Effect of Placenta Feeding on Mineral Composition of Plasma and Milk in Sows and Growth of Piglets

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Abstract

The objective of the present study was to investigate the variations of the mineral composition in plasma and milk of sows fed placenta and on growth of 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: W 9 or 1800 g: W18) of placenta according to 2 × 2 factorial design. In plasma, calcium content on Day 1 (D01) and Day 5 (D05) in Exp. 1 were higher ($P<0.05$) in Ex than in Ct. In milk, magnesium content on Day 15 (D15) and potassium content on D01 and D05 in Exp. 1 was greater ($P<0.05$) in Ex than in Ct. In plasma, calcium content in Exp. 2 was greater in Fp than in Cp on D01 ($P<0.05$). In milk, calcium content was greater ($P<0.05$) in Fp than in Cp on D03, D16 and D20 in Exp. 2 . Daily gain of piglets on DG05 (The difference between body weights on D05 and on D01), DG20 (The difference between D20 and D15) and total daily gain (TDG, the difference between D20 and D01) in Exp. 1 was higher ($P<0.01$) in Ex than in Ct. Daily gain was greater ($P<0.01$) in Fp than in Cp on DG03 (The difference between D03 and D01), DG08 (The difference between D08 and D03) and DG12 (The difference between D12 and D08) in Exp. 2 . The results indicate that fresh placenta when supplied as feed affected the mineral compositions of plasma and milk in sows and daily gain of piglets.

Key words: placenta, plasma, milk, mineral, daily gain, piglets.

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INTRODUCTION

The placenta has profound influence on the growth and the development of the fetus, utero-placenta and perhaps even on metabolism. The placenta has also additional functions such as the production of many kinds of hormones[2,7,17]. Many researchers have been studying about several effects of hormones by using synthetic hormones on the placenta[9,18,20].

At present, swine farmers have not been using the placenta of sows. Some researchers reported that the placenta contains valuable materials[1,7]. Other researchers have reported that the growth hormone in the placenta has effects on the growth of the fetus[1,4,5,6].

Mineral deficiency in animals results in problems during growth and in physiology. Excess minerals have been reported to produce several pathological problems[14]. The regulation of sodium (Na) concentration in the body is controlled by aldosterone and an antidiuretic hormone of the posterior pituitary[14]. Minerals such as sodium and potassium (K) function as an electrolyte within the internal secretion of the hormones and also effect water metabolism, uptake of nutritive substances and the transmission of nerve stimulation[14]. MAHAN *et al.*[12] reported that sodium supplementation was affected to growth of piglets. Milk contains sodium higher than other minerals[14]. Heat stress and milk production requires much potassium[15]. Calcium (Ca) is the most abundant mineral element in the body, and 99% of calcium exists in the bone and the teeth. Calcium absorption occurs up to 30-50% in animals[3], and is directly related to milk production[14]. Magnesium (Mg) combines directly with nitrogen (N), sulfur (S), and halogens. The magnesium within the cells is higher than other minerals except potassium[14].

The objective of the present study was to investigate the effects of feeding placenta to sows after farrowing on mineral composition in the plasma and milk of sows and on growth of piglets.

MATERIALS AND METHODS

Animals

The experimental animals used were sows (Landrace×Large White) of 4 to 6 parities, and 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 ℃. 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 4.5-6.0kg per day of diet (14.0% of crude protein, 5.0% of crude fat, 7.0% of crude fiber, 9.0% of crude ash, 3400kcal/kg of DE) at 1-4, 5-9 and 10-20 days of experimental period, respectively. All nutrient requirements were met or exceeded that of NRC for lactating pigs[16]. 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. This experiment was 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 mineral composition of their plasma and milk, and piglet growth. Placenta was washed and cut into a length of about 5 cm. 1600 g of fresh placenta was mixed with 1200 g commercial diets and fed to the sows at 08:00 on the 1 st day after farrowing.

Blood samples were collected from the jugular vein of the sows by venipuncture. On Day 1 (D01), the blood samples were collected at 14:30 after the placenta feeding. Blood samples were collected at 10:30 on Day 5 (D05), Day 10 (D10), Day 15 (D15) and Day 20 (D 20).

On D01, milk samples were collected from 14:00 to 15:00 after completion of placenta feeding. Milk samples on D05, D10, D15 and D20, were collected between 10:00 and 11:00.

Experiment 2

Experiment 2 (Exp. 2) was designed with conditions (Fresh : Fp or Cooked : Cp) and weights (900 g : W9 or 1800 g : W18) of placenta. Each of experiment groups was made up of 7 sows. A total of 28 sows were used to determine the mineral composition of their plasma and milk, and the growth of piglets 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 cooked placenta was heated to 95℃ for 15 minutes in hot water. The placenta was mixed with 1200 g diet and fed to the sows at 08:00 on the 1 st day after farrowing.

The blood samples were collected from the jugular vein of the sow by venipuncture. On D01, the blood samples were collected at 14:30 after feeding placenta to the sows. Blood samples on D03, D08, D12, D16 and D20 were collected at 10:30.

On D01, the milk samples were collected from 14:00 to 15:00 after the completion of feeding placenta. The milk samples on D03, D08, D12, D16 and D20 were collected between 10:00 and 11:00.

Samples

The plasma was separated after centrifugation at 1500 × g for 20 min within 2 hours after collection and stored at −80℃ until assayed for mineral composition. The milk and placenta samples were stored at −80℃ until assayed for mineral composition.

Mineral analysis

Pre-treatment for analyzing minerals was performed on plasma, milk and placenta samples using a modification of the dry ash method as described by GUO *et al.*[8]. Plasma and milk samples of 1 ml, and placenta samples of 2 g were dry-ashed in a porcelain crucible and it was solubilized in 5 ml of 6 M HCl. They were then transferred into 20ml volumetric flasks. These samples were diluted to volume with double-deionized water. Calcium (Ca) and magnesium (Mg) were analyzed with an automic absorption spectrophotometer (Flame emission spectrophotometer AA-646, Shimadazu Co., Japan). Sodium (Na) and potassium (K) were analyzed with a flame photometer (Photoeleotric ANA-135, Tokyokoden Co., Japan).

Growth of piglet

New born piglets weighing 1.30 ± 0.30 kg were selected in all experimental groups. The piglets were weighed when samples of blood and milk of sows were collected in all experimental groups. Body weights of piglets were weighed after milk sample collection. Daily gain of piglets was calculated as the change in weight on the day of sampling from the previous sampling day. Total daily gain (TDG, g/day) of piglets was calculated from the different between D20 to D01. In the piglets managing system, the male piglets were castrated on the 3 rd 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 accessing ad libitum to water from a nipple.

Statistical Analysis

Statistical analyses were performed by the Statistical Analysis Systems Institute software package[19]. All data in Exp. 1 were 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.

RESULTS AND DISCUSSION

Mineral composition of placentas used in this experiments are presented in Table 1. All minerals content was higher in fresh placenta than in cooked placenta. Minerals in cooked placenta were reduced after heating.

The variations in mineral composition of plasma of sows fed placenta in Exp. 1 are presented in Table 2. Calcium content was significantly higher ($P<0.05$) in Ex than in Ct on D01 and D05. Calcium content was similar ($P>0.05$) between Ex and Ct on other days. Magnesium content was similar ($P>0.05$) between Ex and Ct on each day. Potassium content was not different ($P>0.05$) between Ex and Ct. Sodium content was similar ($P>0.05$) between Ex and Ct on each day. Our results showed that calcium content in plasma tended to be higher in Ex than in Ct from D01 to D05 and calcium and sodium contents changed in Ex from D01 to D20. These results suggest that the contents of calcium and sodium in plasma were affected by high content of mineral in fresh placenta.

The variations in mineral composition of milk of sows fed placenta in Exp. 1 are presented in Table 3. Calcium content was similar ($P>0.05$) between Ex and Ct on each day. Magnesium content was significantly greater ($P<0.05$) in Ex than in Ct on D15. Magnesium content was similar ($P>0.05$) between Ex and Ct on other days but tended to be higher in Ex than in Ct. Potassium

Table 1. Mineral composition (mg/100g) of placentas used

Items	Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Sodium (Na)
Fresh Placenta	312.13	91.38	191.75	1774.75
Cooked Placenta	136.25	47.38	33.88	137.00

Table 2. Variations of mineral composition (mg/100 ml) in plasma of sows fed placenta in experiment 1

Treatment[1)]	D01	D05	D10	D15	D20
Calcium (Ca)					
Ex	13.45**	9.42**	6.88	10.23	7.68
Ct	10.32	7.45	8.50	7.36	7.14
Magnesium (Mg)					
Ex	3.80	3.98	4.12	2.56	3.36
Ct	2.60	4.40	3.80	2.70	4.40
Potassium (K)					
Ex	26.08	22.50	25.83	27.03	27.15
Ct	22.70	20.57	22.70	27.93	25.45
Sodium (Na)					
Ex	280.58	236.92	247.32	235.80	238.57
Ct	272.17	235.32	236.65	192.37	251.00

[1)]Ct, sows not fed placenta; Ex, sows fed placenta.
**$P<0.05$ indicate significant difference between Ex and Ct.

Table 3. Variations of mineral composition (mg/100 ml) in milk of sows fed placenta in experiment 1

Treatment[1)]	D01	D05	D10	D15	D20
Calcium (Ca)					
Ex	550.2	661.7	704.7	694.6	740.4
Ct	391.6	619.5	673.5	705.0	706.8
Magnesium (Mg)					
Ex	134.2	108.9	111.7	126.2**	120.8
Ct	101.6	98.7	105.1	87.9	113.0
Potassium (K)					
Ex	211.7*	78.5**	75.9	79.1	76.3
Ct	86.6	69.8	72.2	70.1	73.6
Sodium (Na)					
Ex	1070	1008	910	827	795
Ct	999	909	837	833	750

[1)]Ct, sows not fed placenta; Ex, sows fed placenta.
*$P<0.01$, **$P<0.05$ indicate significant difference between Ex and Ct.

content was significantly higher in Ex than in Ct on D01 ($P<0.01$) and D10 ($P<0.05$). Potassium content was similar ($P>0.05$) between Ex and Ct on other days. Sodium content was similar ($P>0.05$) between Ex and Ct (Table 2). Our results showed that mineral contents of milk tended to be higher in Ex than in Ct from D01 to D05. Accordingly, feeding placenta may have affected the mineral compositions in plasma and milk of sows.

The variations in mineral composition of plasma of sows fed placenta by C and W in Exp. 2 are presented in Table 4. Calcium content was significantly greater in Fp than in Cp on D01 ($P<0.05$) but was not different ($P>0.05$) by C on other days. Calcium content was not significantly different ($P>0.05$) by W and C × W on each day. Magnesium, potassium and sodium contents were not different ($P>0.05$) by C, W and C× W on each day. Our results show that calcium in plasma was higher in sows fed fresh placenta than in sows fed cooked placenta on D01. Accordingly, feeding fresh placenta affected the mineral composition in the plasma of sows on D01.

The variations in mineral composition of milk of sows fed placenta by the C and W in Exp. 2 are presented in Table 5. Calcium content was significantly greater in Fp than in Cp on D03 ($P<0.05$), D16 ($P<0.05$) and D20 ($P<0.05$). Calcium content was similar ($P>0.05$) between Fp and Cp on the other days but tended to be higher in Fp than in Cp. Calcium content was significantly higher

Table 4. Variations of mineral composition (mg/100 ml) in plasma of sows fed placenta by the conditions and weights in experiment 2

Condition[1]	Fp		Cp		Significance[3]		
Weight[2]	W9	W18	W9	W18	C	W	C×W
Calcium (Ca)							
D01	11.23	12.05	9.97	9.18	**	NS	NS
D03	10.48	9.90	9.97	8.93	NS	NS	NS
D08	10.83	11.23	10.95	10.13	NS	NS	NS
D12	12.23	11.87	11.00	10.68	NS	NS	NS
D16	10.60	10.40	11.38	9.10	NS	NS	NS
D20	11.08	11.80	11.43	11.63	NS	NS	NS
Magnesium (Mg)							
D01	4.05	4.53	4.20	3.73	NS	NS	NS
D03	3.75	3.50	4.60	3.88	NS	NS	NS
D08	4.60	4.03	4.80	4.75	NS	NS	NS
D12	3.75	4.25	3.88	4.03	NS	NS	NS
D16	3.68	4.23	3.80	4.15	NS	NS	NS
D20	3.78	4.15	3.95	3.60	NS	NS	NS
Potassium (K)							
D01	22.68	24.23	22.90	19.50	NS	NS	NS
D03	19.93	20.95	20.85	21.30	NS	NS	NS
D08	19.60	22.75	22.85	22.73	NS	NS	NS
D12	19.00	21.85	21.88	21.30	NS	NS	NS
D16	22.28	21.28	21.20	21.63	NS	NS	NS
D20	20.05	23.85	22.48	20.13	NS	NS	NS
Sodium (Na)							
D01	259.58	287.57	273.87	281.75	NS	NS	NS
D03	272.10	269.27	278.13	243.90	NS	NS	NS
D08	269.27	266.47	267.30	267.10	NS	NS	NS
D12	270.27	272.65	247.33	252.43	NS	NS	NS
D16	231.47	254.57	257.27	252.40	NS	NS	NS
D20	237.43	265.78	262.05	283.43	NS	NS	NS

[1]Fp, sows fed fresh placenta;Cp, sows fed cooked placenta.
[2]W9, sows fed 900g of placenta;W18, sows fed 1800g of placenta.
[3]C, condition effect;W, weight effect;C×W, condition×weight interaction.
**$P<0.05$;NS, not significant.

($P<0.05$) in W9 than in W18 on D01 but was not significantly different ($P>0.05$) on the other days. Calcium content was not affected ($P>0.05$) by C × W from D01 to D20. Magnesium and potassium contents were not significantly affected ($P>0.05$) by C, W and C×W from D01 to D20. Sodium content was greater in Fp than in Cp on D01 ($P<0.01$) and D08 ($P<0.05$) but was not significantly different ($P>0.05$) by C on other days. Sodium content was not significantly different ($P>0.05$) by W from D01 to D20. Sodium content was significantly affected ($P<0.05$) by C × W on D01 but was not affected ($P>0.05$) on other days. It is considered that C × W interactions significantly affected sodium content of sow's milk. This may have been due to the increase in minerals in sow's milk with intake of fresh placenta. These results show that content of calcium and magnesium in milk of sows were higher in sows fed fresh placenta than in those fed cooked placenta.

The variations of body weight (kg) and daily gain (g/day) in piglets of placenta-fed sows in Exp. 1 are presented in Table 6. Body weight on D01 was similar ($P>0.05$) between Ex and Ct. Body weight was significantly higher ($P<0.01$) in Ex than in Ct on D05, D10, D15 and D20. Daily gain on DG05 was significantly higher ($P<0.01$) in Ex than in Ct. Daily gain was similar ($P>0.05$) between Ex and Ct on DG10 and DG15. Daily gain was significantly higher ($P<0.01$) in Ex than in Ct on DG20 and TDG. According to these results, variations in body weight, daily

Table 5. Variations of mineral composition (mg/100 ml) in milk of sows fed placenta by the conditions and weights in experiment 2

Condition[1]	Fp		Cp		Significance[3]		
Weight[2]	W9	W18	W9	W18	C	W	C×W
Calcium (Ca)							
D01	381.3	332.6	380.8	331.9	NS	**	NS
D03	619.4	621.0	592.6	550.4	**	NS	NS
D08	646.6	671.5	630.6	605.9	NS	NS	NS
D12	666.9	616.3	618.1	584.6	NS	NS	NS
D16	710.8	746.8	653.6	645.3	**	NS	NS
D20	764.9	773.5	696.6	645.4	**	NS	NS
Magnesium (Mg)							
D01	95.4	121.8	118.5	103.3	NS	NS	NS
D03	102.4	119.4	108.8	112.2	NS	NS	NS
D08	107.3	125.2	105.8	117.0	NS	NS	NS
D12	106.7	126.0	107.8	119.1	NS	NS	NS
D16	115.6	126.7	112.3	121.0	NS	NS	NS
D20	124.1	134.6	123.1	117.5	NS	NS	NS
Potassium (K)							
D01	142.8	177.0	111.5	154.9	NS	NS	NS
D03	96.8	130.0	127.9	104.4	NS	NS	NS
D08	78.5	120.7	88.7	96.3	NS	NS	NS
D12	79.1	142.6	94.9	80.1	NS	NS	NS
D16	102.4	88.9	99.1	110.7	NS	NS	NS
D20	165.4	144.4	91.4	98.3	NS	NS	NS
Sodium (Na)							
D01	1425	1438	1299	1135	*	NS	**
D03	1141	1033	986	921	NS	NS	NS
D08	1027	985	939	920	**	NS	NS
D12	840	964	933	900	NS	NS	NS
D16	910	987	910	879	NS	NS	NS
D20	928	976	946	1084	NS	NS	NS

[1]Fp, sows fed fresh placenta;Cp, sows fed cooked placenta.
[2]W9, sows fed 900g of placenta;W18, sows fed 1800g of placenta.
[3]C, condition effect;W, weight effect;C×W, condition×weight interaction.
*$P<0.01$;**$P<0.05$;NS, not significant.

gain and total daily gain indicate that feeding placenta affected the growth of piglets. Li[10] reported that body weight of piglets improved by feeding placenta to sows. Our results in this study agree with this report.

The variations of body weight (kg) and daily gain (g/day) in piglets of sows fed placenta by the C and W in Exp. 2 are presented in Table 7. Body weight on D01 was not affected ($P>0.05$) by C, W or C×W. Body weight 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 ($P<0.01$). Body weight was not significantly different ($P>0.05$) by W on any days. Body weight 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 ($P<0.01$). Daily gain 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. Daily gain was not significantly different ($P>0.05$) by W on any days. Daily gain 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 ($P<0.01$). Our results indicate that feeding fresh placenta to sows improved the growth of piglets better than doing cooked placenta.

Table 6. Variations of body weight (kg) and daily gain (g/day) in piglets of sows fed placenta in experiment 1

	Body weight(kg)				Daily gain(g/day)		
Items	Ex	Ct	Significance	Items	Ex	Ct	Significance
D01	1.49	1.43	NS	DG05	162	109	*
D05	2.31	1.97	*	DG10	209	177	NS
D10	3.33	2.86	*	DG15	170	176	NS
D15	4.20	3.74	*	DG20	222	155	*
D20	5.30	4.51	*	TDG	191	154	*

[1]Ct, sows not fed placenta;Ex, sows fed placenta.
[2]DG05 was calculated from the difference between D05 and D01;DG10:between D10 and D06;DG15:between D15 and D11;DG20:between D20 and D16;TDG, total daily gain was calculated from the difference between D20 and D01.
*$P<0.01$ indicate significant difference between Ex and Ct;NS, not significant.

Table 7. Variations of body weight (kg) and daily gain (g/day) in piglets of sows fed placenta by the conditions and weights in experiment 2

Condition[1]	Fp		Cp		Significance[3]		
Weight[2]	W9	W18	W9	W18	C	W	C×W
Body weight (kg)							
D01	1.40	1.40	1.37	1.42	NS	NS	NS
D03	1.87	1.93	1.80	1.81	**	NS	NS
D08	2.80	2.91	2.62	2.47	*	NS	NS
D12	3.58	3.83	3.38	3.17	*	NS	**
D16	4.23	4.67	4.22	3.81	*	NS	*
D20	4.76	5.49	5.00	4.40	*	NS	*
Daily gain (g/day)[4]							
DG03	158	175	143	131	*	NS	NS
DG08	187	197	164	131	*	NS	*
DG12	195	230	190	177	*	NS	**
DG16	160	211	212	159	NS	NS	*
DG20	147	205	194	136	NS	NS	*
TDG	173	205	182	146	*	NS	*

[1]Fp, sows fed fresh placenta;Cp, sows fed cooked placenta.
[2]W9, sows fed 900g of placenta;W18, sows fed 1800g of placenta.
[3]C, condition effect;W, weight effect;C×W, condition×weight interaction.
[4]DG03 was calculated from the difference between D03 and D01;DG08:between D08 and D04;DG12:between D12 and D09;DG16:between D16 and D13;DG20:between D20 and D17;TDG, total daily gain was calculated from the difference between D20 and D01.
*$P<0.01$;**$P<0.05$;NS, not significant.

Some researchers reported that supplement of minerals affected the growth of piglets[11,12,14]. It is considered that C × W interactions significantly affected body weight and daily gain of piglets. This may have been due to the increase in minerals in sow's milk with intake of fresh placenta.

Many researchers have reported that the growth performance of piglets is related to the mineral compositions of blood and milk of sows[12,13,14]. Our results show that feeding placenta especially as fresh placenta improved mineral composition in plasma and milk of sows, and body weight and daily gain in piglets. On our study have found that fresh placenta was higher in mineral contents than cooked placenta and hence improved mineral intake in sows. LI[10] reported that placenta as feed to sows improved the growth of piglets. Our results agree with this report. Placenta feeding may have improved the mineral concentration in the milk. Hence, fresh placenta when supplied as feed to sows could affect the body weight and daily gain of piglets.

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母豚の胎盤摂取が血漿および乳中ミネラル含量と子豚の成長に及ぼす影響

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要　　約

母豚の胎盤摂取が母豚の血漿および乳中ミネラル含量と子豚の成長に与える影響について実験を行った。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、給与胎盤の状態（生区:Fpおよび加熱区:Cp）と量（900g区:W９および1800g区:W18）により、２×２要因実験を行った。実験１において、血漿では、カリウム含量は日齢１（D01）と日齢５（D05）にExがCtより高かった（P<0.05）。乳では、マグネシウム含量はD15に、カリウム含量はD01とD05にExがCtより高かった（P<0.05）。実験２において、血漿では、カリウム含量はD01にFpがCpより有意に高かった（P<0.05）。乳では、カリウム含量はD03、D16およびD20にFpがCpより有意に高かった（P<0.05）。実験１において、子豚の日増体量はDG05（D05の体重－D01の体重）、DG20（D20の体重－D15の体重）および総日増体量（TDG，D20の体重－D01の体重）はExがCtより高かった（P<0.01）。実験２において、日増体量はDG03（D03の体重－D01の体重）、DG08（D08の体重－D03の体重）およびDG12（D12の体重－D08の体重）にFpがCpより有意に高かった（P<0.01）。本試験の結果から、新鮮胎盤給与は母豚の血漿および乳中ミネラル含量と子豚の日増体量を高めることが明らかとなった。

キーワード：胎盤、血漿、乳、ミネラル、日増体量、子豚

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