Impact of L-arginine and L-carnitine addition to a milk replacer on growth performance, body composition and muscle development of artificially reared low-birth weight piglets

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Introduction

The increasing prolificacy of sows results in larger litters. As a consequence, a decreasing average birth weight (BtW) and increasing within litter BtW variability can be observed (Foxcroft et al., 2007). Furthermore, low BtW negatively affects the survival rate within the first week of life as well as postnatal growth especially in the pre- and early post weaning period (Bérard et al., 2008; Quiniou et al., 2002). Recent studies suggest that amino acid requirements of pre-weaning piglets with a great genetic potential for fast growth cannot be completely covered by the sow's milk. This is even more evident in larger litters where the amount per piglet may be limiting. There are indications that the growth in the early postnatal period of piglets can be improved by supplementing the L-arginine (Wu et al., 2004) or L-carnitine (Lösel et al., 2009). L-arginine is an essential amino acid for maximal growth of neonates, but the availability in sow's milk is inadequate (Kim et al., 2004). L-carnitine plays an important role in the transfer of long-chain fatty acids from the cytosol into the mitochondrial matrix for the β-oxidation and therefore is crucial for the energy metabolism pathway.

The aim of this study was to investigate the impact of a milk replacer supplemented with either L-arginine or L-carnitine compared to a non-supplemented milk replacer on growth performance and muscle metabolism of low-birth weight piglets in the early postnatal period.

Material and Methods

The experiment was performed with 30 purebred Large White piglets (16 castrates and 14 females) with a BtW ≤ 1.2 kg and originating from litters with ≥ 14 piglets born. At 7 d of age, piglets were randomly allocated to one of three dietary treatments: control diet (Ctr), control diet + 1.08 g L-arginine/kg body weight/d (Arg; based on Wu et al., 2004) and the control diet + 400 mg L-carnitine/d (Car; based on Lösel et al., 2009). The control diet was formulated based on the diet used by Yao et al. (2008) and contained whey powder, full milk powder, milk protein, glucose,

dicalcium phosphate dehydrate, DL-methionine, L-lysine-HCl and a mineral-vitamin-premix. The piglets were housed in pairs in rescue decks designed for low BtW or supernumerary piglets to ensure the survival during the suckling period. The experimental diets were offered six times per day, every 3 h, starting from 7 am. Piglets had *ad libitum* access to water but no additional creep-feed was offered. Piglets were weighed every morning and the amount of milk replacer was allocated based on this body weight (BW) at 300 g/kg. Prior to each meal, the amount of residual milk replacer was recorded. On day 28, piglets were slaughtered after being anesthetized for 5 min using isoflurane and then euthanized by exsanguination. Spleen, liver, lung, heart, kidneys, brain as well as the right *semitendinosus* muscle (ST) and the adrenal glands were excised and weighed.

Data were analyzed using the Mixed procedure of SAS (version 9.2 SAS Inst. Inc., Cary, NC, USA) considering treatment, gender and treatment × gender interaction as fixed effects and sow nested within experimental series as random effect. Differences with $P < 0.05$ were considered significant and $0.05 \leq P \leq 0.10$ as a trend.

Results and Discussion

According to the experimental design, BtW did not differ ($P = 0.94$) among the three experimental groups. Likewise, the BW at the beginning (d 7 of age), at d 14 after birth, as well as at the end of the experiment (d 28 of age) was not ($P \geq 0.12$) different among treatment groups. Accordingly, the supplementation of L-arginine and L-carnitine did not ($P > 0.10$) affect the growth rate in the period from d 7 to 28 of age. However, at 21 d of age, Car piglets had a greater BW compared to the Ctr piglets (3.85 vs. 3.02 kg, respectively; $P < 0.05$), with intermediate values for the Arg piglets (3.28 kg). This difference was the result of a faster ($P < 0.10$) growth of the Car piglets compared to the Ctr and Arg piglets in the first week of the experiment (d 7 to 14). The findings are in accordance with the results presented by Lösel et al. (2009) in a study using sow-reared piglets fed daily 400 mg of L-carnitine. There was no clear improvement of the ADG from d 7 to d 28 of age in low birth weight and no effect of treatment in medium birth weight piglets. In contrast to the present results, Kim et al. (2004) found an improved growth performance after the supplementation of the milk replacer with L-arginine in the early postnatal period.

Regardless of the treatment, female piglets showed a trend ($P = 0.08$) to be heavier compared to castrated piglets from the start of the experiment until the second experimental week. At slaughter the castrated piglets reached a similar weight as the females.

At slaughter, numerically heavier ST muscles were found in the Car and Arg piglets compared to Ctr (12.9, 12.7 and 12.0 g in Car, Arg and Ctr group, respectively). This coincides with the numerically heavier slaughter weight of the Car and Arg piglets (4.86 and 4.73 vs. 4.30 kg). Dietary treatment had no ($P \geq 0.25$) impact on organ, brain and adrenal gland weights. Furthermore the brain:liver and the brain:ST weight ratios, traits used to evaluate brain sparing effects, were similar ($P \geq 0.20$) in the three treatment groups. Assuming that brain development is independent of nutrition, these findings suggest that neither L-arginine nor L-carnitine had an impact on liver and muscle growth.

Conclusion

The current data suggest that L-carnitine and L-arginine may have some beneficial effects on growth performance in the early postnatal period. Further histological analysis and analysis of key enzymes of muscle metabolic pathways will reveal whether, on a molecular level, these substances affected muscles development. It should be taken into account that housing of piglets in rescue decks is a great challenge in managing young piglets especially due to the occurrence of diarrhea and belly nosing.

References

Berard, J., Kreuzer, M. and Bee, G. (2008): Effect of litter size and birth weight on growth, carcass and pork quality, and their relationship to postmortem proteolysis. *J. Anim. Sci.* **86:** 2357-2368

Foxcroft, G.R., Bee, G., Dixon, W., Hahn, M., Harding, J., Patterson, J., Putman, T., Sarmento, S., Smit, M., Tse, W.-Y. and Town, S.C. (2007): Consequences of selection for litter size on piglet development. In: *Wiseman, J.*, Varley, M.A., McOrist, S., and Kemp, B. (Eds.), Paradigms in Pig Science, Nottingham Univ. Press, Nottingham, UK, pp. 207-229

Lösel, D., Kalbe, C. and Rehfeldt, C. (2009): L-Carnitine supplementation during suckling intensifies the early postnatal skeletal myofiber formation in piglets of low birth weight. *J. Anim. Sci.* **87:** 2216-2226

Quiniou, N., Dagorn, J. and Gaudré, D. (2002): Variation of piglets' birth weight and consequences on subsequent performance. *Livest. Prod. Sci.* **78:** 63-70

Sung Woo, K. and Wu, G. (2004): Dietary arginine supplementation enhances the growth of milk-fed young pigs. *J. Nutr.* **134:** 625-630

Wu, G., Knabe, D.A. and Kim, S.W. (2004): Arginine nutrition in neonatal pigs. *J. Nutr.* **134:** 2783-2790S

Yao, K., Yin, Y.-L., Chu, W., Liu, Z., Deng, D., Li, T., Huang, R., Zhang, J., Tan, B., Wang, W. and Wu, G. (2008): Dietary arginine supplementation increases mTOR signaling activity in skeletal muscle of neonatal pigs. *J. Nutr.* **138:** 867-872.