L-arginine improves reproductive performance of sows

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Introduction

Selection for maximum prolificacy over the last decade has resulted in an increase in litter size at birth and more piglets weaned per litter. However, the increase in litter size might cause a decrease in birth-weight of piglet, the number of piglets born alive per litter, and increase in the variation in birth-weights of piglets and this increase has also resulted in a higher percent mortality of piglets during lactation, which is of high economic loss to swine producers (Roehe and Kalm, 2000). The highest percentage of mortality in commercial pig production occurs prior to weaning and decreasing pre-weaning mortality is of high economic value to swine producers (Roehe and Kalm, 2000).

Previous studies reported that L-arginine supplementation during gestation could result in changes in hormonal secretions, which may affect fetal and maternal metabolism (Chew et al., 1984; Kensinger et al., 1986). Kim et al. (2009) indicated that pregnant pigs (Days 0–70 of the gestation) need 6.09 g/day arginine to support normal fetal growth, and need 140.93 g/day arginine during late gestation (Day 70 of the gestation to farrowing). Pregnant pigs receive 10.00 to 16.25 g/day arginine when fed 2.0 to 2.5 kg/day of a corn–soybean meal diet (arginine content 0.50% to 0.65%). However, only 60% of arginine can enter the blood circulation after the small intestine arginase decomposition, which is insufficient to support fetal growth and the main reason for decrease in the birth-weight of piglets and survival rate of pre-weaning piglets, and an increased piglet stillborn rate. Some studies also proved that the addition of L-arginine in sow's diet significantly increased the average birth-weight, the number of piglets born alive (Gonçalves et al., 2016), stimulated the fetus development, and decreased the embryo mortality rate (Wu et al., 2013; Li and Wu, 2014). Therefore, this article will update the effect of L-arginine supplementation on sow's reproductive performance.

L-arginine metabolism

Arginine is a conditionally essential amino acid for mammals and a vital precursor for synthesis of proteins and other biologically important molecules, including nitric oxide (NO), creatine, glutamine, and polyamines (Wu and Morris, 1998; Blachier et al., 2011) (Figure 1) and hormone (Khajali and Wideman, 2010). L-arginine is a multi-functional amino acid being involved in improvement of reproductivity, reduction of oxidant stress and fat accumulation, and enhancing immunity system as a trend which receives rising interest in a post anti-biotic bad era.

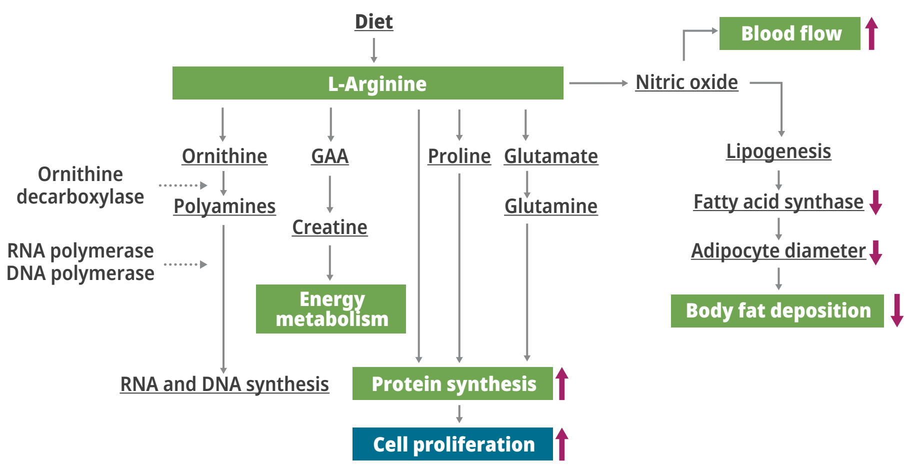

Figure 1. Role of L-arginine in different metabolic pathways (Fouad et al., 2012)

Application of L- arginine to improve reproductive performance of sows:

1. Reduction of intrauterine growth-restricted piglets, increasing placenta weight and number of live-born piglets

Arginine is not only required for protein synthesis and ammonia detoxification, but it is also converted to glutamine, glutamate, proline, aspartate, asparagine, ornithine, polyamine, citrulline and nitric oxide (NO), which play a vital biological role in the growth of placentas and embryos (Wu et al., 2008). Bird et al. (2003) and Wu et al. (2009) also reported that polyamines and NO are essential to placental growth and angiogenesis, thereby regulating the placental-fetal blood flow and the transfer of nutrients, oxygen, ammonia, and metabolic waste between mother and fetus in pregnant mammals. Other studies also pointed that placental efficiency affects litter size and that placental size is highly correlated with fetal weight after day 60 of gestation in swine (Biensen et al., 1998; Wilson et al., 1999), as well as the association between placental size and the decrease in piglets being exposed to intrauterine growth restriction (IUGR), which fetus did not receive enough nutrients for their normal developments. It is also reported that L-arginine supplementation in sow's diet plays a vital role in the placental weight gain (increase by 11%, Figure 2), IUGR (decrease by 41%, Figure 3), and fetus growth (increase by 7%, Figure 4).

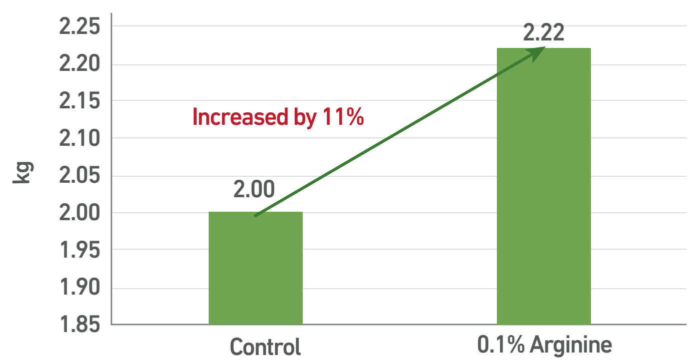

Figure 2. Effect of 0.1% L-arginine supplementation between day 30 and 110 of pregnancy on placental weight (Guo et al., 2016).

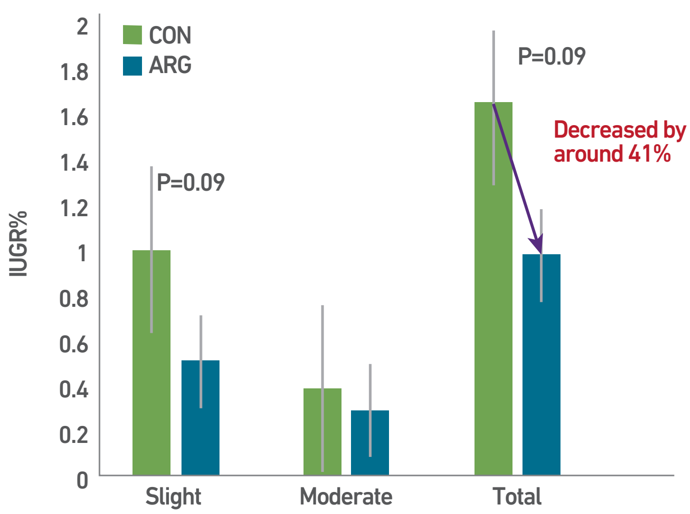

Figure 3. Effect of L- arginine supplementation for the whole pregnancy period of sows on percentage of IUGR piglets (CON: basal diet; ARG: CON + 0.25% L-arginine) (Luise et al., 2020).

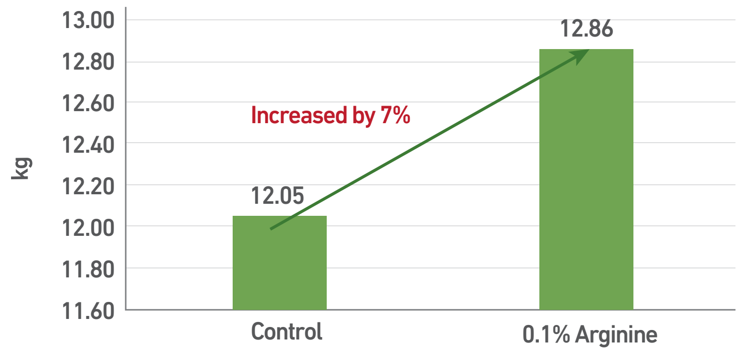

Figure 4. Effects of 0.1% L-arginine supplementation between day 30 and day 110 of pregnancy on total born piglet's weight (Guo et al., 2016).

2. Increasing the number of piglets born alive and decreasing the number of stillborn and mummified piglets

Gao et al. (2012) showed that L-arginine addition increases the number of born alive piglets per litter and tends to decrease the number of stillborn piglets and mummified piglets due to the higher synthesis of spermine and ornithine. Spermine is a secondary cellular signal which plays important roles in cell proliferation, developments, and differentiation, as well as affects the synthesis of protein, DNA, and RNA (Tabor and Tabor, 2006). Additionally, L-arginine can be used as a substrate for the nitric oxide via nitric oxide synthase and polyamine synthesis via ornithine decarboxylase (Flynn et al., 2002; Wu et al., 2004). Both nitric oxide and polyamine are considered key factors for angiogenesis and for improving the placenta vascularization (Hazeleger et al., 2007), which can regulate the placental-fetal blood flow and the transfer of nutrients, oxygen, ammonia, and metabolic waste between mother and fetus in pregnant mammals. Therefore, L- Arginine administration increased the number of born alive piglets and reduced the number of stillborn and mummified.

Guo et al. (2016), who reported that sows fed the diet with 0.1% of L-arginine supplementation significantly increased the number of piglets born (by 1.10 piglets per litter, equivalent to 11% increase, Figure 5), piglets born alive (by 1.15 piglets, equivalent to 13% increase, Figure 5), and significantly lower stillborn and mummified piglets (decrease by 5%, Figure 6) compared to the control group.

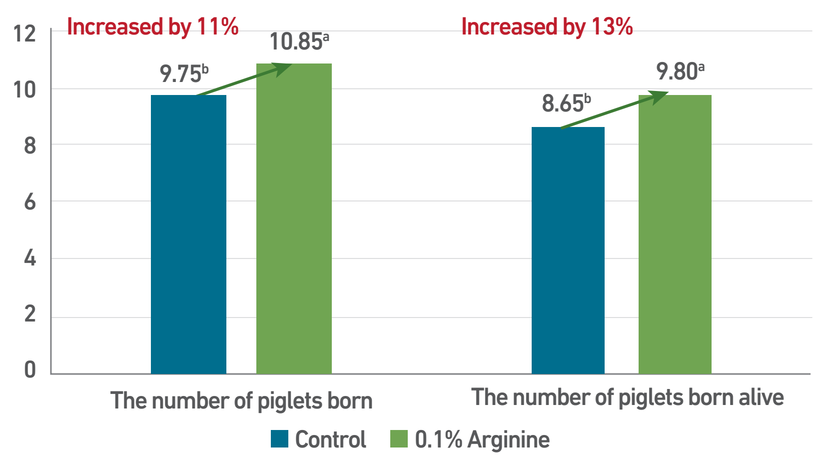

Figure 5. Effects of 0.1% L-arginine supplementation between day 30 and day 110 of pregnancy on the number of born piglets (Guo et al., 2016).

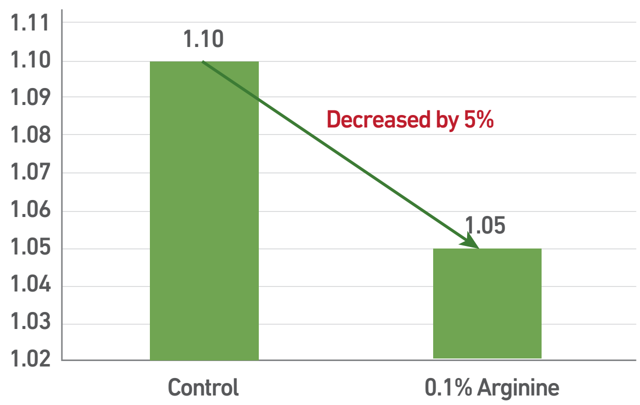

Figure 6. Effects of 0.1% L-arginine supplementation between day 30 and day 110 of pregnancy on the number of stillborn and mummified piglets (Guo et al., 2016).

Conclusions

Supplementing 0.1-0.25% L-arginine in gestating sows feed helps to:
- Increase the number and weight of piglets born.
- Increase the number of piglets born alive.
- Reduce the intrauterine growth restriction (IUGR).
- Decrease the number of stillborn and mummified piglets.

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