Effects of SPC replacing animal protein supplements on intestinal health, nutrient digestibility, and growth performance of weaned pigs

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* This article is based on the research carried out by North Carolina State University, USA. As the data are not published yet, this article just to introduce the key results.

Background

Animal protein supplements have been largely used in nursery diets as source of protein to enhance the growth and health in weaned pigs without anti-nutritional factors (ANF) coming from soybean meal (Coffey and Cromwell, 2001; Lenehan et al., 2007). However, the supply of animal-based ingredients in the market is usually below the demand (Zhang et al., 2015) and therefore they cost more than the plant-based ingredients (Ncobela and Chimonyo, 2015). Also, increasing concern about animal and meat safety has heightened potential uncertainty regarding feeding animal tissue-derived ingredients to animals (Dunsford et al., 1989). It is, therefore, important to explore potential protein sources for successful and sustainable swine production (Brotzge et al., 2014).
The crude protein in soy protein concentrate (SPC) is similar to animal protein ingredients with low concentration of ANF in comparison to SBM. Thus, inclusion of SPC in weanling pig's feed can improve the morphology of villi in the small intestine resulting in improved growth performance compared with pigs fed SBM because of a reduction in dietary soy allergens (Li et al., 1990; Sohn et al., 1994). Therefore, SPC can be used in nursery diets replacing animal protein ingredients.

Objectives

The study was proposed to determine the effects of SPC replacing major animal protein supplements (blood plasma, poultry meal and fish meal) in nursery diets (phase 1 to 3) in Exp.1. and to test how much animal protein supplements can be replaced by SPC without affecting growth performance, intestinal health and nutrient digestibility of weaned piglets (phase 1 to 3) in Exp. 2.

Materials and Methods

Experimental design, animal, diets, and housing

The experimental protocol was approved by the Institutional Animal Care and Use Committee of North Carolina State University (NCSU). A total of 72 twenty one-d-old weaning pigs (control treatment was shared) with an initial average body weight (BW) of 6.4 ± 0.6 kg were allotted in a randomized complete block design into 2 experimental trials based on sex and initial body weights as blocking criteria. Both experiments lasted for 35 days with 3 phases: Phase 1 for 10 d (to reach 7 kg BW), Phase 2 for 12 d (to reach 11 kg BW), and Phase 3 for 13d (to reach 20 kg BW). The diets were formulated to meet or slightly exceed NRC (2012) nutrient requirement. Pigs housed in individual pens in an environmentally controlled room. Throughout the experimental, all pigs were provide with ad libitum access to fed and water through a self-feeder and nipple drinker, respectively.

In Exp. 1, a total of 48 weaned pigs were allotted to 4 dietary treatments (12 replicate pens per treatment, 1 pigs per pen) consisting of the use of SPC (X-Soy 200, Selecta) replacing animal protein supplements. Treatment arrangements are as follow:

Table 1. Dietary treatments of Exp. 1

Group*	Heads	Treatment
CON	12	Fish meal 4/2/1%, poultry meal 10/8/4%, blood plasma 4/2/1% for P1/2/3
RFM	12	SPC replacing 100% fish meal but with poultry meal and blood plasma
RPM	12	SPC replacing 100% poultry meal but with fish meal and blood plasma
RBP	12	SPC replacing 100% blood plasma but with fish meal and poultry meal

*CON = control; RFM = replacing fish meal; RPM = replacing poultry meal; RBP = replacing blood plasma

In Exp. 2, a total of 32 weaned pigs were allotted to 4 dietary treatments (8 replicate pens per treatment, 1 pigs per pen) consisting of increasing levels of SPC (X-Soy 200, Selecta) replacing animal protein supplements. Treatment arrangements are as follow:

Table 2. Dietary treatments of Exp. 2

Group*	Heads	Treatment
CON	8	Fish meal 4/2/1%, poultry meal 10/8/4%, blood plasma 4/2/1% for P1/2/3
R1/3	8	SPC replacing 1/3 of fish meal, poultry meal, and blood plasma
R2/3	8	SPC replacing 2/3 of fish meal, poultry meal, and blood plasma
R3/3	8	SPC replacing 3/3 of fish meal, poultry meal, and blood plasma

*CON = control; R1/3 = replacing 1/3 of animal protein supplements; R2/3 = replacing 2/3 of animal protein supplements; R3/3 = replacing all of animal protein supplements

Statistical analysis

All experimental data was analyzed using the mixed procedure by using SAS 9.4 (SAS 9.4 Inc., Cary, NC, USA). Experimental unit was the pig that was fed and housed individually. Main effect was dietary treatment, considered fixed effect. Data are subject to be analyzed based on a randomized complete block design with sex and initial body weights as blocking criteria (random effects in the model). Power test was completed to have 12 replicates per treatment needing 48 pens (Exp. 1) or 8 replicates per treatment needing 32 pens (Exp. 2) to handle 7 dietary treatments. It was considered statistically significance as P-value less than 0.05 and considered tendency as P-value between 0.05 and 0.10.

Results

Growth Performance

The BW and feed intake were recorded at the end of each phase to calculate average BW, ADG, ADFI, and G:F. In Exp. 1, BW, ADG, ADFI and G:F were not affected during all experimental periods when fish meal, poultry meal, or blood plasma were replaced by SPC. In Exp. 2, the increasing levels of SPC replacing animal protein supplements linearly reduced ($P < 0.05$) ADG, and ADFI during all experimental periods. Whereas, the increasing levels of SPC replacing animal protein supplements decreased linearly ($P < 0.05$) G:F only on phase 1 and d 0 to d 22 after weaning (phase 1 - 2). However, there was no difference in growth performance even when animal protein supplements were replaced by 2/3 with SPC.

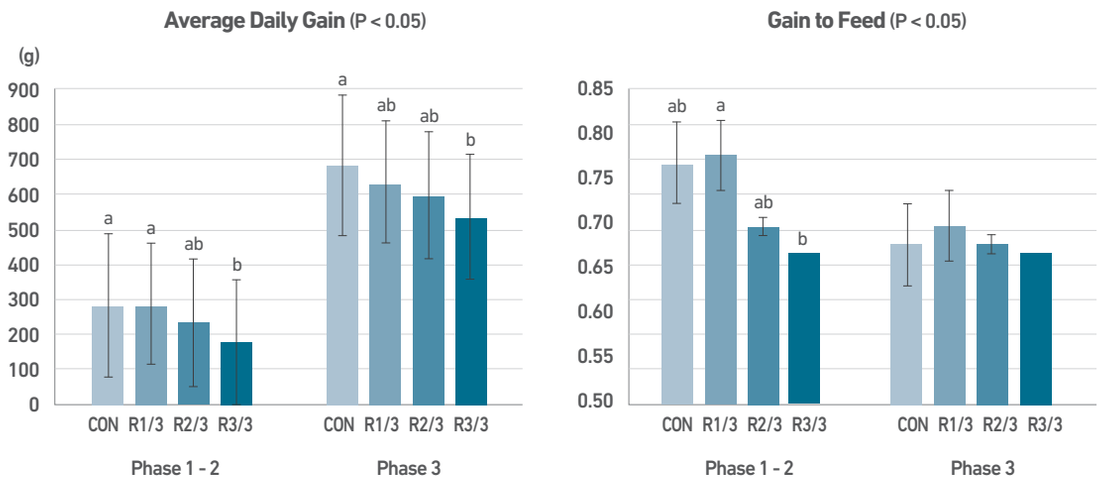

Figure 1. Effect of SPC replacing animal protein supplements on growth performance

Fecal Score

Fecal scores were recorded daily based on a 1-5 scales: (1) very hard and dry feces, (2) firm stool, (3) normal stool, (4) loose stool, and (5) watery stool with no shape. There were no differences among the treatments on fecal score during entire experimental period of Exp. 1 and Exp. 2.

Apparent Ileal Digestibility

Titanium dioxide (0.4%) was added as an indigestible external marker and fed during the last 5 d of phase 3 of the experiment. There were no differences in DM, GE, EE, CP, and AA digestibility among the treatments in Exp. 1 and Exp. 2.

Oxidative Stress and Immune Status

In Exp. 1, SPC replacing fish meal in the diet tended to increase ($P = 0.087$) the IgA content in the jejunal mucosa of weaned pigs compared to CON treatment. In Exp 2, SPC replacing animal protein supplements tended to increase ($P = 0.099$) the concentration of IgA in the mucosa (0 vs. SPC). The concentration of MDA, TNF-α, IL-8, protein carbonyl, and IgG, were not affected by the treatments.

Histological Evaluation

There were no differences in villus height, villus width, crypt depth, VH:CD ratio, and the ratio of Ki-67 positive cells to total cells in the crypt among the treatments in Exp.1 and Exp.2.

Microbiome Sequencing

The microbiome was analyzed in Exp. 1. In phylum level (Table 7), SPC replacing fish meal tended to increase ($P = 0.097$) the relative abundance of Firmicutes in the jejunal mucosa. Soy protein concentrate replacing poultry meal increased ($P < 0.05$) the relative abundance of Firmicutes and Bacteroidetes, which is associated with obesity, whereas it decreased Proteobacteria ($P < 0.05$).

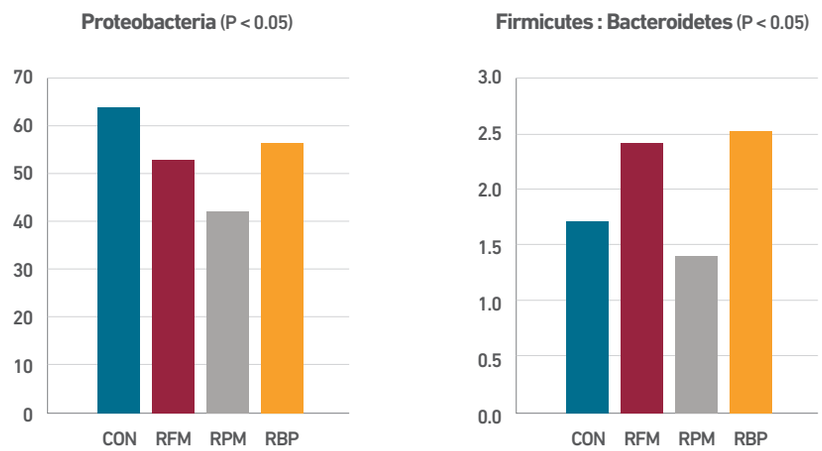

Figure 2. Effect of SPC replacing animal protein supplements on on intestinal microbiome

Conclusion

During phase 1 and 2 feed after weaning, ADG and G:F were not affected by experimental diets. Thus, replacement of blood plasma, poultry meal or fish meal with SPC in diets fed during phase 1 and 2 have no negative impact on growth performance, intestinal health and AID of CP and AAs in weaned piglets. Also, SPC could replace the 2/3 of whole animal protein sources without affecting growth performance in weaned piglets. In addition, SPC could replace the animal protein supplements during phase 3 without negative effects on growth performance. Non-allergenic proteins in SPC successfully replace animal protein supplements partly or fully in nursery diets.

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