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Effects of short term supplementation of L-tryptophan and reducing large neutral amino acid along with L-tryptophan supplementation on growth and stress response in pigs

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ABSTRACT

Two experiments were conducted to evaluate the effects of short term dietary supplementation of L-Trp and reducing large neutral amino acid (LNAA; valine, leucine, isoleucine, tyrosine, and phenylalanine) on growth and stress response in nursery and growing pigs. In Exp. 1, 674 crossbred pigs in 40 pens at 9-week of age were randomly allotted to 2 dietary treatments with supplementation of 0.0% and 0.8% L-Trp to a corn and soybean meal basal diet. Experimental period was composed of 5 days in a nursery and 7 days in a finisher. After 12 days feeding of experimental diets, pigs were provided a common diet for an additional 7 days. In Exp. 2, 108 crossbred barrows at 6-week of age were randomly allotted to 3 dietary treatments: (1) a corn soybean meal basal diet (4.5% LNAA) supplemented with 0.0% L-Trp; (2) a corn soybean meal basal diet (4.5% LNAA) supplemented with 0.8% L-Trp; (3) a reduced LNAA (3.8%) diet supplemented with 0.7% L-Trp, which had the same Trp:LNAA ratio as treatment 2. The experimental period lasted 16 days. In Exp. 1, during the entire period, pigs fed the diet supplemented with 0.8% L-Trp had increased ADG and gain:feed ($P < 0.05$ and $P < 0.01$, respectively) compared with pigs fed the diet without L-Trp supplementation. On day 6, one day after mixing, pigs fed the diet supplemented with 0.8% L-Trp had a lower ($P < 0.05$) concentration of salivary cortisol compared with pigs fed the diet without L-Trp supplementation. In Exp. 2, during the entire period, pigs fed the diet supplemented with 0.8% L-Trp or a reduced LNAA diet supplemented with 0.7% L-Trp had increased gain:feed ($P < 0.01$) compared with pigs fed the diet without L-Trp supplementation. Weight gain and gain:feed were similar ($P > 0.05$) between pigs fed the diet supplemented with 0.8% L-Trp and pigs fed a reduced LNAA diet supplemented with 0.7% L-Trp. In conclusion, short term supplementation of 0.8% L-Trp improved growth performance of pigs during period of social-mixing and was associated with reduced stress hormone concentrations. Dietary supplementation of 0.8% L-Trp had similar effects on feed efficiency as a reduced LNAA diet supplemented with 0.7% L-Trp, suggesting lowering LNAA is a valid method of reducing levels of L-Trp supplementation required for mitigating stress response.

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1. Introduction

Stress occurs at many points in the life of the pig (Adeola and Ball, 1992). Tryptophan has a potential role in facilitating stress adaptation of animals and human through increasing hypothalamic serotonin (5-hydroxytryptamine, 5-HT) level (Koopmans et al., 2005, 2006; Shen et al., 2012b). Previous studies have shown that dietary supplementation of high levels of L-Trp improved growth performance (Shen et al., 2012b), reduced secretion of stress hormones (Adeola et al., 1993; Lepage et al., 2003; Koopmans et al., 2005), alleviated aggressive behaviors (Poletto et al., 2010), and regulated mood and appetite (Markus et al., 2000; Zhang et al., 2007). However, high cost has limited the functional application of L-Trp to reduce stress in the animal production.

The current study tested practical ways of applying a high L-Trp supplementation in swine diets. Firstly, we hypothesized that a short term supplementation of high level of L-Trp right before and during social-mixing and relocation stress can mitigate stress response and improve growth of pigs. Secondly, because Trp competes with the other large neutral amino acids (LNAA; valine, leucine, isoleucine, tyrosine, and phenylalanine) to cross the blood–brain barrier via the L-type amino acid carrier (Pardridge, 1998; Markus et al., 2000), we hypothesized that lowering dietary LNAA may allow pigs to respond to L-Trp at a lower level supplementation and consequently reduce the usage of supplemental L-Trp. The objectives of the current study were to test the effectiveness of a short term supplementation of high level of L-Trp and reducing LNAA along with a lower L-Trp supplementation on growth performance and stress response of pigs facing social-mixing and relocation stress.

2. Material and methods

Two experiments were conducted to evaluate the effect of L-Trp supplementation on stress response of nursery and growing pigs. The first experiment was carried out on a commercial farm at Murphy Brown LLC (Rosehill, NC). The second experiment was completed at the swine education unit of North Carolina State University (Raleigh, NC). Experimental protocols were approved by the Institutional Animal Care and Use Committee at North Carolina State University.

2.1. Experiment 1

Six hundred seventy four crossbred pigs (25.8 ± 2.2 kg; Smithfield Premium Genetics, Roanoke Rapids, NC) in 40 pens at 9-week of age were used in this study. Pigs in pens were randomly allotted to 2 treatments: (1) dietary supplementation of 0.0% L-Trp to a corn and soybean meal basal diet; or (2) dietary supplementation of 0.8% L-Trp to a corn and soybean meal basal diet. Experimental period was composed of 5 days in nursery and 7 days in finisher. After 12 days feeding of experimental diets, pigs were provided a common diet for additional 7 days. The common grower diet contained 3.47 ME Mcal/kg, 19.4% CP, and 1.16% Lys. In this experiment, 2 neighboring pens shared a common multiple-hole self-feeder. The nursery and finisher pens had the same setting. Thus, 2 neighboring pens were the experimental unit (n = 10 per treatment). Each pen had 14–19 pigs. Pigs in each pen were randomly divided into 2 sub-groups and were marked on their back using a marker to identify their sub-groups in 2 neighboring pens. Pigs in 2 neighboring pens, therefore, were able to be divided into 4 sub-groups. During the first 5 days, there was no stress instigated to the pigs to ensure the accumulation of hypothalamic 5-HT prior to social-mixing and relocation stress (Adell et al., 1988; Shen et al., 2012b). On day 5, pigs were transferred from the nursery building to a finishing building. Out of 4 sub-groups in each 2 neighboring pen, 2 sub-groups (1 sub-group from each pen) were randomly selected and switched to create social-mixing stress upon arrival at the finishing building. On day 8, 2 sub-groups (1 switched sub-group and 1 remained sub-group in the other pen) were switched again to rotate the pairing and create further social-mixing stress. All pens were equipped with two nipple drinkers. Pigs had free access to water and diets. Body weight and feed intake were measured on day 0, 5, 8, 12, and 19.

Supplementation of 0.8% L-Trp was determined based on a previous study by Shen et al. (2012b) showing the beneficial effects of L-Trp supplementation on nursery pigs under social-mixing stress was maximized at 0.8% when Trp:LNAA ratio was 0.22. Basal diet in Exp. 1 contained 4.3% LNAA. The Trp:LNAA ratio of the control and Trp supplemented diet was 0.04 and 0.23 respectively. Lys, Met, Trp, and Thr were supplemented in order to ensure all essential amino acids in the diet met the nutritional requirement of pigs (NRC, 1998). Both diets were isonitrogenous using L-Ala as a non-specific N source, and dietary composition is summarized in Table 1. L-Ala is commonly used as a non-specific N source since it is neither toxic nor has a biological function but rather is extensively catabolized (Kim and Wu, 2004; Shen et al., 2012b).

Saliva was collected from randomly selected 2 pigs in each pen using cotton gauze on day 4 and 6 to measure cortisol concentration. In total, 80 pigs were collected on each collection day (10 replicates with 4 sub-samples for each treatment). Pigs were introduced and trained with cotton gauze at the beginning of this experiment to ensure the saliva collection procedure during the experiment period would not disturb the stress condition of the pigs (Shen et al., 2012a, 2012b). Cotton gauze chewed by a pig for approximately 1 min was used to collect saliva. Gauzes were then placed in tubes on ice until centrifugation at 1500 × g for 10 min at 4 °C to separate saliva from the gauze. Saliva samples were stored in −80 °C until analysis.