The effect of nutritional strategy on methane emissions, milk yield and fatty acid profiles in Holstein Friesian dairy cows
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Application Predicting methane emissions from dairy cows using a laser methane detector and fatty acid profiles.

Introduction Methane (CH₄) emissions are a product of the enteric fermentation of ruminants. Individual dairy cows vary in the quantity of CH₄ they produce with estimates ranging from 278 to 456g CH₄/d (Garnsworthy et al., 2012) and this can be linked to feed intake and diet digestibility. Quantifying CH₄ production from individual animals can be time consuming and costly using methods such as respiration chambers or SF₆. CH₄ emissions have been associated with milk composition (Dehareng et al., 2012) and enteric emissions are linked to milk mid-infrared spectrometry based on the synthesis of CH₄ having a relationship to butterfat, and lactose production (Vlaeminck and Fievez, 2005). Non-intrusive estimates of enteric CH₄ can be obtained using a laser methane detector (LMD) and results can be approximated with closed chamber measurements. The aim of this study was to compare the effect of two diets (50% and 100% grazed grass) on CH₄ emissions from dairy cows and to test associations between LMD measurements and fatty acid profiles.

Material and methods Dairy cows in early to mid lactation were randomly allocated to one of two dietary treatments (14 cows per group) as part of a 12 week continuous design feeding experiment. Groups were balanced for live-weight, parity, and lactation stage, with cows milked 3 times per day. Dietary treatments consisted of 100% grazing with no housing, and 50% grazing with housing for one period of approximately 8 hours between evening and morning milking. While housed, cows were fed an ad lib total mixed ration (TMR) consisting of silage, alkaliage, beans, rape meal and whey permeate with both groups of cows being fed 900g of parlour concentrate per day. Milk yield (MY) was recorded at every milking and samples were taken once per week at each of the three milkings and then combined for fatty acid profile analysis using a MilkoScan minor spectrophotometer. CH₄ emissions were estimated using a LMD taking two CH₄ readings per second, for approximately 4 minutes for each animal after midday milking three days per week using the procedure described by Chagunda et al. (2013). CH₄ readings per animal, grouped by week of experiment and reading day, were log transformed to attain normality of the data, with zero readings excluded. Thrice weekly CH₄ estimates were averaged per cow, and mixed models were used to test whether CH₄ emissions and milk production differed between treatment groups. Linear mixed effects models were fitted in R using lmer and Anova packages at a 5% significance level. Weekly means for milk concentrations of fat, protein, urea, lactose, total unsaturated FA, polyunsaturated FA, stearic acid (C18:0), short chain FA, medium chain FA and long chain FA were tested for normality, and correlated with mean weekly methane measurements per cow.

Results Average daily MY of 28.1kg, and 30.8kg was recorded for 100% and 50% grazed groups respectively over the 12 week experiment. CH₄ measurements averaged 55.0 and 46.5 ppm per sample for the 100% and 50% grazed groups respectively. Mean methane emissions were significantly higher [$\chi^2$ (1) =3.416, p<0.05] in the 100% grazed treatment group by approximately 7.97 ppm per sample +/- 1.03 standard errors. Daily MY did not significantly differ between treatment groups across the whole experiment, however a significant difference was found from week 8 onwards; there was a weak (but ns) relationship with CH₄ estimates.

Conclusion Replacing a proportion of grazed grass in the diet with a TMR significantly lowered CH₄ emissions. Fatty acid profiles showed weak correlations with transformed methane measurements, nevertheless, there were differences in milk fatty acids between feed groups and further analysis will be carried out.

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References


The effect of concentrate supplementation strategy on dry matter intake, substitution rate and nitrogen excretion in late lactation spring calving grazing dairy cows

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Application
Offering concentrate supplementation to dairy cows in late lactation is important to improve cow performance and reduce nitrogen excretion when grass quality and quantity are poorer in the autumn.

Introduction
The Irish dairy industry produces high quality dairy products from sustainable grass based systems of production (O’Brien et al., 1996). In the autumn when cows are in late lactation grass quantity and quality are poorer (Burke et al., 2008) and subsequently milk quality is poorer (O’Brien et al., 1996). Grass is limiting in energy and concentrate supplementation can be offered to increase energy intake, improve milk quality (Kolver et al., 1998), increase dry matter intake (DMI) and improve cow performance (Stockdale, 2000). However, important parameters such as DMI and substitution rate [SR; ‘the decrease in pasture intake per kilogram of supplemented feed’ (Kellaway and Porta, 1993)] must be considered as grass is the cheapest feed source for dairy cows and should be maximised in their diet (Finneran et al., 2010). Furthermore, concentrate supplementation may also reduce nitrogen (N) excretion through reducing overall N intake and possibly altering N excretion from urine to faeces (Van Vuuren et al., 1987). The Hypothesis of this experiment was that offering supplementation and altering carbohydrate type would improve cow performance and reduce N excretion. Therefore, the objective of this research was to investigate the effect of concentrate supplementation strategy on DMI, SR and N excretion in late lactation dairy cows.

Material and methods
Thirty six Holsten Friesian dairy cows were blocked on days in milk (+185DIM) and balanced for parity, pre-experimental milk yield and milk composition, predicted 305day milk yield and BCS. Cows were randomly assigned to one of three dietary treatments in a randomised complete block design (n=12). The dietary treatments (T) were: grass only (T1); grass + 2.6kg DM barley based concentrate (T2); grass + 2.6kg DM maize based concentrate (T3). The diets were fed for a 14day acclimatization period and then for a further 63days. Pasture DMI was determined during week five of the study (mid-September - average 220DIM or 31 weeks into lactation) by extracting n-Alkanes from pasture, concentrate and faeces samples according to the method of Dove and Mayes (2006). Data was checked for normality and analysed using repeated measures in PROC MIXED of SAS where treatment, covariate, parity and their interactions were included as fixed effects.

Results
Cows offered T1 had a lower milk yield (14.54kg) than T2 (17.15kg, P<0.001) and T3 (16.73kg, P<0.001). Similarly, T1 had lower fat and protein kgs (1.47kgs) than T2 (1.51kgs; P<0.001). Cows offered T2 (1.51kgs) had higher fat and protein kgs than T3 (1.48kgs, P<0.001). Cows offered T1 had a higher pasture DMI (17.29kg DM/d) than T2 (13.68kg DM/d, P<0.001) and T3 (13.34kg DM/d, P<0.001). Substitution rates were 1.36kg and 1.49kg for T2 and T3 respectively. The N intakes of cows offered pasture only (0.821kg/day) was significantly higher than both supplemented treatments (T2:0.735kg/day, P=0.008; T3:0.737kg/day, P<0.01). Supplemented cows had significantly higher N in milk (T2: 15.7%, P<0.001; T3: 15.5%, P<0.001) than cows offered pasture only (11.9%). Cows offered concentrate supplementation had significantly lower N in urine (T2: 36.6%, P<0.001; T3: 57.3%, P<0.003) than cows offered pasture only (62.3%). Cows offered T2 proportioned significantly more N to faeces (27.7%) in comparison to cows offered grass only (25.9%, P=0.04).

Conclusion
In conclusion, concentrate supplementation in late lactation increased milk yield and kgs of milk solids but reduced pasture intake. Supplemented cows also excreted less N in the urine and more in milk than unsupplemented cows. Of the two supplementation types, cows offered the barley based supplement had higher milk solids and excreted N in urine.

Acknowledgements
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References
Kellaway and Porta. 1993. Dairy Research and Development Corporation Australia
The effect of calcareous marine algae, with or without marine magnesium oxide, and sodium bicarbonate on milk production in mid-lactation dairy cows

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Application The inclusion of rumen buffers, in a TMR fed to Holstein dairy cows, improved milk components. Calcareous marine algae increased milk fat and protein yield, offering dairy producers a solution to improve milk production.

Introduction High producing dairy cows consuming highly fermentable diets often experience low rumen pH (Plaizier et al., 2008), initiated by the accumulation of volatile fatty acids in rumen fluid (Whelan et al., 2013). Rumen buffers are commonly added to lactating cow diets to avoid prolonged episodes of low rumen pH and the associated production losses. The addition of sodium bicarbonate (SB) to the diets of high producing dairy cows, as a rumen buffer, has become a regular practice in many parts of the world (Rauch et al., 2012). In recent years' calcareous marine algae (Lithothamnion calcareum) has been used to stabilise rumen pH and improve fermentation (Cruywagen et al., 2015). The objective of this experiment was to evaluate different dietary buffers on the milk production, milk composition, dry matter intake and feed efficiency of mid-lactation dairy cows.

Material and methods The supplements included were: calcareous marine algae (Lithothamnion calcareum), with or without marine magnesium oxide (precipitated magnesia derived from seawater), and SB. Fifty-two multiparous and four primiparous cows (62.7 ± 3.4 DIM) were assigned to four experimental treatments based on calving BCS (3.1 ± 0.03; scale 1 to 5), pre-experimental milk yield (34.7 ± 0.79 kg/d) and previous 305-day yield (7073 ± 198 kg). Cows were housed in a free stall barn and had ad-libitum access to total mixed ration (TMR) and water. The diets were based on a forage: concentrate ratio of 46:54. Dietary treatments consisted of the control (283 g starch and sugar, and 230 g neutral detergent fibre (NDF) from forage per kg dry matter (DM)) including no dietary buffer (CON); the CON plus 3.5 g/kg DM calcareous marine algae (CMA); the CON plus 3.5 g/kg DM calcareous marine algae and 0.9 g/kg DM marine magnesium oxide (CMA+MM); the CON plus 7 g/kg DM SB. The experiment lasted for 80 days (d), which included 7 d acclimatisation to the diet and 73 d of data collection. Milk production data were analysed using the MIXED procedure (SAS, version 9.4). The model included fixed effects of treatment, week and parity as well as treatment by week interaction with cow considered as the random effect. Week was considered as a repeated measure. Pre-experimental milk yield and calving BCS were considered as covariates.

Results The DMI of cows consuming SB tended to be higher than cows on the CON diet (+ 1.9 kg, P<0.10). CMA increased the production of milk solids (fat and protein kg/d) compared to CON (+ 0.16 kg, P<0.01), CMA+MM (+ 0.09 kg, P<0.05) and SB (+ 0.10 kg, P<0.05). Both CMA (+ 0.09 kg, P<0.01) and CMA+MM (+ 0.06 kg, P<0.01) increased milk fat yield compared to CON but were not different to each other and SB. Cows supplemented with CMA (+ 0.19 %, P<0.01), CMA+MM (+ 0.25 %, P<0.01) and SB (+ 0.19 %, P<0.01) increased milk fat concentration compared to CON but were not different from each other. The CMA treatment increased milk protein yield compared to CON (+ 0.04 kg, P<0.01), CMA+MM (+ 0.06 kg, P<0.01) and SB (+ 0.04 kg, P<0.01). The SB treatment reduced the efficiency of milk production, energy-corrected milk (ECM) per kg of DMI, compared to CON (- 0.11 kg, P<0.01), CMA (- 0.12 kg, P<0.01) and CMA+MM (- 0.13 kg, P<0.01).

Conclusion Results indicate that the addition of rumen buffering products can increase milk fat concentration when included in lactating dairy cow diets. The use of CMA when compared to sodium bicarbonate, in such diets, can increase milk production efficiency and combined fat and protein yield (kg/d). This offers dairy producers, with milk pricing based on milk solids, the opportunity to increase the value of their milk.

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Rumen “inertness” of a novel whey protein gel of fish oil feed supplement for dairy cows
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Application Lipid composite gels may be an effective way of preventing rumen exposure to unsaturated oils, and so could be used to improve milk fatty acid profile, and also enhance transfer of beneficial fatty acids to the cow.

Introduction There is renewed interest in dairy cow supplements containing very long chain n-3 polyunsaturated fatty acids (PUFA), such as those rich in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), to improve cow health and fertility. Feeding such oil sources can have a negative impact on rumen digestion and subsequent milk quality and production. In addition, highly unsaturated oils undergo extensive biohydrogenation in the rumen. Therefore, rumen inertness is key to optimising absorption of the beneficial fatty acids (FA) by the cow, and preventing adverse effects. Rumen inertness technologies vary widely in their effectiveness (especially for oils high in PUFA), with most resulting in inconsistent effects in vivo, but lipid composite gels may offer a practical solution (Gadeyne et al., 2016) The main objectives of this study were (i) to successfully make a whey protein gel of fish oil (WPG-FO), and (ii) to test the rumen inertness when fed to lactating dairy cows.

Material and methods The WPG-FO was manufactured using the method of Carroll et al., (2006) and Kliem et al. (2017). Briefly, whey protein isolate (UltraWhey 90; Volac International Ltd., Royston, UK) was hydrated then mixed with salmon oil (Inovitec, Tarporley, UK; EPA and DHA content of 6 and 7 g/100 g total fatty acids, respectively), before being homogenised, transferred to food cans and then heated to 120°C for 138 min. Four late-lactation cows (mean 286 d in milk ± 11.8 s.e.m.) were randomly allocated to one of two treatment groups, where a standard lactating cow diet was hand-mixed with either WPG-FO or unprotected fish oil (FO). The trial ran for 5 days and each supplement was included incrementally over days 1 and 2, so that from day 3-5 each cow was consuming 200 g fish oil equivalent per day. Cows on the FO diet were also fed whey protein isolate. Cows were fed and milked twice daily. Milk samples were taken at each milking on days 0 and 5, and analysed for milk FA profile and composition. Milk fat trans-11 18:1 and 18:0 concentrations were used as indicators of rumen protection, as EPA and DHA inhibit the final step of biohydrogenation (trans-11 18:1 to 18:0). Results were analysed using the Mixed procedure in SAS with a model which included effects of treatment and day.

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References
Supplementation of dairy cow diets with docosahexaenoic acid enriched microalgae and its effect on milk fatty acid profile over time

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Application Microalgae can be fed to cows to improve the healthiness of milk by increasing the milk content of docosahexaenoic acid (DHA), but rumen adaptation may occur with extended feeding time.

Introduction The benefits of long chain fatty acids (FA) on human health have long been recognised, particularly the very long chain n-3 polyunsaturated fatty acids (LC n-3 PUFA) such as DHA - C22:6n-3, (Marventano et al., 2015). The primary producer of LC n-3 PUFA at the bottom of the food chain is algae (ALG). The addition of dried ALG to the diet of dairy cows has previously been shown to increase the content of LC n-3 PUFA in milk (Till et al., 2016). However, ruminal adaption to high levels of dietary PUFA can occur, altering the formation of specific biohydrogenation intermediates and potentially decreasing the amount of DHA available for secretion in milk (Shingfield et al., 2006), although little information is available for ALG. The objective of the study was to determine the effect of feeding DHA enriched ALG over time on the milk FA profile of Holstein-Friesian dairy cows.

Material and methods Sixty Holstein-Friesian dairy cows were randomly allocated to one of two diets at 3 weeks post calving based on parity, calving date, milk yield at 14-21 days in milk, and live weight measured 1 week prior to the start of the study (week 0). The basal ration contained maize and grass silages and straight feeds, and was supplemented with one of two levels of ALG (Schizochytrium limacinum; Alltech UK Ltd,) to provide two treatments; 0 (Control) or 100 g algae/cow/d (Algae). The ALG contained 13.5 g/kg DM crude protein, 58 g/kg oil, 0.28 g/100 g FA as C20:5 n-3 and 25.7 g/100g FA as C22:6n-3. The diets were fed for a total of 14 weeks. Cows were milked twice daily and samples taken at consecutive am and pm milkings at wks 0, 1, 2, 4, 8 and 14 for subsequent analysis of fatty acids, with milk fat content measured weekly. Individual intake was recorded daily. Data were analysed as repeated measurements analysis of variance using Genstat (version 16.1), using data recorded in week 0 as a covariate where appropriate.

Results Supplementation with ALG had no effect (P> 0.05; Table 1) on DMI or milk yield, which averaged 22.1 and 40.4 kg/d respectively, but there was an effect of time (P< 0.001), with both peaking at week 4 and 5 then declining. Similarly, milk fat content and yield were not affected by diet (P> 0.05), but there was an effect of time (P<0.05). Feeding ALG decreased (P<0.05) milk fat content of C18:0 and increased milk fat content of C18:1 trans-11, C18:2 cis-9 trans-11 conjugated linoleic acid (CLA). Milk fat content of DHA increased (P< 0.001; Figure 1) from week 2 onwards, peaking at week 14 with an increase of 0.35 g/100 g in ALG fed cows compared to those fed control diet at wk 14.

Table 1 Intake, milk yield, milk fat content and selected fatty acids in cows fed algae or control

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Algae</th>
<th>Control</th>
<th>s.e.d</th>
<th>P value1</th>
<th>D</th>
<th>T</th>
<th>D x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake, kg/d</td>
<td>22.0</td>
<td>22.1</td>
<td>0.861</td>
<td>0.905</td>
<td>&lt;0.001</td>
<td>0.791</td>
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<td>Milk yield, kg/d</td>
<td>40.4</td>
<td>40.4</td>
<td>1.023</td>
<td>0.980</td>
<td>&lt;0.001</td>
<td>0.729</td>
<td></td>
</tr>
<tr>
<td>Milk fat, g/kg</td>
<td>36.9</td>
<td>37.5</td>
<td>2.09</td>
<td>0.720</td>
<td>0.048</td>
<td>0.912</td>
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</tr>
<tr>
<td>Milk fat yield, kg/d</td>
<td>1.46</td>
<td>1.52</td>
<td>0.2</td>
<td>0.401</td>
<td>0.013</td>
<td>0.738</td>
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</tr>
<tr>
<td>Milk fatty acids, g/100g</td>
<td>30.3</td>
<td>31.1</td>
<td>0.828</td>
<td>0.507</td>
<td>0.124</td>
<td>0.250</td>
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</tr>
<tr>
<td>C18:0</td>
<td>7.89</td>
<td>8.41</td>
<td>0.439</td>
<td>0.019</td>
<td>0.039</td>
<td>0.345</td>
<td></td>
</tr>
<tr>
<td>C18:1 trans 11</td>
<td>1.21</td>
<td>0.831</td>
<td>0.163</td>
<td>0.002</td>
<td>0.109</td>
<td>0.356</td>
<td></td>
</tr>
<tr>
<td>C18:2 cis-9 trans-11 CLA</td>
<td>0.796</td>
<td>0.532</td>
<td>0.069</td>
<td>0.038</td>
<td>0.003</td>
<td>0.052</td>
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</tr>
<tr>
<td>C20:5n-3 (EPA)</td>
<td>0.129</td>
<td>0.077</td>
<td>0.019</td>
<td>0.376</td>
<td>&lt;0.001</td>
<td>0.242</td>
<td></td>
</tr>
</tbody>
</table>

1Probability of significant effects attributable to the diet (D), time (T), and their interaction (D x T)

Conclusion Algae can be added to the diet of dairy cows from 3 weeks post calving at a rate of 100 g/cow/d to improve milk content of DHA, with no negative impact on cow performance or rumen adaptation over time.

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References