Effects of pelleting and pellet conditioning temperatures on weanling pig performance[1,2]

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ABSTRACT: We conducted two experiments to study the effects of pelleting and pellet conditioning temperature on weanling pig performance. In Exp. 1, 252 weanling pigs (PIC, L326 × C22) averaging 6.0 ± 1.3 kg and 21 ± 3 d of age were used to evaluate six corn-soybean meal-based diets containing 15% dried whey and formulated to contain 1.4% lysine. Treatments consisted of a control diet without spray-dried animal protein (SDAP) fed in meal form, a diet with 5% SDAP fed in meal form, and four diets with 5% SDAP that were conditioned at 60, 66, 71, or 77°C for 10 s prior to pelleting. Pellets had a 3.97-mm diameter. The experimental diets were fed from d 0 to 14 after weaning, and all pigs were fed a common diet in meal form from d 14 to 28 after weaning. From d 0 to 7 after weaning, pigs fed diets containing SDAP had greater ADG, gain/feed ($P < 0.001$), and ADFI ($P < 0.05$) than pigs fed the control diet. No differences ($P > 0.10$) were observed between pigs fed the pelleted diets and those fed the SDAP diet in meal form. Conditioning temperature had no effect ($P > 0.10$) on weanling pig performance from d 0 to 14, and the diet fed from d 0 to 14 had no effect on overall performance (d 0 to 28). In Exp. 2, 252 weanling pigs (6.3 ± 1.5 kg and 22 ± 4 d of age) were used to evaluate diets with same composition as in Exp. 1, but treatments consisted of diets with or without SDAP conditioned at 60°C before pelleting, and four diets containing 5% SDAP that were conditioned at 68, 77, 85, and 93°C before pelleting. As in Exp. 1, conditioning lasted 10 s, pellets were 3.97 in mm diameter, and experimental diets were fed for the first 14 d of the 28-d experiment. From d 0 to 7, pigs fed the SDAP diet conditioned at 60°C had greater ADFI ($P < 0.05$) and tended ($P = 0.12$) to have greater ADG than pigs fed the diet without SDAP and conditioned at 60°C. From d 0 to 7, ADG (quadratic effect, $P < 0.03$) and ADFI (linear effect, $P < 0.002$) decreased as conditioning temperature increased, with the largest decrease observed above 77°C. From d 0 to 14 and 0 to 28, ADG was not affected ($P > 0.10$) by pellet conditioning temperature or SDAP fed from d 0 to 14. The results of these studies suggest that conditioning diets containing 5% SDAP at temperatures above 77°C decreases weanling pig growth performance.

Key Words: Feed Additives, Piglets, Plasma, Temperature

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Introduction

Pelleting of diets has been shown to improve feed efficiency (**G/F**) in nursery pigs. Hansen et al. (1992) observed a 20% improvement in G/F (d 0 to 9) of weanling pigs fed a pelleted diet compared to those fed the same diet in meal form. The improvement in G/F was a result of decreased ADFI of pigs fed pelleted diets, and probably of greater feed wastage by pigs fed meal diets. However, the response to pelleting decreased from d 0 to 28 after weaning; pigs fed the pelleted diet were only 4.5% more efficient than pigs fed the meal diet. Traylor et al. (1996) observed similar responses, 25% and 36% improvements in ADG and G/F, respectively, when weanling pigs were fed a pelleted vs a meal diet from d 0 to 5 after weaning. However, from d 0 to 29 after weaning, G/F was improved by only 4%. Different pellet diameters (2, 4, 8, and 12 mm) used in that study did not affect growth performance.

Spray-dried animal plasma (**SDAP**) has been shown to improve growth performance in weanling pigs (Hansen et al., 1993). This increase in growth performance has led to the inclusion of SDAP in many commercial

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starter diets. Excessively high temperatures during pelleting or other thermal processing (i.e., extruding or expanding) may be responsible for decreased performance of pigs fed diets containing specialty protein sources (i.e., dried whey, fish meal, or SDAP) compared with performance of pigs fed diets processed at lower temperatures (Traylor et al., 1997; Hongtrakul et al., 1998; Johnston et al., 1999). Skoch et al. (1983) showed that diets reach temperatures of 85°C during the pelleting process. This potentially could burn or scorch some of the specialty ingredients and increase the potential for initiating the Maillard reaction, thereby decreasing their nutritional value.

Therefore, our objective was to determine the effects of pellet conditioning temperature of a diet containing SDAP on weanling pig growth performance.

Materials and Methods

Animal Care and Use. The experimental protocol used in this study was approved by the Kansas State University Institutional Animal Care and Use Committee.

Animals. Two 28-d growth trials were conducted with PIC (L326 × C22) weanling pigs from the Kansas State University Swine Teaching and Research Center. Each experiment used 252 pigs (Exp. 1, initial BW of 6.0 ± 1.3 kg, 21 ± 3 d of age; Exp. 2, initial BW 6.3 ± 1.5 kg, 22 ± 4 d of age) to evaluate six treatments. Pigs were housed in an environmentally regulated nursery with woven wire flooring. Initial temperature of the nursery was maintained at 32°C for the first 7 d and decreased approximately 2°C each week thereafter. Pigs were allotted by weight and sex in a randomized complete block design with seven replications (pens) per treatment. Each pen (1.52 m × 1.52 m) contained six pigs and was equipped with one nipple waterer and a four-hole feeder to allow ad libitum access to both water and feed.

Diets. Both experiments used two diets, one without SDAP and one with 5% SDAP (Table 1), which were fed in either the meal form or pelleted using conditioning temperatures ranging from 60 to 93°C. All diets were corn-soybean meal-based and contained 15% dried whey and 3% soy oil. They were formulated to contain 1.4% total lysine, 0.9% Ca, 0.8% P, and to meet or exceed NRC (1998) requirement estimates for all other nutrients. Diets contained no medication or pharmacological levels of zinc oxide. The pelleted diets were steam-conditioned with a 10-s retention time and then pelleted using a Master Model HD 1000 series California Pellet Mill (California Pellet Mill Co., Crawfordsville, IN) equipped with a die that had an effective thickness of 31.8 mm and holes 3.97 mm in diameter. Experiment 1 evaluated the following treatments: 1) the control diet with no SDAP fed in a meal form; 2) a diet in which 5% SDAP replaced soybean meal, also fed in meal form; and the 5% SDAP diet pelleted at conditioning temperatures of 3) 60°C, 4) 66°C, 5) 71°C, or 6) 77°C.

Treatments in Exp. 2 were as follows: 1) the diet containing no SDAP pelleted at a conditioning temperature of 60°C and the diet containing 5% SDAP pelleted at conditioning temperatures of 2) 60°C, 3) 68°C, 4) 77°C, 5) 85°C, or 6) 93°C.

Samples of the pelleted diets were collected to determine pellet exiting temperatures and durability. Exit temperatures were determined immediately after pelleting. Approximately 1 kg of each diet was collected approximately midway through the pelleting process and temperature was recorded. Pellet quality was measured using the standard determination for pellet durability index (ASAE, 1987). Pellet durability was measured using 500 g of cold pellets 30 min after pelleting and is recorded as an average of two individual samples.

On d 14, all pigs were switched to a common diet formulated to contain 1.35% total lysine, 0.85% Ca, 0.75% P, 10% dried whey, and 2.5% spray-dried red blood cells. This diet was fed in meal form for the remainder of the studies, and pig weights and feed disappearance were determined weekly. These data were used to calculate ADG, ADFI, and G/F.

Statistical Analysis. Both experiments were structured as randomized complete block designs. Pigs were blocked by initial weight and each pen contained three barrows and three gilts. Pen was used as the experimental unit, and there were seven replications (pens) per treatment. The GLM procedure of SAS (SAS Inst. Inc., Cary, NC) was used to determine treatment differences. Contrast statements were used to compare 1) the control diets (no SDAP) vs diet containing SDAP in meal (Exp. 1) or pelleted (Exp. 2), 2) meal diets containing SDAP vs pelleted diets containing SDAP (Exp. 1 only), and 3) linear and 4) quadratic effects of increasing pellet conditioning temperature on weanling pig performance.

Results and Discussion

Diet Characteristics. In Exp. 1, the four pelleted treatments conditioned at temperatures of 60, 66, 71, or 77°C had corresponding exit temperatures of 68, 74, 77, and 80°C. Pellet durability indexes ranged from 92.2 to 92.7% and did not seem to be affected by conditioning temperature. In Exp. 2, the six pelleted dietary treatments conditioned at temperatures of 60, 60, 68, 77, 85, and 93°C had corresponding exit temperatures of 70, 70, 76, 82, 85, and 93°C. Again, pellet quality was relatively high (93.7 to 96.7%) and was not affected by conditioning temperature.

Johnston et al. (1999), using a retention time of 10 s, reported pellet durability indexes of 69.5 and 70.6 for the simple nursery diets used in their study. We attribute the higher pellet quality observed in our study to the 15% dried whey included in our diets. The nursery diets used by Johnston et al. (1999) contained no dried whey or lactose. Stark et al. (1994) examined the effects of increasing percentage of fines in pelleted diets on weanling pig performance. Pigs fed pelleted diets with fines removed had 3 to 4% better G/F than pigs fed a

Table 1. Composition of experimental diets

Ingredient, %	Day 0 to 14[a] Control	Day 0 to 14[a] 5% SDAP	Day 14 to 28[b]
Corn	44.66	51.52	53.79
Soybean meal (46.5% CP)	34.04	22.18	25.86
Spray-dried animal plasma	—	5.00	—
Dried whey	15.00	15.00	10.00
Soy oil	3.00	3.00	3.00
Monocalcium phosphate (21% P)	1.40	1.32	1.89
Limestone	0.95	1.00	0.81
Salt	0.30	0.30	0.25
Vitamin premix[c]	0.25	0.25	0.25
L-Lysine HCl	0.15	0.15	0.15
Trace mineral premix[d]	0.15	0.15	0.15
DL-Methionine	0.10	0.13	0.10
Zinc oxide	—	—	0.25
Medication[e]	—	—	1.00
Spray-dried red blood cells	—	—	2.50

[a]Diets were formulated to contain 1.4% lysine, 0.9% Ca, and 0.8% P.
[b]Fed in meal form to all pigs and formulated to contain 1.35% lysine, 0.85% Ca, and 0.75% P.
[c]Premix provided the following per kilogram of complete diet: 11,025 IU vitamin A, 1,103 IU vitamin D_3, 44 IU vitamin E, 4.4 mg menadione (menadione sodium bisulfite), 8.3 mg riboflavin, 29 mg d-pantothenic acid, 50 mg niacin, 166 mg choline (choline chloride), and 33 μg vitamin B_{12}.
[d]Premix provided the following per kilogram of complete diet: 12 mg Zn, 16 mg Cu, 0.3 mg I, and 0.3 Se.
[e]Provided 55 μg carbadox/kg (Pfizer Inc., Lee's Summit, MO).

meal diet. Pigs fed pelleted diets with as little as 20% fines had G/F similar to that of pigs fed the meal diet.

Growth Performance. In Exp. 1, pigs fed the control diet had decreased ADG ($P < 0.001$), ADFI ($P < 0.04$), and G/F ($P < 0.001$) compared to pigs fed the diet containing 5% SDAP in meal form from d 0 to 7 and d 0 to 14 (Table 2). These results agree with other studies that have demonstrated improved growth performance when SDAP was used in postweaning diets (Gatnau and Zimmerman, 1990, 1991; Hansen et al. 1993; Kats et al., 1994). Although the differences were not significant ($P > 0.10$), pigs fed the pelleted diets had a 10% increase in ADG, a 4% decrease in ADFI, and 14% better G/F than pigs fed the 5% SDAP diet in meal form from

Table 2. Effects of pelleting and increasing pellet conditioning temperature on weanling pig performance (Exp. 1)[a]

	Meal diets		Pellet conditioning temperature, °C					Contrast ($P <$)[c]			
Item	Control	5% SDAP	60	66	71	77	SEM	1	2	3	4
Treatment[b]	1	2	3	4	5	6					
Day 0 to 7											
ADG, g	138	194	216	215	217	203	12.8	0.001	0.21	0.53	0.65
ADFI, g	237	270	269	263	248	255	10.5	0.04	0.37	0.25	0.56
Gain:feed, kg/kg	.59	.73	0.82	0.82	0.88	0.80	0.056	0.001	0.13	0.98	0.44
Day 0 to 14											
ADG, g	191	252	250	271	250	242	11.9	0.001	0.94	0.39	0.24
ADFI, g	332	373	354	361	347	348	12.1	0.03	0.15	0.55	0.80
Gain:feed, kg/kg	0.57	0.68	0.70	0.75	0.72	0.69	0.022	0.001	0.12	0.54	0.11
Day 14 to 28											
ADG, g	644	618	617	598	605	623	11.5	0.12	0.56	0.62	0.13
ADFI, g	823	827	836	823	815	816	18.6	0.89	0.82	0.41	0.69
Gain:feed, kg/kg	0.78	0.75	0.74	0.73	0.75	0.77	0.013	0.07	0.75	0.08	0.24
Day 0 to 28											
ADG, g	418	435	433	435	428	430	10.1	0.23	0.73	0.69	0.97
ADFI, g	577	600	595	592	581	579	13.2	0.24	0.38	0.31	0.96
Gain:feed, kg/kg	0.72	0.73	0.73	0.74	0.74	0.74	0.011	0.79	0.43	0.31	0.94

[a]A total of 252 weanling pigs (six pigs/pen and seven pens/treatment) with an average initial BW of 6.0 kg were used. Experimental diets were fed from d 0 to 14. From d 14 to 28, all pigs were fed a common diet in meal form.
[b]The diet for treatment 1 contained no spray-dried animal plasma (SDAP). Diets for treatments 2, 3, 4, 5, and 6 contained 5% SDAP.
[c]Contrasts were as follows: 1) control (treatment 1) vs SDAP meal (treatment 2); 2) meal (treatment 2) vs pellet (mean of treatments 3, 4, 5, and 6); 3) conditioning temperature (treatments 3, 4, 5, and 6) linear; and 4) conditioning temperature (treatments 3, 4, 5, and 6) quadratic effect.

Table 3. Effects of increasing pellet conditioning temperature on weanling pig performance (Exp. 2)[a]

		Pellet conditioning temperature, °C						Contrast (P <)[c]		
Item	Control[b]	60	68	77	85	93	SEM	1	2	3
Day 0 to 7										
ADG, g	233	259	260	271	238	214	11.3	0.12	0.01	0.03
ADFI, g	241	269	262	268	249	225	9.65	0.05	0.01	0.11
Gain:feed, kg/kg	0.96	0.96	0.99	1.01	0.95	0.96	0.040	0.97	0.63	0.32
Day 0 to 14										
ADG, g	236	234	232	257	251	244	9.67	0.87	0.20	0.29
ADFI, g	294	312	310	314	313	303	10.6	0.23	0.64	0.60
Gain:feed, kg/kg	0.80	0.75	0.75	0.82	0.81	0.81	0.024	0.10	0.03	0.47
Day 14 to 28										
ADG, g	625	626	602	622	629	627	17.2	0.97	0.58	0.63
ADFI, g	825	854	818	850	849	880	26.5	0.21	0.34	0.31
Gain:feed, kg/kg	0.76	0.73	0.74	0.74	0.74	0.71	0.014	0.21	0.41	0.31
Day 0 to 28										
ADG, g	430	430	417	440	440	436	11.1	0.97	0.32	0.92
ADFI, g	560	583	564	582	581	591	17.3	0.34	0.55	0.53
Gain:feed, kg/kg	0.77	0.74	0.74	0.76	0.76	0.74	0.013	0.08	0.70	0.22

[a]A total of 252 weanling pigs (six pigs/pen and seven pens/treatment) with an average initial BW of 6.3 kg were used. Experimental diets were fed from d 0 to 14. From d 14 to 28, all pigs were fed a common diet in meal form.
[b]Control diet contained no spray-dried animal plasma (SDAP) and was conditioned at 60°C. All other diets contained 5% SDAP and were conditioned at their respective temperatures.
[c]Contrasts were as follows: 1) control vs 60°C; 2) conditioning temperature linear; 3) conditioning temperature quadratic.

d 0 to 7 after weaning. This is supported by the work of Traylor et al. (1997), who showed that pigs fed a simple diet in pelleted form had an 11% increase in ADG and a 7% improvement in G/F compared to pigs fed a meal diet during d 10 to 28 after weaning. Hansen et al. (1992) observed a 20% improvement in G/F during d 0 to 9 in pigs fed a pelleted diet compared to those fed the diet in meal diet.

From d 0 to 7 or 0 to 14, pellet conditioning temperature had no effect on pig performance. In a study of the effects of steam conditioning prior to pelleting on the growth performance of weanling pigs, Skoch et al. (1983) reported exit temperatures of 85 and 68°C for diets pelleted with or without steam conditioning prior to pelleting. They observed no differences in performance of pigs fed any of these diets.

From d 14 to 28, all pigs were fed a meal diet. Pigs previously fed the control diet tended to have improved ($P < 0.07$) G/F compared to those previously fed the meal diet containing 5% SDAP. Kats et al. (1994) observed a decrease in ADG from d 14 to 28 with increasing concentrations of SDAP fed from d 0 to 14 (linear, $P < .08$). Overall (d 0 to 28) in this study, no effects of feeding SDAP or pellet conditioning temperature of diets fed from d 0 to 14 were observed.

In Exp. 2, from d 0 to 7, pigs fed the 5% SDAP diet conditioned at 60°C had greater ($P < 0.05$) ADFI and numerically greater ($P = 0.12$) ADG than pigs fed the control diet that contained no SDAP (Table 3). This is consistent with the results observed in Exp. 1. From d 0 to 7, ADG was similar as pellet conditioning temperature increased to 77°C but then decreased with conditioning temperatures above 77°C (quadratic, $P < 0.03$). From d 0 to 7, increasing conditioning temperature also decreased feed intake (linear, $P < 0.01$), with the most pronounced decrease observed after 77°C. Johnston et al. (1999) examined the effects of standard and long-term conditioning (79°C for 10 and 160 s, respectively) on diets fed from d 16 to 28 after weaning. They observed 4 and 11% decreases in ADG and ADFI, respectively, for pigs fed the long-term conditioned diets compared to those for pigs fed the diets conditioned for the standard time. Although diets were conditioned at equal temperatures, results suggest that decreased growth performance may occur when nursery diets are exposed to high temperatures for extended periods of time. Therefore, conditioning time and temperature must be monitored closely during pelleting of nursery diets.

From d 0 to 14, increasing pellet conditioning temperature had no effect on ADG or ADFI, but G/F improved with increasing conditioning temperature (linear, $P < 0.03$) and was highest for pigs fed diets conditioned at 77°C. As in Exp. 1, ADG from d 14 to 28 was not different among pigs previously fed either the control diet or 5% SDAP. However, pigs previously fed the control diet had numerically ($P < 0.08$) better G/F than those fed 5% SDAP pelleted at the same conditioning temperature from d 0 to 28. Pellet conditioning temperature of the diet fed from d 0 to 14 had no effect on performance from d 14 to 28 or from d 0 to 28 after weaning.

Implications

Results suggest that adding spray-dried animal plasma to weanling pig starter diets, whether prepared in meal form or pelleted, improves growth performance from d 0 to 7 after weaning. Furthermore, results indicate that conditioning diets containing spray-dried animal plasma at temperatures above 77°C decreases weanling pig growth performance.

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