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Original research article

Effects of catechins on litter size, reproductive performance and antioxidative status in gestating sows

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ABSTRACT

This study was conducted to investigate the effects of catechins on reproductive performance, antioxidative capacity and immune function of gestating sows. A total of 60 cross-bred (Landrace × Large White) multiparious sows were blocked by body weight, parity and backfact and randomly allocated to 1 of 5 treatments: 0, 100, 200, 300, or 400 mg/kg catechins. Dietary treatments were imposed from mating to d 40 of gestation of sows. At farrowing, litter total born, born alive, dead, and normal-(healthy piglets, ≥0.85 kg) and low-birth weight piglets (<0.85 kg) were recorded. Within 3.00 ± 0.50 days after farrowing litter size was standardized to 8.00 ± 1.50 piglets within treatment. The piglets were weighed at birth (d 1) and weaning (d 28). Sows serum samples were obtained from blood samples collected on d 40 of gestation for analyses of glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), catalase (CAT), malondialdehyde (MDA), hydrogen peroxide (H_2O_2), nitric oxide synthetase (NOS) and nitrogen monoxide (NO). Our results showed that supplementation of catechins at levels of 200 or 300 mg/kg led to improvements in litter born alive ($P < 0.01$) and piglet born healthy ($P < 0.01$) and a decrease in stillborn ($P < 0.05$) at farrowing when compared with the control. In comparison with the control, catechins at any supplemental levels all enhanced the serum SOD ($P < 0.05$) and CAT ($P < 0.01$) activities of sows at farrowing but no obvious differences in the serum GSH-Px and NOS activities were observed in this trial ($P > 0.05$). Sows received 200 mg catechin per kg diets showed a reduction ($P < 0.05$) of the serum MDA level at farrowing compared with all other treatments. Sows received all the levels of catechin showed a reduction ($P < 0.05$) of serum H_2O_2 level compared with sows received the control diet on both d 40 of gestation and farrowing. Our results demonstrated that the catechins may be a potential antioxidant to increase the reproductive performance and antioxidative capacity of sows when it was added into diets during the early gestation.

1. Introduction

Rapid fetal development during the gestation led to a catabolic status of pregnant women or dams which is known to contribute to the production of excessive free radicals including superoxide and hydrogen peroxide and the induction of systemic oxidative stress (Herrera and Ortega-Senovilla, 2010; Kim et al., 2013). Increased oxidative stress was reported to be an important factor causing decreased availability of antioxidants during late gestation, which could impaired placenta and fetal growth (Prater et al., 2008) and trigger a disrupted antioxidant system that was involved in a variety of pregnancy complications such as preterm labor, fetal growth restriction, preeclampsia and miscarriage (Gupta et al., 2003;

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Sugino et al., 2007). This elevated oxidative stress during gestation and lactation was likely to influence not only the litter performance, but also the well-being and health status of sows including impaired milk production, reproductive performance, and longevity (Agarwal et al., 2003; Jabbour et al., 2009; Zhao et al., 2011, 2013). Therefore, much attention has been paid to how to reduce maternal oxidative stress levels and inflammatory responses of highly prolific sows in late gestation by feed antioxidant additives. In numerous previous studies, antioxidants such as vitamin E, vitamin C, carotenoids, and selenium (Lykkesfeldt and Svendsen, 2007), fish oil and olive oil (Shen et al., 2015) and soy isoflavones (Hu et al., 2015) were added into the diet during gestation period in order to compensate for the substantial loss of these feed antioxidant additives. Excessive reactive oxygen and radical were actually produced from placental and maternal metabolism during the early pregnancy of sows. Although oxidative stress in late gestation was more serious than that in early gestation with the course of pregnancy (Berchieri-Ronchi et al., 2011; Casanueva and Viteri et al., 2003; Myatt and Cui, 2004), indicating that early pregnancy may be a key phase for prevention of oxidative damage.

Catechins are members of the flavonoid family and belong to plant polyphenolic constituents (Uzun et al., 2010), which are not only existing in a high concentration within tea, but also present in many foods, such as apples, grapes, vine and their processed beverages (Tichopad et al., 2005; Suzuki et al., 2007). Previous studies showed that catechins has a certain degree of hydrophobicity and can capture the OH^{-1}, which protect the DNA from the oxidant damage (Yoshioka et al., 1996); And catechins also alleviated the damage by up-regulating the expression of genes of some antioxidant enzymes such as superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), catalase (CAT) so that increase those enzyme's production and activity (Mkimura et al., 2002). Previous studies showed that catechins prevented metal ions from participating in peroxidase reactions by binding them and had the potential to scavenge reactive oxygen and nitrogen species, thus reducing their damage to lipid membranes, proteins, and nucleic acids in cell-free systems (Wiseman et al., 1997). These findings indicated that catechins prevented metal ions from participating in peroxidase reactions by binding them and had the potential to scavenge reactive oxygen and nitrogen species (Wiseman et al., 1997). It was reported that catechins administration significantly decreased malondialdehyde (MDA) level and noticeably increased activities of CAT, GSH-Px and SOD, suggesting that catechins provided effective protection from oxidative damages through their antioxidant properties (Tarek et al., 2012). Therefore, it is believed that catechins have a beneficial role on physiological functions and biotransformation of physiological processes involved in the detoxification activities and preventing oxidative damage as a result of their ability to scavenge reactive oxygen species such as hydroxyl radical and superoxide anion (Galati et al., 2002) and metal chelating (Pedrielli and Skibsted, 2002), thereby providing some protection from toxic metabolic actions of oxidative stress (Suhel et al., 2006).

Considering the antioxidant properties of catechins and oxidative stress for highly prolific sows in early pregnancy, the aim of this study was to determine the effect of catechins supplementation in diets fed to sows in early pregnancy on reproductive performance and antioxidative status of gestating sows.

2. Materials and methods

This experiment was conducted at the Zhenghong Swine Research Farm in Miluo District, Hunan Province, China. This study was performed in accordance with Chinese Animal Welfare Act guidelines and approved by the Animal Care and Use Committee of the Institute of Subtropical Agriculture, the Chinese Academy of Sciences (Wu et al., 2012).

2.1. Animals and experimental design

A total sixty of multiparous lactating sows (Landrace × Large White) were used in this experiment. The sows were evenly allocated by BW, back fat, expected farrowing date and parity into 5 dietary treatments, with 12 replicates. Litter size was standardized to 8.00 ± 1.50 piglets within 3.00 ± 0.50 days after farrowing. The sows were housed individually in crate stalls from mating. Five days before the expected date of farrowing/parturition, all the sows were moved into the individual farrowing crates with a heated piglet nest on d 109 of pregnancy. Rooms were ventilated mechanically.

The sows receive a gestational diet (Table 1) with levels of nutrients and minerals based on NRC (1998) recommendations from mating to d 40 of gestation, which is only different in the dose of catechins: 0 (Group I), 100 (Group II), 200 (Group III), 300 (Group IV) or 400 (Group V) mg catechins per kg diet. The sows were given 1.8, 2.3, and 2.5 kg/d during the pregnancy period, respectively, and thin sows were provided an extra amount of feed (0.3 kg/d). The day of farrowing sows did not receive any feed and the daily amount of feed was increased by 0.75 kg/d until ad libitum at d 4 of lactation, and thereafter the sows were fed twice daily, in the morning and evening, and had free access to water from nipple drinkers. The lactation length was 28 days. The litter total born, born alive, stillborn, and low-birth weight piglets (birth weight ≤0.8 kg) were recorded. Pigs born healthy number was obtained by the difference between the litter total born and stillborn and mummies. The piglets were weighed at farrowing. No creep feed was provided. Natural catechins (99% purity) were obtained from National Research Center of Engineering Technology For Utilization of Functional Ingredients From Botanicals (Hunan, China).

2.2. Sample collection and chemical analysis

On farrowing day, colostrum samples were drawn manually from every active teat of a sow after injection of 15 IU oxytocin. Blood samples (10 mL) were taken from ear veins into vacuum blood collection tubes on farrowing and d 40 of gestation. The blood samples were allowed to clot at room temperature for 30 min, and then centrifuged at 3,000 × *g* for 15 min at room temperature with the resulting serum stored at −20°C until analysis (Liu et al., 2012). The activities of SOD, GSH-Px, catalase, nitric oxide synthetase (NOS) and MDA were determined by assay kits

Table 1
Ingredient and chemical composition of basal diet (air-dry basis).

Ingredient, %	Content	Chemical composition, % of DM	Content
Corn	70.00	Digestible energy, MJ/kg DM	13.40
Soybean meal	11.20	Crude protein	13.10
Wheat bran	14.40	Lysine	0.60
Fish meal	1.60	Methionine	0.20
$CaHPO_4$	1.10	Calcium	0.75
$CaCO_3$	0.16	Total phosphorus	0.60
NaCl	0.40	Available-P	0.37
Premix[1]	1.14	Crude fiber	3.30
Total	100		

DM = dry matter.
[1] The premix provided the following per kilogram of diet: Cu5 mg, Fe 80 mg, Zn 50 mg, Mn 20 mg, Se 0.15 mg, I 0.14 mg, VA 4,000 IU, VD_3 200 IU, VE 44 IU, VK_3 4.00 mg, VB_1 1.0 mg, VB_2 3.75 mg, VB_3 40.60 mg, pantothenic acid 20.0 mg, VB_6 10 mg, VB_{12} 0.015 μg, folic acid 12 mg, d-biotin 0.34 mg.