Effect of $N,N$-dimethylglycine supplementation in parturition feed for sows on metabolism, nutrient digestibility and reproductive performance

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The current pilot study assessed the influence of $N,N$-dimethylglycine (DMG) on insulin sensitivity, glucose and fat metabolism, nutrient digestibility and reproductive performance of sows in the peripartal period. At day 105 of gestation, 25 sows were randomly assigned to the control ($n = 13$) or the DMG group ($n = 12$). Sows from the DMG group were supplemented with 1 g DMG/kg feed until day 3 of lactation. After an overnight fast 1 day after farrowing, a blood sample of each sow was drawn. The plasma was analyzed for insulin, glucose, fructosamine, leptin, thiobarbituric acid reactive substances (TBARS), ferric reducing ability of plasma (FRAP), non-esterified fatty acids (NEFA) and triglycerides (TG) and an oral glucose tolerance test was performed. A rectal feces sample was collected and the apparent fecal digestibility (AFD) of crude fat (CFAT), crude protein (CP) and nitrogen-free extract (NFE) was calculated after proximate analyses. Finally, a colostrum sample was collected from each sow and analyzed for the presence of DMG. Reproductive performance parameters were recorded. The results showed an improvement in the AFD of CFAT, CP and NFE when DMG was supplemented. This beneficial effect confirms the hypothesis that DMG acts as an emulsifying agent. The improvement in digestibility in the DMG group was accompanied by a numerical increase in plasma TG ($P = 0.067$). Plasma NEFA concentrations were not different between treatment groups. DMG supplementation neither affected glucose clearance nor influenced plasma insulin, glucose, fructosamine or leptin levels. TBARS and FRAP also remained unaffected, despite previously reported anti-oxidative properties of DMG. Furthermore, no significant impact on reproductive performance could be recorded. In conclusion, DMG supplementation significantly improved nutrient digestibility. Possible beneficial effects on energy metabolism and reproductive performance of sows should be tested when DMG is supplemented for a longer period of time or at a higher dose.

**Keywords:** sow, $N,N$-dimethylglycine, nutrient digestibility, glucose metabolism, reproduction

**Implications**

The supplementation of $N,N$-dimethylglycine (DMG) in parturition feed of sows has an emulsifying effect. This resulted in improvements in not only fat digestibility, but also the digestibility of the protein and the nitrogen-free dietary fraction. However, measures of reproductive performance were not affected by DMG supplementation. The addition of this supplement to gestation and lactation feed should be investigated. Supplementation of DMG over a longer period of time can possibly be beneficial in terms of sow body condition and reproductive performance of sows.

**Introduction**

The peripartal period is a critical period in commercial sow herds. During the last third of gestation, the sow’s metabolic and hormonal state dramatically changes (Weldon et al., 1994a; Pere et al., 2000). Sows can become catabolic during the last month of gestation (Close et al., 1985), which was evidenced by increased concentrations of non-esterified fatty acids (NEFA) and glycerol in plasma (Revell et al., 1998). This is due to increased fetal demand and can lead to reduced appetite (Weldon et al., 1994a) and, in very rare cases, even to porcine ketosis (Alsop et al., 1994). After day 85 of gestation, insulin sensitivity decreases (Pere et al., 2000). Poor glucose tolerance during late gestation has also been reported (Weldon et al., 1994b) and related to an increased...
Several studies indicate that both feed composition and the amount of feed offered during late gestation are of major importance in preventing reproductive problems in the peripartal period and the first few days of lactation. Overfeeding sows during late gestation and high back fat thickness at parturition predispose to several problems in the first few days post partum: low voluntary feed intake (Revell et al., 1998), higher catabolic rate (Hulten et al., 1993), increased NEFA mobilization and decreased insulin secretion (Weldon et al., 1994a). In this regard, it is important to consider not only the amount of energy but also the source from which the energy is derived. For instance, van der Peet-Schwering et al. (2004) reported a decreased glucose tolerance and an increased number of stillborn piglets when sows were fed extra energy from fat during late gestation. But none of these problems were recorded when energy was supplied as starch, indicating the importance of feed components (van der Peet-Schwering et al., 2004).

General feed composition not only influences the reproductive performance of sows, but also feed additives can have an influence on production results. Choline is one of those supplements. It has been commonly used for many decades as an additive in sow feed and its beneficial effect on sow and piglet performance has been reported in several studies (Kornegay and Meacham, 1973). More recently, a study on supplementation of betaine, a metabolite of choline, reported significantly improved total tract digestibility of crude fat (CFAT), crude ash (CA) and fiber (CF) in weaned piglets without affecting digestibility of crude protein (CP) and nitrogen-free extract (NFE) (Eklund et al., 2006). A less known substance is $N,N$-dimethylglycine (DMG), which – similar to choline and betaine – is related to glycine metabolism (Figure 1). DMG can act as a methyl donor (Friesen et al., 2007) similar to betaine and, additionally, has anti-oxidative properties (Hariganesh and Prathiba, 2000). As methyl donation capacity (Jin et al., 2007) and anti-oxidative action (Lai, 2008) are both associated with increased insulin sensitivity, DMG can possibly influence insulin sensitivity. Other studies report that DMG, used as a dietary supplement, reduces blood lactate level and improves athletic performance in men (Tonda and Hart, 1992), horses (Greene et al., 1996) and dogs (Gannon and Kendall, 1982). Only one study investigated the effect of DMG as a feed additive in livestock production, namely on broiler performance (Kalmar et al., 2010). In that study, an improved feed conversion rate of DMG-supplemented broilers was reported. Besides the application of DMG as a supplement for both humans and animals, DMG-derived molecules are also used as surfactants in industrial applications (Guan and Tung, 1998), which indicates that DMG can possibly function as an emulsifying agent when added to the feed.

The current pilot study assessed the influence of DMG on insulin sensitivity, glucose and fat metabolism, nutrient digestibility and reproductive performance of sows in the peripartal period.

Figure 1 Overview of the choline pathway in which dimethylglycine (DMG) is an intermediate metabolite.
Material and methods

The experiment was approved by the Ethics Committee of the Faculty of Veterinary Medicine, Ghent University Belgium (EC 2008/070) and by the Federal Public Service Health Food Chain Safety and Environment, Belgium.

Animals, experimental design and dietary treatment

The experiment was performed at the experimental farm of a feeding company (AVEVE N.V., Leuven, Belgium) during the months June, July and August 2008. In the herd, a 3-week batch production system for sows was practiced. One group of the batch system, comprising 25 sows (Rattlerow Seghers hybrid) of different parities, was included in the study. The sows were housed individually in mechanically ventilated stables with a 12-h light period from weaning until day 28 of gestation and were fed a standard gestation diet (Table 1). Thereafter, the sows were moved to a group housing system with ad libitum access to a gestation feed, rich in soluble fiber, for creating a feeling of satiety (Table 1). At day 105, the beginning of the experiment (day 1), the sows were removed from the gestation unit, body weight (BW) of each individual sow was recorded and they were transferred to the farrowing unit. They were housed individually in farrowing crates until weaning. Sows were randomly allocated into two treatment groups: a control group (n = 13, parity 3.8 ± 3.0) and a DMG group (n = 12, parity 3.8 ± 2.4).

All sows were daily fed 3.5 kg of a standard gestation feed starting from day 105 of gestation until day 109 of gestation (day 5). On days 110 and 111 of gestation (days 6 and 7), all sows received 3.0 and 2.5 kg of the same standard gestation feed, respectively (Table 1). From day 112 of gestation (day 8) until 3 days after the calculated farrowing date (day 14), all sows received the same parturition feed containing 1% celite® (source of acid insoluble ash (AIA)) as an external marker to measure apparent fecal digestibility (AFD; Sales and Janssens, 2003; Tables 1 and 2). The amount of parturition feed provided to each sow at days 112, 113 and 114 of gestation was 2.0, 1.5 and 1.0 kg, respectively. One kg was given daily until parturition, and from parturition onward the daily amount was increased again with 0.5 kg a day. On day 15 of the trial, all sows were switched to a standard lactation diet (Table 1) that was provided ad libitum. Feed samples of each diet were taken and analyzed according to the Association of Official Analytical Chemists (AOAC) methods (Thiex, 2002; Table 1). For the parturition feed also, the amount of AIA was determined as described by (Sales and Janssens, 2003).

From day 1 (day 105 of gestation) until day 14 of the trial, all sows in the DMG group received 1 g DMG (Taminizer-D, supplied by Taminco N.V., Ghent, Belgium) per kg feed supplemented on top of their daily feed portion. The dose of 1000 ppm was based on the supplementation levels recommended for choline nutrient requirements of swine (NRC, 1998).

During the entire experiment, all sows had free access to fresh drinking water (drinking nipple — flow 1.5 to 2 l/min).

Blood sampling and oral glucose tolerance test (OGTT)

One day after parturition, a blood sample was taken and an OGTT performed after an overnight fasting period of 12 h, as described by Kemp et al. (1996) and van der Peet-Schwering et al. (2004). For sows that started farrowing after 2100 h, blood sampling and OGTT were performed 2 days after the actual farrowing date, also after an overnight fasting period of 12 h.

At 0700 h, a 30-ml blood sample was taken from the vena jugularis. Blood samples were divided into four subsamples: 9 ml on serum cloth activator (fructosamine and insulin analyses), 9 ml on lithium heparin (leptin, triglycerides (TG), thiobarbituric acid reactive substances (TBARS) and ferric

Table 1 Feeding scheme and nutrient content of the different diets provided to the sows before, during and after the trial

<table>
<thead>
<tr>
<th>Feeding period</th>
<th>Insemination – day 28</th>
<th>Day 29 to day 104</th>
<th>Day 105 to day 111</th>
<th>Day 112 – parturition + 3°</th>
<th>Lactation</th>
<th>Farrowing + 4° – weaning 8°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of feed</td>
<td>Gestation</td>
<td>Gestation</td>
<td>Gestation</td>
<td>Parturition</td>
<td>Lactation</td>
<td>Farrowing + 4° – weaning 8°</td>
</tr>
</tbody>
</table>
| Control        | Restricted           | ad libitum       | Restricted        | Restricted                | Restricted| Restricted
| DMG            |                      |                  |                   |                           |           |                          |
| Feeding level  |                      |                  |                   |                           |           |                          |
| Dry matter 1°  | 884.9                | 907.8            | 884.9             | 902.9                     | 911.3     | 58.2                     |
| Crude ash 2°   | 62.3                 | 62.6             | 62.3              | 78.6                      | 78.6      | 51.3                     |
| Crude protein 2° | 135.3            | 135.5            | 135.3             | 148.6                     | 160.6     | 59.6                     |
| Crude fat 2°   | 41.4                 | 33.6             | 41.4              | 51.3                      | 51.3      |                          |
| Crude fibre 2° | 76.8                 | 62.2             | 76.8              | 70.0                      | 70.0      |                          |
| NE 3°          | 8.7                  | 8.0              | 8.7               | 9.5                       | 9.5       |                          |

DMG = N,N-dimethylglycine.

1° Period of reproduction cycle during which the particular feed was given to the sows.
2° Diet analyses (g/kg feed).
3° Net energy (MJ/kg feed), calculated value using feed formulation software (Bestmix® Feed, Adifo N.V., Maldegem, Belgium).
4° N,N-dimethylglycine, supplemented on top of feed at a ratio of 1 g/kg feed.
5° Acid insoluble ash 1% added to the parturition feed.
6° Three days post partum.
7° Four days post partum.
8° Weaning at day 26 = 2 of lactation.
Colostrum and feces sampling

After the OGTT was completed, sows were fed their morning feed portion. Subsequently, a colostrum sample was taken from each sow after an intramuscular injection of 1 ml oxytocine. Finally, a fresh rectal feces sample of each sow was taken. Both the colostrum and feces samples were stored frozen at $-20^\circ$C until analysis.

Analyses of blood samples

Insulin was analyzed using an immunoradiometric assay kit (BioSource INS-IRMA Kit, BioSource Europe S.A., Nivelles, Belgium). Glucose and fructosamine were both determined spectrophotometrically (Roche/Hitachi Modular P Analyzer, Roche Diagnostics, Mannheim, Germany) by adding hexokinase and glucose-6-phosphate dehydrogenase (Gluco-quart, Roche Diagnostics, Mannheim, Germany) for glucose analysis and nitrotetrazolium-blue (Fructosamine, Roche Diagnostics, Mannheim, Germany) for fructosamine analyses. TG were also measured spectrophotometrically (Monarch Chemistry System, Instrumentation Laboratories, Zaventem, Belgium) using a commercial colorimetric diagnostic kit (IL Test kit No. 181610-60, Instrumentation Laboratories, Zaventem, Belgium). Leptin in plasma samples was measured using a multispecies immunometric assay kit (Multi-Species Leptin RIA Kit, Linco Research Inc., St. Charles, Missouri, USA). Plasma NEFA concentrations were determined using a WAKO NEFA-HR(2) test (Wako Chemicals GmbH, Neuss, Germany), modified for use on the Monarch Chemistry System. Plasma lipid peroxidation, expressed as TBARS, was measured spectrophotometrically (Monarch Chemistry System, Instrumentation Laboratories) as described in detail by Lin et al. (2004). Results are reported as the concentration of malondialdehyde (MDA) measured per milliliter of plasma after reaction. Similarly, the total plasma anti-oxidative capacity of plasma, expressed as FRAP, was measured spectrophotometrically (Monarch Chemistry System, Instrumentation Laboratories) as described by Benzie and Strain (1996). Results are reported as the concentration of Fe$^{2+}$ measured per liter of plasma after reaction.

Colostrum analyses

First, the colostrum samples were extracted with hexane to remove the fat fraction. The aqueous layer that contained the DMG was then separated from the hexane layer. Subsequently, diethylglycine sodium salt was added to the aqueous extract as an internal standard. After evaporation of the aqueous solution under a nitrogen stream, N,N-dimethylglycine (DMG) was derivatized with a split injector and flame ionization detector. The results were calculated based on the internal standard.

Feces analyses

Feces samples of each sow were analyzed for AIA, dry matter, CP, CA, CFAT and CF according to Thiex (2002). Using these results and the analyses of the parturition feed, the AFD of these nutrients was calculated using the external

Table 2 Composition of the parturition diet

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean meal</td>
<td>17.49</td>
</tr>
<tr>
<td>Barley</td>
<td>14.26</td>
</tr>
<tr>
<td>Sugar beet pulp</td>
<td>14.26</td>
</tr>
<tr>
<td>Wheat</td>
<td>12.55</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>9.50</td>
</tr>
<tr>
<td>Soy hulls</td>
<td>6.45</td>
</tr>
<tr>
<td>Molasses$^1$</td>
<td>5.70</td>
</tr>
<tr>
<td>Manioc</td>
<td>4.75</td>
</tr>
<tr>
<td>Wheat gluten feed</td>
<td>3.29</td>
</tr>
<tr>
<td>Maize</td>
<td>2.38</td>
</tr>
<tr>
<td>Fish oil</td>
<td>1.98</td>
</tr>
<tr>
<td>Pork lard</td>
<td>1.98</td>
</tr>
<tr>
<td>Chalk</td>
<td>1.65</td>
</tr>
<tr>
<td>Pork lard</td>
<td>1.98</td>
</tr>
</tbody>
</table>

$^1$Sugar beet molasses.
$^2$Mineral premix: 4.8% mono iron sulphate, 0.5% copper sulphate, 85.3% magnesium phosphate, 6.8% monocalcium phosphate and 2.6% zinc sulphate.
$^3$Vitamin premix: 6.33 g/kg vitamin A, 272.15 g/kg vitamin E, 0.063 g/kg vitamin D$_3$, 5.02 g/kg vitamin H, 75.30 g/kg vitamin B$_6$, 0.08 g/kg vitamin B$_2$, and 0.75 g/kg vitamin H.
$^4$Luctarom S is an industrial flavor, added to the feed to improve feed intake.
$^5$Trace elements premix: 4.85.07 g manganese/kg premix, 1.02 g cobalt/kg premix, 1.23 g iodine/kg premix, 2.00 g selenium/kg premix.
$^6$L-threonine 0.01
$^7$Soy hulls 6.45
$^8$Wheat bran 9.50
$^9$Wheat 12.55
$^{10}$Wheat gluten feed 3.29
$^{11}$Soy hulls 6.45
$^{12}$Wheat bran 9.50
$^{13}$Wheat 12.55
$^{14}$Sugar beet pulp 14.26
$^{15}$Barley 14.26
$^{16}$Soybean meal 17.49

Reducing ability of plasma (FRAP analyses), 9 ml on K$_3$EDTA (NEFA analyses) and 3 ml on sodium fluoride/potassium oxalate (glucose analyses). The blood subsamples were stored on iced water (4°C) until analysis.

After this blood sampling, the tail of each sow was washed with disinfectant soap. At 0750 h, a blood sample from a small incision in the tail was taken and the glucose concentration in this blood sample was measured using a glucose analyser (Abbott Diabetes Care, Illinois, USA). Blood glucose concentration was measured spectrophotometrically, expressed as TBARS, measured spectrophotometrically (Monarch Chemistry System, Instrumentation Laboratories) as described in detail by Lin et al. (2004). Results are reported as the concentration of malondialdehyde (MDA) measured per milliliter of plasma after reaction. Similarly, the total plasma anti-oxidative capacity of plasma, expressed as FRAP, was measured spectrophotometrically (Monarch Chemistry System, Instrumentation Laboratories) as described by Benzie and Strain (1996). Results are reported as the concentration of Fe$^{2+}$ measured per liter of plasma after reaction.

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marker method with AIA as the external marker, according to the following formula:

$$AFD = [1 - (F/D \times D_{AIA}/F_{AIA})] \times 100$$

with $F$ = % nutrient in the feed, $D$ = % nutrient in the feces, $F_{AIA}$ = % AIA in the feed and $D_{AIA}$ = % AIA in the feces (Goddard and McLean, 2001).

**Reproductive performance parameters**

The following reproductive parameters of the sows were investigated: gestation length, number of total born, live born and stillborn piglets and the number of weaned piglets. The litter weight at birth and at weaning and the mortality rate of piglets before weaning were also recorded.

**Statistical analyses**

The effect of DMG supplementation on glucose tolerance, blood parameters, AFD and reproduction parameters were analyzed using Student’s $t$-test for independent samples after performing a Kolmogorov–Smirnov test to verify normality and Levene’s test to determine equality of variance. The DMG content in the colostrum and the number of stillborn piglets were not normally distributed and therefore these data were analyzed using the non-parametric Mann–Whitney test. All statistical analyses were performed using SPSS 17.0 (SPSS, 2008), considering statistical significance when $P < 0.05$. All data are reported as mean ± s.d.

**Results**

**Oral glucose tolerance test**

The OGTT was successfully performed in 11 sows of the control group and 10 sows of the DMG group. Four sows (two from the control and two from the DMG group) were excluded from the OGTT because their tail was too short to perform the protocol correctly. Basal glucose levels, measured 10 min before the sows were offered their individual glucose load, were similar for both treatments ($4.2 ± 1.1$ mmol/l and $4.1 ± 1.7$ mmol/l for control and DMG group, respectively, $P > 0.05$). Glucose tolerance, represented as the AUC after the OGTT, was not significantly influenced by supplementation of DMG. The average AUC values were $612 ± 105$ mmol $\times$ min/l for the control group and $650 ± 151$ mmol $\times$ min/l for the DMG group. A maximal increase in blood glucose level of $2.4 ± 1.4$ mmol/l above basal level was recorded for sows of the control group after $57 ± 35$ min, which was not significantly different from the maximal increase observed in sows of the DMG group ($2.7 ± 1.5$ mmol/l after $54 ± 29$ min). After $120$ min, blood glucose levels had decreased again to $4.7 ± 0.8$ mmol/l in the control group and to $5.2 ± 0.7$ mmol/l in the DMG group ($P > 0.05$).

**Blood parameters**

The results of the blood parameters are given in Table 3. Supplementation of DMG had no significant influence on glucose, insulin or fructosamine ($P > 0.05$). Similarly, leptin concentration in blood samples was not significantly affected by dietary treatment ($P > 0.05$). Although no significant difference could be seen for NEFA ($P > 0.05$), TG tended to be lower ($P = 0.067$) for the control group (0.29 ± 0.16 ng/ml) compared to the DMG group (0.47 ± 0.31 ng/ml). Neither TBARS nor FRAP were significantly affected by supplementation of DMG ($P > 0.05$).

**AFD of nutrients**

Feces samples of 11 sows of the control group and nine sows of the DMG group were analyzed. No rectal feces samples could be taken from two sows of the control group and three sows of the DMG group because these five sows were constipated. The AFD results are given in Table 4. AFD of CFAT, CP and of NFE were significantly improved in the DMG group compared to the control group ($P < 0.05$).

**Colostrum analyses**

Colostrum samples of 13 sows of the control group and 11 sows of the DMG group were analyzed. From one sow of the DMG group, the amount of colostrum sampled was insufficient for analysis. The concentration of DMG in the colostrum of both groups was low and not significantly

### Table 3 Results (mean ± s.d.) of the blood parameters of sows in the control group (n = 13) and the DMG group (n = 12)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control group</th>
<th>DMG group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (mmol/l)</td>
<td>4.3 ± 0.4</td>
<td>4.2 ± 0.5</td>
<td>0.394</td>
</tr>
<tr>
<td>Insulin (mU/l)</td>
<td>18.3 ± 12.8</td>
<td>21.2 ± 17.2</td>
<td>0.597</td>
</tr>
<tr>
<td>Fructosamine (µmol/l)</td>
<td>247 ± 19</td>
<td>241 ± 14</td>
<td>0.397</td>
</tr>
<tr>
<td>Leptin (ng/ml)</td>
<td>1.9 ± 0.6</td>
<td>1.8 ± 0.6</td>
<td>0.874</td>
</tr>
<tr>
<td>TBARS (nmol/ml)</td>
<td>1.3 ± 0.5</td>
<td>1.5 ± 0.6</td>
<td>0.318</td>
</tr>
<tr>
<td>TRAP (µmol/l)²</td>
<td>116 ± 20</td>
<td>129 ± 30</td>
<td>0.198</td>
</tr>
<tr>
<td>Triglycerides (mmol/l)</td>
<td>0.29 ± 0.16</td>
<td>0.47 ± 0.31</td>
<td>0.067</td>
</tr>
<tr>
<td>NEFA (mmol/l)</td>
<td>0.63 ± 0.31</td>
<td>0.77 ± 0.32</td>
<td>0.291</td>
</tr>
</tbody>
</table>

DMG = N,N-dimethylglycine; TBARS = thio-barbituric acid reactive substances; MDA = malondialdehyde; FRAP = ferric reducing ability of plasma; NEFA = non-esterified fatty acids.

Blood samples were taken at day one post partum. Sows of the DMG group were supplemented with 1 g DMG/kg feed during 14 days.

¹TBARS expressed as the amount of MDA measured in plasma.

²FRAP expressed as the concentration of Fe³⁺ measured in plasma.

### Table 4 Results (mean ± s.d.) of the AFD of nutrients of sows of the control group (n = 11) and the DMG group (n = 9)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control group</th>
<th>DMG group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFD crude fat</td>
<td>84 ± 9</td>
<td>91 ± 2</td>
<td>0.032</td>
</tr>
<tr>
<td>AFD CP</td>
<td>67 ± 17</td>
<td>81 ± 4</td>
<td>0.024</td>
</tr>
<tr>
<td>AFD NFE³</td>
<td>75 ± 15</td>
<td>87 ± 4</td>
<td>0.029</td>
</tr>
</tbody>
</table>

AFD = apparent fecal digestibility; DMG = N,N-dimethylglycine; NFE = Nitrogen-free extract.

Feces samples were taken at day 1 post partum. The DMG group was supplemented with 1 g DMG/kg feed during 14 days.

³NFE calculated based on the complete proximate analyses of feed and feces samples (NFE = dry matter – crude fiber – crude fat – CP – crude ash).
**N,N-dimethylglycine in parturition feed of sows**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control group</th>
<th>DMG group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestation length (days)</td>
<td>116.4 ± 3.3</td>
<td>115.4 ± 1.2</td>
<td>0.334</td>
</tr>
<tr>
<td>Number of total born piglets</td>
<td>13.9 ± 2.5</td>
<td>13.6 ± 3.0</td>
<td>0.759</td>
</tr>
<tr>
<td>Number of live born piglets</td>
<td>13.0 ± 2.6</td>
<td>13.3 ± 2.7</td>
<td>0.743</td>
</tr>
<tr>
<td>Number of stillborn piglets</td>
<td>0.9 ± 1.4</td>
<td>0.3 ± 0.6</td>
<td>0.180</td>
</tr>
<tr>
<td>Litter weight at birth (kg)</td>
<td>19.2 ± 2.4</td>
<td>20.5 ± 3.0</td>
<td>0.259</td>
</tr>
<tr>
<td>Mean individual piglet weight at birth (g)</td>
<td>1522 ± 215</td>
<td>1590 ± 248</td>
<td>0.469</td>
</tr>
<tr>
<td>Number of weaned piglets</td>
<td>10.9 ± 1.5</td>
<td>10.8 ± 2.3</td>
<td>0.908</td>
</tr>
<tr>
<td>Mortality during lactation (%)</td>
<td>13.8 ± 16.6</td>
<td>18.5 ± 15.2</td>
<td>0.466</td>
</tr>
<tr>
<td>Litter weight at weaning (kg)</td>
<td>68.8 ± 7.4</td>
<td>69.0 ± 13.2</td>
<td>0.966</td>
</tr>
<tr>
<td>Mean individual piglet weight at weaning (g)</td>
<td>6378 ± 916</td>
<td>6487 ± 1117</td>
<td>0.792</td>
</tr>
</tbody>
</table>

DMG = N,N-dimethylglycine.

The DMG group was supplemented with 1 g DMG/kg feed during 14 days.

1 In contrast to all the other parameters, the number of stillborn piglets was tested using a non-parametric test instead of a parametric test because data were not normally distributed.

The results of this study observed at day 1 post partum indicated that the prepartual blood glucose levels were almost two-fold those recorded in studies testing glucose tolerance in a similar way at days 104 and 108 of gestation (Kemp et al., 1996; van der Peet-Schwereing et al., 2004). Similarly, maximal increase in blood glucose level during the OGT in this study performed post partum was higher and occurred later in time than in OGTT performed in late gestation (Kemp et al., 1996; van der Peet-Schwereing et al., 2004). In line with this study and the previously mentioned studies of Kemp et al. (1996) and van der Peet-Schwereing et al. (2004), the results of intravenous glucose tolerance tests performed on sows at day 109 of gestation and at day 4 of lactation confirm that glucose half-life is shorter in late gestation than in early lactation (Quesnel et al., 2009). Different explanations can be given for the basal hyperglycemia and decreased glucose clearance rate observed in early lactation. Oliviero et al. (2008) reported elevated plasma cortisol levels for more than 1 day after parturition for sows housed in farrowing crates. These increased cortisol levels could explain the lowered insulin sensitivity of tissue at the beginning of lactation (Kronfeld et al., 2005). Although cortisol was not measured in this study, it could be a possible explanation for the observed lower glucose clearance in early lactation. Hence, interference of cortisol with glucose metabolism could mask a possible effect of DMG on the glucose metabolism in early lactation in sows. This could also explain the lack of influence of DMG supplementation on the preprandial glucose, insulin and fructosamine levels, all these parameters being related to the glucose metabolism.

Despite the anti-oxidative properties of DMG reported in rats (Hariganesh and Prathiba, 2000), no influence on the oxidative parameters TBARS and FRAP were reported in this study. However, the doses used by Hariganesh and Prathiba (2000) were much higher than the dose used in the present trial (25 or 35 mg/kg BW in rats, in contrast to at the highest approximately 15 mg/kg BW for sows consuming the maximum of 3.5 kg feed/day in the present trial). In addition, the rats in this study suffered gastric ulceration resulting in a physiologically different status than sows on day one post partum.

Research on leptin in many different species, including humans, has revealed that this hormone is related to energy metabolism (Barb et al., 2001; Budak et al., 2006). Moreover, levels of leptin in sows can vary in relation to the feeding level (Quesnel et al., 2009), feed composition, time after transition from one feed to another (Papadopoulos et al., 2009) and body condition, mostly measured as back fat thickness (Prunier et al., 2001). In this study, both feeding scheme and body condition of all sows were similar, resulting in similar fasting leptin levels at the first day of lactation for both treatment groups. Given the inducing role of leptin in insulin resistance, as reviewed by Barb et al. (2001), these similar leptin levels likely reduced the chance of finding differences in glucose tolerance induced by different dietary treatments. Fasting NEFA levels were also similar between treatments, indicating a similar amount of energy mobilized from fat reserves in both treatment groups. The absence of an influence of DMG supplementation on leptin combined with lack of effect on fasting NEFA concentration, the equal feed intake and similar body condition of all sows indicates that the present DMG supplementation over a period of 10 days did not affect the lipid metabolism of sows in the peripartal period. Although no influence on lipid metabolism could be recorded, the slight increase in TG blood levels and the significant improvement in AFD of CFAT indicate
that DMG supplementation over a longer period of time or at a higher dose might have a beneficial influence on lipid metabolism. Indeed, the results of AFD in this study indicate that DMG may act as an external emulsifier in pig feed (Wieland et al., 1993; Dierick and Decuyper, 2004). The emulsifying effect of DMG incorporation in the sow’s diet not only resulted in improvement of CFAT digestibility, but also improved digestibility of CP and NFE. These findings corroborate with the results of a previously published study on the addition of emulsifying agents to pig feed (Dierick and Decuyper, 2004). Studies on the effects of emulsification of fat sources in piglet feed indicate that the addition of emulsifiers to piglet feed improve nutrient digestibility, resulting in a reduction of feed costs (Jones et al., 1992; Odle et al., 1994). Seeing the limited number of studies published on the effects of addition of emulsifiers to the diets for sows, it would be worthwhile to do further research on the effect of DMG on nutrient digestibility.

Results of colostrum analyses in this study indicate that the technique used is not sensitive enough to measure small amounts of DMG in the colostrum samples. The low DMG levels detected in both groups indicate that little DMG is transferred into the colostrum. This finding is in line with previous studies reporting that most DMG is eliminated from the organism by demethylation rather than by excretion (Lever et al., 2005) or in this case by secretion in the colostrum.

No direct effect of DMG supplementation on reproductive performance parameters was noted, except for a numerical decrease in the number of stillborn piglets in litters of sows fed diets supplemented with DMG. The incidence of piglet mortality at or after farrowing may be linked to an increased glucose intolerance of sows during late gestation (Kemp et al., 1996).

In conclusion, this study showed that short-term supplementation of DMG had an emulsifying effect that resulted in an improved nutrient digestibility. However, neither a significant influence on glucose clearance one day after parturition nor improved reproductive performance parameters could be substantiated in the present trial. Further research, in which DMG is supplemented for a longer period and/or at a higher dose, is warranted to investigate the possible beneficial effects of DMG on energy and lipid metabolism, health and performance of the sow and the piglets.

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References


SPSS Inc. 2008. SPSS version 17.0. SPSS Inc., Chicago, Illinois, USA.


