

Effects of dietary leucine and tryptophan supplementations on serotonin metabolism and growth performance of growing pigs

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Abstract

This experiment was conducted to test the hypothesis that increase of standardized ileal digestible (SID) Trp:Lys is needed in diets for growing pigs if the SID Leu:Lys exceeds the requirement to prevent drops in both plasma serotonin (PS) and hypothalamic serotonin (HS) concentrations and to maintain growth performance of animals. Nine diets were formulated using a 3×3 factorial treatment arrangement (100, 200 or 300% SID Leu:Lys and 18, 23 or 28% SID Trp:Lys), and 144 growing pigs (28.2±1.9 kg) were assigned to the 9 diets in a randomized complete block design. Initial and final body weight of pigs and daily feed provisions were recorded, and average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio were calculated. On d 0, 11 and 21, blood samples were collected, and hypothalamus samples were collected on d 21. Data were analyzed using a response surface model by removing the terms in the model that were not significant. Interactions between SID Trp:Lys and SID Leu:Lys for ADG, ADFI, PS, and HS were observed. For prediction of ADG, ADFI, and HS, both positive linear SID Trp:Lys and SID Leu:Lys terms were included in each model. However, negative linear SID Trp:Lys and positive linear SID Leu:Lys terms were observed in the model for PS. In conclusion, increasing SID Trp:Lys in diets is needed to alleviate the negative impact of excess dietary Leu on growth performance and HS concentration of growing pigs.

Keywords: growth performance, leucine, serotonin, tryptophan, pigs

Introduction

Tryptophan is an indispensable AA that is often limiting for growth in pigs fed corn-soybean meal-based diets (Lewis, 2001). Tryptophan can also act as a regulator of feed intake by enhancing serotonin signaling in the brain (Henry *et al.*, 1992), because Trp is a precursor for serotonin, which is a cerebral neurotransmitter that plays an important role in appetite regulation (Zhang *et al.*, 2007). Recent study indicates that excess dietary Leu can reduce synthesis of serotonin in the brain (Wessels *et al.*, 2016), which is likely a result of reduced availability of Trp in the brain, because Leu and Trp are both categorized as large neutral AA, and therefore, share a common uptake pathway across the blood-brain barrier (Barea *et al.*, 2009). As a consequence, it is possible that an increased concentration of dietary Trp is needed to overcome the reduction in serotonin concentrations that is caused by excess dietary Leu.

Material and methods

A total of 144 growing pigs were divided into 2 blocks and randomly assigned to 9 dietary treatments in a randomized complete block design. Pigs were housed in pens, and each treatment had 8 replicate pens (2 pigs per pen and 4 replicate pens per block). Nine diets based on corn, soybean meal, wheat, and barley were formulated to contain different levels of standardized ileal digestible (SID) Trp (18, 23 or 28% SID Trp:Lys) and SID Leu (100, 200 or 300% SID Leu:Lys). The average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio were calculated for each pen of pigs and for each treatment group according to the initial and final body weight of pigs and daily feed provisions at the conclusion of the experiment. On d 0, 11 and 21 of the experiment, blood samples were collected to analyze plasma urea nitrogen and plasma serotonin (PS), and hypothalamus samples were collected to analyze hypothalamic serotonin (HS) on the last d of the experiment.

Results and discussion

The reduced model was used to predict ADG, ADFI, PS, and HS (Table 1). The interaction between SID Trp:Lys and SID Leu:Lys with both positive linear SID Trp:Lys and SID Leu:Lys terms were included in each predicted model for ADG, ADFI, and HS. For predicted model of PS concentration, however, the negative linear SID Trp:Lys and positive SID Leu:Lys terms along with the interaction between SID Trp:Lys and SID Leu:Lys were included. Increasing SID Trp:Lys in diets is needed to alleviate the negative impact of excess dietary Leu on growth performance and HS concentration of growing pigs.

Table 1. Least squares means for concentrations of plasma urea nitrogen (PUN), plasma serotonin, and cerebral serotonin of growing pigs fed diets with varying ratios between standardized ileal digestible (SID) Leu:Lys and SID Trp:Lys.

SID Leu:Lys, %:	100			200			300			SEM
SID Trp:Lys, %:	18	23	28	18	23	28	18	23	28	
Growth performance										
ADG, g/d ¹	867	898	852	845	869	905	750	815	777	61
ADFI, g/d ²	1,675	1,724	1,630	1,657	1,656	1,720	1,519	1,584	1,506	95
G:F ³	0.52	0.52	0.52	0.51	0.52	0.53	0.49	0.51	0.51	0.02
Serotonin, ng/ml										
Plasma ⁴	30.6	33.2	32.4	30.7	23.8	18.6	26.6	27.4	18.6	4.4
Hypothalamus ⁵	69.5	69.7	71.6	64.6	66.2	69.3	62.7	63.6	63.3	4.5

¹ Results indicated that ADG from d 0 to d 21 at different combinations of SID Trp and SID Leu could be described by the following model: $975.196 - 1.792 \times \text{SID Trp} - 0.944 \times \text{SID Leu} + 0.021 \times \text{SID Trp} \times \text{SID Leu}$ ($P < 0.05$).

² Results indicated that ADFI from d 0 to d 21 at different combinations of SID Trp and SID Leu could be described by the following model: $1839.196 - 0.299 \times \text{SID Trp} - 1.062 \times \text{SID Leu} + 0.016 \times \text{SID Trp} \times \text{SID Leu}$ ($P < 0.05$).

³ Results indicated that G:F could not be predicted using SID Trp or SID Leu.

⁴ Results indicated that serotonin concentration in plasma at different combinations of SID Trp and SID Leu could be described by the following model: $26.844 + 0.322 \times \text{SID Trp} + 0.076 \times \text{SID Leu} - 0.005 \times \text{SID Trp} \times \text{SID Leu}$ ($P < 0.05$).

⁵ Results indicated that serotonin concentration in hypothalamus at different combinations of SID Trp and SID Leu could be described by the following model: $65.054 + 0.397 \times \text{SID Trp} - 0.020 \times \text{SID Leu} - 0.001 \times \text{SID Trp} \times \text{SID Leu}$ ($P < 0.05$).

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