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Beneficial effects of dietary soluble fiber supplementation in replacement gilts: Pubertal onset and subsequent performance

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ABSTRACT

The aim of this study was to examine the effects of soluble fiber supplementation prior to puberty on age at puberty and subsequent reproductive performance of gilts. A total of 136 gilts of similar body weight (BW, 60.59 ± 7.02 kg) and age (140 ± 10 days) were fed a control diet (CON) or control diet supplemented with 0.8% soluble fiber (SF) until mating at the third estrus. Circulating concentrations of cholesterol, triglyceride, and estradiol in gilts fed the SF diet were lower than in CON gilts at 205 d of age. Compared with CON-fed gilts, the SF-fed gilts attained observed puberty 15.6 d earlier ($P < 0.05$), at a 12.2 kg lower body weight, and a 0.84 mm lower backfat thickness at the P_2 point ($P < 0.05$). The total number of piglets born, the number born alive, and average birthweight, were not affected by diet ($P > 0.05$). However, the incidence of intrauterine growth restriction (IUGR) was lower for SF gilts (4.62%) than for CON gilts (11.3%) ($P < 0.05$). There was also a greater intra-litter uniformity ($P < 0.05$) and a tendency for a higher number of piglets born in the SF gilts compared with the CON gilts ($P = 0.07$). In summary, prepubescent dietary soluble fiber supplementation can reduce the age at puberty in gilts and increase their subsequent reproductive performance as sows.

1. Introduction

Gilts represent a large portion of breeding females, used for the annual replacement of culled sows. However, 50% of the replacement gilts entering the breeding herd are culled before their third or fourth parity, and therefore provide only 30–40 piglets in their lifetime (Lucia et al., 2000; Zhao et al., 2015), emphasizing the importance of successful gilt development for overall herd performance and profitability.

The occurrence of puberty in the gilt represents the attainment of reproductive capability. Gonadal maturation, manifested by the occurrence of puberty, must coincide with peripheral tissue development to prevent premature disposal. In particular, the age at puberty can predict subsequent reproductive performance; for example, the early attainment of puberty predicts a lower incidence of culling and larger litter size in subsequent parities (Roongsitthichai et al., 2013; Tummaruk et al., 2007). It is generally accepted that growth rate and age are the main factors determining the age at puberty, and that gilts require a minimum accretion of lean tissue or fat to initiate the onset of puberty (Kirkwood and Aherne, 1985; Klindt et al., 1999). Therefore, nutritional decisions during the

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prepubescent phase, such as dietary energy and amino acid intake levels, can influence pubertal onset and gonadal development (Calderón Díaz et al., 2015; Miller et al., 2011; Zhou et al., 2010; Zhuo et al., 2014). In principle, the development of follicles (particularly oocyte quality) in replacement gilts during their prepubescence can determine their subsequent fertility as sows, and this might be an important issue for the rearing of replacement gilts, since the premature disposal of gilts is quite common in practical swine production (Lucia et al., 2000; Zhao et al., 2015).

Dietary fiber is usually included in gestational diets for sows to reduce aggression, increase satiety, and maintain normal reproductive performance (Che et al., 2011; DeDecker et al., 2014; Sapkota et al., 2016). However, data on the effects of dietary fiber on reproductive performance, particularly pubertal maturation, in replacement gilts are relatively sparse. It has previously been demonstrated that inclusion of dietary fiber for 19 days prior to mating modulated follicular development and improved oocyte maturity in replacement gilts, possibly by altering circulating estradiol levels (Ferguson et al., 2007). However, the impact of dietary fiber during the growth phase on pubertal onset and the subsequent reproductive performance of gilts remains ill-defined. Dietary fiber, based on its dissolution in water, can be classified as soluble or insoluble (Eastwood and Kritchevsky, 2005). It has been observed that embryonic survival was increased by soluble fiber, but decreased by insoluble fiber supplementation to sows (Renteria-Flores et al., 2008), indicating that the effects of dietary fiber on the reproductive performance of pigs might be dependent on its type. Additionally, soluble fiber had a greater influence on cholesterol metabolism and circulating estradiol concentrations (Arjmandi et al., 1992; Eastwood and Kritchevsky, 2005), and an estrogen-dependent mechanism has been proposed to play a vital role in pubertal maturation in gilts (Mayer et al., 2010). Therefore, in the present study, the objective was to examine the age at pubertal onset and its effects on subsequent reproductive function in gilts fed a diet with soluble fiber supplementation.

2. Materials and methods

All experimental procedures were approved by the Animal Care and Use Committee of Sichuan Agricultural University and complied with local animal protection laws.

2.1. Animals and experimental design

All gilts were fed a standard grower diet until they reached approximately 60 kg. A total of 136 Landrace × Yorkshire gilts with an initial body weight (BW) of 60.59 ± 7.02 kg and aged 140 ± 10 d were allocated one of two diets: a control diet (CON) or

Table 1
Composition of diets (% as fed).

Ingredients	CON[a]	Gestation I	Gestation II
Corn	62.67	64.85	72.95
Soybean meal	22.0	13.5	18.5
Wheat bran	6.0	18.0	5.0
Fish meal	3.1	0	0
Soybean oil	3.0	0	0
Fine limestone	1.48	1.15	1.08
$CaHPO_4{\cdot}2H_2O$	0.97	1.65	1.72
Salt	0.4	0.4	0.4
Trace minerals[b]	0.15	0.15	0.15
Vitamins[c]	0.02	0.02	0.02
Choline chloride (50%)	0.15	0.15	0.15
L-Lysine HCl (98.5%)	0.05	0.05	0
DL- Methionine (99%)	0	0.02	0.02
L-Threonine (98.5%)	0	0.05	0
Phytase	0.01	0.01	0.01
Total	100	100	100
Calculated nutrient content,			
Crude protein (%)	17.3	13.5	14.3
Digestible energy (Mcal/kg)	3.37	3.05	3.2
Total Lysine (%)	0.92	0.65	0.70
Soluble fiber (%)	1.18	1.32	1.29
Insoluble fiber (%)	10.8	12.1	11.6
Calcium (%)	0.9	0.9	0.9
Total phosphorus (%)	0.7	0.72	0.67
Available phosphorus (%)	0.41	0.45	0.45

[a] Soluble fiber (0.8%), containing 17.4% rhamnose, 4.1% fucose, 11.1% arabinose, 30.6% xylose, 16.4% galactose, 3.4% glucose, 8% water, 4% ash and 3.4% crude protein, was added to CON diet at the expense of corn for gilts fed SF diet. Gestation diet I was provided at 2.20 kg/d from d 35 to 90 of gestation, and gestation diet II was provided at 2.6 kg/d from d 91 of gestation to parturition.

[b] Provided per kg of diet: copper, 10 mg, 10 mg and 20 mg for CON, gestation and lactation diet, respectively; iron, 80 mg; zinc, 100 mg; manganese, 25 mg; selenium, 0.15 mg; iodine, 0.14 mg.

[c] Vitamin premix provided per kg of diet: vitamin A, 4000 IU; vitamin D_3, 800 IU; vitamin E, 441 IU; menadione, 0.5 mg; thiamine, 1.0 mg; riboflavin, 3.75 mg; vitamin B_6, 1.0 mg; vitamin B_{12}, 15 μg niacin, 10 mg; D-pantothenic acid, 12 mg; folic acid, 1.3 mg; D-biotin, 200 μg.