EVALUATION OF THE EFFECTS OF WHEAT GLUTEN SOURCE AND ANIMAL PLASMA BLENDS ON THE GROWTH PERFORMANCE OF NURSERY PIGS

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Summary

A total of 472 weanling pigs (initially 13.5 lb) were used in two experiments to evaluate the effects of wheat gluten source (WG) and combinations with spray-dried animal plasma (SDAP) on growth performance of nursery pigs. In Exp. 1, the five dietary treatments included a control diet containing 6% SDAP, wheat gluten that was enzymatically hydrolyzed (Source 1), and a non-hydrolyzed wheat gluten (Source 2). The wheat gluten sources replaced L-lysine HCl and replaced 50% or 100% of the spray-dried animal plasma. From d 0 to 7, 7 to 14, and 0 to 21, increasing wheat gluten decreased (linear; $P<0.05$) ADG. There were no differences between wheat gluten sources. Average daily feed intake decreased similar to ADG, with the exception that ADFI of pigs fed wheat gluten Source 2 had only a slight decreasing trend ($P<0.11$) from d 0 to 7. Pigs fed the diet containing 6% SDAP had the greatest ADG and ADFI from d 0 to 21. When the SDAP was replaced with either wheat gluten source, ADG and ADFI linearly decreased ($P<0.01$) but F/G improved ($P<0.04$). When pigs were fed the common diet from d 21 to 35, there were no differences ($P<0.05$) in ADG, ADFI or F/G. In Exp. 2, the six dietary treatments included a negative control with no SDAP or WG (0:0 ratio), 9% WG (100:0 ratio), 6.75% WG and 1.25% SDAP (75:25 ratio) combination, 4.5% WG and 2.5% SDAP (50:50 ratio) combination, 2.25% WG and 3.75% SDAP (25:75 ratio) combination, and a positive control with 5% SDAP (0:100 ratio). The wheat gluten (Source 1) was enzymatically hydrolyzed, but from a different lot than Exp. 1. From d 0 to 14, pigs fed 6% SDAP had numerically greater ADG and ADFI compared to pigs fed the negative control diet. However, replacing SDAP with increasing amounts of WG tended to decrease ($P<0.10$) ADG and ADFI. These results confirm the improved ADG and ADFI of pigs fed SDAP immediately after weaning. In these experiments, replacing SDAP with WG resulted in decreased ADG.

(Key Words: Wheat Gluten, Spray-Dried Animal Plasma, Nursery Pigs.)

Introduction

Wheat gluten is derived from wheat flour that is mixed with water to form a dough and then is separated into gluten, starch, and effluents. After the separation process, wheat gluten is washed to remove excess starch and then dried at low temperatures in ring driers. This results in a wheat by-product, vital wheat gluten. The dried wheat gluten can be further processed by enzymatic hydrolysis. Enzymatic hydrolysis results in a wheat protein that is highly soluble, has a high protein content, and is very digestible. Previous research at Kansas State University has shown that pigs fed a 50:50 blend of spray-dried porcine

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plasma (SDPP):wheat gluten had greater ADG and ADFI compared to those fed a control diet containing 8% SDPP. Wheat gluten has become increasingly available from a variety of sources. The objective of this experiment was to determine the effects of substituting enzymatically hydrolyzed and non-modified ring-dried wheat gluten for spray-dried animal plasma (SDAP). Our second objective was to determine the effects of combinations of WG and SDAP on the growth performance of nursery pigs.

Procedures

In Exp. 1, a total of 220 pigs (initially 13.4 lb and 21 ± 3 d of age) were used in a 35-d growth assay. There were six pigs per pen and eight pens per treatment. Experimental diets were fed to all pigs from d 0 to 21 after weaning. All diets were corn-soybean meal-based and formulated to 1.26% digestible lysine corresponding to a range of 1.46% to 1.51% total lysine, 1.04% Ca, and 0.56% available phosphorus (Table 1). The control diet contained 6% SDAP, with SDAP being replaced with either 50% or 100% enzymatically hydrolyzed wheat gluten Source 1 or non-modified flash-dried wheat gluten Source 2 and L-lysine HCl for the other diets to consist of 3% SDAP combined with 3% wheat gluten Source 1 or 2 (50:50 blend), or 6% wheat gluten Source 1 or 2 (0:100 ratio). Pigs were fed the same common diet from d 21 to 35 after weaning.

In Exp. 2, a total of 252 pigs (initially 13.7 lb and 21 ± 3 d of age) were used in a 28-d growth assay. There were six pigs per pen and six pens per treatment. Experimental diets were fed to all pigs from d 0 to 14 after weaning. All diets were corn-soybean meal-based and formulated to 1.50% total lysine, 0.85% Ca, and 0.43% available phosphorus (Table 2). The six dietary treatments included a negative control with no SDAP or WG (0:0 ratio), 9% wheat gluten (100:0 ratio), 6.75% WG and 1.25% SDAP (75:25 ratio) combination, 4.5% WG and 2.5% SDAP (50:50 ratio) combination, 2.25% WG and 3.75% SDAP (25:75 ratio) combination, and 5% SDAP (0:100 ratio). All pigs were fed the same common diet from d 14 to 28 after weaning.

In both experiments, all pigs were housed in the Kansas State University Swine Teaching and Research Center's environmentally controlled nursery, with a self-feeder and nipple waterer in each pen to allow ad libitum access to feed and water. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance every 7 d upon initiation of the experiments.

Data were analyzed using the MIXED procedure of SAS as a randomized complete block design with pen as the experimental unit. For Exp. 1, linear and quadratic contrasts were used to determine the effects of wheat gluten sources. In Exp. 2, linear and quadratic contrasts were used to determine the effects of an increasing wheat gluten to decreasing SDAP ratio. Least significant differences also were used for making pairwise comparisons of the treatment means in each experiment.

Results and Discussion

In Exp. 1, ADG and ADFI decreased (linear, $P<0.05$) from d 0 to 7 and d 7 to 14 with increasing wheat gluten Source 1. Also, increasing wheat gluten Source 2, decreased (linear, $P<0.05$) ADG from d 0 to 7 and ADG and ADFI (linear, $P<0.05$) from d 7 to 14. From d 14 to 21 there were no differences in ADG or F/G, but there was a decrease (linear, $P<0.05$) in ADFI when either wheat gluten source was fed. Pigs fed the control diet had the highest intake with the diet containing 6% wheat gluten source having the lowest ADFI. For the overall treatment period, d 0 to 21, there was a decrease (linear, *P*<0.05) for both ADG and ADFI when either wheat gluten source was added. However, there was also an improvement in F/G (linear, *P*<0.05) when wheat gluten Source 2 was added to diets. Feed efficiency was best for pigs fed 6% wheat gluten Source 2, with the pigs fed 5% SDAP having the poorest F/G, but with no differences between wheat gluten sources. In the common period, d 21 to 35, there were no differences in ADG, ADFI, or F/G. Overall, the pigs fed the control diet had the highest ADG and ADFI. There was a decrease (linear, *P*<0.05) in ADG and ADFI when either wheat gluten source was fed. However, pigs had improved F/G (linear, *P*<0.05) when either source of wheat gluten was fed.

From d 0 to 7 and 7 to 14 in Exp. 2, there was an improvement (linear, *P*<0.06) in F/G with increasing wheat gluten. There was a decrease (linear, *P*<0.05) in ADG from d 7 to 14 when wheat gluten increased. For the overall treatment period, d 0 to 14, pigs fed 5% plasma had the highest ADG with a decrease (linear, *P*<0.05) when wheat gluten was increased in the diets. There were no differences in ADFI or F/G for the treatment period. For the common period, d 14 to 28, there were no differences seen in growth performance. The overall results (d 0 to 28) show no differences in ADG, ADFI, or F/G. In conclusion, as in many past trials, spray-dried animal plasma will stimulate feed intake and improve growth performance of nursery pigs. In these two experiments, when different wheat gluten sources are combined with spray-dried animal plasma at increasing levels, ADG and ADFI decreased.

Table 1. Diet Composition (Exp. 1)[a]

Ingredient, %	Wheat Gluten:SDAP Ratio		
	0:100	50:50	100:0
Corn	47.03	46.69	46.37
Soybean meal (46.5% CP)	19.21	19.21	19.21
Spray-dried whey	15.00	15.00	15.00
Spray-dried plasma	6.00	3.00	-
Wheat gluten[b]	-	3.00	6.00
Soy oil	5.00	5.00	5.00
Menhaden fish meal	3.00	3.00	3.00
Monocalcium phosphate, 21% P	1.08	1.30	1.50
Limestone	1.30	1.18	1.08
Antimicrobial[c]	1.00	1.00	1.00
Salt	0.30	0.30	0.30
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Zinc oxide	0.35	0.35	0.35
Threonine	0.04	0.10	0.15
Tryptophan	-	0.02	0.04
Lysine HCl	0.15	0.34	0.51
DL-Methionine	0.15	0.13	0.10
Total	100.00	100.00	100.00
Calculated analysis			
Digestible lysine, %	1.29	1.29	1.29
Total lysine, %	1.51	1.49	1.46
Isoleucine:lysine, %	57	58	59
Met & Cys:lysine, %	61	60	60
Threonine:lysine, %	66	66	65
Tryptophan:lysine, %	19	19	19
Valine:lysine, %	73	70	67
ME, kcal/lb	1,573	1,548	1,542
Protein, %	21.30	21.30	21.40
Ca, %	1.05	1.04	1.04
P, %	0.79	0.79	0.78
Available P, %	0.56	0.56	0.56
Lysine:calorie ratio, g/mcal	4.35	4.36	4.35

[a]Values calculated on an as-fed basis.
[b]Wheat gluten was fed from two different sources consisting of four of the five experimental treatments consisting of enzymatically hydrolyzed (Source 1) and a non-hydrolyzed wheat gluten (Source 2).
[c]Provided 50g/ton carbadox.

Table 2. Diet Composition (Exp. 2)[a]

	Wheat Gluten:SDAP Ratio					
Ingredient, %	0:0	100:0	75:25	50:50	25:75	0:100
Corn	35.93	38.48	39.59	40.71	41.82	42.94
Soybean meal, 46.5%	36.71	24.79	24.79	24.79	24.79	24.79
Spray-dried whey	20.00	20.00	20.00	20.00	20.00	20.00
Wheat gluten[b]	-	9.00	6.75	4.50	2.25	-
Spray-dried animal plasma	-	-	1.25	2.50	3.75	5.00
Soy oil	3.00	3.00	3.00	3.00	3.00	3.00
Monocalcium phosphate, 21%	1.04	1.11	1.02	0.93	0.84	0.75
Limestone	0.98	1.03	1.07	1.11	1.15	1.19
Antimicrobial[c]	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Zinc oxide	0.35	0.35	0.35	0.35	0.35	0.35
Threonine	0.04	0.06	0.45	0.03	0.02	-
Lysine HCl	0.15	0.45	0.38	0.30	0.23	0.15
DL-Methionine	1.05	0.04	0.07	0.09	0.12	0.14
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
Digestible lysine, %	1.27	1.32	1.31	1.29	1.28	1.27
Total lysine, %	1.50	1.50	1.50	1.50	1.50	1.50
Isoleucine:lysine, %	67	67	65	63	61	60
Met & Cys:lysine, %	56	61	61	61	60	60
Threonine:lysine, %	64	64	64	64	64	64
Tryptophan:lysine, %	20	19	19	19	19	19
Valine:lysine, %	73	74	74	74	73	73
ME, kcal/lb	1,518	1,518	1,522	1,525	1,529	1,532
Protein, %	22.50	24.40	23.70	23.00	22.20	21.50
Ca, %	0.85	0.85	0.85	0.85	0.85	0.85
P, %	0.72	0.67	0.67	0.67	0.68	0.68
Available P, %	0.43	0.43	0.43	0.43	0.43	0.43
Lysine:calorie ratio, g/mcal	4.48	4.48	4.47	4.46	4.45	4.44

[a]Values calculated on an as-fed basis.

[b]Wheat gluten was enzymatically hydrolyzed and fed from one lot consisting of four of the six experimental diets.

[c]Provided 50g/ton carbadox.

Table 3. Evaluation of Two Wheat Gluten Sources and Spray-Dried Animal Plasma in Diets for Early Wean Pigs[a]

	Treatment (Wheat Gluten:SDAP Ratio)					Contrasts, Probability (P<)					
	6% SDAP	WG Source 1		WG Source 2		Source 1		Source 2		Source	
Item	0:100	50:50	100:0	50:50	100:0	Linear[d]	Quadratic[e]	Linear[f]	Quadratic[g]	1 vs 2[h]	SEM
Diet no.	1	2	3	4	5						
Day 0 to 7											
ADG, lb	0.53	0.43	0.40	0.45	0.41	0.02	0.52	0.04	0.68	0.63	0.04
ADFI, lb	0.49	0.41	0.36	0.42	0.38	0.05	0.78	0.11	0.74	0.72	0.06
Feed/gain	0.93	0.98	0.92	0.94	0.93	0.77	0.20	0.99	0.80	0.75	0.03
Day 7 to 14											
ADG, lb	0.98	0.90	0.79	0.93	0.84	<0.01	0.71	0.01	0.76	0.30	0.04
ADFI, lb	1.11	0.99	0.84	1.05	0.86	<0.01	0.76	<0.01	0.26	0.40	0.06
Feed/gain	1.13	1.10	1.08	1.14	1.02	0.29	0.98	0.03	0.14	0.83	0.03
Day 14 to 21											
ADG, lb	1.21	1.15	1.14	1.23	1.14	0.22	0.63	0.22	0.32	0.38	0.04
ADFI, lb	1.49	1.36	1.33	1.43	1.34	0.02	0.43	0.03	0.80	0.42	0.06
Feed/gain	1.24	1.18	1.17	1.17	1.18	0.15	0.65	0.23	0.34	0.95	0.03
Day 0 to 21[b]											
ADG, lb	0.91	0.83	0.77	0.87	0.80	<0.01	0.68	<0.01	0.62	0.19	0.03
ADFI, lb	1.03	0.92	0.84	0.97	0.86	<0.01	0.70	<0.01	0.60	0.32	0.04
Feed/gain	1.10	1.09	1.05	1.08	1.04	0.09	0.62	0.04	0.64	0.71	0.02
Day 21 to 35[c]											
ADG, lb	1.21	1.18	1.20	1.21	1.16	0.90	0.42	0.30	0.50	0.95	0.03
ADFI, lb	1.85	1.75	1.80	1.83	1.75	0.34	0.11	0.06	0.54	0.71	0.05
Feed/gain	1.55	1.53	1.50	1.52	1.53	0.17	0.62	0.59	0.59	0.66	0.02
Day 0 to 35											
ADG, lb	1.03	0.97	0.95	1.00	0.95	<0.01	0.42	<0.01	0.43	0.33	0.03
ADFI, lb	1.36	1.25	1.22	1.31	1.22	<0.01	0.22	<0.01	0.45	0.33	0.04
Feed/gain	1.28	1.26	1.23	1.26	1.24	0.03	0.86	0.06	0.98	0.99	0.01

[a]A total of 220 weanling pigs initially 13.4 lb.
[b]Experimental diets were fed from d 0 to 21 after weaning to all pigs.
[c]A common diet was fed from d 21 to 35 after weaning.
[d]Linear effect of Source 1, Diets 1, 2, and 3.
[e]Quadratic effect of Source 1, Diets 1, 2, and 3.
[f]Linear effect of Source 2, Diets 1, 4, and 5.
[g]Quadratic effect of Source 2, Diets 1, 4, and 5.
[h]Source 1 vs. Source 2, Diets 2 and 3 vs. Diets 4 and 5.

Table 4. Effect of Wheat Gluten and Spray-Dried Animal Plasma Blends on the Growth Performance of Nursery Pigs[a]

	Wheat Gluten : SDAP Ratio						Contrasts, Probability (*P*<)				
Item	0:0	100:0	75:25	50:50	25:75	0:100	Linear Effect[d]	Quadratic Effect[e]	Diet 1 vs Diet 2[f]	Diet 1 vs Diet 6[g]	SEM
Day 0 to 7											
ADG, lb	0.52	0.53	0.59	0.51	0.57	0.58	0.50	0.83	0.86	0.24	0.04
ADFI, lb	0.43	0.42	0.48	0.45	0.49	0.51	0.13	0.99	0.85	0.17	0.04
Feed/gain	0.85	0.81	0.81	0.87	0.87	0.88	0.02	0.68	0.28	0.45	0.03
Day 7 to 14											
ADG, lb	0.85	0.77	0.81	0.83	0.84	0.88	0.02	0.87	0.06	0.64	0.04
ADFI, lb	0.97	0.90	0.96	0.93	0.93	0.99	0.19	0.82	0.18	0.67	0.04
Feed/gain	1.14	1.18	1.18	1.13	1.11	1.13	0.06	0.48	0.30	0.87	0.03
Day 0 to 14[b]											
ADG, lb	0.69	0.65	0.70	0.67	0.70	0.73	0.05	0.97	0.25	0.27	0.03
ADFI, lb	0.70	0.66	0.72	0.69	0.71	0.75	0.10	0.89	0.37	0.29	0.04
Feed/gain	0.99	0.99	0.99	1.00	0.99	1.01	0.72	0.83	0.98	0.65	0.02
Day 14 to 28[c]											
ADG, lb	1.05	1.06	1.04	1.07	1.04	1.03	0.54	0.61	0.79	0.67	0.03
ADFI, lb	1.47	1.43	1.46	1.50	1.45	1.44	0.91	0.20	0.47	0.57	0.04
Feed/gain	1.41	1.36	1.41	1.40	1.41	1.40	0.12	0.15	0.12	0.54	0.02
Day 0 to 28											
ADG, lb	0.87	0.85	0.87	0.87	0.87	0.88	0.37	0.74	0.54	0.64	0.03
ADFI, lb	1.08	1.05	1.09	1.10	1.08	1.10	0.28	0.47	0.32	0.76	0.03
Feed/gain	1.20	1.17	1.20	1.20	1.20	1.20	0.17	0.36	0.15	0.83	0.01

[a]A total of 252 pigs initially 13.7 lb.
[b]D 0 to 14 treatment diets.
[c]D 14 to 28 common Phase II Diets.
[d]Linear effect, Diets 2, 3, 4, 5, 6.
[e]Quadratic effect, Diets 2, 3, 4, 5, 6.
[f]0% SDAP and WG vs. 9%WG, Diets 1 vs. 2.
[g]0% SDAP and WG vs. 5% P, Diets 1 vs. 6.