Reproductive performance of gilts and sows associated with their serum insulin-like growth factor-I and the supplementation of fermented potato protein

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The present study aims to determine the influence of fermented potato protein supplementation in feed on the concentrations of serum insulin-like growth factor-I (IGF-I) and reproductive performances in gilts and sows. Two experiments were conducted: Exp I included 61 gilts were fed with conventional gilt feed (n=30) or conventional gilt feed supplemented with the fermented potato protein (Lianol®) (n=31). Serum IGF-I concentrations were measured before and after the feed supplementation. In Exp. II included 119 sows were fed with a conventional lactation feed (n=58) or conventional feed supplemented with the fermented potato protein (n=61). Reproductive performance data were recorded. In conclusions, the supplementation of the fermented potato protein in gilts did not alter their serum IGF-I and reproductive performances. Nevertheless, the supplementation of the fermented potato protein in sows significantly decreased WSI and FSI.

Keywords: flushing, IGF-I, litter size, non-productive day, pig

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INTRODUCTION

Insulin-like growth factors I (IGF-I) are peptide hormones involving in metabolic regulation of growth (Lamberson et al., 1996; Lackey et al., 2000), body composition and puberty onset in gilts (te Pas et al., 2004; Silva et al., 2009). IGF-I also influence proliferation of ovarian granulosa cells in many species (Gooneratne et al., 1990). Furthermore, IGF-I involve in many aspects of the ovarian function including folliculogenesis, steroidogenesis and induction of luteinizing hormone receptors (Silva et al., 2009). Several tissues in pigs have been found to produce IGF-I (Sangel and Roxas, 2011). Serum IGF-I are positively correlated with growth rate of pig (Sangel and Roxas, 2011). Patterson et al. (2010) found that 100-day-old gilts with high level of plasma IGF–I reached puberty earlier than those with low plasma IGF–I levels.

A fermented potato protein (Lianol®) has recently been developed to be used as a feed supplementation in order to promote the level of serum IGF-I in pigs (Smulders, 2012b). Earlier study has demonstrated that IGF-I is an important modulator of reproductive function in pig (Whitley et al., 1995). An increase in serum IGF-I concentration is associated with puberty onset, GnRH secretion and follicular function (Whitley et al., 1995). Furthermore, IGF-I receptor has been found in the pituitary gland indicating that IGF-I may involve in the function of pituitary gland (Richards et al., 1991). However, no clinical study on the application of the fermented potato protein in gilts and sows associated with their reproductive performance, e.g., litter size and non-productive days, has been conducted.

The present study was undertaken to quantify the concentrations of serum IGF-I in gilt and to determine the influence of the supplementation of fermented potato protein in feed for 14 days in gilts (exp I) and 34 days in sows (exp II) on serum IGF-I and reproductive performances in gilts and sows.

MATERIALS AND METHODS

Experimental design

In Experimental I, a total of 31 Landrace x Yorkshire replacement gilts received fermented potato protein (20 grams/day, Lianol® Solapro, Huvepharma Ltd., Susteren, The Netherlands). The supplement was added on top of the gilt feed for 14 days before insemination. The control group received a conventional gilt feed. Blood samples were collected before and at 14 days after the supplementation of the fermented potato protein. Serum was analyzed for IGF-I concentration. After farrowing, the reproductive performances data including number of total piglets born/litter (TB), number of piglets born alive/litter (BA), percentage of mummified fetuses (MM) and stillborn piglets/litter (SB) were recorded.
In Experimental II, a longitudinal study was conducted in 119 Landrace x Yorkshire sows. The sows were classified into 2 groups: control (n=58) and treatment group (n=61). The treatment group received the fermented potato protein added on top of the lactation feed (20 grams/day) for 34 days, starting on the next day after being moved into farrowing house until insemination. The control group received a conventional lactation feed. Reproductive performances data including TB, BA, MM, SB, weaning-to-first-service interval (WSI) and farrowing-to-service interval (FSI) were recorded.

Animal

The current study was conducted in a swine herd in the eastern region of Thailand between August and September 2011. A total number of 31 Landrace x Yorkshire crossbred gilts and 119 sows were included in the experiment. The gilts age 8 months, weight >130 kg and exhibited standing oestrus at least once. The mean±SD of parity number of sows was 3.1±1.3 (ranged 2 to 7). The gilts and sows were accommodated in a conventional open housing system. The gilts were weighed before being moved into the breeding house. The sows were moved into farrowing house at 7 days before expected time of farrowing. The lactating sows were fed with a rice-corn-soybean-fish ration containing 18.0% crude protein, 3250 kcal/kg metabolizable energy and 1.10% lysine. The gilts were fed with the gilt’s feed containing 16.0% crude protein, 2900 kcal/kg metabolizable energy and 1.0% lysine. All insemination in the herds was carried out using conventional artificial insemination (AI).

Blood venipuncture

The blood sample was collected twice via jugular venipuncture of gilt on the day before they received the fermented potato protein and at 14 days after the supplementation. The blood was collected by using 18 gauge 1.5 inches length needle with 5 ml syringe. The blood was immediately transferred into 6-ml plastic VACUETTE® heparin tube (Greiner Bio-One GmbH, Kremsmunster, Austria). The tube was put in an ice box for transportation to the laboratory within 24 hours. The blood samples were centrifuged at 3000 rpm for 15 min. The serum was separated and kept in eppendorf tube and frozen at -20 °C until it was used for IGF-I analysis.

Serum IGF-I assay

Serum IGF–I concentration was determined by using enzyme immunoassay (ELISA) kit (IGF–I–ELISA test kit, Mediagnost®, Reutlingen, Germany). The assay protocol followed the manufacturer’s instruction. Briefly, the principle of the assay was to utilize two specific and high affinity antibodies for IGF-I protein. The IGF-I in the sample was combined to the immobilized first antibody on the microtiter plate. Thereafter, the biotinylated and streptavidin-peroxidase conjugated second specific anti-IGF-I-antibody were added to the immobilized IGF-I. Finally, the closing substrate was added and the color
was changed depending on the IGF-I-level of the samples. All the specimen and reagents were set at room temperature (25 °C), the serum sample and control serum were diluted with sample buffer at a dilution of 1:21. In total, 80 µl of antibody conjugate was added to all wells. Sample (20 µl) buffer and standard (2-50 ng/ml) were added. The wells were covered with sealing tape, incubated and washed with washing buffer (250 µg). The enzyme conjugate (100 µl) and substrate solution were added in each well and repeat the incubation and washing procedure again. Stopping solution (100 µl) was added in each well to stop the reaction and then measure the absorbance within 30 min at 450 nm. All standard and samples were analyzed in duplicate. The intra-assay CV for low and high concentrations was 3.2% and 9.8%, respectively.

Reproductive performance data

The reproductive performance data of gilts and sows were collected. At farrowing, the date of farrowing, TB, BA, MM and SB were recorded and after weaning WSI and FSI were calculated.

Statistical analyses

The statistical analyses were performed by using SAS (SAS Inst. Cary, NC., USA.). Multiple ANOVA and student t-test were used to analyze the data. Pearson's correlation analysis was conducted to determine the association among continuous variables. The levels of serum IGF-I concentration of the gilts before and after fermented potato protein supplementation were analyzed by using pair t-test. p<0.05 were regarded to be statistically significance.

RESULTS

IGF-I concentration

On average, the body weight of the replacement gilts was 138.9±7.3 kg (range 130-160). The mean serum IGF-I of the gilts was 136.7±44.7 ng/ml (range 64.1-271.9). The serum IGF-I did not alter after the fermented potato protein supplementation (p=0.310). Nevertheless, individual variation on the serum IGF-I concentration after the fermented potato protein supplementation was observed (Figure 1). In some gilts, the serum IGF-I was increased up to 75.0%, while in some gilts the serum IGF-I was decreased down to 38.3% (Figure 1).

Gilts reproductive performance

Reproductive performances, i.e., TB (11.8 and 11.5 piglets/litter, p=0.786), BA (10.9 and 10.5 piglets/litter, p=0.703), SB (4.5% and 4.6%, p=0.990) and MM (4.9% and 3.2%, p=0.642) were not significantly different between groups.
The supplementation of fermented potato protein in sows decreased WSI (9.9 and 4.8, \( p=0.043 \)) and decreased FSI (35.5 and 30.4, \( p=0.041 \)), but did not influence TB (12.4 and 11.1 piglets/litter, \( p=0.110 \)), BA (11.1 and 10.0 piglets/litter, \( p=0.105 \)), MM (5.7% and 4.2%, \( p=0.295 \)) and SB (3.9 and 5.5, \( p=0.331 \)).

**DISCUSSION**

The level of serum IGF-I in gilts in the present study is relatively low but still within the normal range compared to other studies (Silva et al., 2009; Patterson et al., 2010). It is well established that IGF-I is involved with ovarian folliculogenesis in mammals, including stimulation of growth of secondary follicles, proliferation of granulosa cells of antral follicles and steroidogenesis (Silva et al., 2009). It can be expected that this increase in IGF-I will result in a better ovarian function. However, in the present study, serum IGF-I was only slightly increased after the supplementation of the fermented potato protein for 14 days, but no significant difference could be gained. Additional research work maybe needed to carry out in a higher number of gilts or with a longer period of the feed supplementation (i.e., >14 days) to obtain a significant result.

A previous study demonstrated that the oral administration of the fermented potato protein in neonatal piglets resulted in a 44% increase in serum IGF-I level compared to the control group (Smulders, 2012b). In the present study, the supplementation of the fermented potato protein in the gilt feed for 14 days slightly increase serum IGF-I level for 11% but did not differ significantly compared to the control group. The reason might be due to that the supplementation in feed for 14 days maybe too
short for digestion, metabolism and utilization the potato protein and increase the IGF-I level in the blood stream of the gilts. In fact, the digestive system of the gilts and the neonatal piglets is obviously difference. For instance, the gut of the gilt has already well developed, while the gut of the neonatal pig is under developed. The tight junction of the immature gut had a higher permeability than the tight junction of the mature gut. Thus, the neonatal piglets may absorb the potato protein more easily than the gilts. Furthermore, in neonatal pigs, the potato protein so call ‘ready to use’ preparation was orally fed directly, while the potato protein used in gilts was mixed with feed. This may cause the loss of some potato protein during feeding. Therefore, prolong feed supplementation period or increase the dose of the potato protein in the gilts feed are recommended. Additionally, the increment of serum IGF-I differed among gilts (Figure 1). This is due to the fact that each gilt has different feed consumption, digestion and metabolism, thus the level of serum IGF-I is largely variable. We found that the serum IGF-I levels varied from 64.1 ng/ml to 271.9 ng/ml among gilts. This indicates that the serum IGF-I in some of the gilts is needed to be improved.

A previous study demonstrated that the supplementation of the potato protein around weaning in sows increased 0.76 TB and 0.66 BA (Smulders, 2012a). This implies that the potato protein may improve the reproductive performance. In the present study, the supplementation of the fermented potato protein in the gilts for 14 days did not improve any reproductive performance significantly compared to the control group.

In the present study, the supplementation of fermented potato protein in sow decreased WSI. This is in accordance with Xue et al. (2011) who found that the supplementation of fermented potato protein in the sow lactation feed reduced body weight loss during lactation and shorten WSI. On the other hand, Smulders et al. (2011) found that WSI are increased in the sow that were fed with the fermented potato protein, but the pregnancy rate at day 28 after insemination and number of farrowed sow in the treatment group were higher than control group (Smulders et al., 2011). These studies implied that the supplementation of the fermented potato protein during lactation in sows may enhance follicle development and might have had a beneficial effect on post-weaning reproductive performance and/or fertility of sows.

In conclusions, the supplementation of the fermented potato protein in gilts for 14 days before mating did not alter their serum IGF-I and reproductive performances. Nevertheless, the supplementation of the fermented potato protein in sows for 34 days before mating significantly decreased WSI and FSI.

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