Effect of Spray-Dried Plasma Form and Duration of Feeding on Broiler Performance During Natural Necrotic Enteritis Exposure

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Primary Audience: Veterinarians, Nutritionists, Commercial Poultry Producers

SUMMARY

The effect of duration of feeding (continuous or discontinued after d 14) and form (granular vs. powder) of spray-dried plasma (SDP) on performance and mortality of broilers using used litter was evaluated with 240 Ross × Ross 308 male broilers (6 broilers per pen, 8 pens per treatment). Dietary treatments were control (no SDP) or SDP as powder or granular included in the pellet and fed continuously (d 0 to 35) or discontinued after d 14. During the experiment, broilers developed necrotic enteritis, and tissue cultures were positive for *Escherichia coli* and *Salmonella*, resulting in 50% mortality on control broilers. Addition of SDP to the feed improved ($P < 0.05$) average daily gain, feed intake, and feed efficiency for each period of the study (d 0 to 14, 15 to 28, 29 to 35, and 0 to 35). Continuous feeding of SDP improved ($P < 0.05$) average daily gain, feed intake, and feed efficiency from d 15 to 35 compared with broilers fed SDP to d 14. Liveability was improved ($P < 0.05$) in broilers consuming SDP either for 14 d or continuously throughout the experiment compared with control broilers. Spray-dried granular plasma was more effective than spray-dried powder plasma from d 0 to 14. The results of this experiment confirmed that SDP improved broiler growth rate, feed intake, feed efficiency, and minimized enteric challenge associated with necrotic enteritis with maximal protection afforded by continuous feeding. The response to SDP was independent of age of the broiler.

Key words: broiler, growth, spray-dried plasma, necrotic enteritis

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DESCRIPTION OF PROBLEM

Feeding spray-dried plasma (**SDP**) to animals (pigs, poultry, calves, and pets) improves growth performance and health [1, 2, 3, 4, 5]. Spray-dried plasma is available in multiple forms, including powder, granules, or in a water-soluble form. Previous research [6] demonstrated that, in pigs, granulated SDP (Appetein) [7] improved growth performance to a greater extent than did powdered SDP (AP 920) [7]. However, no research has been reported comparing the efficacy of granulated SDP to powdered SDP in broilers.

When fed to pigs, SDP is generally fed during the first 1 to 2 wk postweaning [2] and is not typically fed thereafter. However, recent reports have suggested that SDP will improve growth performance of broilers [8] and pigs [9] in later phases of production. Thus, the objective of the study was to evaluate the effect of duration of feeding and form (granular vs. powder) of SDP on performance and mortality of broilers under simulated production conditions.

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Table 1. Experimental treatments

Treatment	d 0 to 14	d 15 to 28	d 29 to 35
Control	Control	Control	Control
Powder,[1] continuous	1.0%	0.5%	0.25%
Powder, discontinued	1.0%	Control	Control
Granular,[2] continuous	1.0%	0.5%	0.25%
Granular, discontinued	1.0%	Control	Control

[1] Powder = spray-dried powder plasma (AP 920) [7].
[2] Granular = spray-dried granular plasma (Appetein) [7].

MATERIALS AND METHODS

Broilers used in the experiment were handled in accordance with published guidelines [10]. Two hundred forty 1-d-old Ross × Ross 308 male broilers (BW = 33.6 g) [11] were randomly assigned to 1 of 5 experimental treatments blocked by initial BW. Treatments included a control (no plasma) and 2 forms of SDP (powder, AP 920; granular, Appetein) fed continuously throughout the experiment or discontinued after d 14 (Table 1). Diets were formulated to meet or exceed nutrient requirements for broilers [12].

The feeding program consisted of 3 phases, with starter from d 0 to 14, grower from d 15 to 28, and finisher from d 29 to 35 of the experiment. Spray-dried plasma [7] was produced according to standard manufacturing procedures and added at the rate of 1.0, 0.5, and 0.25% in the starter, grower, and finisher diets, respectively. Feed was manufactured according to standard procedures at Kansas State University [13] (Table 2). In all diets, 1% fat was added before pelleting, with the remaining fat added after pelleting. Diets were pelleted at a 85°C conditioning temperature using a 0.40 × 3.18 cm die and a conditioning retention time of 15 s. Starter diets were crumbled. From d 0 to 3, feed was offered ad libitum in trays (729 cm^2), followed by hanging gravity-flow feeders [14]. The hanging feeders were adjusted regularly to maintain optimal height for feed consumption. Water was delivered via free-standing 3.8-L poultry founts. The founts were washed daily and refilled with fresh water. Broilers (6 per pen; 8 pens per treatment) were housed in floor pens (56 × 122 cm). Pens contained soiled litter (softwood shavings used in 3 consecutive experiments), resulting in a high pathogen load environment. Following removal of broilers from the previous experiments, all pens were raked, allowed to dry (2 d), and caked dry litter was removed. The remaining litter was mixed with new litter and leveled to an average depth of 10 cm. Heat lamps maintained average temperatures at bird levels of 32, 29, 27, and 24°C for wk 1, 2, 3, and 4 to the end, respectively. Broilers were maintained on 23L:1D. Vaccinations prehatch were half a dose of Marek's and, before shipping, half a dose of Newcastle and Bronchitis. On d 7, all birds were vaccinated with Bursal Disease Vaccine [15] via the water, and on d 14, they were vaccinated with Newcastle-Bronchitis Vaccine [16] by coarse spray.

Feed intake and mortality were measured daily. Pen weight was measured daily to d 7 and weekly thereafter. Individual BW were measured on d 0. Data were analyzed as a randomized complete block design using the GLM procedures of SAS [17]. Pen was the experimental unit, and placement within room of the facility was the blocking criterion. Least squares means were considered significantly different if $P < 0.05$.

RESULTS

The experiment was originally planned for 42 d; however, it was terminated on d 35 due to increasing mortality of control broilers. Mortality was the result of a natural challenge occurring in the facility. Broilers were necropsied by a trained pathologist and confirmed to have necrotic enteritis and cultured positive for *Escherichia coli* and *Salmonella*. Furthermore, the broilers were exhibiting rickets as a result of malabsorption from severe necrotic enteritis and had litter in the gizzard.

No interactions ($P > 0.10$) between duration of feeding (continuous or not) or form (powder vs. granular) of SDP were noted (Table 3). Compared with that of control broilers, the addition of SDP improved ($P < 0.05$) average daily gain (**ADG**), average daily feed intake (**ADFI**), and feed effi-

Table 2. Formula and calculated analysis of diets on an as-is basis (%)

Item	Starter (d 0 to 14)		Grower (d 15 to 28)		Finisher (d 29 to 35)	
	Control	Plasma	Control	Plasma	Control	Plasma
Corn	57.66	59.23	60.12	60.91	65.43	65.82
Soybean meal, 47%	35.60	33.72	32.04	31.11	26.97	26.50
SDP[1]	0.00	1.00	0.00	0.50	0.00	0.25
Animal/vegetable fat	2.64	2.07	3.94	3.66	3.89	3.75
Dicalcium phosphate, 18.5%	1.76	1.69	1.63	1.59	1.56	1.54
Limestone	1.30	1.34	1.26	1.29	1.21	1.22
Vitamin/mineral premix[2]	0.25	0.25	0.25	0.25	0.25	0.25
Coban 60[3]	0.08	0.08	0.08	0.08	0.08	0.08
Salt	0.47	0.39	0.47	0.43	0.47	0.45
DL-Met	0.24	0.22	0.19	0.18	0.13	0.12
L-Lys HCl	0.02	0.00	0.02	0.01	0.02	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrient analysis						
CP, %	21.5	21.5	20.00	20.00	18.00	18.00
Fat, %	5.21	4.70	6.56	6.31	6.67	6.54
ME, kcal/kg	3,050	3,050	3,150	3,150	3,200	3,200
Ash, %	5.66	5.64	5.35	5.34	5.02	5.02
Ca, %	1.00	1.00	0.95	0.95	0.90	0.90
P, %	0.70	0.70	0.66	0.66	0.63	0.63
Inorganic P, %	0.45	0.45	0.42	0.42	0.40	0.40
Na, %	0.20	0.20	0.20	0.20	0.20	0.20
Lys, %	1.25	1.25	1.15	1.15	1.00	1.00
Met, %	0.58	0.57	0.52	0.51	0.43	0.43
Met + Cys, %	0.95	0.95	0.86	0.86	0.75	0.75
Trp, %	0.30	0.30	0.28	0.28	0.25	0.25
Thr, %	0.83	0.85	0.77	0.78	0.69	0.70
Ile, %	1.10	1.08	1.02	1.01	0.90	0.90

[1] SDP = spray-dried plasma (powder [AP 920] treatments 2 and 3 or granular [Appetein] treatments 4 and 5 [7]).

[2] Vitamin/mineral premix provided the following per kilogram of diet: Mn, 100 mg; Zn, 100 mg; Fe, 50 mg; Cu, 11 mg; I, 1.5 mg; Se, 0.15 mg; vitamin A (retinyl acetate), 7,700 IU; cholecalciferol, 41.2 µg; vitamin E (α-tocopherol), 16.5 IU; vitamin B_{12}, 11 µg; menadione, 0.8 mg; riboflavin, 6.6 mg; thiamine, 1.1 mg; D-pantothenic acid, 6.6 mg; niacin, 27.5 mg; vitamin B_6, 1.4 mg; folic acid, 0.7 mg; choline, 385 mg; biotin, 0.03 mg.

[3] The coccidiostat was Coban 60 (Elanco Animal Health, Indianapolis, IN) and provided 90 g of monensin Na per ton of feed.

ciency (gain:feed) at each period (d 0 to 14 and 0 to 35; Table 3). Likewise, compared with control broilers on d 35, SDP improved ($P < 0.05$) BW (Table 4) and liveability (Table 4; Figure 1).

Compared with that of broilers consuming powdered SDP, granulated SDP improved ($P < 0.05$) ADG and feed efficiency from d 0 to 14 and improved ($P = 0.10$) ADFI from d 15 to 28 (Table 3). Overall (d 0 to 35; Table 3), no differences ($P > 0.10$) were noted in ADG, ADFI, and feed efficiency due to different plasma forms (granular vs. powder). Granulation improved BW of broilers when measured on d 14 ($P = 0.04$), 21 ($P = 0.09$), and 35 ($P = 0.08$) compared with broilers consuming powder SDP (Table 4).

Continuous feeding of SDP improved ($P < 0.05$; Table 3) ADG, ADFI, and feed efficiency for each period (d 15 to 28, 29 to 35, and 0 to 35) compared with that of broilers when SDP was removed from the diet on d 14. Body weight was also improved ($P < 0.05$; Table 4) on d 28 and 35 when broilers continued to consume SDP compared with broilers when SDP was removed from the diet on d 14.

Average daily feed intake of control broilers was lower than that of SDP-fed broilers ($P < 0.05$) by d 9 and began to plateau by d 14 (Figure 2). Additionally, the removal of SDP from the diet on d 14 (discontinued treatments Powder/D and Granular/D; Figure 2) resulted in ADFI

Table 3. Least squares means of performance when broilers consumed spray-dried plasma (SDP) in the feed[1]

	Treatment						Contrasts[2] (*P*-values)			
	Control	Powder, continuous	Powder, discontinuous	Granular, continuous	Granular, discontinuous					
Item	1	2	3	4	5	SEM	1	2	3	4
d 0 to 14										
ADG, g/d	19.21	25.97	24.61	25.97	26.96	0.54	0.0001	0.0372	NS	—
ADFI, g/d	28.58	34.72	32.83	33.55	34.66	0.60	0.0001	NS	NS	—
Gain:feed	0.675	0.751	0.753	0.777	0.778	0.009	0.0001	0.0087	NS	—
d 15 to 28										
ADG, g/d	22.63	59.64	46.56	62.27	50.94	2.40	0.0001	NS	0.0001	NS
ADFI, g/d	45.10	94.57	79.74	97.57	87.15	3.04	0.0001	0.0983	0.0003	NS
Gain:feed	0.489	0.631	0.581	0.639	0.581	0.013	0.0001	NS	0.0003	NS
d 29 to 35										
ADG, g/d	9.33	66.39	27.80	69.47	31.08	3.66	0.0001	NS	0.0001	NS
ADFI, g/d	46.29	132.93	80.97	136.43	90.26	5.37	0.0001	NS	0.0001	NS
Gain:feed	0.124	0.497	0.338	0.508	0.320	0.048	0.0001	NS	0.0011	NS
d 0 to 35										
ADG, g/d	19.18	47.05	34.10	48.88	37.33	1.69	0.0001	NS	0.0001	NS
ADFI, g/d	38.73	78.30	61.22	79.73	66.78	2.28	0.0001	NS	0.0001	NS
Gain:feed	0.502	0.609	0.558	0.619	0.560	0.009	0.0001	NS	0.0001	NS

[1] Values represent the mean of 8 replicates per treatment with 6 broilers per pen. ADG = average daily gain; ADFI = average daily feed intake. NS = nonsignificant at $P > 0.10$. Powder = spray-dried powder plasma (AP 920) [7]; Granular = spray-dried granular plasma (Appetein) [7].

[2] Contrasts were as follows: 1) control (treatment 1) vs. SDP (treatments 2, 3, 4, and 5); 2) Powder (treatments 2 and 3) vs. Granular (treatments 4 and 5); 3) SDP continuous feeding (treatments 2 and 4) vs. SDP discontinued feeding (treatments 3 and 5); 4) interaction of feeding duration and form of SDP (treatments 3 and 4 vs. 2 and 5).

plateauing by d 20 but remaining significantly greater ($P < 0.05$) than control broilers. Average daily feed intake of broilers consuming SDP to d 35 (continuous treatments Powder/C and Granular/C; Figure 2) increased throughout the experiment.

Mortality of control broilers began to increase by d 15 of the experiment and continued through-

Table 4. Least squares means of BW and liveability when broilers consumed spray-dried plasma (SDP) in the feed[1]

	Treatment						Contrasts[2] (*P*-values)			
	Control	Powder, continuous	Powder, discontinuous	Granular, continuous	Granular, discontinuous					
Item	1	2	3	4	5	SEM	1	2	3	4
Day										
0	33.57	33.57	33.57	33.57	33.57	0.04	NS	NS	NS	—
7	141.56	151.93	144.17	149.25	149.32	3.07	0.0475	NS	NS	—
14	304.09	396.60	379.45	398.86	410.96	7.77	0.0001	0.0382	NS	NS
21	456.22	779.18	722.05	780.48	792.71	20.46	0.0001	0.0895	NS	NS
28	640.08	1,239.79	1,032.99	1,267.72	1,129.24	38.04	0.0001	NS	0.0001	NS
35	746.38	1,704.51	1,220.31	1,773.70	1,359.37	58.23	0.0001	0.0846	0.0001	NS
Liveability, %	56.25	93.75	89.58	93.75	93.75	4.37	0.0001	NS	NS	NS

[1] Values represent the mean of 8 replicates per treatment with 6 broilers per pen. NS = nonsignificant at $P > 0.10$. Powder = spray-dried powder plasma (AP 920) [7]; Granular = spray-dried granular plasma (Appetein) [7].

[2] Contrasts were as follows: 1) control (treatment 1) vs. SDP (treatments 2, 3, 4, and 5); 2) Powder (treatments 2 and 3) vs. Granular (treatments 4 and 5); 3) SDP continuous feeding (treatments 2 and 4) vs. SDP discontinued feeding (treatments 3 and 5); 4) interaction of feeding duration and form of SDP (treatments 3 and 4 vs. 2 and 5).

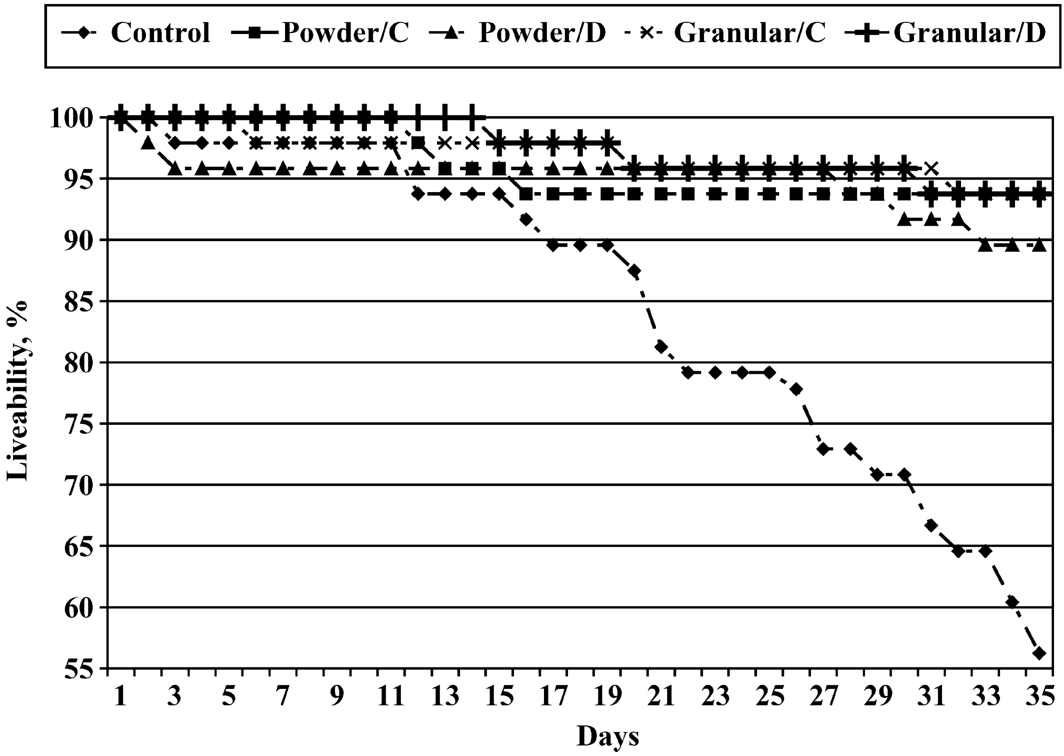

Figure 1. Effect of spray-dried plasma (powder or granular) fed continuously (C) or not (D) on liveability (%).

out the experiment (Figure 1). Spray-dried plasma improved ($P < 0.05$) liveability, and the effect was independent ($P > 0.10$) of SDP form (powder or granular) or duration of feeding (continuous or not).

DISCUSSION

The present experiment was conducted to evaluate duration of feeding (continuous vs. discontinuous) and form of SDP (powder vs. granular) on broiler performance in simulated production conditions (using used litter from previous experiments). Consistent with data in previous reports, addition of SDP to the diets of poultry (broilers or turkeys) increased growth rate, feed intake, and feed efficiency compared with control [3, 4, 8].

The relative response to SDP is greater when animals are housed in a high antigen environment [3, 4, 8, 18]. In this experiment, the environment was contaminated as a result of continued litter use after 3 consecutive experiments, resulting in a high pathogen environment. The high pathogen environment was demonstrated by high chronic mortality (Figure 1) of control broilers and a progressively lower growth rate (Figure 3) of control broilers in the 4 consecutive experiments. In the current experiment, daily feed intake of control broilers increased to d 14 then plateaued after d 14 when mortality began to increase more rapidly.

When the immune system is stimulated, metabolism is altered [19, 20, 21], resulting in reduced feed intake, growth rate, and protein accretion [22, 23, 24, 25]. Recent reports indicate that SDP prevents overstimulation of the immune system [26]. Many researchers have reported an initial growth response to plasma the first week after broiler placement or weaning of pigs but have not been able to detect a significant difference in final BW by the end of the experimental period, 3 to 6 wk later [27, 28, 29]. In the present experiment, the performance response to SDP continued throughout the 35-d experiment. This supports the hypothesis that SDP provides passive protection and prevents overstimulation of the immune system, lessening the effects of immune system activation on feed intake, growth, and protein accretion. This implies that the growth response

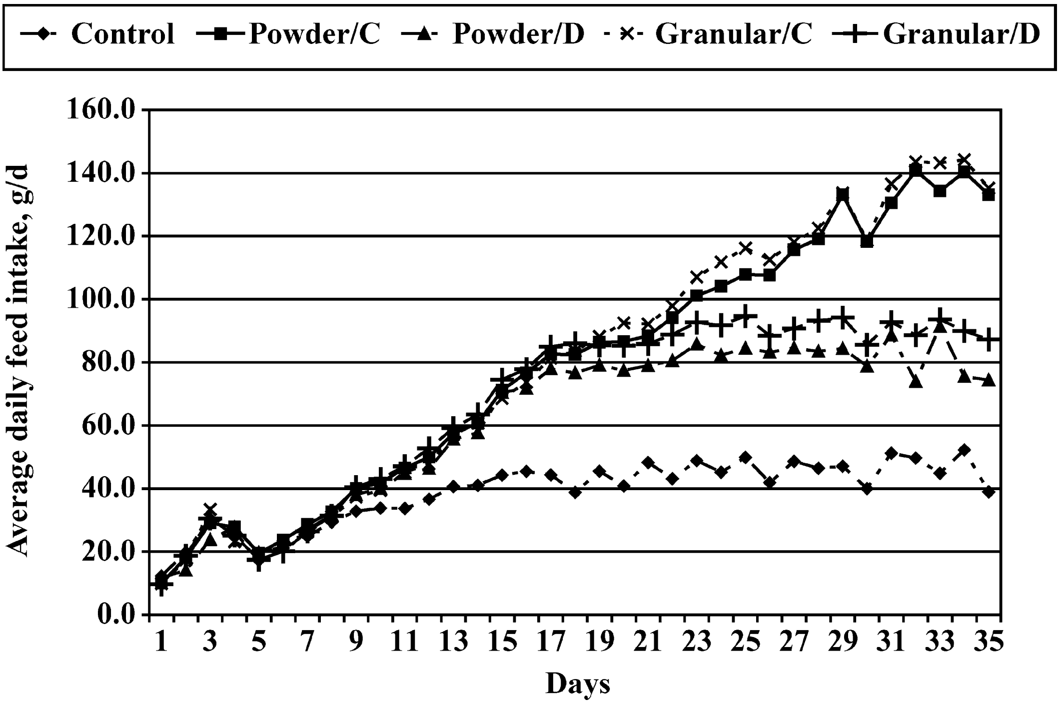

Figure 2. Effect of spray-dried plasma (powder or granular) fed continuously (C) or not (D) on average daily feed intake (g/d).

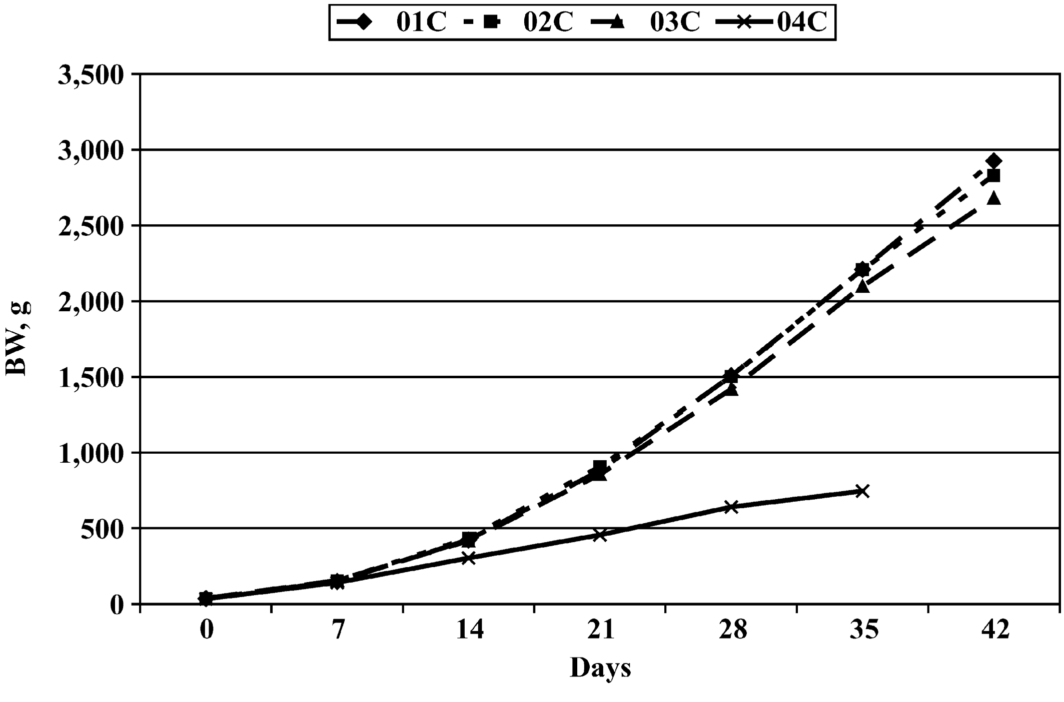

Figure 3. Body weight of control broilers from 3 previous experiments (01 to 03C) and the current experiment (04C) in the same facility.

to SDP is influenced more by the relative degree of immune stimulation rather than by the relative age of the animal.

Early nutrition influences intestinal and immune system development and has been shown to result in improved growth in subsequent phases [30, 31, 32]. When included in the diet, SDP has been shown to improve intestinal morphology [33, 34], digestive enzyme activity [35], and diet digestibility [36] in pigs and dogs. Furthermore, bursal weights were significantly heavier in SDP fed broilers compared with control [37], indicating an influence on immunocompetence. Following the removal of SDP (powder or granular) from the diet on d 14, ADFI (Figure 2) plateaued and remained greater than that of the control broilers throughout the experiment. This suggests that early consumption of SDP resulted in a broiler more resistant to the deleterious effects of a high pathogen environment due to improved intestinal health. Similar responses have been reported for pigs. Pigs fed SDP during the nursery phase had improved growth during the finishing phase [38].

This experiment did not involve a planned disease challenge. However, there was significant mortality, especially for the control broilers. After d 17 of the experiment, a postmortem examination by a trained pathologist was performed to determine the cause of mortality on all birds that died. Initial results of necropsy determined that broilers were experiencing enlarged spleens, indicative of immune stimulation from the Newcastle vaccine. Death losses were continually monitored, and results of the necrospy indicated that broilers developed necrotic enteritis and cultured positive for *E. coli* and *Salmonella*. Cultures were performed for *Clostridium perfringens*; however, it was not isolated. Broilers were also exhibiting rickets due to malabsorption from severe enteritis and had litter in the gizzard. Analysis of diets revealed no nutrient deficiencies. The addition of SDP to the drinking water reduced mortality of turkey poults challenged with *Pasteurella multocida* [5]. In addition, SDP has been shown to reduce morbidity and mortality of animals challenged with *Crytosporidium parvum* [39], coronavirus [40], and *E. coli* [1] in calves; *E. coli* [33, 41, 42] and *Salmonella* [43] in pigs; *Yersinia ruckeri* in trout [44]; and white spot syndrome virus in shrimp [45]. In the present experiment, addition of SDP to the diet reduced mortality of birds housed in a high antigen environment.

Compared with powdered SDP, granulated SDP resulted in further improvements in growth rate and feed efficiency the first 2 wk of the experiment and increased BW from d 14 to the end of the experiment. When fed to pigs, granulated SDP has also been shown to be superior to powdered SDP [6]. In poultry, coarse ground grains induce gizzard motility, resulting in improved digestibility and feed efficiency [46]. In broilers, granulated SDP may induce more gizzard motility as well.

CONCLUSIONS AND APPLICATIONS

1. The results of this experiment confirm data from previous research that SDP improves growth rate, feed intake, and feed conversion of broilers.
2. The response to SDP is dependent on the degree of immune stimulation rather than the relative age of the broiler.
3. Mortality is reduced in broilers with *E. coli*- and *Salmonella*-associated enteritis.
4. Spray-dried granular plasma is more effective than spray-dried powder plasma.

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