EFFECT OF PLASMA PROTEIN ON PERFORMANCE AND PLASMA INSULIN LIKE GROWTH FACTOR-I, GROWTH HORMONE, INSULIN, AND GLUCOSE CONCENTRATIONS IN EARLY WEANED PIGS

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Story in Brief

Previous studies have found that plasma protein markedly improves performance in the early weaned pig. However, the mechanism responsible for this increased performance has not been elucidated. Determinations in our laboratory indicates that plasma protein contains high levels of insulin like growth factor-I (IGF-I). Therefore, this study was conducted to determine the effect of plasma protein on performance, IGF-I, growth hormone, insulin and glucose concentrations in plasma of the early weaned pig. Eighteen Yorkshire pigs weaned at 19 to 20 days of age were randomly allotted to one of two treatments: 1) a control prestarter diet containing 21.5% soybean meal and 2) a diet containing 14% porcine plasma protein. Treatments were applied for 2 weeks (Period 1), followed by feeding a common starter diet for two more weeks (Period 2). During week 1 and Period 1, pigs fed plasma protein grew faster and consumed more feed than those fed soybean meal. Feed efficiency was similar in both treatments for week 1 and Period 1. Performance during Period 2 was not affected by treatment. Replacing soybean meal with plasma protein did not affect IGF-I and glucose concentrations. However, plasma protein replacement increased plasma growth hormone concentrations. Insulin levels were higher in pigs fed soybean meal when compared to those fed plasma protein. These data support previous findings that the addition of plasma protein to the early-weaned pig diets increases growth rate and feed intake. The factor responsible for this improved performance does not appear to involve increased plasma levels of IGF-I.

(Key Words: Early-Weaned Pig, Plasma Protein, Performance, IGF-I, Growth Hormone.)

Introduction

Early weaning is commonly followed by a reduction in performance during the first to second week after weaning and milk proteins have been used to substitute soybean proteins to minimize the effect of this postweaning lag period. Recent research has been directed toward attempts to identify

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other protein sources which can be effectively substituted for milk proteins or soy proteins to improve performance. Among the ingredients tested, spray dried plasma protein (SDPP) has been shown to consistently improve performance when added to starter diets at the expense of soy protein (Fakler et al., 1992; Gatnau and Zimmerman, 1991), dried skim milk (Sohn et al., 1991) or whey (Hansen et al., 1993).

The mechanism by which SDPP increased growth rate in early weaned pigs is unknown. The endocrine system is known to play an important role in regulation of animal growth. Positive correlations of IGF-I concentrations with weight and weight gain have been reported for swine (Buonomo et al., 1987). In addition, it has been suggested that feeding recombinant human IGF-I (rhIGF-I) to neonatal calves increased IGF-I plasma concentrations with prolonged treatment (Skaar et al., 1994). Determinations in our laboratory indicate that SDPP contains high levels of IGF-I (1.5 ng/mg). In addition, other metabolic hormones such as growth hormone (GH) and insulin have been demonstrated to be involved in growth (Davis, 1988).

The present study was conducted to evaluate the effect of plasma protein on performance, IGF-I, GH, insulin and glucose concentrations in early weaned pigs.

Materials and Methods

Eighteen Yorkshire pigs weaned at 19 to 20 days of age averaging 13.2 lb were randomly assigned within litter to one of two treatments: 1) a control prestarter diet containing 21.5% soybean meal (SBM) and 2) a diet containing 14% SDPP (substituted on an equal lysine basis at the expense of SBM and lysine HCl; Table 1). Treatment duration was 2 weeks (Period 1) with interim gain and efficiency estimates obtained weekly. Subsequently, all pigs were fed a common corn-soybean meal starter diet (1.1% lysine; Table 1) for an additional 2-week period (Period 2) to evaluate any carryover effect on performance from diets fed during Period 1. Pigs were allowed to consume their diets and water on an ad libitum basis during both periods. These pigs were individually housed in metabolism crates in an environmentally controlled room. Temperature was maintained at 86°F during the first week of the experiment and was decreased 2°F per week for the remainder of the experiment.

Blood samples were taken via anterior vena cava puncture on alternate days for the first week and twice per week thereafter. Immunoreactive IGF-I, GH, and insulin concentrations in plasma were determined by radioimmunoassay. Plasma glucose concentrations were measured using the Roche reagents for glucose (Roche, NJ).

Performance data were analyzed by least squares analysis of variance with treatment, litter, and the two-way interaction in the model. Hormone and glucose data were analyzed according to a split plot design with treatment as

Table 1. Composition of experimental diets.

	Diets[a]		
	Period 1		Period 2
Ingredient, %	SBM	Plasma protein	
AP-820[b]	--	14.0	--
Soybean meal, 44%	21.5	--	28.5
Whey, dehydrated	14.0	14.0	--
Steam rolled oats	10.0	10.0	--
Pro-88 (cheese by-product)[c]	5.0	5.0	--
Corn, yellow	35.574	43.264	67.695
Soybean oil	4.0	4.0	--
Fishmeal, sel. menhaden	5.0	5.0	--
Egg, protein	1.8	1.8	--
Lysine, HCl	.31	--	.15
CTC-50[d]	.2	.2	--
Biotin	.001	.001	--
Flavor	.1	.1	--
Salt	.2	.2	.4
Copper sulfate	.1	.1	.075
DL-Methionine	.23	.06	--
Mecadox premix[e]	--	--	.25
Dicalcium phosphate	1.2	1.75	1.90
Calcium carbonate	.26	--	.65
Ethoxyquin	.025	.025	--
Vit. min. premix	.5	.5	.38
Calculated analysis, %			
Crude protein	22.04	22.62	18.35
Lysine	1.6	1.6	1.11
Calcium	.95	.95	.85
Phosphorus	.84	.84	.72

[a] As fed basis.

[b] Plasma protein source, American Protein Corp., Ames, IA.

[c] Morgan Mfg. Co., Inc., Paris, IL.

[d] Contained 110 g chlorotetracycline per kg.

[e] Contained 22 g Carbadox per kg.

the main plot and day postweaning as a subplot, and all appropriate interactions.

Results and Discussion

Pigs fed SDPP grew 57 and 27% faster (P<.05) than pigs fed diet with SBM during the first week on trial (week 1) and during the overall two-week period (Period 1), respectively (Table 2). During week 1 and Period 1 average daily feed intake was greater (P<.05) for pigs fed the SDPP diet than those fed the SBM diet. Pigs fed the SDPP diet consumed 26 and 20% more feed during week 1 and Period 1, respectively than those fed SBM (Table 2). The results of this study support the finding of Gatnau and Zimmerman (1990) and Fakler et al. (1992) who reported that pigs fed SDPP had better performance than those fed SBM. Little difference was noted between treatment groups in feed efficiency during the first week and for the overall 2-week period. No differences in performance were observed between treatments during Period 2.

Replacing SBM with SDPP did not affect (P>.10) plasma concentrations of IGF-I (Figure 1, Panel A) which is in contrast to the expected positive association with the higher growth rate in SDPP fed pigs. These results may suggest that even though SDPP contains high levels of IGF-I, it is not readily

Table 2. The effect of plasma protein on performance of early weaned pigs[a].

	Treatment		
Item	SBM	SDPP	SE
No of pigs	9	9	
Average daily gain, lb			
Week 1	.35[b]	.55[c]	.04
Week 2	.92	1.03	.06
Period 1	.62[b]	.79[c]	.04
Period 2	1.08	1.10	.04
Average daily feed intake, lb			
Week 1	.68[b]	.86[c]	.04
Week 2	1.17	1.39	.06
Period 1	.93[b]	1.12[c]	.04
Period 2	1.76	1.87	.11
Feed efficiency, gain/feed			
Week 1	.49	.64	.06
Week 2	.77	.74	.04
Period 1	.63	.69	.03
Period 2	.63	.59	.02

[a] Least squares means.

[b,c] Means in the same row with different superscripts differ (P<.05).

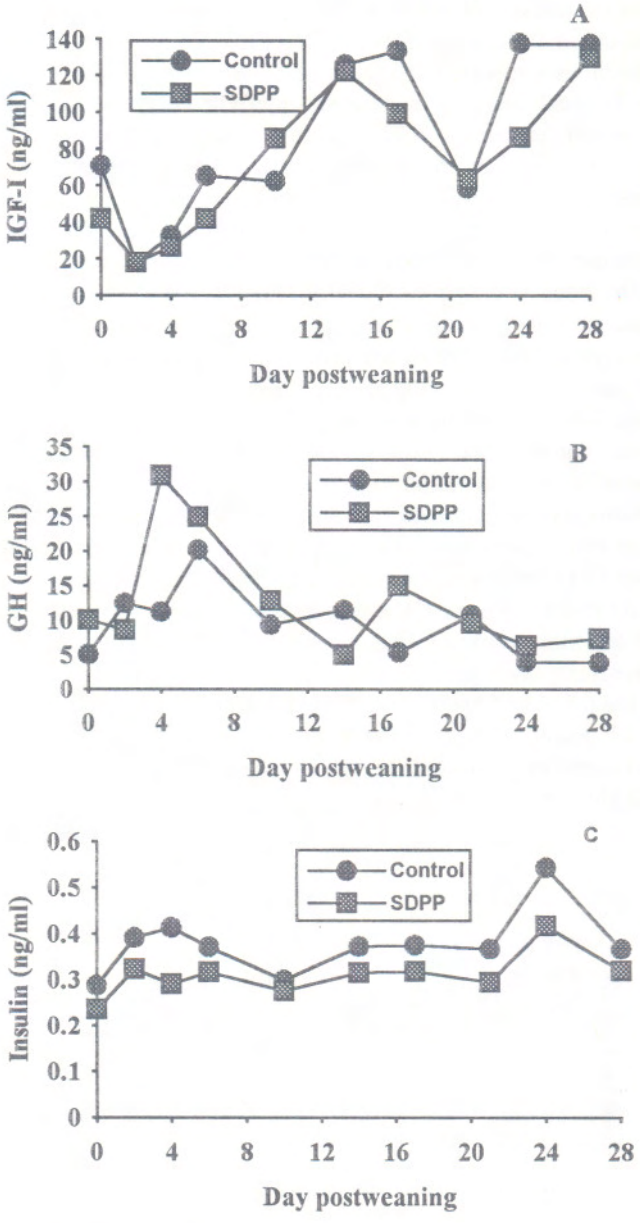

Figure 1. Concentrations of insulin-like growth factor-I (IGF-I; Panel A), growth hormone (GH; Panel B) and insulin (Panel C) in plasma of early weaned pigs from day 0 to 28 postweaning.

absorbed or the amount of SDPP fed may not have been high enough to cause an increase in circulating IGF-I levels. The effect of SDPP on IGF-I levels has not been previously reported. Skaar et al. (1994) reported that feeding rhIGF-I (in experimental diets) at a dose of approximately 60 µg/kg BW/day to neonatal calves increased IGF-I plasma concentrations with prolonged treatment. However, in the present study SDPP fed pigs were receiving approximately 15 µg IGF-I/kg BW/day which may explain the failure of SDPP to increase IGF-I plasma concentrations in this study. Nonetheless, these levels of dietary IGF-I may be great enough to influence intestinal mucosal function. Previous studies in rats have suggested an important role of IGF-I in the stimulation of gastrointestinal growth (Heinz-Erian et al., 1991). Concentrations of IGF-I increased with time after weaning in control and SDPP-fed pigs (day postweaning effect, P<.01).

Plasma GH concentrations were higher (P<.06) in pigs fed SDPP than pigs fed the control diet (12.5 vs 8.8 ± 2.0 ng/ml; Figure 1, Panel B). Exogenous pGH administration to pigs after weaning increases plasma IGF-I concentrations and their growth rate and feed efficiency (Chung et al., 1985). Whether the higher growth rate shown by pigs fed SDPP in this study is due to their higher GH concentrations remains to be determined. Day postweaning also affected (P<.01) plasma GH concentrations (Figure 1, Panel B); in control and SDPP-fed pigs, plasma GH increased during the first week postweaning and then generally decreased.

Pigs fed SBM had higher (P<.06) insulin levels than those fed SDPP (.37 vs .31 ± .02 ng/ml; Figure 1, Panel C). Glucose concentrations, however, were not affected by treatment (Figure 2). Day postweaning affected (P<.01) insulin and glucose concentrations.

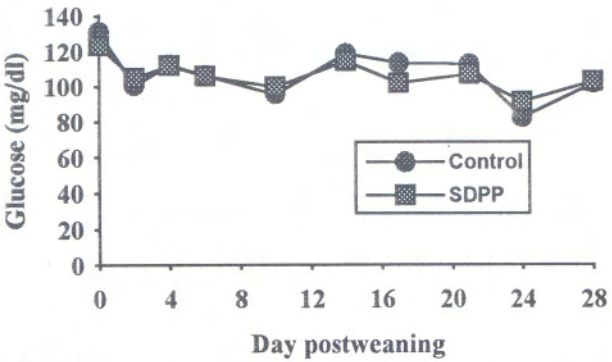

Figure 2. Concentrations of glucose in plasma of early weaned pigs from day 0 to 29 postweaning.

This study indicates that replacing SBM with SDPP in complex prestarter diets for early weaned pigs alters hormone concentrations and results in increased performance. The factor(s) responsible for this improved performance does not appear to involve plasma levels of IGF-I, but may involve GH.

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