootechnical and economical performances. Grazing decreased feeding costs and feeding environmental impacts while methane emissions per kg milk increased. This highlights the complexity of mitigation actions of GHG in the dairy sector.

Keywords: grazing, methane, dry ration, dairy cows, ruminal function

Introduction

Agriculture is usually considered responsible for 12% of the global production of greenhouse gases (GHG) (Tubiello et al., 2014). Methane from ruminal fermentation contributes for 40% of the total agricultural emissions. Thus, mitigation of methane (CH_4) production could allow reducing livestock impact on climate change and may improve the public perception towards this sector. On the other hand, grasslands are well known as a carbon sink. Although grazing has several benefits e.g. for animal welfare, most Belgian farmers lack confidence in grazing because of the limited control over grass intake. Furthermore, a decrease in milk yield is usually observed with high amounts of grazed grass in cows' diets in comparison with the performance recorded with a controlled barn-fed diet. Lower percentages in fibres of dry rations could decrease CH_4 emissions. The aim of this trial is to assess in an holistic way, the effects of two feeding strategies – grazing (G) and dry diet (DR) – on milk yield, milk composition, CH_4 emissions, ruminal function, milk carbon footprint and feeding costs.

Materials and method

The study was conducted at the CTA in Wallonia from May to July 2017. Twenty-two Holstein cows in early lactation were divided into two groups balanced regarding milk yield (MY), days in milk (DIM) and lactation number (LN). The group DR received a dry ration composed of 12.2 kg DM concentrates, 1.7 kg DM straw, 0.7 kg DM molasses and 36 kg DM alfafa while the group G grazed day and night. Both rations were completed by 3.5 kg of concentrate provided at the automatic concentrate supplier. The crude protein (CP) content in the concentrate was 20%. The DR chemical composition were 880 VEM kgDM^{-1} (Dutch unit for energy), 96 g DVE kg^{-1} DM (Dutch unit for protein available in intestine), 182 g CP kg^{-1} DM and 326 g NDF kg^{-1} DM. At the beginning of the trial, specifications of groups were for DR: 57±41 DIM, 2.4 ± 4.4 LN and 35.7 ± 8.0 kg MY while for G group, DIM were 62 ± 42, LN 2.5±1.8, MY 36.3±7.7 kg. Grass growth was measured in a plot excluded from grazing where grass was mowed on a 10m-length band every week. The mowed grass was weighted and dried to calculate the grass density. Grass intake was calculated by subtracting the grass height when cows left the paddock from the grass height when they entered the paddock and multiplying it by the grass density (240 kg dry matter (DM) cm^{-1} ha^{-1}), by the surface of the paddock. This figure is then divided by the number of cows present on the paddock. Individual milk samples were analysed monthly for milk quality and for methane emissions prediction which were evaluated by milk spectra analysis following Vanlierde *et al.* (2016). Methane emissions during concentrate intake were measured by the Guardian® following the procedure described by Garnsworthy *et al.* (2012), allowing methane emissions to be measured on a daily basis. Ruminal fluid was obtained by oro-pharyngeal sampling and ruminal function was evaluated following the procedure described by Lessire *et al*. (2017). Feeding costs were calculated on current feed price basis. Environmental impact of feeding was estimated by calculating emission factors (kg-eq CO_2) of each feed component using the Feedprint® (Vellinga et al., 2014) then by adding them in *pro rata* of their % in the ration. Data were analysed by SAS 9.3. A proc mixed model was used with repeated measures (repeated days/subject animal) statement and a covariance analysis type cs.

$Y_{ij}= \mu + Gr_i + NL_j + date + date\ X\ Gr_i + e_{ijk}$

where μ = the overall mean with fixed effects being Gr_i = group effect (i = 1 to 2 for group 1 = dry diet to Group2= grazing), date: day of sampling or measurement, NL: effect of lactation number (k=1 to 3- 1= primiparous, 2: 2d lactation and 3= over the second lactation), date XGr_i: interaction group X date; $e_{ijk:}$ residual error.

Results

The weather conditions during the trial period were drier and hotter than the previous years, affecting the grass growth estimated at 27.2 kg DM d^{-1} ha^{-1} and 27.1 kg DM d^{-1} ha^{-1} in June and July, respectively. The grass intake of the G group was estimated at 15.1 kg DM grass per day over the grazing time. The mean grazed grass composition was 21 ± 6% DM, 216 ± 37 g CP kg^{-1} DM, 432 ± 26 g NDF kg DM^{-1}. The digestibility was on average 85 ± 2%, the energy value 1018 ± 31 VEM g kg^{-1} DM, DVE 103 ± 7 g kg^{-1} DM. The daily concentrate intake was 3.3 kg per cow in DR and 3.4 kg in G group.

The DR group had a significantly higher milk yield and lower milk fat content (Table 1).

The CH_4 emission prediction per cow was similar in the two groups. Expressed by kg of milk, this was significantly lower in the DR group compared to the G group: 12.3 ± 0.5 vs 18.1 ± 0.5 respectively ($p < 0.001$). This is coherent with the measurements obtained with the Guardian®.

Regarding ruminal function parameters, ruminal pH and redox potential were lower in DR than in G (5.94± 0.12 vs 6.58 ± 0.12, $p < 0.001$and 17.06 ± 4.35 sec vs 52.8 ± 4.13 sec , $P <$ 0.001). Protozoa evaluation was graded at 2.11 ± 0.32 in DR vs 1.4 ± 0.31 in G (ns).

The daily feeding cost of the G group was lower than that of the DR group (1.98 vs 5.93 € / cow). The cost per kg of milk in G group was cut in half compared to DR group (0.08 vs 0.17 € / kg milk). The environmental impact of feeding was lower in grazing group compared with DR group whatever the used unit. The feed related emissions of the G group were 2.800 kg eqCO_2.d^{-1} while they reached 15.020 kg eqCO_2.d^{-1}in the DR group. Reported per kg milk or kg ECM, they were still lower in the G group (107 g $eqCO_2$. kg^{-1} milk vs 415 g $eqCO_2$. kg^{-1} milk; 116 g $eqCO_2$ kg^{-1} ECM vs 481 g $eqCO_2$ kg^{-1} ECM, respectively).

Table 1. Comparison of milk yield and composition, methane emissions (g cow^{-1} d^{-1}- g kg^{-1} milk) predicted from infrared spectrum between the groups.

	Group 1 (Dry diet)	Group 2 (Grazing)	Statistical significance
Milk yield (kg.cow^{-1}.d^{-1})	36.2 ± 1.2	26.2 ± 1.2	***
ECM (Kg)	31.2 ± 0.9	24.0± 0.9	***
% Fat	3.03 ± 0.10	3.52 ± 0.10	***
% Protein	3.09 ± 0.05	2.98 ± 0.05	ns
Urea (mg.L^{-1})	358 ± 20	376 ± 20	ns
CH4 (g.d^{-1})	434 ± 8	452 ± 8	ns
CH4 (g.Kg $milk^{-1}$)	12.3 ± 0.5	18.1 ± 0.5	***
CH4 ECM (g.Kg ECM^{-1})	14.3 ± 0.9	19.8 ± 0.9	***

Different superscripts show statistically different values. Values are LSMeans ± SE. ECM: energy corrected milk.

Conclusion

Feeding with grazed grass was beneficial in terms of feeding costs and feed related environmental impact while methane emissions per kg milk were higher than those of the DR group. This demonstrates the need to get an overview as complete as possible as some mitigation actions (e.g. grazing) could have contradictory impacts on the different GHG components emitted by the dairy sector.

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References

Garnsworthy P. C., Craigon J., Hernandez-Medrano J. H., Saunders N. (2012) On-farm methane measurements during milking correlate with total methane production by individual dairy cows**.** J. Dairy Sci. 95 :3166–3180

Lessire F., Knapp E., Theron L., Hornick J.L, Dufrasne I., Rollin F. (2017) Evaluation of the ruminal function of Belgian dairy cows suspected of subacute ruminal acidosis. Vlaams diergeneeskundige tijdschrift, 86(1), 16-23

Tubiello F.N., Salvatore M., Cóndor Golec R.D., Ferrara A., Rossi S., Biancalani R., Federici S., Jacobs H., Flammini A. (2014). Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks. 1990-2011 Analysis. In FAO Statistics Division

Vanlierde A, Vanrobays M-L, Gengler, N, Dardenne P., Froidmont E., Soyeurt H, McParland S, Lewis, E, Deighton M, Mathot M, Dehareng F. (2016) Milk mid-infrared spectra enable prediction of lactation-stage-dependent methane emissions of dairy cattle within routine population-scale milk recording schemes. Animal production, 56, 258-264

Vellinga TH.V, Blonk H, Marinussen M, Zeist W.J van, Starman D.A.J. Methodology used in FeedPrint: a tool quantifying greenhouse gas emissions of feed production and utilization (2014) Wageningen UR Livestock Research SN - 1570-8616.UR - http://edepot.wur.nl/254098