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Excessive dietary taurine supplementation reduces growth performance, liver and intestinal health of weaned pigs

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ABSTRACT

This study was conducted to investigate the effects of dietary taurine (Tau) supplementation on growth performance, liver and intestinal health of weaned pigs. A total of 96 cross 28-d old barrows weaned at 21 ± 2 d (initial average BW$=7.39 \pm 0.40$ kg) were allotted randomly on the basis of the initial body weights (BW) to dietary Tau supplementation of 0%, 0.3%, 1.5%, and 3% for 28 d. Each treatment had six replicate pens, and each pen had four pigs. Our results showed that gain/feed ratio (*G*/*F*) increased with the lower supplementation of Tau but decreased with the higher supplementation (quadratic, $P < 0.05$). The liver antioxidant enzyme activities (SOD, GSH-PX and T-AOC) were lower ($P < 0.05$) in pigs fed 0% and 3% Tau than those fed 0.3% Tau, and the lipid peroxidation (MDA) contents were lower ($P < 0.05$) in pigs fed 0% and 0.3% Tau than those fed 1.5% and 3% Tau, which combined with the hepatic pathological analysis indicated that dietary supplementation with appropriate Tau could help maintain liver health but dietary supplementation with excessive Tau would lead to liver damage. In addition, dietary supplementation with 0.3% Tau increased ($P < 0.05$) villus heights related to the control group. Meanwhile, the higher diarrhea index ($P < 0.05$), lower ($P < 0.05$) villus heights and deeper ($P < 0.05$) crypt depths in pigs fed 3% Tau than those fed 0% or 0.3% Tau may be partially due to increased inflammatory cytokines (IL-6 and TNF-α) and Caspase-3 levels, and decreases in GLP-2 secretions. In conclusion, our results suggested that appropriate (0.3%) Tau supplementation in diets had different degrees of beneficial effects on piglet health but excessive (1.5% or 3%) Tau had adverse effects on growth performance, liver and intestinal health of piglets.

1. Introduction

Taurine (Tau), β-aminoethanesulfonic acid, is an important amino acid derivative that is abundantly distributed in many mammalian tissues (Lee et al., 2004b). Tau is not used for proteins synthesis, but found mainly in free form (Bouckenooghe et al., 2006). Therefore, Tau had been considered an end product of sulfur amino acids metabolism with no biological significance except its conjugation with bile acids to form bile salts that are essential for fat digestion. Subsequently, Tau had been proved to play an important role in membrane stabilization, anti-oxidation, detoxification, osmoregulation, growth modulation, calcium homeostasis,

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immunomodulation as well as development of neural and retinal system (Wright et al., 1986; Huxtable, 1992; Tadolini et al., 1995; Pasantes-Morales et al., 1998; Redmond et al., 1998; Lima et al., 2001; Militante and Lombardini, 2002; Lima et al., 2004). Furthermore, Tau had also been implicated in the metabolism of proteins, lipid, minerals, glucose and cholesterol (Thompson and Tomas, 1987; Yun et al., 2012b; Zeng et al., 2012). However, the synthesized Tau cannot meet the requirement of most mammals because most mammalians, especially young animals, have low activity of the cysteinesulfinic acid decarboxylase (CSAD) (Hayes and Sturman, 1981), which is a rate-limiting enzyme of Tau synthesis in mammals (O'flaherty et al., 1997). Therefore, an exogenous supplementation of Tau is required in the certain life stages of some animals.

There are some differences about the effects of dietary Tau supplementation on growth performance of piglets among previous studies. Some studies reported that dietary Tau supplementation significantly improved the growth performance of piglets fed with high plant protein diet (Huang and Peng, 2008). However, Stephen et al. (1991) discovered that supplementation of Tau had no effect on growth performance of early weaned piglets fed with milk replacer. Consequently, taurine requirement in the piglet needs further investigation. Additionally, less is known about the impact of high Tau levels in diets on piglet health and performance. Therefore, the objectives of this study were to determine the effects of Tau supplementation on pig growth performance, and to evaluate whether high dietary Tau levels could have negative effects on piglet health.

2. Materials and methods

The experiment was approved by the Sichuan Agricultural University Institutional Animal Care and Use Committee and conducted at the Experimental base of Animal Nutrition Institute, Sichuan Agricultural University.

2.1. Animals and experimental design

A total of 96 28-d old barrows weaned at 21 ± 2 d (Duroc × Landrace × Yorkshire; initial average BW = 7.39 ± 0.40 kg) were allotted randomly on the basis of the initial body weights (BW) and origin of litters to four treatments, consisting of formulated Tau supplementation of 0%, 0.3%, 1.5%, and 3%. Each treatment had six replicate pens, and each pen had four pigs. The pigs were housed in the pen (2.2 × 1.3 m), which had fully slatted floors. Pigs had ad libitum access to feed and water through a dry feeder and a nipple drinker provided in each pen. Room temperature was maintained at about 26 °C. The experimental period lasted 28 d.

2.2. Diets

Table 1 lists the ingredient and nutrient composition of all experimental diets. All experimental diets were corn–soybean meal-based and fed in meal form. All nutrients met or exceeded National Research Council-recommended nutrient requirements (NRC, 2012) for piglets (7–11 kg).

Table 1
Ingredient and nutrient composition of the experimental diets (as-fed basis).

Item	Dietary taurine addition, %			
	0	0.3	1.5	3
Ingredient, %				
Corn	24.55	24.55	24.55	24.55
Extruded corn meal	24.5	24.5	24.5	24.5
Extruded full-fat soybean	11.2	11.2	11.2	11.2
Dehulled soybean meal, 47.9% CP	11	11	11	11
Soybean protein concentrate	6.3	6.3	6.3	6.3
Whey powder, 3% CP	9	9	9	9
Fish meal, 64.5% CP	4	4	4	4
Soybean oil	3.6	3.6	3.6	3.6
Chaff	1.2	1.08	0.6	–
Glycine	1.8	1.62	0.9	–
Taurine	–	0.3	1.5	3
L-Lysine · Hcl	0.33	0.33	0.33	0.33
D-L-Methionine	0.22	0.22	0.22	0.22
L-Threonine	0.17	0.17	0.17	0.17
Chloride choline	0.1	0.1	0.1	0.1
$CaCO_3$	0.6	0.6	0.6	0.6
$CaHPO_4$	0.8	0.8	0.8	0.8
Salt	0.3	0.3	0.3	0.3
Vitamin premix[a]	0.03	0.03	0.03	0.03
Mineral premix[b]	0.3	0.3	0.3	0.3
Nutrient composition, %				
Digestible energy, MJ/kg	14.83	14.83	14.83	14.83
Crude protein	20.02	20.02	20.02	20.02
Calcium	0.8	0.8	0.8	0.8
Total Phosphorus	0.65	0.65	0.65	0.65
Lysine	1.54	1.54	1.54	1.54
Methionine	0.55	0.55	0.55	0.55
Methionine and cysteine	0.88	0.88	0.88	0.88
Threonine	0.96	0.96	0.96	0.96
Tryptophan	0.25	0.25	0.25	0.25
Taurine[c]	0.03	0.35	1.54	3.05

[a] Vitamin premix provided the following per kilogram of diet: vitamin A, 12,000 IU as vitamin A acetate; vitamin D_3, 2,500 IU as cholecalciferol; 30 IU of vitamin E; vitamin K, 3.0 mg as menadione sodium bisulfate; thiamine, 2.0 mg as thiamine mononitrate; 5.9 mg of riboflavin; pyridoxine, 2.0 mg as pyridoxine hydrochloride; 12 μg of vitamin B_{12}; pantothenic acid, 33.07 mg as D-calcium pantothenate; 40 mg of niacin; 0.66 mg of folic acid; and 0.10 mg of biotin.

[b] Mineral premix provided the following per kilogram of diet: Fe, 100 mg as iron sulfate; Cu, 150 mg as copper sulfate; Zn, 120 mg as zinc sulfate; Mn, 10 mg as manganous sulfate; I, 0.3 mg as potassium iodate; Se, 0.3 mg as sodium selenite.

[c] Measured nutrient levels (DM basis).

The basal diet was formulated by adding 1.8% glycine whose nitrogen content is equal to 3% Taurine. The other three diets were formulated by adding 0.3%, 1.5% and 3% Tau to the basal diet at the expense of glycine and chaff with an attempt made to keep the nitrogen content equal among all experimental diets. Feed grade taurine (99.5% purity) and glycine (98.5% purity) were purchased from Yongan Pharmaceutical Co., Ltd. (Qianjiang, Hubei, China) and Shanghai Yimengsi Chemical Technology Co., Ltd. (China), respectively. The recommended dose of the commercial taurine is 0.1–0.3%. The levels (1.5% and 3%) of supplementation corresponded to five times and ten times of the highest recommended dose (0.3%) of the commercial taurine. Taurine concentrations in the diets were