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Iron Injection in Sow and Piglets on Blood Profiles, Milk Composition and Performance of Piglets

모돈과 자돈에게 철분주사가 번식성적, 포유자돈의 성적, 혈액성상, 돈유성분에 미치는 영향

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Summary

Improving the reproductive performance of sows and the growth performance of piglets by injecting iron has been a popular research topic around the world. Several studies have reported that iron-deficient sows have lower piglet birth weights, along with an elevated risk of piglet stillbirth. Iron levels have been shown to impact the pre-weaning survival of piglets. There have been various research investigating different methods and periods of iron injection in weaning piglets. However, no studies have been conducted to improve the reproductive performance of sows and the growth performance of piglets by injecting iron into sows in late pregnancy. Therefore, this study was conducted to evaluate the effects of iron injection during late gestation on the reproductive performance of sows, growth performance of nursing piglets, milk composition, and blood profiles. Additionally, the study aimed to determine the appropriate form of iron injection for weaning piglets. A total of 60 F1 multiparous sows (Yorkshire × Landrace) with average body weight (BW) of 259.1 ± 3.97 kg, backfat thickness of 25.7 ± 0.63 mm, and parity of 5.20 ± 0.281 were allotted to one of 4 treatments considering BW, backfat thickness, and parity in a complete randomized design (CRD) with 15 replicates. Treatments were 1) SNPG (no iron injection on sows and gleptoferron), 2) SNPD (no iron injection on sows and iron dextran), 3) SYPG (iron injection on sows and gleptoferron), and 4) SYPD (iron injection on sows and iron dextran). As a result, there were no significant differences in body weight and backfat thickness of sows measured within 24 hours of farrowing and on the 21st day of lactation when sows were injected with iron on day 110 of gestation. Iron injection to sows in late gestation did not have any significant effect on the number of total born, born alive, stillbirth piglets and litter performance. Iron injection to sows in late gestation or providing piglets with different types of iron did not show any significant differences in red blood cells, white blood cells, hematocrit, hemoglobin concentration, platelet, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, or iron concentration in the serum of sows and piglets Additionally, milk composition of lactating sows was not affected by iron injections.

Consequently, SNPG treatment with iron injection to piglets but no injection to sows is considered hindering body condition of sows, reproductive performance, and blood profiles, piglet's blood profiles, and milk composition.

Keywords : gleptoferron, iron dextran, late gestation, lactating sows, piglets

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List of Abbreviations

ADG	:	Average daily gain
ADFI	:	Average daily feed intake
AI	:	Artificial insemination
ANOVA	:	Analysis of variation
ARC	:	Agricultural Research Council
BF	:	Backfat
BW	:	Body weight
CRD	:	Completely randomized design
DCP	:	Dicalcium phospate
FCR	:	Feed conversion ratio
GLM	:	General linear model
IU	:	International unit
LSD	:	Least significance difference
ME	:	Metabolizable energy
MPB	:	Menadione dimethylpyrimidinol bisulfite
NRC	:	National Research Council
SAS	:	Statistical analysis system
SBM	:	Soybean meal
SEM	:	Standard error of the mean
WEI	:	Weaning to estrus interval

I. Introduction

Korea is highly dependent on imports of feed ingredients from other countries, making it highly sensitive to fluctuations in international grain market prices. The highest cost is also the price of the ingredients used in the feed. Recently, the ongoing conflict between Russia and Ukraine has led to increased, prices in infrastructure industries associated with countries exporting feed ingredients. This situation has had a significant adverse impact on the domestic livestock industry. While the introduction of hyper-prolificacy of modern hybrid sows in the late 1900s led to an increase in the number of piglets, there is insufficient availability of nutrients for all piglets to grow uniformly. In particular, a lack of nutrients received through sow’s milk has a significant impact on the productivity of the farm. For example, a deficiency in iron results in anemia, leading to growth retardation and increased mortality rates due to reduced feed intake.

Therefore, it is necessary to approach both the economic aspects of productivity and price as well as balanced supply of nutrients for the growth. By reducing unnecessary nutrients and adequately providing nutrient like iron, productivity can be effectively increased. Therefore, this study was conducted to evaluate the effects of feeding effects of iron injection on reproductive performance of sows, growth performance of nursing piglets, blood profiles, and milk composition.

II. Review of Literature

1. Introduction

1.1 Recent situation of livestock industry in Korea

The pig farming industry in Korea is facing many challenges such as the economic downturn and the African Swine Fever (ASF) issue. The industry is also affected by complex relationships with pig breeding and production in the United States, the European Union, Brazil, and Canada. According to the statistics of HanDon Farms by Korea Pork Producers Association(2021), there is a growing polarization of farm productivity in the Korea's pig industry. Therefore, It is crucial to focus on enhancing performance in order to secure competitiveness.

Productivity in pig farming is evaluated based on the number of piglets produced per sow per year. Piglet mortality is very important because it reduces farm productivity from the first stage of production. Mortality rates are higher in farrowing than in other production stages. Although pre-weaning mortality rates for piglets are high, post-weaning mortality rates are relatively low at about 2.5% (Muns et al., 2016). The rapid growth of piglets after birth, particularly in the case of multi-parity sows, leads to a rapid depletion of their body's iron reserve. This leads to anemia, which makes piglets weak and lowers their survival rate.

Piglets are born with a minimum of 40mg of iron (Venn et al.,1947). Depending on the concentration of iron, it protects against bacterial infections after childbirth and affects their growth performance. Piglets receive approximately 1mg of iron per day through the milk of gestating sows. However, since piglets require a minimum 7mg of iron per day, their iron reserves are sufficient for about 5 days. However, piglets with insufficient iron show symptoms of anemia and have low growth rates and high mortality rates. If an appropriate amount of iron is supplied, it can reduce unnecessary stress on Gestating Sows and piglets, reduce the use of antibiotics, and help productivity.

1.2 Supplementation of iron in swine farm

Right after birth, it is generally confirmed whether the placenta has completely come out. After that, the umbilical cord of the piglet is examined to verify if it has fully dried out and then given a birth treatment. Caution should be exercised if the umbilical cord is not completely dry, as there is a risk of the internal organs protruding through the umbilical opening. In the case of piglets, the timing of castration is determined by considering their health and growth status. Typically, castration is performed on the third day, once they have consumed an adequate amount of colostrum. At this time, teeth cutting, tail cutting, and iron injection are mostly done at the same time. There are various forms of iron supplements given to piglets raised in domestic pig farms.

Typically, iron supplementation is administered through intramuscular injection or oral administration. When performing various treatments such as birth treatment and other treatments on young piglets, stress is inevitably generated. Therefore, it is recommended to quickly and accurately complete the treatment and minimize additional contact afterward to reduce the total amount of stress.

All domestic pig farms administer iron injections, but an appropriate form of iron that can properly supply iron to mammalian pigs has not yet been determined.

2. Requirements of iron

Iron (Fe) is an essential component of hemoglobin in RBC. It is also present in muscle as myoglobin, in serum as transferrin, in the placenta as uteroferrin, in milk as lactoferrin, and in the liver as ferritin and hemosiderin (Zimmerman, 1980; Ducsay et al., 1984). it is also an important component of several metabolic enzymes in the body (Hill and Spears, 2001). Pigs are born with about 50 mg of Fe, most of which is present as hemoglobin (Venn et al., 1947). However, a high level of Fe fed to sows during late gestation (Brady et al., 1978) or parenteral administration of iron dextran to sows in gestation does not substantially increase placental transfer of Fe to fetuses (Rydberg et al., 1959; Pond et al., 1961; Ducsay et al.,1984). The postweaning dietary Fe requirement is reported to be about 80 ppm by some investigators but as high as 200 ppm by other authors. In later growth and maturity, Fe requirement diminishes as the rate of increase in blood volume slows. The recommended amount of iron intake for pregnant pigs in NRC2012 is about 80mg/kg (Table 1). Natural feed ingredients usually supply sufficient Fe to meet postweaning requirements. Feed-grade defluorinated phosphate and dicalcium phosphate, which contain from 0.6 to 1.0% Fe, also supply substantial amounts of Fe. Availability of Fe from different sources varies greatly. Ferrous sulfate, ferric chloride, ferric citrate, ferric choline citrate, and ferric ammonium citrate are effective in preventing Fe deficiency anemia (Harmon et al., 1967; Ammerman and Miller, 1972; Ullrey et al., 1973; Miller et al., 1981). Iron compounds with low solubility, such as ferric oxide, are ineffective (Ammerman and Miller, 1972). The bioavailability of Fe in ferrous carbonate is lower and more variable than that of Fe in ferrous sulfate (Harmon et al., 1969; Ammerman et al., 1974). The Fe in defluorinated phosphate is about 65% as available to the pig as the Fe in ferrous sulfate (Kornegay, 1972a). Soybean meal contains 175-200 ppm of Fe, and the bioavailability of Fe in soybean meal has been estimated to be 38%, based on hemoglobin depletion-repletion assays in chicks (Biehl et al., 1997). The Fe requirement of young pigs fed milk or purified liquid diets is 50-150 mg/kg of milk solids (Matrone et al.,1960; Ullrey et al., 1960; Manners and McCrea, 1964; Harmon et al., 1967; Hitchcock et al., 1974). suggested a requirement of 100 mg of Fe/kg of milk solids for pigs raised in a conventional or germ-free environment. The Fe requirement of pigs fed a dry, casein-based diet is about 50% higher per unit of dry matter than for those fed a similar diet in liquid form (Hitchcock et al., 1974). Studies have shown that a single intramuscular injection of 100-200 mg of Fe in the form of iron dextran, iron dextrin, or gleptoferron given in the first 3 days of life is effective (Barber et al., 1955b; McDonald et al., 1955; Maner et al., 1959; Rydberg et al., 1959; Ullrey et al., 1959; Zimmerman et al., 1959; Kernkamp et al., 1962; Pollmann et al., 1983). And a previous study comparison of gleptoferron with iron dextran on mortality and growth (Table 2). The intestinal mucosa of the newborn pig actively absorbs Fe (Furugouri and Kawabata, 1975, 1976, 1979). Oral administration of Fe from bioavailable inorganic or organic sources within the first few hours of life also meets the Fe needs of the suckling pig.

Table 1. Iron requirements of gestating and lactating sows (90% dry matter, NRC)

Mineral elements	Requirements of gestating sows (amount/kg of diet)
	NRC, 2012
Iron(mg/kg)	80
Copper(mg/kg)	20
Manganese(%)	0.15
Chlorine(%)	0.16
Zinc(mg/kg)	100
Selenium(mg/kg)	0.15
Iodine(mg/kg)	0.14

Table 2. Comparison of gleptoferron with iron dextran on mortality and growth

Criteria	Treatment			SEM[1)]
	Control	Iron dextran	Gleptoferron	
No. pigs	46	87	84	
No. died	5	10	6	
Mortality, %	10.9	11.5	7.1	
Average daily gain weight, kg				
Birth	1.5	1.5	1.5	0.04
3 weeks	4.8[2)]	5.3[3)]	5.3[3]	0.16
8 weeks	13.2[2)]	14.8[3)]	14.8[3)]	0.35

[1)] Standard error of mean

[2, 3)]Means within same with different superscripts differ (P<0.01)

(Pollmann et al., 1983)

3. Characteristics and functions of iron

Iron is a mineral that is present in small amounts in the body of animals and it is one of the important trace elements. Iron is a core component of hemoglobin, which is necessary for the formation of red blood cells and plays an important role in transporting oxygen in the blood. Iron is also used as a component of essential enzymes for various biological activities. Iron should be consumed in appropriate amounts, and if there is a lack of iron, it can cause symptom such as anemia. Anemia refers to a state where there is a lack of hemoglobin, which is a component that transports oxygen. Iron is an important component that makes up hemoglobin in red blood cells. In addition, it is important to accurately meet the daily iron requirements of animals because animals require it for functions such as homeostasis, growth, development, immunity. It is also found in myoglobin in muscles, transferrin in serum, ferritin and hemosiderin in the liver, lactoferrin in milk and uteroferrin in placenta. Iron plays an important role as a component of metabolic substances in the body. Piglets are born with about 50 mg of iron, most of which exists as hemoglobin. Mammals need to consume 7-16 mg of iron per day or 21 mg of iron per kg of body weight to maintain appropriate levels of hemoglobin and iron storage. Pig milk contains only an average of 1 mg of iron per liter. Therefore, piglets that consume only pig milk are easily susceptible to anemia. Feeding various iron compounds such as ferrous sulfate and iron chelate at high levels to pregnant and lactating sows does not increase the iron content of pig milk enough to prevent iron deficiency. The form of anemia caused by iron deficiency is hypochromic microcytic anemia. Pigs with anemia have delayed growth, lack of vitality, rough hair, wrinkled skin, pale mucous membranes. If fast-growing pigs become anemic, they suddenly die due to oxygen deficiency. Major symptoms include difficulty breathing even with small activity or convulsions in the diaphragm muscle. On autopsy, the liver is enlarged and fatty, the blood is thin having few platelets and watery, the heart is severely dilated, and the pancreas is hard and enlarged. Pigs with anemia are more susceptible to disease infection.

3.1 Gleptoferron

Iron supplementation via intramuscular injection is a common practice during the phase of rapid neonatal growth. This is because iron deficiency will invariably lead to anaemia during this phase. The authors suggested that reduced handling for application of therapeutic compounds at the same time. Iron supplementation and anticoccidial therapy may reduce stress for the piglets since animal manipulation is needed for all these interventions. The combination product of toltrazuril and gleptoferron provided an effective alternative approach to current conventional separate treatment for the prevention of iron deficiency anaemia and coccidiosis in neonatal piglets (Hiob et al., 2019). It reduced the numbers of potentially stressful interventions and work time.

3.2 Dextran

Dextran is classified by its average molecular weight and molecular weight distribution and is used in various fields such as pharmaceuticals and agriculture. The versatile use of dextran products is due to their neutral nature, water solubility, easy filtration, and biocompatibility. Injecting newborn piglets with varying doses of injectable dextran iron enhances their blood profiles and promotes improved growth performance during the nursing period. This is according to the experiment conducted (Chevalier et al., 2020). Increasing the dose of iron injection at birth increases ADG during the nursing period. The provided dose also affects the timing and size of the maximum Hb response.

4. Deficiency and toxicity of iron

4.1 Iron

Insufficient iron is the most prevalent nutritional issue among newborn mammals. However, only pigs showed the iron deficiency anemia, representing the most severe consequence of inadequate iron levels. This does not happen regularly in other mammals. Pigs with anemia are very susceptible to disease infections and their growth could be delayed and they could develop skin wrinkles and become lethargic due to iron deficiency anemia (Osborne and Davis, 1968). Piglets get iron injections in the muscle or under the skin when they are one to seven days age. This helps them avoid getting anemia from low iron levels. Sometimes the sows do not have sufficient vitamin E or selenium when they are pregnant. Then the piglets are born with low levels too. The iron requirement will gradually decrease as the blood volume increases with the growth stage. According to recent research results, it is explained that 200ppm is needed (Hill and Spears, 2001). If the recommended amount of iron is not supplied, probability is relatively higher susceptible to bacterial infection and have little resistance to environmental chilling.

Therefore, if visual symptoms such as growth retardation or lethargy are detected, it can be considered that the immune system or the growth rate of piglets has already been significantly negatively affected.

5. Effects of iron supplementation in gestating sows

5.1 Physiological response of sow

Iron is a very important trace element that is essential for all kinds of animals. Deficiency of iron in pregnant mammals could increase the risk of miscarriage and mortality. In the case of livestock, it can lead to low birth weight, high incidence of stillbirths and vulnerability to external diseases in piglets (Moore et al., 1965). Iron requirements typically rise during the late-gestation period due to increased usage, making iron supplementation crucial for the health and growth of both sows and piglets during this period (Wan, D et al., 2018). However, the amount of iron in sow's milk is not enough to meet the needs of fast-growing piglets (Svoboda and Drabek, 2005).

According to Bhattarai et al. (2019), the iron content in dry food for pregnant sows has remained unchanged at 80 mg/kg for the past 40 years. Attempts to administer higher doses of iron orally to the sows did not significantly impact their blood iron levels. This suggests that the current iron content in the food may be insufficient for sows with larger litters.

5.2 Reproductive performance and litter performance

According to Mahan and Newton (1995), the mineral content of sows such as iron decreases after three reproductive cycles, and the degree of decrease is exacerbated as the productivity of high-producing sows increases. During the late pregnancy period, the growth rate of fetuses and mammary glands increases significantly. In particular, if nutrients are insufficient during this period when nutrients such as nutrition and oxygen are transmitted from sow to offspring, fetal development may be hindered (Guo et al., 2022). It is also known that the sow has high metabolic activity during the lactation period (Williams et al., 2013).

5.3 Iron concentration of blood

Newborn piglets grow rapidly in the immediate postnatal period and therefore require large amounts of iron. Metabolic activity related to iron in suckling pigs requires 7mg to 16mg of iron per day (NRC 1998). Iron is involved in the metabolic process as a component of hemoglobin in the blood. According to Zhao et al. (2015), when ferrous dextran was administered, it was conducted on sow's growth performance and blood characteristics. This experiment, showed that the injection of ferrous dextran increased the concentration of iron, white blood cells, red blood cells, and hemoglobin in the blood of piglets. The systemic iron concentration is a critical factor that affects the risk of anemia, premature birth, low birth weight in infants, and delayed maturation in piglet (Zhang et al., 2017)

III. Iron Injection in Sow and Piglets on Blood Profiles, Milk Composition and Performance of Piglets

ABSTRACT: This experiment was designed to verify the effects in body condition, reproductive performance, blood profiles, and milk composition of sows and growth performance of piglets in regard to iron injection on sows in late gestation and types of iron injection on piglets. a total of 60 F1, crossbred ([Yorkshire x Landrace]) sows (average parity: 5.20 ± 0.281) with an average mean body weight of 259.1 ± 3.97 kg were selected and allotted in a completely randomized design (CRD) per sow for each replicate with four treatments and 15 replicates. During gestation, sows were placed to gestation stalls (2.4 × 0.64 m^2) for 110 days of gestation. On the 110th day, they were relocated to farrowing stalls (2.5 × 1.8 m^2). Temperature and ventilation of all stalls were automatically adjusted by ventilation fans and automatic control devices. The experiment followed a two-factor design that involved iron injection to sows and types of iron injection to piglets (gleptoferron, dextran + iron). Sows in the iron-injection control group were injected with 200 mg/ml of iron on the 100th day of gestation, were limit-fed for five days after farrowing, and had unlimited access to feed afterward. On the third day after birth, all piglets went through several procedures of clipping naval cords, docking tails, castrating, and being injected with 200 mg/ml of iron.

The result showed no significant difference in body weight or backfat thickness measured within 24 hours of farrowing and 21st day of lactation when sows were injected with iron on day 110 of gestation (P>0.05). There was no distinctive difference in lactating sows’ feed intake (P>0.05). No notable differences were made in the number of litters farrowed, stillborn piglets, pigs born alive, piglets per lactating sow, weaned piglets, birthweight, and weaning weight from the experiment (P>0.05). Injecting iron to sows in late gestation or providing piglets with different types of iron didn't draw any significant differences in red blood cells, white blood cells, hematocrit, hemoglobin concentration, platelet, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, or iron concentration in the blood of sows and piglets (P>0.05). The levels of casein, protein, fat, total solids, solids-not-fat, and lactose concentration were not presenting meaningful differences either with iron injections on sows (P>0.05). The economic analysis showed no statistical differences among the treatments. However, SNPG treatment, which is the group that piglets were injected with gleptoferron while sows were not injected with anything, turned out to have the lowest total production cost per sow at 133,228 won and per piglet as well at 10,982 won.

Therefore, SNPG treatment with gleptoferron injection to piglets but no injection to sows is considered to be most economical without hindering sow's body condition, reproductive performance, and blood profiles, piglet's blood profiles, and milk composition.

Key words: Iron, Blood profiles, Reproductive performance, Piglets, Sow

Introduction

Iron plays an essential role as a component of various metabolites in pigs, and it is one of the major components of hemoglobin in RBC (Hills & Spears, 2001). In addition, it is present in myoglobin, transferrin in serum, uteroferrin in the placenta, ferritin, and hemosiderin in the liver (Zimmerman, 1980). To maintain adequate hemoglobin levels and store iron, piglets require a daily intake of 7 to 16 mg of iron or 21 mg per kilogram of body weight gain (Braude et al., 1962). However, piglets are susceptible to anemia since sows' milk contains only 1 mg per L on average (Venn et al., 1947; Brady et al., 1978).

Improving the reproductive performance of sows and the growth performance of piglets by injecting iron has been a popular research topic all across the world. Several studies reported that iron-deficient sows lower the birthweight of piglets, not to mention a high probability of piglet stillbirth (Halbald and Hancock et al., 1939; Moore et al., 1965). It's known that the level of iron affects the pre-weaning survival of piglets (Bhattai et al., 2019). According to research conducted by Svoboda and Drabek (2005), 200 mg of iron dextran injection on 3-day-old piglets increases their weight measured on the 28th day after birth. In addition, piglets injected with iron on the 21st day after birth have shown an increase in the level of hemoglobin concentration and hematocrit. Another research done by Streyl et al. (2015) showed a meaningful increase in body weight of piglets that were injected with 228 mg of iron dextran on 21-day of weaning when test groups of newly-born piglets were injected with 200 mg and 228 mg of iron dextran, respectively.

There have been various research exploring different methods and periods of iron injection on weaning piglets. However, no studies have been conducted to improve the reproductive performance of sows and the growth performance of piglets by injecting iron into sows in late gestation period.

Therefore, this study is designed to verify how iron injection affects the reproductive performance of sows, the growth performance of nursing piglets, milk composition, and blood profile as well as to determine the appropriate form of iron injection on nursing piglets.

Materials and Methods

Experimental animals and management

All experimental procedures involving animals were conducted in accordance with the Animal Experimental Guidelines provided by the Seoul National University Institutional Animal Care and Use Committee.

A total of 60 F1 multiparous sows (Yorkshire × Landrace) with average body weight (BW) of 259.1 ± 3.97 kg, backfat thickness of 25.7 ± 0.63 mm, and 5.20 ± 0.281 parity were housed in an individual gestation stall to be artificially inseminated. All sows were allotted to one of 4 treatments considering BW, backfat thickness, and parity in completely randomized design (CRD) with 15 replicates. During gestation, sows were placed to gestation stalls (2.4 × 0.64 m^2) for 110 days of gestation. On the 110th day, they were relocated to farrowing stalls (2.5 × 1.8 m^2). Temperature and ventilation of all stalls were automatically adjusted by ventilation fans and automatic control devices. The experiment followed a two-factor design that involved iron injection to sows and types of iron injection to piglets (gleptoferron, dextran + iron). Sows in the iron-injection control group were injected with 200 mg/ml of iron on the 100th day of gestation, were limit-fed for five days after farrowing, and had unlimited access to feed afterward. On the third day after birth, all piglets went through several procedures of clipping naval cords, docking tails, castrating, and being injected with 200 mg/ml of iron.

Experimental design and design

Pigs were allotted to one of four treatments: 1) SNPG (no iron injection on sows and gleptoferron), 2) SNPD (no iron injection on sows and iron dextran), 3) SYPG (iron injection on sows and gleptoferron), and 4) SYPD (iron injection on sows and iron dextran). Sows were injected with iron as gleptoferron. A corn-soybean meal based diet was used in the experiment. The gestating sow feed contains 12.00% of crude protein, 0.74% of lysine, 0.23% of methionine, 0.75% of calcium, and 0.60% of total phosphorus. The lactating sow feed contains 13.43% of crude protein, 0.96% of lysine, 0.26% of methionine, 0.76% of calcium, and 0.65% of total phosphorus. The levels of other amino acids, vitamins, and minerals were met or exceeded the requirement of NRC (1998). The formula and chemical composition of experimental diets are presented in Table 1. Commercial sow feeds produced by Daehan feed were used for gestating sows and lactating sows.

Body condition

Lactating sows' body weight within 24 hours of farrowing, body weight on the 21st day, backfat thickness at P_2 position, and their feed intake were measured in order to examine their physiological changes. Backfat thickness was measured at P_2 position (mean value from both sides of the last rib and 65 mm away from the backbone) using an ultrasound device (Lean-meter, Renco Corp., Minneapolis, USA).

Reproductive performance

Piglets' body weight and daily weight gain were measured within 24 hours of farrowing, and again on day 21 of lactation in order to measure growth performance of piglets and lactation performance of sows. The period between the first day of weaning and the first day sows showed heat in gestation stalls was measured to determine weaning to estrus interval (WEI) of sows.

Milk composition

Colostrum and milk were collected by injecting 0.5 IU/ml of oxytocin intravenously within 24 hours after farrowing and day 21 of lactation. The collected milk was stored in a freezer at 20℃ until analyzed. The level of casein, fat, protein, lactose, total solids, and solids not fat (SNF) in collected milk was measured using a milk analyzer (MilkoScan FT20, FOSS Electric Co., Denmark).

Blood profiles

Blood of sows was collected on day 21 of gestation, within 12 hours of farrowing, and day 21 of lactation. Blood of piglets was collected within 12 hours after birth and the 21st day of lactation. Each blood was collected in plasma tube and serum tube. Collected serum tubes were centrifuged (Eppendorf centrifuge 5810R, Hamburg, Germany) for 15 min at 3,000 rpm at 4℃. Then the samples were stored in microtubes at 4℃ after removing the supernatant. Collected plasma tubes were immediately refrigerated at 4℃. The stored plasma tubes were used to analyze white blood cells, red blood cells, hemoglobin, hematocrit, and platelets, whereas the stored serum tubes were used to analyze iron.

Results and Discussion

Body weight, backfat thickness, daily feed intake and WEI

Table 2 shows how iron injections on sows in late gestation and the types of iron injection on lactating piglets affect sows' body weight and backfat thickness during lactation. According to the experiment, there were no significant differences in sows' body weight, backfat thickness, and daily feed intake during lactation that measured either within 24 hours of farrowing or day 21 of farrowing (P>0.05). There was no significant difference in feed intake among the treatments (P>0.05). The result of the WEI analysis showed no significant difference among the treatments (P>0.05).

Decreased feed intake during lactation leads to excessive weight loss which may cause various problems related to reproduction as well as WEI (Baidoo et al., 1992). Additionally, several research results reported that the nutritional and metabolic state of lactating sows affect WEI (Foxcroft, 1996; Pettigrew et al., 1998). Feed type during gestation and feed intake (O'Grady, 1967; Young and King, 1981), post-weaning feed intake (Brooks and Cole, 1972), and lactation period (Baker et al., 1953; Self and Grummer, 1958) are a few of many other factors known to influence WEI.

According to a precedent study done by Verum et al. (1965), no significant differences were found in sows' body weight or weight gain in treatments when

150 mg of iron dextran was injected into sows. Backfat thickness of sows remained consistent even after third parity when they were injected with 100 mg of iron dextran (Ashemead, 1993). Another relevant research conducted by Zhao et al. (2015) found no significant differences in sows' body weight, backfat thickness, and feed intake in treatments when sows were injected with 50 mg of iron dextran while 0.1% or 0.2% of iron was supplied in the form of bacterial iron in their feed. There was no significant difference in feed intake among treatments when 0.2% of iron was supplied in the form of iron chelate in the sow feed (Barros et al., 2019). Therefore, it is considered to have no effect on WEI after weaning since there were no differences in feeds during gestation, feed intake during lactation, and lactation period in this experiment. In other words, iron injection to sows in late gestation is not considered to have negative effects in terms of their body weight, backfat thickness, feed intake, or WEI.

Reproductive performance of sows and growth performance of nursing piglets

Table 3 shows how iron injection on sows in late gestation and types of iron injection on nursing piglets are related to sows' reproductive performance and piglets' growth performance in lactation. There were no significant differences in the number of litters farrowed, stillborn piglets, pigs born alive, piglets per lactating sow, weaned piglets, birthweight, and weaning weight from the experiment ($P>0.05$). No significant differences were found in the reproductive performance of sows in treatments when supplied with 0.2% of iron in the form of iron chelate in the feed from preceding research (Barros et al., 2019). Another relevant report by Bhattarai et al. (2019) also didn't find any significant differences either in the total number of litters farrowed, the number of stillborn piglets, or birthweight of piglets when 200 mg of iron dextran was injected into sows. In addition, Wang et al. (2014) reported that they couldn't find meaningful differences in reproductive performance of sows and growth performance of piglets in cases of adding 103 mg of iron methionine chelate and 107 mg of ferrous sulfate into sows' feed on day 84 of gestation. In terms of birthweight of newly-born piglets, there was no notable difference between injecting 200 mg and 228 mg of iron dextran. However, a meaningful weight gain was observed in the treatment injected with 228 mg on day 21 of weaning (Streyl et al., 2015). No noticeable difference was reported neither in piglets' weaning weight when 150 mg of ferrous fumarate was added to lactating sows' feed nor in piglets' weight gain with 150 mg of iron dextran injected to them (Veum et al., 1965). Similarly, Schoneweis and Allee (1977) found that there were no distinctive differences in piglets' birthweight and weaning weight when 150 mg of iron proteinate was added to sows' feed for 30 days in the period of late gestation and 28 days in lactation. It is also reported that there was no significant difference in weight gain of piglets whether they were injected with 200 mg of iron dextran or 300 mg in treatments (Murphy et al., 1997). According to the findings proceeded by Barros et al. (2019), treatments showed no noteworthy difference in reproductive performance when 0.15% of iron chelate was added to their feed. Wang et al. (2014) reported that they failed to find distinctive evidence on how the level of iron in sows and piglets affect the growth performance of piglets during lactation and the number of litters farrowed. The total weight gain of piglets is indirectly measured by the estimated amount of milk production. This reported that piglet's body weight increases by 1 g per 3.88 g of milk intake (Clowes et al., 1998). Sow milk provides piglets with the nutrition they need. Known that higher feed intake helps produce more milk which has a positive influence on piglet's growth performance (Gourdine et al., 2006). Sow's milk production and its composition are closely related to the growth rate of piglets during lactation (Nobel and Etienne et al., 1989). In this experiment, no distinctive differences were observed in the growth performance of piglets since 200 mg of iron injection on piglets suffices their iron requirement, and there was no significant difference in milk composition in treatments.

As a result, injecting iron to sows in late gestation and providing piglets with different types of iron did not appear to hinder the reproductive performance of sows or the growth performance of piglets during lactation.

Blood profiles of sows

The effects of iron injection on sows during late gestation and types of iron injection on nursing piglets on blood profiles of sows is presented in Table 4.

This experiment’s result shows no significant differences in red blood cells (RBC), white blood cells (WBC), hematocrit (HCT), hemoglobin concentration (Hb), platelet, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and iron concentration of sows when they are injected with iron in late gestation.

According to a previous study conducted by Bhattarai et al. (2019), no notable differences were found in Hb, RBC, HCT, MCV, MCH, MCHC, red blood cell distribution width (RDW), and hemoglobin distribution width (HDW) when sows were injected with 100 mg of ferrous fumarate. Zhao et al. (2015) reported that no significant differences were observed in iron level, RBC, WBC, Hb, and lymphocytes when 50 mg of iron dextran was injected to sows. Additionally, no notable differences were found in RBC, Hb, and serum iron concentration between treatments within 24 hours and on day 21 of lactation when 0.2% of inorganic and organic type of chelated iron was added to sow feed on 86th day of gestation. One study done by Klenbeck and Mcglone (1999) showed a significant difference in WBC when 200 mg of iron dextran was injected to sows. Meanwhile, another study by Veum et al. (1965) reported that there was no notable difference in hemoglobin level in treatments when sows were injected with 200 mg of iron dextran. The normal RBC range for lactating sows is 4.1-5.1 106/μP, and the normal HCT range is 35-46% (Marshall et al., 2011). The normal Hb range is 10.13-11.37 g/dl (Girard et al., 1996), and the normal MCV range is 65.6-77.2 fL (Made and Wujanz, 1997). Therefore, the fact that all RBC, HCT, Hb, MCV were in the normal range may have contributed to this experiment's result which iron injection on sows in late gestation or various type of iron injected to piglets did not have a negative impact on blood profiles of sows.

To sum up, injecting iron to sows in late gestation or giving various type of iron to piglets may not lead to negative results in sows' blood profiles.

Blood profiles of piglets

Table 5 showed the effects of iron injection on sows in late gestation and types of iron injection on nursing piglets on blood profiles of piglets.

There were no significant differences in RBC, WBC, HCT, Hb, platelet, MCV, MCH, MCHC, or iron concentration in the blood of piglets when sows were injected with iron in late gestation and different types of iron were injected into piglets ($P>0.05$).

Generally, the combination of diferric transferrin and Tf receptor 1 needs to be carefully regulated to facilitate the delivery of iron from the sow's placenta to the piglet. However, it remains challenging to ensure successful transfer of iron to the piglet's bloodstream (Lipinski et al., 2012). The level of iron transferred from sow to piglet is known to be extremely low compared to other mammals due to the fact that iron delivered through the placenta is little to none (Douglas et al., 1972).

The previous researches indicated notable differences in piglets' RBC, Hb concentration, and platelet measured on the first day of birth as the added amount increased when ferrous glycine chelate was gradually added to sow feed from day 86 of gestation through the lactation period (Bollwahn et al., 1972; Li et al., 2018). An increase in piglets' Hb concentration and the level of iron in milk was observed when sows were injected with 100 mg of iron dextran during gestation and lactation (Furugouri et al., 1975).

Mcgowan and Crichton (1924) conducted a study that there was a significant increase in RBC and Hb concentration level in piglets' blood when they were injected with 150 mg of iron dextran. However, Veum et al. (1965) reported that injecting 200 mg of iron dextran to piglets did not show any notable difference in Hb concentration in treatments. Also, there was no significant difference in RBC concentration between 14-day-old piglets and 21-day-old piglets when they were injected with 52 mg of glutamic acid-chelated Fe (Egeli and Framstad, 1998). Similarly, Schoneweis and Allee (1977) reported that their treatments showed no difference in Hb concentration when 150 mg of iron proteinate was added to sow feed for 30 days in late gestation and 28 days during lactation. Moreover, the amount of iron delivered from the placenta or milk did not increase even though 140 mg of ferrous iron was injected into sows during gestation or lactation (Pond et al., 1961) 7 mg of iron per day is required to prevent nursing piglets from getting anemia (Venn et al., 1947), and the same amount of iron is needed every day for them to keep their Hb concentration and iron to the normal level (Braude et al., 1962). Therefore, injecting nursing piglets with 200 mg of iron dextran on day 3 after birth keeps them safe from getting anemia (Carlsson et al., 1974; Yu et al., 2002). Egeli and Framstad (1999) observed that there was no significant difference in the treatments when injecting 180 mg of iron dextran to 1-day-old piglets, as it already provided enough iron intake to meet their requirements for a span of three weeks. Treatments of this experiment did not present much significant difference because the 200 mg of iron injection on 3-day-old piglets already met their iron requirement.

Consequently, injecting sows with iron in late gestation or giving a various type of iron to piglets may not have a negative impact on the blood profiles of piglets.

Milk composition of sows

Table 6 indicated how iron injection on sows in late gestation and types of iron injection on nursing piglets affect lactating sows' milk composition.

The concentration levels of casein, protein, fat, total solids, solids-not-fat, and lactose didn't present much distinctive difference even with iron injections on sows or a various type of iron injections on piglets ($P>0.05$).

It was reported that required iron intake of sows during gestation, iron content in the feed, and types of iron might affect the composition of colostrum (Peters et al., 2010). Iron intake during the last stage of fetal growth in sows has the greatest impact on piglet development, as it influences the formation of colostrum, which typically begins before farrowing (Papadopoulos et al., 2009). Feed intake during gestation is known to affect the components of milk than that of lactation (Boyd and Kensinger, 1998). Coffey and Britt (1993) reported that sow milk tends to contain more lipid because iron is stored in muscles or bones rather than in fat. Nutrients stored in sows are primarily used to produce milk, but their effect on milk components is relatively small (Peters, 2010). Colostrum contains 2 ppm of iron, whereas milk only contains half of it (1 ppm). According to a study conducted by Miler and Ulrey (2012), 100 mg of iron dextran injection on sows did not produce significant differences in the iron content of colostrum and milk because milk is not where iron is reserved. In addition, lactating sows require a sufficient amount of nutrients for milk production. It has already been reported that the better than sows are fed, the more milk with the improved quality they produce (Boyd and

Kensinger et al., 1998). In that sense, no noteworthy difference in sows' feed intake in this experiment led to little changes in milk composition, including the concentration levels of casein, protein, fat, total solids, solids-not-fat, and lactose.

Therefore, injecting iron to sows in late gestation and providing piglets with different types of iron do not appear to influence milk composition negatively.

Conclusion

This experiment was designed to verify the effects in body condition, reproductive performance, blood profiles, and milk composition of sows and growth performance of piglets in regard to iron injection on sows in late gestation and types of iron injection on piglets.

The result showed no significant difference in body weight or backfat thickness measured within 24 hours of farrowing and 21st day of lactation when sows were injected with iron on day 110 of gestation ($P>0.05$). There was no distinctive difference in lactating sows' feed intake ($P>0.05$). No notable differences were made in the number of litters farrowed, stillborn piglets, pigs born alive, piglets per lactating sow, weaned piglets, birthweight, and weaning weight from the experiment ($P>0.05$). Injecting iron to sows in late gestation or providing piglets with different types of iron didn't draw any significant differences in RBC, WBC, HCT, Hb, platelet, MCV, MCH, MCHC, or iron concentration in the blood of sows and piglets ($P>0.05$). The levels of casein, protein, fat, total solids, solids-not-fat, and lactose concentration were not presenting meaningful differences either with iron injections on sows ($P>0.05$). Therefore, SNPG treatment with iron injection to piglets but no injection to sows is considered hindering body condition of sows, reproductive performance, and blood profiles, piglet's blood profiles, and milk composition.

Table 1. The Formulas and chemical composition of the experimental gestation diet

Item	Gestating sow	Lactating sow
Ingredient (%)		
Corn	76.80	68.21
SBM-46	11.98	15.36
Wheat	0.00	5.00
Wheat bran	5.99	5.00
Tallow	1.78	2.79
L-lysine HCL, 78%	0.26	0.41
DL-methionine	0.04	0.03
DCP	1.35	1.53
Limestone	1.20	1.07
Vitamin premix[1)]	0.10	0.10
Mineral premix[2)]	0.10	0.10
Choline chloride-50	0.10	0.10
Salt	0.30	0.30
Sum	100.00	100.00
Chemical composition[3)]		
ME, kcal/kg	3,265.03	3,300.00
CP, %	12.00	13.43
Lysine, %	0.74	0.96
Methionine, %	0.23	0.26

Ca, %	0.75	0.76
Total P, %	0.60	0.65

[1)] Provided the following quantities of vitamins per kg of complete diet : Vit. A, 4,000 IU; Vit. D_3, 800 IU; Vit. E, 44 IU; Vit. K_3, 0.50 mg; Biotin, 0.20 mg; Choline, 1.00 g; Folate, 1.30 mg; Niacin, 10 mg; Pantothenic acid, 12 mg; Rivoflavin, 3.75 mg; Thiamin, 1.00 mg; Vit. B_6, 1.00 mg; Vit. B_{12}, 15 ug.
[2)] Provided the following quantities of minerals per kg of complete diet : Na, 0.20%; Cl, 0.16%; Mg, 0.06%; K, 0.20%; Cu, 20 mg; I, 0.14 mg; Fe, 80 mg; Mn, 25 mg; Se, 0.15 mg; Zn, 100 mg.
[3)] Calculated value.

Table 2. Effects of iron injection in late gestation and different types of iron injection in piglets on physiological responses, average daily feed intake and weaning to estrus interval during lactation

Criteria	Treatments[1)]				SEM[2)]	P-value
	SNPG	SNPD	SYPG	SYPD		
Body weight, kg						
24 hr postpartum	261.94	269.97	256.34	256.46	3.966	0.93
21^{st} day of lactation	254.55	251.50	249.69	245.82	3.784	0.88
Changes (0-21d)	-6.09	-10.46	-6.64	-10.64	2.329	0.85
Backfat thickness, mm						
24 hr postpartum	25.86	26.46	25.50	24.89	0.720	0.90
21^{st} day of lactation	24.46	24.23	23.57	23.00	0.803	0.92
Changes (0-21d)	-0.89	-2.23	-1.89	-1.89	0.260	0.30
ADFI, kg	5.16	5.41	5.06	5.22	0.155	0.89
WEI, day	5.00	4.25	4.50	5.25	4.730	0.31

[1)] SNPG: no iron injection to sows + gleptoferron to piglets, SNPD: no injection to sows + iron dextran to piglets, SYPG: iron injection to sows + gleptoferron to piglets, SYPD: iron injection to sows + iron dextran to piglets.
[2)] Standard error of means.

Table 3. Effects of iron injection in late gestation and different types of iron injection in piglets on reproductive performance during lactation

.	Treatments[1)]				SEM[2)]	P-value
	SNPG	SNPD	SYPG	SYPD		
Reproductive performance, N						
Total born/litter	13.07	12.77	13.64	13.14	0.293	0.78
No. of born alive	11.86	11.77	12.50	12.43	0.253	0.66
No. of stillbirths	1.07	1.00	1.14	0.71	0.139	0.72
After cross-foster[3)]	12.21	12.23	12.14	12.00	0.138	0.94
21^{st} day of lactation	10.43	10.38	10.21	10.21	0.170	0.96
Litter weight, kg						
Total litter weight	18.44	19.75	17.98	17.82	0.431	0.40
Litter birth weight	17.38	18.49	16.93	17.14	0.432	0.61
After cross-foster	17.77	19.41	16.29	16.42	0.367	<0.01
21^{st} day of lactation	59.32	60.81	55.99	57.64	1.557	0.73
Litter weight gain	41.55	41.40	39.69	41.23	1.515	0.97
Piglet weight, kg						
Piglet birth weight	1.46	1.59	1.37	1.38	0.032	0.05
After cross-foster	1.46	1.59	1.34	1.38	0.031	0.02
21^{st} day of lactation	5.64	5.83	5.47	5.61	0.092	0.61
Piglet weight gain	4.18	4.24	4.12	4.23	0.086	0.96

[1)] SNPG: no iron injection to sows + gleptoferron to piglets, SNPD: no injection to sows + iron dextran to piglets, SYPG: iron injection to sows + gleptoferron to piglets, SYPD: iron injection to sows + iron dextran to piglets.
[2)] Standard error of means.
[3)] After cross-fostering day within 24 hrs postpartum.

Table 4. Effects of iron injection in late gestation and different types of iron injection in piglets on blood profiles of sows during lactation

Criteria	Treatments[1)]				SEM[2)]	P-value
	SNPG	SNPD	SYPG	SYPD		
RBC[3)], 10^6/μL						
Initial	--------------5.05-------------					
21^{st} day of lactation	4.52	5.20	4.78	4.80	0.131	0.39
WBC[4)], 10^3/μL						
Initial	-------------14.97-------------					
21^{st} day of lactation	13.21	16.82	13.84	15.59	0.735	0.33
HCT[5)], %						
Initial	-------------35.34-------------					
21^{st} day of lactation	34.42	38.55	36.80	36.22	0.795	0.38
Hb[6)], g/dL						
Initial	-------------26.75-------------					
21^{st} day of lactation	10.42	11.48	11.00	10.80	0.229	0.49
Platelet, 10^3/μL						
Initial	------------179.91-------------					
21^{st} day of lactation	220.40	285.50	211.20	218.00	11.193	0.08
MCV[7)], fL						
Initial	-------------66.06-------------					
21^{st} day of lactation	76.60	74.05	77.02	75.92	0.824	0.67
MCH[8)], pg						
Initial	-------------39.36-------------					
21^{st} day of lactation	23.18	22.00	22.98	22.70	0.282	0.55
MCHC[9)], g/dL						
Initial	-------------35.81-------------					
21^{st} day of lactation	30.26	29.75	29.86	29.88	0.179	0.79
Iron, μg/dL						
Initial	-------------64.65-------------					
21^{st} day of lactation	99.40	86.25	123.40	111.00	5.422	0.09

[1] SNPG: no iron injection to sows + gleptoferron to piglets, SNPD: no injection to sows + iron dextran to piglets, SYPG: iron injection to sows + gleptoferron to piglets, SYPD: iron injection to sows + iron dextran to piglets.
[2] Standard error of means.
[3] RBC: red blood cell count.
[4] WBC: white blood cell count.
[5] HCT: hematocrit.
[6] Hb: hemoglobin concentration.
[7] MCV: mean corpuscular volume.
[8] MCH: mean corpuscular hemoglobin.
[9] MCHC: mean corpuscular hemoglobin concentration.

Table 5. Effects of iron injection in late gestation and different types of iron injection in piglets on blood profiles of piglets during lactation

Criteria	Treatments[1)]				SEM[2)]	P-value
	SNPG	SNPD	SYPG	SYPD		
RBC[3)], 10^6/μL						
Initial	--------------4.53--------------					
21^{st} day of lactation	5.98	5.82	5.76	6.08	0.385	0.87
WBC[4)], 10^3/μL						
Initial	--------------8.75--------------					
21^{st} day of lactation	9.78	11.54	11.26	11.23	1.134	0.88
HCT[5)], %						
Initial	------------34.72-------------					
21^{st} day of lactation	43.57	42.13	43.37	44.55	2.095	0.83
Hb[6)], g/dL						
Initial	--------------9.22--------------					
21^{st} day of lactation	12.73	12.23	12.67	13.05	0.623	0.84
Platelet, 10^3/μL						
Initial	--------------354.65---------------					
21^{st} day of lactation	456.67	487.67	348.33	420.50	27.835	0.26
MCV[7)], fL						
Initial	-------------77.05-------------					
21^{st} day of lactation	73.03	72.40	75.23	73.40	1.452	0.44
MCH[8)], pg						
Initial	-------------20.47-------------					
21^{st} day of lactation	21.40	21.00	21.93	21.45	0.404	0.52
MCHC[9)], g/dL						
Initial	-------------26.58-------------					
21^{st} day of lactation	29.30	29.03	29.17	29.30	0.361	0.98
Iron, μg/dL						
Initial	-------------69.17-------------					
21^{st} day of lactation	131.00	146.20	153.20	131.40	23.696	0.70

[1] SNPG: no injection + gleptoferron to piglets, SNPD: no injection + iron dextran to piglets, SYPG: iron injection to sows + gleptoferron to piglets, SYPD: iron injection to sows + iron dextran to piglets.
[2] Standard error of means.
[3] RBC: red blood cell count.
[4] WBC: white blood cell count.
[5] HCT: hematocrit.
[6] Hb: hemoglobin concentration.
[7] MCV: mean corpuscular volume.
[8] MCH: mean corpuscular hemoglobin.
[9] MCHC: mean corpuscular hemoglobin concentration.

Table 6. Effects of iron injection in late gestation and different types of iron injection in piglets on milk composition during lactation

Criteria	Treatments[1) SNPG	SNPD	SYPG	SYPD	SEM[2)]	P-value
Casein						
24 hr postpartum		-----------5.72-----------				
21st days of lactation	3.77	3.98	3.88	3.90	0.058	0.69
Protein						
24 hr postpartum		-----------8.19-----------				
21st days of lactation	4.74	5.00	4.85	4.80	0.087	0.81
Fat						
24 hr postpartum		-----------7.03-----------				
21st days of lactation	6.07	6.95	6.29	7.20	0.270	0.41
Total solid						
24 hr postpartum		-----------21.52-----------				
21st days of lactation	17.84	19.22	18.28	19.14	0.303	0.32
SNF						
24 hr postpartum		-----------13.39-----------				
21st days of lactation	11.14	11.51	11.29	11.17	0.094	0.59
Lactose						
24 hr postpartum		-----------4.21-----------				
21st days of lactation	5.61	5.68	5.73	5.71	0.038	0.70

[1)] SNPG: no injection + gleptoferron to piglets, SNPD: no injection + iron dextran to piglets, SYPG: iron injection to sows + gleptoferron to piglets, SYPD: iron injection to sows + iron dextran to piglets.
[2)] Standard error of means.

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V. Summary in Korean

본 실험은 철분주사가 모돈의 체형변화, 번식성적, 포유자돈 성적, 돈유성분 및 혈액성상에 미치는 영향을 검증하고자 수행되었다. 본 실험은 평균체중이 259.1 ± 3.59kg 인 2 원 교잡종 (Yorkshire × Landrace) F1 모돈 60 두를 선발하여 4 처리, 15 반복, 반복 당 한 두씩 완전임의 배치법(CRD)으로 배치하였으며, 처리구는 모돈 철분주사 여부와 자돈의 철분제 철 공급형태에 따라 1) A (모돈 철분 주사 X +gleptoferron) 2) B (모돈 철분 주사 X + iron dextran) , 3) C (모돈 철분 주사 O + gleptoferron) 4) D (모돈 철분 주사 O + iron dextran)로 나뉘었다. 모돈의 철분주사제는 gleptoferron 을 사용하였다. 실험결과, 임신기 110 일령에 모돈에게 철분주사를 투여하여도 분만 24 시간이내 및 포유 21 일령의 체중 및 등지방 두께에서 유의적인 차이가 나타나지 않았다 (P>0.05). 또한, 포유기 모돈의 사료섭취량에서도 유의적인 차이가 나타나지 않았다 (P>0.05). 번식성적 및 자돈성적에 있어서 임신 말기 모돈에게 철분주사를 투여하고, 포유자돈에게 다른 종류의 철분주사를 투여하여도 총 산자 수, 사산두수, 생존자돈 수, 포유개시두수, 이유두수, 복당 생시체중 및 복당 이유체중에서 처리구 간 유의적인 차이가 나타나지 않았다 (P>0.05). 결론적으로, 임신 말기 모돈에게 철분주사를 투여하지 않고, 포유자돈에게 철분을 투여하였을 때 모돈의 체형변화, 번식성적 및 자돈성적에서 부정적인 영향을 미치지 않을 것으로 사료 된다.

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