Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 1103

2006

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Recommended Citation

Groesbeck, C N.; DeRouchey, Joel M.; Tokach, Michael D.; Goodband, Robert D.; Nelssen, Jim L.; and Dritz, Steven S. (2006) "The effects of electron beam and gamma ray irradiation levels in spray-dried animal plasma on nursery pig performance," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 10. https://doi.org/10.4148/2378-5977.6943

The effects of electron beam and gamma ray irradiation levels in spray-dried animal plasma on nursery pig performance

Abstract

A total of 385 pigs (initially 13.4 Â± 2.2 lb and 21 Â± 3 d of age) were used in a 28-d trial to determine the effects of electron beam and gamma ray irradiation dosage of spray-dried animal plasma (plasma) on nursery pig performance. Pigs were allotted to pen and blocked by weight by using an incomplete block design with either 7 or 8 replications per treatment. Dietary treatments were randomly allotted to pen within block. Ten dietary treatments were fed from d 0 to 14, including: a negative control diet with no added plasma, a positive control diet with added plasma, or one of 8 irradiated plasma diets. The 8 irradiated treatments included plasma irradiated with either electron beam or gamma radiation at increasing dosages of 2, 4, 6, or 10 kGy. All the pigs were fed a common diet from d 14 to 28. Irradiation of the plasma reduced the total bacterial and coliform counts at every dose, regardless of irradiation source. There were no interactions (P>0.05) between irradiation source and dosage for the entire trial. From d 0 to 14, pigs fed the diets containing plasma had increased (P<0.01) ADG and ADFI, compared with those of the pigs fed the negative control diet. Irradiating the plasma did not improve pig performance. There also were no differences (P>0.12) in growth performance between the pigs fed the plasma irradiated by electron beam or by gamma ray, which confirms previous research. But the majority of previous research has shown improvements in growth performance when pigs were fed diets with irradiated plasma, compared with performance of pigs fed diets containing regular plasma. Irradiation of plasma did not improve performance in this study.; Swine Day, 2006, Kansas State University, Manhattan, KS, 2006

Keywords

Kansas Agricultural Experiment Station contribution; no. 08-83-S; Swine day, 2006; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 966; Nursery pig; Spray-dried animal plasma; Irradiation; Swine

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THE EFFECTS OF ELECTRON BEAM AND GAMMA RAY IRRADIATION LEVELS IN SPRAY-DRIED ANIMAL PLASMA ON NURSERY PIG PERFORMANCE[1]

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Summary

A total of 385 pigs (initially 13.4 ± 2.2 lb and 21 ± 3 d of age) were used in a 28-d trial to determine the effects of electron beam and gamma ray irradiation dosage of spray-dried animal plasma (plasma) on nursery pig performance. Pigs were allotted to pen and blocked by weight by using an incomplete block design with either 7 or 8 replications per treatment. Dietary treatments were randomly allotted to pen within block. Ten dietary treatments were fed from d 0 to 14, including: a negative control diet with no added plasma, a positive control diet with added plasma, or one of 8 irradiated plasma diets. The 8 irradiated treatments included plasma irradiated with either electron beam or gamma radiation at increasing dosages of 2, 4, 6, or 10 kGy. All the pigs were fed a common diet from d 14 to 28. Irradiation of the plasma reduced the total bacterial and coliform counts at every dose, regardless of irradiation source. There were no interactions (P>0.05) between irradiation source and dosage for the entire trial. From d 0 to 14, pigs fed the diets containing plasma had increased (P<0.01) ADG and ADFI, compared with those of the pigs fed the negative control diet. Irradiating the plasma did not improve pig performance. There also were no differences (P>0.12) in growth performance between the pigs fed the plasma irradiated by electron beam or by gamma ray, which confirms previous research. But the majority of previous research has shown improvements in growth performance when pigs were fed diets with irradiated plasma, compared with performance of pigs fed diets containing regular plasma. Irradiation of plasma did not improve performance in this study.

Key Words: Nursery Pig, Spray-dried Animal Plasma, Irradiation.)

Introduction

Previous research conducted at Kansas State University has demonstrated an improvement in growth performance in weanling pigs when fed diets that contain irradiated spray-dried animal plasma (plasma) compared with non-irradiated plasma. The levels of irradiation dosage in those experiments have ranged from 2.5 to 20.0 kGy, with most of the studies using 10 kGy. Increasing the irradiation dosage level will result in a decrease in throughput at the irradiation facility and an increase in irradiation cost. Additional research evaluating levels of irradiation needs to be conducted. Commercial irradiation sources include electron beam and gamma ray. There is limited data comparing these two methods.

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[1]Appreciation is expressed to Sadex, Sioux City, IA, for providing the electron beam irradiation of the spray-dried animal plasma for this research project.

[2]Food Animal Health and Management Center, College of Veterinary Medicine.

Therefore, the objective of our study was to evaluate the effects of electron beam and gamma ray irradiation dosage levels of plasma on diet bacterial reduction and nursery pig performance.

Procedures

A total of 385 pigs (initially 13.4 ± 2.2 lb and 21 ± 3 d of age) were used in a 25-d growth assay. Dietary treatments were randomly allotted to pen within block. Pigs were allotted to pen and blocked by weight by using an incomplete-block design. There were 7 replications for the negative control, the positive control, and the gamma ray irradiation at 2 kGy. All other treatments had 8 replications. The pigs were housed in the Kansas State University Segregated Early Weaning Facility. Each pen was 4 × 4 ft and contained one self-feeder and one cup waterer to provide *ad libitum* access to feed and water.

Dietary treatments were fed from d 0 to 14, and a common diet was fed to all pigs from d 14 to 28 (Table 1). The 10 dietary treatments consisted of a negative control diet with no added plasma, a positive control diet with plasma, or one of 8 diets with irradiated plasma, irradiated by electron beam or gamma ray radiation at increasing dosage levels of 2, 4, 6, or 10 kGy. A single lot of plasma was used and was divided into three groups, non-irradiated, or irradiated by either electron (Sadex; Sioux City, IA) or gamma ray (Sterigenics; Schaumburg, IL).

The negative control diet and a basal diet with all ingredients except plasma were manufactured at the Kansas State University Animal Science Feed Mill. The plasma treatment diets were manufactured by using the basal diet at the Kansas State University Poultry Unit in a 400-lb ribbon mixer. The basal diet, followed by the plasma, was weighed and added to the mixer and then mixed for 10 minutes. The mixer was cleaned, sprayed with alcohol, and allowed to dry between treatments to reduce carryover contamination. Samples of the negative control diet, the basal diet, all plasma bags, and all completed diets were collected and analyzed for total bacterial plate count and total coliform count. The ADG, ADFI, and F/G were determined by weighing pigs and feeders on d 4, 7, 14, 21, and 28.

Data were analyzed as an incomplete-block design by using Proc MIXED procedures in SAS 8.1. Linear and quadratic contrasts were used to determine the effects of increasing irradiation dosage level. Contrasts were also used to test for differences between irradiated and non-irradiated diets, electron beam and gamma irradiation, and between the negative control with no added plasma and diets with added plasma.

Results and Discussion

As expected, irradiation of the plasma effectively reduced total bacterial plate count and coliform concentrations, regardless of irradiation type or dosage (Table 2). The high counts in the diets indicate that ingredients besides plasma contribute a significant portion of total bacteria and coliforms in the experimental treatments.

From d 0 to 14, pigs fed the diets with plasma had increased ($P<0.01$) ADG and ADFI, compared with those of the pigs fed the negative control diet (Table 3). Pigs fed the diet containing regular plasma had a tendency ($P<0.09$) toward increased ADFI, compared with ADFI of the pigs fed the diets with irradiated plasma. There was no effect ($P>0.22$) of irradiation dose or source on growth performance.

From d 14 to 28, pigs fed diets containing electron beam irradiated plasma from d 0 to 14 had a tendency toward increased ($P<0.10$) ADG and ADFI, compared with performance of the pigs fed gamma ray irradiated plasma diets.

Overall (d 0 to 28), pigs fed the diets containing plasma had a tendency for increased (P<0.08) ADFI, compared with that of the pigs fed diets without added plasma. Although there was not a significant plasma response in ADG, the 2-lb advantage on d 14 for pigs fed plasma from d 0 to 14 was maintained through the end of the trial. There were no differences (P>0.12) in growth performance between the pigs fed diets containing plasma irradiated by electron beam or gamma ray. The irradiation dosage level and irradiation source had no effect (P>0.12) on growth performance.

These data indicated that irradiation of plasma will reduce total bacteria and coliforms in plasma, regardless of irradiation source or dosage. There were no differences in growth performance between pigs fed plasma irradiated by either the electron beam or gamma ray, which confirms previous research comparing these two sources. But data showed no improvements in performance for pigs fed the irradiated plasma, compared with performance of pigs fed regular plasma. This is in contradiction to previous research that has consistently shown improvements in growth performance when pigs were fed diets with irradiated plasma.

Results from this study indicated that irradiation of plasma at 2 kGy was sufficient to dramatically reduce the total bacteria and coliform counts, but growth performance was not improved by either irradiation source. Therefore, both electron beam and gamma ray may be used as an effective source of irradiation to reduce bacteria and coliform counts in plasma, but more research is needed to further understand the reason for a lack of growth response in this trial, compared with previous research at Kansas State University.

Table 1. Composition of Diets (As-fed Basis)

	D 0 to 14[a]		D 14 to 28[b]
Item	Neg Control	Plasma[c]	Phase 2
Corn	36.63	44.02	53.71
Soybean meal (46.5% CP)	31.78	19.4	31.54
Spray-dried whey	20.00	20.00	10.00
Spray-dried animal plasma	---	5.00	---
Menhaden fish meal	5.00	5.00	---
Soy oil	3.00	3.00	---
Monocalcium phosphate (21% P)	0.75	0.75	1.5
Limestone	0.65	0.65	0.95
Salt	0.25	0.25	0.35
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Antibiotic[d]	0.70	0.70	0.70
Zinc oxide	0.38	0.38	---
L-lysine HCl	0.23	0.23	0.33
DL-methionine	0.15	0.15	0.15
L-threonine	0.08	0.08	0.13
Total	100.00	100.00	100.00
Calculated Analysis			
Total lysine, %	1.50	1.50	1.30
ME, kcal/lb	1,539	1,552	1,474
Protein, %	23.8	22.6	20.9
Ca, %	0.92	0.88	0.84
P, %	0.78	0.80	0.76
Available P, %	0.50	0.57	0.46
Lysine:calorie ratio, g/Mcal	4.42	4.38	4.00

[a]The treatment diets were fed in meal form from d 0 to 14. The diets included a negative control with no added spray-dried animal plasma, a positive control with added spray-dried animal plasma, or irradiated spray-dried animal plasma at various levels of electron beam and gamma irradiation.
[b]Phase 2 (d 14 to 28) was a common diet fed to all pigs in meal form.
[c]Positive control diet and all irradiated spray-dried animal plasma (plasma) treatments.
[d]Neoterramycin® 144 g/ton.

Table 2. Aerobic Bacteria Concentration[a]

Item	Total Plate Count, CFU/g	Total Coliform Count, CFU/g
Spray-dried animal plasma		
Plasma, non-irradiated	4.2×10^5	3.0×10^1
Plasma, electron beam		
2 kGy	1.0×10^3	$< 1.0 \times 10^1$
4 kGy	4.0×10^1	$< 1.0 \times 10^1$
6 kGy	2.0×10^1	$< 1.0 \times 10^1$
10 kGy	6.0×10^1	$< 1.0 \times 10^1$
Plasma, gamma ray		
2 kGy	8.3×10^2	$< 1.0 \times 10^1$
4 kGy	7.0×10^1	$< 1.0 \times 10^1$
6 kGy	3.0×10^1	$< 1.0 \times 10^1$
10 kGy	3.0×10^1	$< 1.0 \times 10^1$
Complete diets		
Basal diet[b]	2.8×10^4	8.8×10^3
Negative control[c]	1.8×10^5	7.9×10^2
Positive control[d]	1.9×10^4	1.5×10^4
Electron beam diets		
2 kGy	3.7×10^4	1.3×10^3
4 kGy	4.9×10^3	3.8×10^3
6 kGy	1.1×10^4	1.0×10^4
10 kGy	5.8×10^4	1.1×10^4
Gamma ray diets		
2 kGy	1.5×10^4	7.8×10^3
4 kGy	6.7×10^3	4.9×10^3
6 kGy	7.9×10^3	4.7×10^3
10 kGy	4.3×10^4	4.9×10^3

[a]Spray-dried animal plasma was irradiated at an average dose of 2, 4, 6, or 10 kGy.
[b]Basal diet included all ingredients for the diets containing spray-dried animal plasma, except the spray-dried animal plasma.
[c]Negative control diet with no added spray-dried animal plasma.
[d]Positive control diet with regular spray-dried animal plasma.

Table 3. Effects of Electron Beam and Gamma Ray Irradiation of Spray-Dried Animal Plasma on Nursery Pig Performance[a]

			E-Beam Irradiation, kGy				Gamma Irradiation, kGy						Irradiation Effect, P<			
Item	Negative Control	Positive Control	2	4	6	10	2	4	6	10	SE	Source× Dose	Source	Dose	Linear	Quadratic
d 0 to 14																
ADG, lb[d]	0.45	0.60	0.63	0.53	0.51	0.56	0.54	0.56	0.54	0.53	0.03	0.16	0.43	0.66	0.72	0.59
ADFI, lb[df]	0.49	0.64	0.65	0.56	0.58	0.61	0.6	0.63	0.63	0.54	0.03	0.12	0.79	0.83	0.76	0.09
F/G	1.11	1.07	1.05	1.06	1.11	1.10	1.11	1.13	1.18	1.05	0.04	0.33	0.22	0.74	0.89	0.21
d 14 to 28																
ADG, lb	0.99	0.99	0.98	0.97	0.94	1.00	0.93	0.98	0.96	0.89	0.03	0.08	0.07	0.35	0.12	0.67
ADFI, lb	1.38	1.42	1.42	1.42	1.33	1.38	1.32	1.38	1.40	1.28	0.05	0.11	0.08	0.19	0.08	0.66
F/G	1.41	1.44	1.45	1.46	1.42	1.38	1.42	1.40	1.46	1.43	0.03	0.36	0.99	0.26	0.65	0.24
d 0 to 28																
ADG, lb	0.72	0.79	0.80	0.76	0.73	0.78	0.74	0.77	0.75	0.71	0.03	0.10	0.12	0.12	0.26	0.89
ADFI, lb[e]	0.93	1.03	1.04	0.99	0.95	0.99	0.96	1.00	1.03	0.91	0.03	0.26	0.23	0.19	0.22	0.12
F/G	1.31	1.30	1.29	1.31	1.31	1.28	1.31	1.3	1.36	1.29	0.03	0.71	0.37	0.41	0.68	0.13
Pig wt, lb																
d 0	13.5	13.4	13.3	13.4	13.4	13.5	13.5	13.4	13.4	13.4	0.8	0.14	0.41	0.74	0.65	0.14
d 14[d]	19.9	21.8	22.1	20.8	20.6	21.2	21.0	21.2	20.9	20.8	1.01	0.28	0.51	0.63	0.63	0.78
d 28	33.6	35.6	35.9	34.6	33.7	35.3	34.2	34.9	34.4	33.2	1.3	0.23	0.12	0.21	0.97	0.22

[a]A total of 385 pigs (5 pigs per pen) with an average initial weight of 13.4 ± 2.2 lb were used in the study. There were 7 replications for the negative control, the positive control, and the gamma ray irradiation at 2 kGy; all other treatments had 8 replications.
[b]Pigs were fed either a negative control diet with no added plasma, a positive control diet with plasma, or 1 of 8 irradiated plasma diets irradiated by electron beam or gamma ray irradiation at increasing dosage levels of 2, 4, 6, or 10 kGy.
[c]All pigs were fed a common diet in meal form from d 14 to 28.
[d]Plasma effects, (P<0.01).
[e]Plasma effects, (P<0.10).
[f]Irradiation vs. non-irradated effects, (P<0.10).