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Chitooligosaccharide supplementation improves the reproductive performance and milk composition of sows

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ABSTRACT

The objective of this study was to investigate the effects of chitooligosaccharides (COSs) on the reproductive performance of sows. Thirty-eight pregnant sows were investigated in this study. These sows were fed with corn–soybean-based diets supplemented with COS (COS group) or without COS (control group) during the estrous stage. An isotopic-MS relative quantification method was used to analyze the porcine milk oligosaccharide (PMO) diversity between the two groups. COS supplementation increased the total number of piglets born by 18.5% ($P<0.05$), the number of piglets born alive by 19.2% ($P<0.05$), and the live born litter weight by 31.3% ($P<0.01$). In the milk of lactating sows, 17 distinct PMOs were identified in the two groups. Among them, a trisaccharide (Hex_3) and a tetrasaccharide ($Hex_2GlcNAcNeuAc$) were 60% and 150% higher in the COS group than in the control group. These findings indicate that litter size and litter birth weight were increased in sows through COS intervention; meanwhile, COS supplementation can modify the oligosaccharides in porcine milk.

1. Introduction

In the last 20 years, litter size has been shown to have low heredity in sow breeding. Total porcine litter size is low in China, and this has restricted the rapid development of the pig industry. It has been acknowledged that 30–50% of fertilized ova result in embryonic loss or fetal death during gestation (Pope, 1994), and this directly results in a decrease in piglet number after farrowing. Moreover, increased litter size results in a reduction of the blood supply to the fetuses (Pere and Etienne, 2000). On the other hand, larger fetuses correlate with fewer piglets being born (Pere et al., 1997; Johnson et al., 1999; Vallet et al., 2002). Recently, some approaches have been claimed to improve litter size and the individual weights of piglets at birth.

A recent study indicated that fructooligosaccharide (FOS) supplementation increased the number of live born piglets by one (Tan, 2010). However, the total number of piglets was not significantly improved in those studies. In addition, L-arginine supplementation throughout pregnancy increased rat litter size by 4, and the number of surviving embryos was increased when L-arginine supplementation was supplied in the dam's diet from day 1 to day 7 of pregnancy (Zeng et al., 2008). In other studies, L-arginine supplementation of 1% between days 30 and 114 of gestation increased the total number of live piglets and

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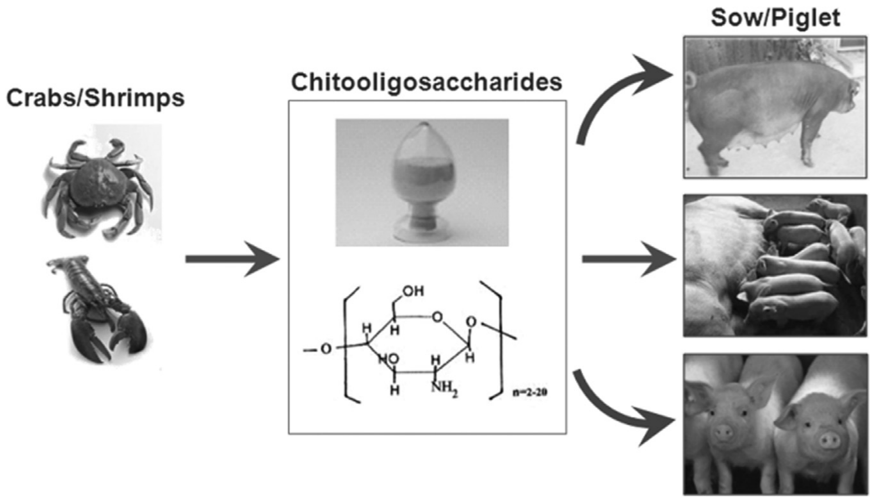

Fig. 1. Schematic diagram of chitooligosaccharide application in swine production.

the litter born weight of live piglets by 22% and 24%, respectively (Mateo et al., 2007). However, the total number of piglets was not been significantly increased in those studies. Those previous investigations focused on litter size, the effect of diet supplementation on embryonic survival and placental development.

As the only nutritional source for new born piglets, milk is crucial for piglet health; thus, it is valuable to investigate the alteration of the contents of porcine milk. Milk oligosaccharides are a family of structurally variable glycans that are highly abundant and play a vital role in mammalian milk. Milk oligosaccharides have several potential biological activities, including preventing pathogens from sticking to the intestinal epithelia and serving as nutrients for beneficial intestinal bacteria. In humans, oligosaccharides are the third most abundant components in milk (after lipids and lactose), and it is now well-known that milk oligosaccharides are significant for the healthy growth of infants (Bode, 2006). Some human milk oligosaccharides (HMOs) have similar structural motifs to glycans on the infant's intestinal epithelia that are receptors for pathogens; thus, these HMOs serve to prevent binding of pathogens to epithelial cells and, thereby, protect infants from disease (Newburg, 2000). Together with other functions, milk oligosaccharides contribute to the generation of a protective intestinal environment that is helpful for the health of infants (Newburg et al., 2005). Despite their importance in humans, there is little information on porcine milk oligosaccharides.

Recently, chitooligosaccharides (COSs) have been used as a feed additive in the piglet diet to enhance growth performance (Fig. 1) (Sun et al., 2009; Walsh et al., 2013). COSs possess an antibacterial activity in the weaned pig (Kong et al., 2014). Moreover, COS supplementation increased the digestive capabilities of the piglets (Zhou et al., 2012). However, the effect of COSs on the reproductive capacity of pregnant animals was not investigated. Sow reproductive performance is low in China. Some functional oligosaccharides have been used to improve the sows' reproductive performance, such as fructooligosaccharides and chitooligosaccharides. Feedback information from the breed company indicated that COSs might increase litter size by one, and a recent study indicated the fructooligosaccharide supplementation increased the number of live born piglets by one. Additionally, preliminary studies in our laboratory indicated that COS supplementation improved the number of embryos implanted in mice (data unpublished). Based on the above-mentioned data, this research was conducted to investigate the effect of COS on the litter size of sows.

2. Materials and methods

2.1. Animals and diets

This study was approved by the Animal Welfare Committee of the Chinese Academy of Sciences. A total of 38 pregnant sows whose parity was from 2 to 4 (Landrace × Large White Sows) were used in this study. All sows were determined to be in the estrous stage and were then inseminated twice, 4–7 days after weaning with unfrozen semen via artificial insemination. From day 1 of mating, the sows were assigned to one of two treatment groups to ensure that each group had a similar number of sows with the same parity. The sows were fed a corn–soybean based diet supplemented with 40 mg/kg COS (experimental group) or without COS supplementation (control group). There were 18 and 20 sows in the control and COS-supplemented groups, respectively. The numbers of sows were not the same between the two groups because a few sows initially assigned to these groups did not become pregnant. Both groups were provided with 13.0 MJ/kg metabolizable energy and 12.2% crude protein. Sows were fed with diet limitation during gestation to control their body weight. Water was provided to all pregnant sows ad libitum throughout the course of the experiment. All pregnant sows were transferred from the pregnancy room to the farrowing room in individual farrowing crates. Sow body weight before delivery and on day 21 of lactation were measured. Meanwhile, the total number of piglets born, total number of piglets born alive, and the individual weights of the piglets at birth were recorded.