Variations in Glucose and Protein Contents of Milk in Placenta-fed Sows

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Abstract

The objective of the present study was to investigate the effect of placenta as feed on protein and glucose in milk of sows and on growth of piglets. The experimental animals used were total of 40 sows and 413 piglets. First experiment (Exp. 1) was designed with experiment (Ex: with placenta) and control (Ct: without placenta) depending on feeding placenta or not. Second experiment (Exp. 2) was designed with conditions (fresh: Fp or cooked: Cp) and weights (900g: W9 or 1800g: W18) of placenta according to 2 × 2 factorial design. Glucose content in milk in Exp. 1 was higher (P<0.05) in Ex than in Ct on Day 1 (D01) and Day 5 (D05). Glucose content in milk in Exp. 2 was greater (P<0.01) in Fp than in Cp on D01 and Day 3 (D03). It was not different (P>0.05) by weights over the days. Protein content in milk in Exp. 1 was higher (P<0.05) in Ex than in Ct on D01. Protein content in milk in Exp. 2 was greater (P<0.01) in Fp than in Cp on D01. It was not different (P>0.05) by weights over the days. In Exp. 1, daily gain (DG) of piglets on DG05, DG20 and total daily gain (TDG) was higher (P<0.01) in Ex than in Ct. In Exp. 2, DG of piglets was greater (P<0.01) in Fp than in Cp from DG03 to DG12 and TDG. DG and TDG of piglets were not affected (P>0.05) by weights over the days. These results indicate that DG of piglets was improved because the glucose and protein content in milk increased after fresh placenta supplied as feed to sows.

Key Words: placenta, milk, glucose, protein, daily gain

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INTRODUCTION

The yield and composition of the sow's colostrum and milk are of great importance for the growth and development of the new-born piglets. The reason is that the colostrum and milk of sow are the main sources of nutrition and passive immunity for the piglets. BLUM and HAMMON (1977) and CAMPANA and BAUMRUCKER (1983) reported that colostrum contains a large number of hormones, growth factors, cytokines, enzymes, polyamines and nucleotides.

The placenta is generally the organ through which respiratory gases, nutrients, and wastes are transported between maternal and fetal system, and its primary function is to supply the metabolic substrates necessary to support fetal growth. The placenta itself is an active endocrine organ and it produces a large number of hormones including growth hormone and IGF-1 as well as their corresponding receptors (1,2,9).

Protein synthesis and glucose levels in plasma are affected by growth hormone (1,3,4). The effect of growth hormone by oral intake may be allied by digestion. However, there have been no reports until now. Since the placenta contains useful hormones, it is considered that placenta as feed will help to improve glucose and protein content in milk and also the growth of piglets.

The objective of the present study was to investigate the effect of feeding placenta to sows after farrowing on protein and glucose in milk of sows and on growth of piglets.

MATERIALS AND METHODS

Animals
A total of 40 sows (Landrace × Large White) were used in a series of experiment, and the experimental animals used were sows of 4 to 6 parities. Each sow was suckled by 10 ± 1 piglets. Experimental animals were moved into the farrowing piggery of a windowless barn before the 10th day of farrowing. The temperature of the farrowing piggery was 25 ± 2 °C. Placenta was collected within 3 to 7 hours after farrowing. All sows were supplied with the same amount of feed during experimental days. They were fed 1.2-3.5, 3.5-4.5 and 4.5-6.0 kg per day of diet (14.0% of crude protein, 5.0% of crude fat, 7.0% of crude fiber, 9.0% of crude ash, 3400 kcal/kg of DE) at 1-4, 5-9 and 10-20 days of experimental period, respectively. The feed supplied was a restricted diet for all sows according to the system adapted by the farm (HIDAKA Swine Farm, Miyazaki, Japan).

Sows were allowed access to this diet at 08:00 and 15:00, and were allowed ad libitum access to water from the nipple. These experiments were done with permission from committee of animal experiment (University of Miyazaki, No. 2004-053).

Experiment 1
Experiment 1 (Exp. 1) was designed with experiment (Ex) and control (Ct) depending on feeding placenta or not. Each treatment was made up of 6 sows. A total of 12 sows were used to determine the protein and glucose of their milk. Placenta was washed and cut into a length of about 5 cm. Sixteen hundred gram of fresh placenta was mixed with 1200 g commercial diets and fed to the sows at 08:00 on the 1st day after farrowing. The milk samples were collected from 14:00 to 15:00 after completion of placenta feeding on Day 1 (D0). The milk samples on Day 5 (D5), Day 10 (D10), Day 15 (D15) and Day 20 (D20) were collected between 10:00 and 11:00.

Experiment 2
Experiment 2 (Exp. 2) was designed with fresh (Fp) or cooked (Cp) as condition of placenta and amounts by weight (900 g: W9 or 1800 g: W18) of placenta. Each of experiment group was made up of 7 sows. A total of 28 sows were used to determine the protein and glucose contents of their milk by feeding placenta according to 2 (Conditions) × 2 (Weights) factorial design. The placenta was washed and cut into a length of about 5 cm. The placenta for Cp was heated to 95 °C for 15 minutes in hot water. The placenta was mixed with 1200 g diet and fed to the sows at 08:00 on the 1st day after farrowing. The milk samples were collected from 14:00 to
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15:00 after the completion of feeding placenta on D01. The milk samples on D03, D08, D12, D16 and D20 were collected between 10:00 and 11:00.

Samples and Analyses

The milk samples were stored at −80°C until assay for protein and glucose. The protein content in milk of sows was determined by the method of BRADFORD. The glucose content in milk of sows was analyzed using the glucose-oxidase method.

Growth of piglet

New born piglets weighing 1.30 ± 0.30 kg on the same farrowing day were selected in all experimental groups. Each sow was suckled by 10 ± 1 piglets. The piglets were weighed after milk sample collection in all experimental groups. Body weight (BW), daily gain (DG) and total daily gain (TDG) of piglets were calculated according to the day. DG in Exp. 1 was calculated as the difference between BW on D05 and D01 (DG05), D10 and D05 (DG10), D15 and D10 (DG15), D20 and D15 (DG20), and D20 and D01 (TDG). DG in Exp. 2 was calculated as the difference between BW on D03 and D01 (DG03), D08 and D03 (DG08), D12 and D08 (DG12), D16 and D12 (DG16), and D20 and D16 (DG20), and D20 and D01 (TGD). In the piglets managing system, the male piglets were castrated on the 3rd day after birth and all piglets were administrated chalybeate. All piglets were supplied with synthetic milk (CP 22%, EE 4%, NFE 88%) from the 11th day after birth. Piglets were allowed ad libitum access to water from a nipple.

Statistical Analysis

Statistical analyses were performed by the Statistical Analysis Systems Institute software package. All data in Exp. 1 was evaluated by using a student's t-test. All data in Exp. 2 were analyzed by two-way analysis of 2 × 2 factorial design. The model included the effects of condition (C), weight (W) and C × W interaction. The significant differences among treatments were separated with the least squares mean. The results were given as means and standard deviation.

RESULTS AND DISCUSSION

The change of glucose concentration in milk of sows fed placenta in Exp. 1 are presented in Table 1. Glucose content was significantly higher (P < 0.05) in Ex than in C on D01 and D05. It tended to be higher in Ex than in C on the other experimental days but the difference was not significant. Glucose content of milk was higher during

<p>| Table 1. Change of glucose content (mg/100 ml) in milk of sows fed placenta in experiment 1 |</p>
<table>
<thead>
<tr>
<th>Treatment</th>
<th>D01</th>
<th>D05</th>
<th>D10</th>
<th>D15</th>
<th>D20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex</td>
<td>13.28±1.26**</td>
<td>9.26±1.14**</td>
<td>7.57±1.06</td>
<td>7.59±1.00</td>
<td>6.65±1.09</td>
</tr>
<tr>
<td>Ct</td>
<td>10.24±1.88</td>
<td>7.67±0.82</td>
<td>6.56±1.08</td>
<td>6.33±1.21</td>
<td>5.75±0.58</td>
</tr>
</tbody>
</table>

**P < 0.05 indicate significant difference between Ex and Ct.

<p>| Table 2. Change of glucose content (mg/100 ml) in milk of sows fed placenta by the conditions and weights in experiment 2 |</p>
<table>
<thead>
<tr>
<th>Condition</th>
<th>Fp</th>
<th>Cp</th>
<th>Weight</th>
<th>W 9</th>
<th>W18</th>
<th>W 9</th>
<th>W18</th>
<th>C</th>
<th>W</th>
<th>C×W</th>
</tr>
</thead>
<tbody>
<tr>
<td>D01</td>
<td>12.35±1.83</td>
<td>9.74±1.41</td>
<td>10.65±1.63</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D03</td>
<td>9.83±1.89</td>
<td>10.92±1.57</td>
<td>7.43±0.65</td>
<td>8.07±1.24</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D08</td>
<td>6.70±0.70</td>
<td>7.59±1.00</td>
<td>3.69±0.89</td>
<td>6.77±1.23</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D12</td>
<td>6.55±0.96</td>
<td>6.46±1.04</td>
<td>5.59±1.09</td>
<td>6.70±1.31</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D16</td>
<td>6.28±1.30</td>
<td>5.92±1.27</td>
<td>5.27±1.22</td>
<td>5.45±1.26</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D20</td>
<td>5.73±1.18</td>
<td>5.81±1.21</td>
<td>5.90±1.51</td>
<td>5.45±1.26</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fp, sows fed fresh placenta; Cp, sows fed cooked placenta.

1) Fp, sows fed fresh placenta; Cp, sows fed cooked placenta.
2) W 9, sows fed 900 g of placenta; W18, sows fed 1800 g of placenta.
3) C, condition effect; W, weight effect; C×W, condition × weight interaction.

*P < 0.01; NS, not significant.
early lactation and tended to decline over the days in Ex and Ct. The result in this study indicated that glucose content of milk was affected by feeding placenta during early lactation.

The change of glucose content in milk of sows fed placenta by C and W in Exp. 2 are presented in Table 2. Glucose content in milk was significantly greater (P<0.01) in Fp than in C and D01 and D03 but was not different (P>0.05) by C on the other days. It was not significantly different (P>0.05) by W and CXW over the days. The results in this study indicated that glucose content in milk of sows during early lactation was higher when fed fresh placenta than cooked placenta.

The change of protein content in milk of sows fed placenta in Exp. 1 are presented in Table 3. Protein content in milk was significantly higher (P<0.05) in Ex than in Ct on D01. It tended to be higher in Ex than in Ct on other days but the difference was not significant. The result indicated that protein content in milk was numerically higher during early lactation and tended to decline over the days both in Ex and Ct. This is consistent with previous reports\(^{12,13,15}\). It was considered that the reason why protein content in milk was greater in Ex than in Ct on D01 was that feeding placenta might affect it during early lactation.

The change of protein content in milk of sows fed placenta by C and W in Exp. 2 are presented in Table 4. Protein content in milk was significantly greater (P<0.01) in Fp than in C and D01 but was not different (P>0.05) by C on other days. It was not significantly different (P>0.05) by W and CXW over all. Protein content in milk was numerically higher during early lactation and tended to decline over the days\(^{19}\). COFFEY et al.\(^{8}\) reported that protein content was higher in colostrums than in milk. Our results in this study are also consistent with previous reports\(^{12,13,15}\). This result shows that milk protein content was higher in sows fed fresh placenta than in those fed cooked placenta.

The change of body weight (kg) and daily gain (g/day) in piglets of placenta-fed sow in Exp. 1 are presented in Fig 1 and Fig 2. BW on D01 was similar (P>0.05) between Ex and Ct. It was significantly higher (P<0.01) in Ex than in Ct on D05, D10, D15 and D20. DG on D05 was significantly higher (P<0.01) in Ex than in Ct. DG was similar (P>0.05) between Ex and Ct on DG10 and DG15. DG was significantly higher (P<0.01) in Ex than in Ct on DG20 and TDG. According to these results, variations in BW, DG and TDG indicate that feeding placenta affected the growth of piglets. LEWIS et al.\(^{17}\) and NOBLET

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Table 3. Change of protein content (g/kg) in milk of sows fed placenta in experiment 1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>D01</th>
<th>D05</th>
<th>D10</th>
<th>D15</th>
<th>D20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex</td>
<td>60.95±3.06**</td>
<td>44.40±4.70</td>
<td>42.98±4.73</td>
<td>39.01±3.18</td>
<td>38.39±2.14</td>
</tr>
<tr>
<td>Ct</td>
<td>54.41±5.02</td>
<td>42.93±5.71</td>
<td>38.95±2.80</td>
<td>37.07±4.43</td>
<td>36.76±2.12</td>
</tr>
</tbody>
</table>

**P<0.05 indicate significant difference between Ex and Ct.

Table 4. Change of protein content (g/kg) in milk of sows fed placenta by the conditions and weights in experiment 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>W9</th>
<th>W18</th>
<th>W9</th>
<th>W18</th>
<th>C</th>
<th>W</th>
<th>C×W</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>D01</td>
<td>71.89±6.36</td>
<td>62.92±6.04</td>
<td>50.99±7.18</td>
<td>53.22±8.35</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>D03</td>
<td>41.17±4.40</td>
<td>43.80±3.33</td>
<td>40.86±4.96</td>
<td>39.87±3.62</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>D08</td>
<td>41.24±4.82</td>
<td>40.02±2.36</td>
<td>39.40±3.80</td>
<td>38.37±3.47</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>D12</td>
<td>38.96±3.52</td>
<td>41.47±4.36</td>
<td>36.65±1.66</td>
<td>37.61±4.83</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>D16</td>
<td>37.69±3.17</td>
<td>38.10±2.68</td>
<td>35.73±4.50</td>
<td>36.99±3.31</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>D20</td>
<td>35.02±4.16</td>
<td>37.94±4.01</td>
<td>35.71±3.65</td>
<td>37.04±2.73</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

\(^{11}\)Fp, sows fed fresh placenta; Cp, sows fed cooked placenta.

\(^{12}\)W9, sows fed 900g of placenta; W18, sows fed 1800g of placenta.

\(^{13}\)C, condition effect; W, weight effect; C×W, condition×weight interaction.

\(^{*}\)P<0.01; NS, not significant.
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Fig 1. Change of body weight (kg) in piglets of sows fed placenta in experiment 1
Ex, sows were fed placenta; Ct, sows were not fed placenta.
*P<0.01 indicate significant difference between Ex and Ct.

Fig 2. Change of daily gain (g/day) in piglets of sows fed placenta in experiment 1
Ex, sows were fed placenta; Ct, sows were not fed placenta.
DG05, The difference between body weights on D05 and D01; DG10, The difference between body weight on D10 and D05; DG15, The difference between body weight on D15 and D10; DG20, The difference between body weight on D20 and D15; TDG, Total daily gain. The difference between body weight on D20 and D01. *(P<0.01) indicate significant difference between Ex and Ct.
Fig 3. Change of body weight (kg) in piglets of sows fed placenta by the conditions and weights in experiment 2
Fp, sows fed fresh placenta; Cp, sows fed cooked placenta; W9, sows fed 900g of placenta; W18, sows fed 1800g of placenta.
*(P<0.01) and **(P<0.05) indicate significant difference between Fp and Cp.
+(P<0.01) and ++(P<0.05) indicate condition × weight interaction.

Fig 4. Change of daily gain (g/day) in piglets of sows fed placenta by the conditions and weights in experiment 2
Fp, sows fed fresh placenta; Cp, sows fed cooked placenta; W9, sows fed 900g of placenta; W18, sows fed 1800g of placenta.
DG03, The difference between body weights on D03 and D01; DG08, The difference between body weight on D08 and D03; DG12, The difference between body weight on D12 and D08; DG16, The between body weight on D16 and D12; DG20, The between body weight on D20 and D16; TDG, Total daily gain, The difference between body weight on D20 and D01.
*(P<0.01) indicate significant difference between Fp and Cp.
+(P<0.01) and ++(P<0.05) indicate condition × weight interaction.
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and ETIENNE\textsuperscript{10} reported that milk nutrients contributed to the growth of piglets during lactation. A high protein content of colostrums was associated with antibodies in colostrums\textsuperscript{8}. Daily gain of piglets increased with the level of colostrums intake\textsuperscript{5}. Li\textsuperscript{9} reported that body weight of piglets improved by feeding placenta to sows. It is considered that growth of piglet may be affected by glucose and protein content in milk.

The change of body weight (kg) in piglets of sows fed placenta by the C and W in Exp. 2 are presented in Fig 3. BW on D01 was not affected (P>0.05) by C, W or C×W. It was significantly greater in Fp than in Cp on D03 (P<0.05), D08 (P<0.01), D12 (P<0.01), D16 (P<0.01) and D20 (P<0.01). BW was not significantly different (P>0.05) by W on any days. It was not significantly affected (P>0.05) by C×W on D01, D03 and D08 but was significantly affected on D12 (P<0.05), D16 (P<0.01) and D20 (P<0.01).

The difference of daily gain (g/d) and total daily gain (g/d) in piglets of sows fed placenta by the C and W in Exp. 2 are presented in Fig 4. DG was significantly greater in Fp than in Cp on DG03 (P<0.01), DG08 (P<0.01), DG12 (P<0.01) and TDG (P<0.01) but was similar (P>0.05) between Fp and Cp on DG16 and DG20. DG was not significantly different (P>0.05) by W on other days. It was not significantly affected (P>0.05) by C×W on DG01 but was significantly affected on DG08 (P<0.01), DG12 (P<0.05), DG16 (P<0.01), DG20 (P<0.01) and TDG (P<0.01). As shown in Fig 3 and 4, feeding fresh placenta to sows improved the growth of piglets better than doing cooked placenta. Milk nutrients contributed to the growth of piglets during lactation\textsuperscript{11,17,26}. COFFEY et al.\textsuperscript{8} reported that a high protein content of colostrums was associated with antibodies in colostrums. Daily gain of piglets increased with the level of colostrums intake\textsuperscript{10}. Li\textsuperscript{9} reported that body weight of piglets improved by feeding placenta to sows.

This study examined the effect of milk glucose and protein contents on growth of piglets. It was seen that fresh placenta as feed affected milk glucose and protein content when compared to cooked placenta. However, further studies on the effect of hormones in functional materials on piglet growth performance should be done.

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胎盤を摂取した母豚の乳中グルコースおよびたんぱく質含量の変化

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要　約

母豚の胎盤摂取が母豚の乳中グルコースおよびたんぱく質含量に与える影響について実験を行った。実験動物は母豚40頭と子豚413頭を供試した。実験1では、胎盤摂取の有無により試験区（Ex）と対照区（Ct）とし、試験2では、給与胎盤の量（生区：Fpおよび加熱区：Cp）と量（900g区：W9および1,800g区：W18）により、2×2要因実験を行った。試験1において、グルコース含量は、日齢1（D01）と日齢5（D05）にExがCtより高かった（P<0.01）。試験2において、グルコース含量は、D01とD03にFpがCpより高かった（P<0.01）。グルコース含量には給与量による差はなかった（P>0.05）。試験1において、たんぱく質含量は、D01にExがCtより高かった（P<0.01）。試験2では、たんぱく質含量はD01にFpがCpより有意に高かっ
た（P<0.01）。たんぱく質含量には給与量による差はなかった（P>0.05）。試験1において、子豚の日増体重はDG05、日齢20（DG20）および総日増体重にExがCtより高かった（P<0.01）。試験2において、子豚の日増体重は日齢3（DG03）から12（DG12）にFpがCpより有意に高かっ
た（P<0.01）。子豚の日増体重と総日増体重には給与量による差はなかった（P>0.05）。本試験の結果から、新鮮胎盤給与は母豚の乳中グルコースとたんぱく質含量を増加させ、子豚の日増体重を高めることが明らかとなった。

キーワード：胎盤摂取，乳，グルコース，たんぱく質，日増体重

2005年10月11日受付
2005年11月30日受理