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Influence of organic iron complex on sow reproductive performance and iron status of nursing pigs

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ABSTRACT

This experiment was conducted to evaluate the effects of organic iron complex on sow reproductive performance and iron status of nursing pigs. At day 84 of gestation, a total of 58 PIC sows at five-parity were randomly assigned to two groups receiving diets containing organic iron complex (n=33) and ferrous sulfate (n=25). According to a 2×2 factorial design of treatments, nursing pigs (2.09 ± 0.34 kg) within a given litter were divided into two groups and given either an injection with or without iron (0 vs. 200 mg/pig) on day three of lactation. The feeding trial lasted for 51 days, including 30 days of gestation and 21 days of lactation. The results showed that organic iron complex did not improve the reproductive performance of sows or the growth performance of piglets. In particular, nursing pigs injected with iron had greater individual body weight at day 21 of lactation compared to pigs that were not treated with iron ($P<0.05$). Compared with ferrous sulfate, organic iron complex significantly increased the Cu content in mature milk ($P<0.01$), and the serum iron concentration at day one of lactation ($P<0.05$), as well as ceruloplasmin activity at day 21 of lactation ($P<0.01$). Piglets from sows fed organic iron complex tended to have a greater total iron binding capacity (P=0.08) and ceruloplasmin activity (P=0.05) at day 10 of lactation, and tended to have a higher concentration of hemoglobin (P=0.08), total iron binding capacity ($P<0.01$) and serum iron ($P<0.01$) at day 21 of lactation compared with piglets from sows fed ferrous sulfate. Piglets injected with iron had a greater red blood cell count ($P<0.01$), hemoglobin ($P<0.01$), serum iron ($P<0.01$) and total iron binding capacity ($P<0.05$) at day 10 and 21 of lactation compared to piglets that were not treated with iron. In conclusion, organic iron complex had minor positive effects on the iron status of sows and nursing pigs, but did not significantly improve the performance of sows and their offspring. Therefore, attempts to replace the commonly used Fe injection with a maternal organic iron complex dietary supplement failed to prevent iron-deficiency anemia of nursing pigs.

1. Introduction

Historically, ferrous sulfate has been used as an oral supplement in swine diets (Kegley et al., 2002). However, recent studies have emphasized the biological effects of organic iron over the iron salt, which has low bioavailability (Spears et al., 1992; Henry and Miller, 1995; Pineda and Ashmead, 2001). Organic iron improves iron absorption and iron status of animals (Ashmead, 1993; Yu et al., 2000). In particular, Ashmead (1993) and Du et al. (1996) proposed that organic iron limits interactions with dietary factors that prevent absorption through a special

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uptake mechanism in the intestine. Feeding organic iron to pregnant sows has been shown to increase newborn and weaning weight, reduce stillbirths and postnatal mortalities, as well as improve iron status of piglets (Close, 1998, 1999).

In rats and humans, substituting iron glycine chelate (Fe-Gly) for ferrous sulfate improved iron absorption and bioavailability (Layrisse et al., 2000; Pineda and Ashmead, 2001). Similar to Fe-Gly, iron methionine chelate and iron lactate are better absorbed in nursing pigs under experimental conditions (Spears et al., 1992; Svoboda et al., 2004). Likewise, ferrous fumarate has been added to infant food to prevent and treat iron deficiency (Davidsson et al., 2000). However, previous studies have primarily focused on the bioavailability of single organic iron sources, while detailed bioavailability and biological responses to organic iron complexes are still unknown.

In sows, iron is essential for embryonic and fetal development. During late pregnancy and lactation, the iron requirement rapidly grows due to increasing iron storage by the fetus and needs of the newborn (Mahan and Shields, 1998; Mahan et al., 2009). Fetal growth and development relies entirely on the maternal supply of nutrients, including trace mineral elements (Van Saun, 2008). Mineral deficiency in the fetus induced by inadequate transfer of these elements from the maternal system can result in poor growth and health of the conceptus with negative effects continuing well into the neonatal period (Hostetler et al., 2003). In particular, organic iron has been reported to increase the quantity of iron transferred across the placenta to the fetus (Ashmead and Graff, 1982). On the other hand, feeding organic minerals to sows could improve micro-mineral output in mature milk and increase mineral retention in weaning pigs (Peters et al., 2010). Therefore, we hypothesized that feeding an organic iron complex to sows could improve the iron status of their offspring.

Finally, since it had been shown previously that high dietary iron did not improve iron absorption (Hansen et al., 2009), 80 mg/kg iron was provided for gestating and lactating sows according to NRC (1998) recommendations. Thus, we compared the effect of organic iron complex and ferrous sulfate on the reproductive performance of sows and the growth performance of piglets, as well as tested whether supplementation of an organic iron complex to sows improved the iron status of sows and their offspring.

2. Materials and methods

2.1. Materials

The composition of the organic iron complex included ferrous fumarate (35%), iron lactate (25%), iron glycine chelate (37%) and iron methionine chelate (3%). The measured value of Fe^{2+} in the organic iron complex and ferrous sulfate was 20.84% and 30%, respectively.

2.2. Experimental design

Experimental design, animal care, and animal handling procedures were approved by the Biosafety and Animal Care and Use Committees at Sichuan Agricultural University. A total of 58, five-parity PIC sows, which had a similar sized number of piglets (10–12 pigs/sow) from parity 1 to parity 4, were assigned to the experiment at day 84 of gestation. Sows in ideal body condition (body condition score=3) were randomly allotted to receive diets

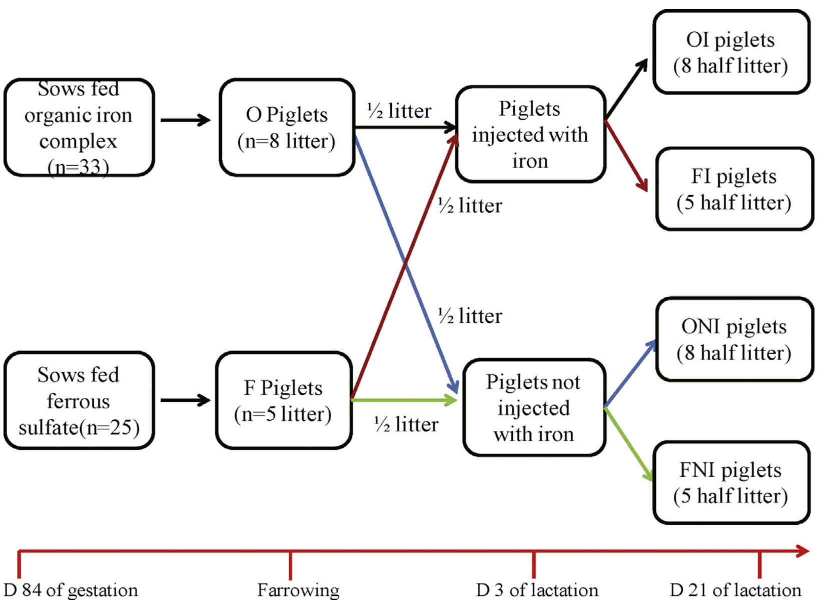

Fig. 1. The experimental design and the timing of the different treatments and procedures. O and F represent sows fed the organic iron complex and ferrous sulfate, respectively. OI and ONI represent piglets injected with or without iron under the condition of nursing sows fed organic iron complex, respectively; FI and FNI represent piglets injected with or without iron under the condition of nursing sows fed ferrous sulfate, respectively.