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Vedrørende notat om effekten på udledning af metan fra malkekøer, når de tildeles ekstra fedt i foderet – set over hele laktationscyklussen (Effect of fat supplementation on methane production in dairy cows – is the effect persistent throughout lactation?)

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Notatet er udarbejdet af ph.d.-stipendiat Lene Alstrup og seniorforsker Peter Lund, begge Institut for Husdyrvidenskab. Det er udformet på engelsk med en kort dansk konklusion på side 2.

Som Appendix 1 er til orientering vedlagt et manuskript til videnskabelig artikel. Manuskriptet er indsendt til tidsskrift, men endnu ikke accepteret og udgivet – derfor bedes det behandlet som fortroligt.

Med venlig hilsen

Susanne Elmholt
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Effect of fat supplementation on methane production in dairy cows – is the effect persistent throughout lactation?

"Notat om effekten på udledning af metan fra malkekøer, når de tildeles ekstra fedt i foderet – set over hele laktationscyklussen"

Institut for Husdyrvidenskab, AU Foulum

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KONKLUSION

Det er blevet påvist i flere forsøg at tilsætning af fedt i foderet til malkekøer sænker deres udledning af metan. Der er dog mangel på studier omkring langtidseffekten af denne fedttilsætning. Det man kan finde i litteraturen indikerer at effekten af fedt er persistent over tid. Der har kørt et forsøg på Institut for Husdyrvidenskab, AU Foulum i 2011/2012, hvor det er blevet testet om effekten af fedt på metan-emissionen er vedvarende henover laktationen. Forsøget viste at produktionen af metan stiger henover laktationen, men at man ved tilsætning af fedt kan mindske denne stigning. Denne effekt på metan ved tilsætning af fedt til rationen var persistent henover laktationen. Derudover fik tilsætning af fedt mælkeydelsen til at stige.

GENERAL INTRODUCTION

During the recent years there has been an increase in the concern of environmental and climatic impact of livestock production; mainly from ruminants, as e.g. methane production contributes to the accumulation of greenhouse gases in the atmosphere. Livestock, and especially ruminants, are the most notable sources of methane (CH_4), accounting for up to one third of the emission of CH_4 worldwide (Smith et al., 2007). In 2008, enteric CH_4 from lactating dairy cows accounted for 27 % of all emitted CH_4 in Denmark (Nielsen et al., 2010).

The enteric CH_4 that is produced in ruminants has mainly its origin in the rumen. When feed components are digested by the microbiota (bacteria, protozoa, fungi), volatile fatty acids (VFA) (mainly acetate, propionate and butyrate) and gases (CO_2 and CH_4) are produced. VFA is used by the animal as a source of energy and the gases are eliminated by eructation. During fermentation hydrogen is released in the rumen, and is being used by methanogens to reduce CO_2 into CH_4. This is necessary to have an optimal performance of the rumen since hydrogen accumulation is avoided. Production of acetate and butyrate results in a net release of hydrogen and favors production of CH_4, whereas formation of propionate is a competitive pathway for hydrogen use in the rumen (Martin et al., 2010). The CH_4 produced represents an energy loss to the animal that could have been used for milk production, and will vary with feed composition and intake. Under extreme circumstances 2–12% of gross energy intake is converted into CH_4, but in an intensive dairy production values between 3–7% are more realistic (Martin et al., 2008).

There are three general categories of practices for reducing CH_4 emissions: improved feeding practices, use of specific agents or dietary additives; and longer-term management changes and animal breeding (Smith et al., 2007).

FAT SUPPLEMENTATION

Short term effects

It has been shown that supplementation of fatty acids (FA) to the feed decreases CH_4 emission on a short term (Brask et al., 2013). Supplementation with fat to the diet is the most promising dietary strategy to reduce enteric CH_4 emission (Grainger and Beauchemin, 2011). As fat is not degraded in the rumen, the amount of organic matter being fermented is lowered, and thereby the amount of hydrogen produced is reduced; resulting in decreased CH_4 emission. Further, supplementation with fat reduces the activity of ruminal methanogens and protozoal numbers (Johnson and Johnson, 1995). In a review of Grainger and Beauchemin (2011) it is stated that with a 10 g/kg increase in dietary fat it is possible to reduce CH_4 yield with 1 g/kg DMI. However, there has not been paid much attention to the long term effects of feeding strategies for reduction of greenhouse gas emission. Some studies suggest that the positive effect on CH_4 emission of supplementation with a feed additive may not be maintained over time, since the ruminal microflora seems to be able to adapt (Johnson and Johnson, 1995). This may also be the case for fat supplementation, where the turnover rate in the rumen may adapt to the FA and thereby emission will return to the original level over time.

Long term effects

There is a lack of studies on the long term effect of fat supplementation on methane emission. Most studies are short intensive studies, though a few have measured over 7–12 weeks.

In a study from New Zealand (Woodward et al., 2006), effect of supplementation with oil (200 g linseed oil and 100 g fish oil) on methane emission were compared to no oil supplementation. 20 cows on pasture received either no oil or 300 g oil for 11 weeks, and methane emissions were measured using the sulfur hexafluoride (SF_6) tracer gas technique in week 12. No effect of oil was seen after 12 weeks, on either methane production or DM intake. Woodward et al. (2006) suggest that the microflora adapt to oil during the 11 weeks before measuring methane emission. They did not measure methane emission right after treatment with oil started, so there is no knowledge about an initial reduction that diminished over time, or whether there was no reduction at any time. However, if there is no persistent improvement in methane reduction, then the application on-farm is useless. In an experiment from Australia, Moate et al. (2011) fed 3 different kinds of fat additives (brewers grains, hominy meal or cold-pressed canola and hominy meal), that all reduced methane emission. By combining data from all groups, they indicated that the inhibitory effect of supplementary fat on enteric CH_4 emissions persisted for at least 7 weeks. Grainger et al. (2010) (also from Australia) state that they have found a persistent reduction of CH_4 emission by supplementation with whole cottonseed (WCS), after running the experiment for 12 weeks. They looked at the effect of supplementation of WCS, resulting in control: 1.97% fat and WCS: 5.26% fat. The experiment included 50 cows (177 DIM), and they used the SF_6 tracer gas technique (12 per diet) to measure methane emission. They also included samples of rumen fluid to compare the rumen methanogens. Feeding with WCS resulted in an increased reduction in CH_4 (g/d) from 13% to 23% from week 3 to 12. The reduction in CH_4 g/kg DMI also increased from 5.1% to 14.5%. No effect of WCS on rumen methanogens was found. Also Holter et al. (1992) showed that the increase in CH_4 decreased with time, due to supplementation with WCS. They compared 3 groups of feed: control, and whole cottonseed with or without calcium soap. Methane was measured using standard large animal calorimetric in week 7 and week 16 after calving.

Monensin, which is a carboxylic polyether ionophore antibiotic that is widely used in ruminant feeds to manipulate ruminal fermentation and thereby improve feed efficiency (Odongo et al., 2007), though not allowed for this purpose in Denmark. It has been shown that long term administration of monensin to dairy cattle reduces methane by 7% and this reduction persisted for 6 months with no undesirable effect on milk yield (Odongo et al., 2007). The effect of ionophores on production of CH_4 has been linked to protozoal populations, which adapted to ionophores over time. It should be mentioned that propionate enhancement persisted throughout the 14 week experiment (Guan et al., 2006). Grainger et al. (2009) drenched lactating dairy cows with condensed tannins and methane emission was measured in week 2 and week 5 with SF_6 tracer. Reduction in methane emission due to supplementation of condensed tannins was similar in week 2 and 5; indicating that the effect did not diminish over time.

EFFECT OF STAGE OF LACTATION

As the material of studies examining the long term effect of fat supplementation on methane emission is scarce, also the material examining the effect of stage of lactation is limited.

Münger and Kreuzer (2006) found no effect of lactation stage on CH_4 production in g/day, but CH_4 in g/kg energy corrected milk (ECM) increased with stage of lactation due to decreased milk yield with increased days in milk (DIM). Johnson et al. (2002) fed oilseeds to cows during the whole lactation. 36 cows were fed 2.3, 4.0, or 5.6% fat; fat being evenly contributed from whole cottonseeds and ground canola oilseeds. Every 3rd month methane emission was measured with a room tracer approach. They did not show any effect of supplementation with oilseeds on methane emission. Though, there was a tendency towards increased efficiency of milk produced per unit of methane emitted. Cammell et al. (2000) studied energy and nitrogen balances in open-circuit respiration chambers over 6 days during lactation weeks 6, 12, 18, and 24. Energy lost as methane was relatively constant throughout lactation, whereas methane loss as percentage of digestible energy increased from week 6 to week 24 after calving. Though, this may be explained by a concurrently decreased feed intake.

Danfær (2005) made simulations in the simulation model Karoline, which is a dynamic, mechanistic whole animal model of lactating cows. Simulations were done to evaluate the ability of the model to give realistic predictions of the methane production in dairy cows depending on stage of lactation, feeding level and feed composition. Simulations showed that stage of lactation had no effect on the total methane formation, but production of methane per kg milk increased during lactation as well as production as percentage of net energy. This is due to decreased milk yield.

Extended lactation

Apart from feeding strategies there are also other initiatives to decrease methane emission. At Foulum AU there is a project focusing on extended lactation in dairy production in favor of climate, animal welfare and productivity (Reprolac). The hypothesis is that an extension of lactation from the normal 350 days up to 500 days will increase sustainability of milk production in terms of reduced emission of green house gasses and nitrogen per kg milk produced and increases the overall efficiency. The reduced emission of green house gases should be due to e.g. reduced proportion of nonproductive animals and lower amount of feed used per kg milk produced.

OWN EXPERIMENT

Draft of manuscript to be submitted to Journal of Dairy Science is attached as Appendix I.

Summary

In the period August 2011 to February 2012 an experiment was carried out at Department of Animal Science, AU Foulum. The aim of this experiment was to study if an effect of fat supplementation on methane emission would persist throughout lactation. Moreover the effect of supplementing a methionine analogue in the form of MetaSmart in order to compensate for a potential reduction in microbial protein synthesis due to reduced organic matter fermentation was

studied. Twelve lactating Danish Holstein cows were used in a randomized block design experiment with four rations: control (CON), control supplemented with whole cracked rapeseed (WCR), control supplemented with rumen protected fat (FAT), and FAT supplemented with methionine analogue (FATA). All mixed rations consisted of approximately 22.5% corn silage, 22.5% grass clover silage, 12% beet pulp and 43% concentrate on dry matter (DM) basis. The dietary fat concentration was 27 g/kg DM in CON and approximately 56 g/kg DM in rations supplemented with fat. All cows were offered 3 kg per day of a standard concentrate during milking in addition to the mixed ration. In four different parts of lactation production of CH_4 was measured for four days in open-circuit respiration chambers, and feed intake and milk yield was recorded in the chamber period. Production of methane was measured 4 times during lactation: at 50, 125, 170, and 220 days in milk (DIM). DIM did not affect intake of DM (DMI). Fat supplementation affected DMI numerically, with lowest intake for WCR and highest intake for CON. Increased DIM decreased milk yield, both measured as kg milk and kg energy corrected milk (ECM). Treatment only tended to affect ECM yield, and contrast effect showed that fat supplementation tended to increase milk yield compared to CON. Methane emission increased with DIM, both when measured in l/d, l/kg DM and l/ECM. However, when cows were fed rations high in fat the increase in methane production was less pronounced.

GENERAL CONCLUSION

There is a lack in literature concerning the effect of fat over time/throughout lactation. In general, some anti-methanogens have only transitory effects and others persist (Moate et al., 2011). Overall, it seems like supplementation with fat (in any kind) to the ration of cattle reduces emission of CH_4. Although it is not consistent with results of all studies, it seems like the effect persists over time/during lactation.

Our results showed that methane emission in liters increased with DIM, and also increased with DIM when related to DMI and ECM. However, when cows were fed rations high in fat the increase in methane production was less pronounced. The study thereby demonstrates that methane production increases with days in milk, especially when related to liters/kg ECM. However, adding fat to the ration appears to reduce this increase in methane production and thereby the effect seems to persist during the lactation. Further, supplementation with fat seems to increase milk yield, whereas DMI only tended to be affected.

PERSPECTIVES/FUTURE STUDIES

It is challenging to find the right method to decrease methane production. Most dairy farmers are interested in reducing methane emission, but not at the expence of milk production and economy in general. Supplementaion with fat is one of the most promising methods to decrease methane emission and as a side-effect it is also expected to increase milk yield. Therfore we have focused on supplementaion with fat in our study.

The knowledge about the possible persistency in reduction of methane by supplementaion of fat is little. From the results of our experiment it seems like the effect of fat on methane emission is sustained during the whole lactation. To get some more information on this subject, additional studies are needed. Based on the core of the present study, future studies should have some modifications. First of all, only a few cows were used in the present experiment and more data is needed. Secondly it could be interesting to see for how long time the effect of fat on methane emission will sustain after supplementation has stopped, looking at the possibility of feeding the cow a single dose e.g. every second month and to see if the length of period supplementing with fat will affect the possible persistency. Thirdly, it could be relevant to pay attention to a possible carry-over effect from one lactation to another.

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