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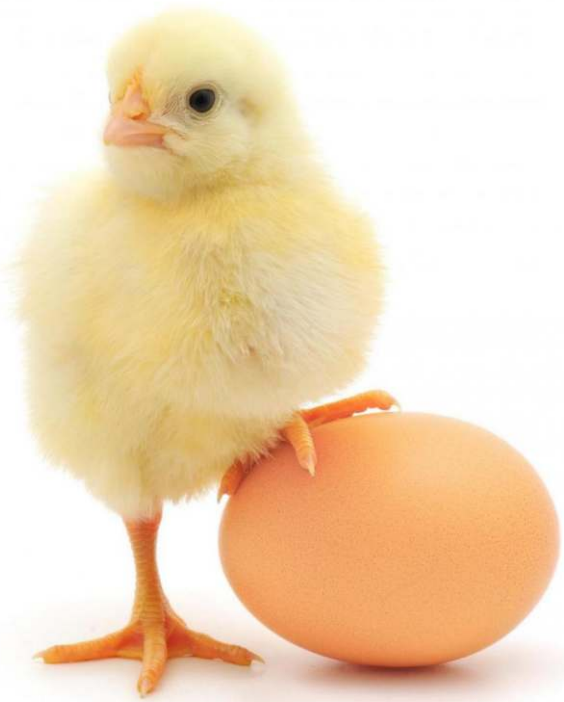

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Effects of Early Skip-A-Day Feed Removal and Litter Material on Broiler Live and Processing Performance and Litter Bacterial Levels

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Abstract: This study investigated effects of early skip-a-day feed removal and litter materials on broiler live and processing performance and levels of litter bacteria. A total of 1600 male broilers were evenly distributed in 16 pens. Eight pens were provided feed ad libitum (AL Treatment) and 8 were provided feed ad libitum except for 24 hour removal periods at 6, 8, 10 and 12 days of age (4R Treatment). Half the pens in each feeding treatment were provided used pine shavings and the other half were provided used sand as litter. An increasing photoperiod program was provided which decreased from 23L:1D to 13L:11D at 6 days, then increased 2 hours/week beginning at 13 days and reached 23L:1D at 41 days. Body weight and feed consumption were determined and feed conversions calculated approximately weekly. Mortalities were necropsied and recorded daily. At 47 days, 10 birds from each pen were processed, cut up and deboned to determine carcass and parts weights and yields. Litter samples were collected from 3 locations in each pen the day before chicks were placed, weekly during the rearing period and 9 days after bird removal. Relative to the AL Treatment, 4R body weights were decreased 27% immediately after feed removal, this smaller than expected reduction was likely due to the short photoperiod provided at that time. Body weights of AL and 4R Treatments diverged until partial compensatory growth occurred in the 4R Treatment once 23L:1D was provided. Feed consumption was reduced in the 4R Treatment following the initiation of feed removal, while feed conversion was only transiently reduced. Metabolic and total mortality were reduced by the 4R Treatment. Differences in carcass weights and yields and parts weights were proportional to live weight differences due to feeding treatments. Live production and processing performance were not influenced by litter material. In general, litter bacterial numbers were only influenced slightly by feeding treatments. However, litter type played a more marked role, with sand having lower aerobic, anaerobic and enteric counts than pine shavings.

Key words: Broiler, feed restriction, litter material, growth, parts yield and litter bacteria

Introduction

A period of skip-a-day (SAD) feed removal early in rearing may improve broiler performance by limiting growth in a manner similar to lighting programs providing short photoperiods at early ages (Classen and Riddell, 1989; Classen *et al.*, 1991; Charles *et al.*, 1992; Renden *et al.*, 1993; Downs *et al.*, 2006; Lien *et al.*, 2007). Four or 7 days of feed removal in SAD programs reduced mortality due to ascites in broilers reared at high altitudes while minimally affecting slaughter weights (Arce *et al.*, 1992). Three days of feed removal in a SAD program begun at 7 days did not significantly affect broiler weight or feed efficiency at 39 days; however, 6 days reduced weight but improved efficiency (Ballay *et al.*, 1992). Four days of feed removal in a SAD program begun at 7 days did not affect broiler weight at 56 days but decreased abdominal fat (Santoso *et al.*, 1995). Two or 4 days of feed removal in SAD programs begun at 8 days did not reduce broiler live or carcass weights at 54 days; however, 6 days did (Dozier *et al.*, 2002). Five days of feed removal in SAD programs begun at 8 or 9 days reduced broiler weights at 54 days and although compensatory growth was inhibited by shorter photoperiods, it was unaffected by strain or sex (Dozier *et al.*, 2003).

The use of sand as poultry litter has received considerable interest as the cost and difficulty of obtaining plant based litter sources has increased. Broilers reared on clean sand had greater weights than those reared on clean pine shavings; however, weights did not differ for two successive flocks grown on the used litter and abdominal fat yields were always lower for those reared on sand (Bilgili *et al.*, 1999a). Body weights of the fourth and fifth successive flocks reared on sand and pine shavings did not differ, although gizzard weights were greater and foot pad lesions were more prevalent in males reared on shavings (Bilgili *et al.*, 1999b). Sand litter was observed to have lower bacterial counts and moisture levels than pine shavings during initial but not later successive grow - outs (Bilgili

Table 1: Effects of early skip-a-day feed removal and used litter material on body weight and average daily gain of broilers[1].

Item	Body weight (kg)						Average daily gain (g/day)				
	Day 6	Day 13	Day 20	Day 27	Day 41	Day 47	Day 13-20	Day 20-27	Day 27-41	Day 41-47	Day 13-47
Feeding treatment											
Ad libitum[2] (AL)	0.136	0.345	0.704	1.230	2.533	2.942	51.3	75.1	93.1	68.2	76.4
4 Days removal[3] (4R)	0.135	0.252	0.572	1.067	2.324	2.792	45.7	70.7	89.8	78.0	74.7
Litter material											
Pine shavings	0.136	0.298	0.640	1.153	2.438	2.856	48.9	73.3	91.8	69.7	75.3
Sand	0.135	0.299	0.640	1.144	2.420	2.874	48.7	72.0	91.1	75.7	75.7
SEM[4]	0.002	0.003	0.010	0.017	0.031	0.042	2.53	1.19	1.20	3.01	1.23
Effects	P value										
Feeding	0.824	< 0.001	< 0.001	< 0.001	0.002	0.029	0.128	0.016	0.102	0.064	0.320
Litter	0.676	0.845	0.999	0.822	0.695	0.461	0.974	0.644	0.612	0.213	0.613
Feeding x litter	0.708	0.099	0.184	0.222	0.576	0.765	0.642	0.343	0.805	0.881	0.939

[1]Values are least squares means of 8 pens per main effect treatment with each having 100 birds at placement. [2]Feed provided ad libitum from 1 to 47 days. [3]Feed provided ad libitum except for 24-hr removal periods beginning at 6, 8, 10 and 12 days of age. [4]Pooled SEM for main effects (n=8).

et al., 1999a and b; Macklin *et al.,* 2005). Broilers given a choice between sand and pine shavings spent more time and performed more of their behaviors on sand, but when not given a choice their behaviors did not differ (Shields *et al.,* 2005). The present study's purpose was to determine the effects of 4 days of feed removal in a SAD program and sand as a litter material on the live performance, carcass and parts yields of broilers and bacterial levels of the two litter types.

Materials and Methods

Bird management: A total of 1600 male, 1 day-old, Ross X Ross 308 broiler (Aviagen, Inc., Huntsville, AL) chicks were obtained from a commercial hatchery after vaccination for Newcastle disease, infectious bronchitis and Marek's disease. One hundred chicks were randomly distributed in each of sixteen pens (9.25 birds/m^2) of an open-sided house with thermostatically controlled curtains, forced air gas furnaces and sidewall ventilation. House temperatures were maintained between 27 and 33^{o}C from 1 to 7 days; 25 and 30^{o}C from 8 to 14 days; 23 and 30^{o}C from 15 to 21 days and 21 and 30^{o}C from 22 to 47 days, respectively. The temperature under a 1.5 m square brooder in each pen was 35^{o}C from 0 to 7 days and decreased 2^{o}C every 7 days until they were removed at 21 days. This study was conducted in Auburn, Alabama, USA, during September through November. Outside ambient temperatures ranged from 9 to 33^{o}C. Birds were provided common corn-soy broiler starter (fed days 1 to 20), grower (fed days 21 to 41) and withdrawal (fed days 42 to 47) feeds containing 22.9, 20.3 and 20.1% CP and 3220, 3245 and 3255 kcal ME/kg, respectively. Feeds satisfied National Research Council (1994) nutrient recommendations. The starter was crumbled, while other feeds were pelleted. Two tube feeders and a 3.4 m nipple waterer line with 12 nipples were provided in each pen. Water was provided continuously. An increasing photoperiod program (23L:1D,1 to 6 days; 13L:11D, 6 to 13 days; 15L:9D, 13 to 20 days; 17L:7D, 20 to 27 days; 19L:5D, 27 to 34 days; 21L:3D, 34 to 41 days and 23L:1D, 41 to 47 days) of both natural and incandescent light was provided. The Auburn University Institutional Animal Care and Use Committee approved all procedures.

Experimental treatments: Feeding treatments consisted of continuously providing feed ad libitum (AL Treatment) or providing feed ad libitum except for 24 hour feed removal periods beginning at 6, 8, 10 and 12 days of age (R4 Treatment). Litter treatments provided a 10 cm layer of either pine shavings or sand both of which had been previously used to rear two flocks of broilers. Feeding and litter treatments made up a 2 by 2 factorial arrangement with 4 replicate pens in each interaction treatment.

Production measurements: Individual body weights were determined and uniformity calculated (the percentage of birds within 10% of the pen body weight mean) at 6, 20, 41 and 47 days. Pen body weight was determined at 13 and 27 days. Average daily gains were calculated for weekly periods from the end of the last feed removal period to the end of the trial. Feed consumption was determined by pen and feed conversion (g feed/g gain) was calculated at 6, 13, 20, 27, 34, 41 and 47 days. Mortalities were necropsied and classified as either metabolic (either ascites, skeletal disorders, or sudden death syndrome) or non-metabolic (other causes).

At 47 days, a sample of 10 birds per pen was selected for processing, subjected to a 10 hour feed withdrawal, placed in coops and transported to the processing plant. Birds were hung on shackles, electrically stunned and killed by severing the right carotid artery and jugular vein. Following bleed-out, birds were subscalded at 56.6^{o}C for 90 seconds, defeathered in an automatic picker, automatically eviscerated and chilled in static slush ice for 4 hours. Carcasses were drained for 3 minutes and abdominal fat pads removed and weighed. Carcasses were then weighed, cut up and deboned to obtain

Table 2: Effects of early skip-a-day feed removal and used litter material on feed consumption and conversion of broilers[1]

	Cumulative feed consumption (kg/bird)							Cumulative feed conversion (kg feed/kg gain)					
Item	Day 6	Day 13	Day 20	Day 27	Day 34	Day 41	Day 47	Day 6	Day 13	Day 20	Day 27	Day 41	Day 47
Feeding treatment													
Ad libitum[2] (AL)	0.117	0.413	0.940	1.743	2.838	4.150	5.584	0.87	1.21	1.35	1.42	1.64	1.91
4 Days removal[3] (4R)	0.109	0.272	0.754	1.480	2.515	3.786	5.130	0.81	1.08	1.32	1.39	1.63	1.83
Litter material													
Pine shavings	0.116	0.341	0.844	1.616	2.679	3.945	5.312	0.86	1.15	1.33	1.41	1.62	1.86
Sand	0.111	0.343	0.849	1.607	2.670	3.991	5.403	0.82	1.14	1.34	1.41	1.65	1.87
SEM[4]	0.003	0.004	0.011	0.022	0.031	0.051	0.090	0.016	0.008	0.011	0.006	0.013	0.024
Effects	P Value												
Feeding	0.086	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.007	0.032	< 0.001	0.231	0.019	0.637	0.112
Litter	0.274	0.794	0.775	0.787	0.825	0.515	0.360	0.191	0.856	0.661	0.894	0.100	0.751
Feeding x litter	0.847	0.128	0.088	0.144	0.158	0.201	0.239	0.505	0.982	0.683	0.473	0.240	0.263

[1]Values are least squares means of 8 pens per main effect treatment with each having 100 birds at placement. [2]Feed provided ad libitum from 1 to 47 days. [3]Feed provided ad libitum except for 24-hr removal periods beginning at 6, 8, 10 and 12 days of age. [4]Pooled SEM for main effects (n=8).

Table 3: Effects of early skip-a-day feed removal and used litter material on uniformity and mortality of broilers[1]

	Uniformity (% within 10% of mean body weight)				Mortality (%)		
Item	Day 6	Day 20	Day 41	Day 47	Metabolic[2]	Nonmetabolic[3]	Total
Feeding treatment							
Ad libitum[4] (AL)	86	84	83	83	3.1	1.8	4.9
4 Days removal[5] (4R)	84	81	85	87	0.8	1.3	2.0
Litter material							
Pine shavings	86	85	85	85	2.0	2.2	4.2
Sand	83	80	83	86	1.8	0.9	2.7
SEM[6]	1.7	1.6	1.8	1.5	0.77	0.38	0.91
Effects	P Value						
Feeding	0.589	0.339	0.417	0.279	0.036	0.377	0.087
Litter	0.264	0.072	0.404	0.692	0.635	0.119	0.275
Feeding x litter	0.278	0.267	0.237	0.056	0.300	0.581	0.657

[1]Values are least squares means of 8 pens per main effect treatment with each having 100 birds at placement. [2]Values are the combined occurrence of mortality due to sudden death syndrome, ascites and skeletal abnormalities. [3]Values are mortality due to factors other than those listed in 2 above and undetermined factors. [4]Feed provided ad libitum from 1 to 47 days. [5]Feed provided ad libitum except for 24-hr removal periods beginning at 6, 8, 10 and 12 days of age. [6]Pooled SEM for main effects (n = 8).

skinless boneless breast fillet (Pectoralis major muscles), breast tender (Pectoralis minor muscles), whole breast, wing and leg weights. Parts yields were calculated as a percentage of live weight.

Litter bacterial measurements: Litter samples (150 g) were collected from each pen the day before chicks were placed, weekly until birds were removed at 47 days and then 9 days after bird removal. Each litter sample consisted of three subsamples (50 g each) that were taken from each pen; one from under the nipple waterers, one from near the feeder and one from the middle of the pen. The three subsamples from each pen were pooled, thoroughly mixed and immediately processed for populations of bacteria. Aerobic, anaerobic and enteric bacteria were enumerated (CFU/g) for each pen using Plate Count Agar (PCA) (BD Biosciences, Sparks, MD), Reduced Blood Agar (RBA) (BD Biosciences, Sparks, MD) and MacConkey Agar (MA) (BD Biosciences, Sparks, MD), respectively. Dilutions were performed by adding 10 g of litter to 90 ml of sterile physiological saline (0.75% NaCl). Further dilutions were performed by successively transferring 10 ml into bottles containing 90 ml sterile saline to make dilutions of from 10^{-1} to 10^{-8}. Dilutions were then spiral plated (DW Scientific-Microbiology International, Fredrick, MD) in triplicate onto each media type and incubated. PCA and MA were incubated aerobically at 37 C; RBA was incubated at 37°C in an anaerobic chamber (Bactron IV-Shel Lab, Cornelius, OR) containing 5% CO_2, 5% H_2 and 90% N_2. After 18 hours colonies were quantified on a digital plate reader (ProtoCol-Microbiology International, Fredrick, MD) and an average bacterial count in CFU/g for each media was obtained with the plate reader's software.

Statistical analysis: Four replicate pens served as the experimental units for each feeding by litter type treatment of the 2 by 2 factorial arrangement. Treatment effects were determined using PROC GLM (2004 version, SAS Institute, Inc., Cary, NC). The square roots of mortality data expressed as decimals were arc sine transformed and litter bacteria counts were converted to a $\log_{10}$ scale, prior to analysis. Statistical significance was set at $P \leq 0.05$ for body weight, average daily gain, feed consumption, feed conversion, uniformity and litter

Table 4: Effects of early skip-a-day feed removal and used litter material on final live weight and carcass characteristics of broilers[1]

Item	Preslaughter live weight (lb)	Chilled carcass weight[2] (lb)	Chilled carcass yield (% of live weight)	Abdominal fat (%)
Feeding treatment				
Ad libitum[3] (AL)	2.959	2.165	73.2	1.56
4 Days removal[4] (4R)	2.829	2.053	72.6	1.58
Litter material				
Pine shavings	2.876	2.100	73.0	1.57
Sand	2.905	2.111	72.7	1.57
SEM[5]	0.0658	0.0456	0.29	0.06
Effects	---------- P value ----------			
Feed	0.191	0.113	0.194	0.917
Litter	0.683	0.767	0.456	0.999
Feed x litter	0.777	0.703	0.634	0.374

[1]Values are least squares means of 8 pens per main effect treatment which each contributed a sample of 10 birds. [2]Carcasses without necks and giblets after 4 hours of static chilling and removal of abdominal fat. [3]Feed provided ad libitum from 1 to 47 days. [4]Feed provided ad libitum except for 24-hr removal periods beginning at 6, 8, 10 and 12 days of age. [5]Pooled SEM for main effects (n = 8).

Table 5: Effects of early skip-a-day feed removal and used litter material on carcass part weights and yields of broilers[1]

Item	Whole Breast Wt. (g)	Whole Breast Yield (%)[2]	Fillet Wt. (g)	Fillet Yield (%)[2]	Tender Wt. (g)	Tender Yield (%)[2]	Wing Wt. (g)	Wing Yield (%)[2]	Leg Wt. (g)	Leg Yield (%)[2]
Feeding treatment										
Ad libitum[3] (AL)	557	18.8	451	15.2	106	3.57	244	8.23	751	25.4
4 Days removal[4] (4R)	529	18.7	429	15.2	100	3.54	230	8.14	715	25.3
Litter material										
Pine shavings	538	18.7	436	15.1	102	3.56	237	8.24	731	25.4
Sand	546	18.8	443	15.2	103	3.55	236	8.12	733	25.2
SEM[5]	12.4	0.15	10.3	0.13	2.3	0.043	5.7	0.057	14.8	0.17
Effects	---------- P Value ----------									
Feed	0.154	0.722	0.175	0.816	0.106	0.563	0.137	0.348	0.111	0.609
Litter	0.633	0.775	0.620	0.709	0.721	0.930	0.977	0.212	0.831	0.443
Feed x litter	0.784	0.153	0.688	0.085	0.742	0.892	0.761	0.877	0.658	0.745

[1]Values are least squares means of 8 pens per main effect treatment which each contributed a sample of 10 birds. [2]Yield data were calculated as a percentage of live body weight. [3]Feed provided ad libitum from 1 to 47 days. [4]Feed provided ad libitum except for 24-hr removal periods beginning at 6, 8, 10 and 12 days of age. [5]Pooled SEM for main effects (n = 8).

bacterial levels and at $P \leq 0.10$ for mortality and processing parameters.

Results and Discussion

Live performance: Relative to the AL Treatment, the 4R Treatment resulted in a significant body weight decrease of 93 g or 27% at 13 days of age immediately after the last feed removal period (Table 1). Santoso *et al.* (1995) observed a 41% decrease in body weight following 4 days of feed removal in a SAD program begun at 7 days. Previously we also observed greater body weight differences per day of feed removal after 2, 4, 6 (Dozier *et al.,* 2002) and 5 days (Dozier *et al.,* 2003) of early feed removal in SAD programs. The disparity in these observations is likely because photoperiods during feed removal were 23 or 24 hours in earlier studies, while they were only 13 hours in the present study. Shorter photoperiods decrease body weight at early ages (Charles *et al.,* 1992; Downs *et al.,* 2006, Lien *et al.,* 2007). Therefore, growth of the AL Treatment was likely restricted by the photoperiod when the 4R Treatment was subjected to feed removal, which resulted in a smaller body weight difference between the 2 treatments.

Average daily gains were significantly greater in the AL Treatment from 20 to 27 days and nearly significantly greater from 13 to 20 (P=0.128) and 27 to 41 (P=0.102) days (Table 1). This resulted in an increase in the absolute body weight difference between the AL and 4R Treatments to 209 g at 41 days. During that period photoperiods increased from 15 to 21 hours. Average daily gain was nearly significantly greater (P=0.064) in the 4R Treatment from 41 to 47 days when the photoperiod was 23 hours. This resulted in a decrease in the absolute body weight difference to 150 g at 47 days. However, this difference still significantly favored the AL Treatment. Short photoperiods following the feed removal period likely prevented the 4R Treatment from being able to consume enough feed to manifest compensatory growth and recover from their body weight deficit. In an earlier trial, we observed more complete compensatory growth under constant light once feed removal periods were ended (Dozier *et al.,* 2002). At 56 days, body weights of broilers provided constant light after four days of feed removal in a SAD program did not differ in from those continuously provided feed *ad libitum* (Santoso *et al.,* 1995). We also observed an inhibition of

Table 6: Effects of early skip-a-day feed removal and litter material on litter aerobic bacterial counts when broilers were reared to 47 days[1]

	Aerobic bacterial counts (Log_{10})								
Item	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 47	Day 56
Feeding treatment									
Ad libitum[2] (AL)	4.14	7.41	7.91	7.96	8.04	8.61	9.17	9.29	8.42
4 Days removal[3] (4R)	4.12	7.38	7.48	8.00	8.07	8.55	9.34	9.51	8.46
Litter material									
Pine Shavings	4.09	7.68	8.02	8.14	8.22	8.57	9.54	9.56	8.50
Sand	4.16	7.11	7.38	7.83	7.88	8.59	8.97	9.24	8.39
SEM[4]	0.171	0.055	0.367	0.234	0.187	0.078	0.073	0.104	0.074
Effects	P Value								
Feeding	0.89	0.68	0.24	0.87	0.87	0.42	0.02	0.03	0.58
Litter	0.66	< 0.01	0.09	0.20	0.07	0.77	< 0.01	< 0.01	0.15
Feeding x litter	0.18	0.01	0.47	0.87	0.93	0.02	0.13	0.27	0.01

[1]Values are least squares means of 8 pens per main effect treatment with each contributing samples from 3 locations within each pen on each sampling day. [2]Feed provided ad libitum from 1 to 47 days. [3]Feed provided ad libitum, except for 24 hour removal periods beginning at 6, 8, 10 and 12 days of age. [4]Pooled SEM for main effects (n = 8).

Table 7: Effects of early skip-a-day feed removal and litter material on fecal coliform counts when broilers were reared to 47 days[1]

	Fecal coliform counts (Log_{10})								
Item	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 47	Day 56
Feeding treatment									
Ad libitum[2] (AL)	3.19	6.37	5.65	7.96	7.17	6.69	7.19	7.32	6.07
4 Days removal[3] (4R)	3.19	6.51	4.88	8.00	7.73	6.81	7.47	7.50	5.48
Litter material									
Pine Shavings	3.24	7.20	6.87	7.62	8.11	8.01	7.71	7.50	6.50
Sand	3.13	5.68	3.66	7.04	6.79	5.50	6.96	7.32	5.05
SEM[4]	0.119	0.118	0.848	0.230	0.215	0.376	0.162	0.202	0.401
Effects	P Value								
Feeding	0.96	0.26	0.37	0.17	0.01	0.75	0.08	0.38	0.15
Litter	0.36	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.39	< 0.01
Feeding x litter	0.99	0.99	0.95	0.06	0.10	0.74	0.37	0.40	0.15

[1]Values are least squares means of 8 pens per main effect treatment with each contributing samples from 3 locations within each pen on each sampling day. [2]Feed provided ad libitum from 1 to 47 days. [3]Feed provided ad libitum, except for 24 hour removal periods beginning at 6, 8, 10 and 12 days of age. [4]Pooled SEM for main effects (n = 8).

compensatory growth during exposure to a photoperiod of 18L: 6D from 23 to 43 days while exposure to 23L: 1D from 44 to 54 days allowed an increase in compensatory growth (Dozier *et al.,* 2003). Ballay *et al.* (1992) observed near complete body weight recovery in broilers provided continuous light after being subjected to 3 days of feed removal in a SAD program imposed during the second week of age.

In the present study, the used litter type did not influence body weight or average daily gains. This is consistent with previous reports in which body weight differences were only observed in the first and second of 3 successive trials with what were initially fresh sand and fresh pine shavings (Bilgili *et al.,* 1999a). A later report observed no body weight differences in the fourth and fifth successive flocks reared on sand and pine shavings (Bilgili *et al.,* 1999b).

During the week from 6 to 13 days that included the feed removal periods, the 4R Treatment consumed 136 g or 45% less feed than the AL Treatment (Table 2). In each of the 5 following weeks the 4R Treatment always consumed less feed than the AL Treatment. This was true even from 41 to 47 days when average daily gain was greater in the 4R than AL Treatment. Therefore, following the feed removal periods, cumulative feed consumption was always significantly reduced in the 4R Treatment and the disparity between it and that of the AL Treatment continuously increased. This likely accounted for the failure of 4R Treatment body weights to catch up with those of the AL Treatment. Previously we observed compensatory growth following a period of SAD feed removal when feed consumption of SAD birds was equal to that of continuously ad libitum fed birds (Dozier *et al.,* 2002). The significant reduction in feed conversion (Table 2) and nearly significant decrease (P=0.086) in feed consumption at 6 days in the 4R Treatment was likely due to bird and feed weighing 6 hours after the onset of the first feed removal period. Feed conversion was significantly reduced in the 4R Treatment at 13 and 27 days, and nearly significantly reduced (P=0.112) at 47 days. Programs which reduce feed consumption and body weight have often been observed to improve feed conversion (Ballay *et al.,* 1992; Dozier *et al.,* 2003).

Feed consumption and conversion were not affected by litter type. Previous reports on the use of sand litter have

Table 8: Effects of early skip-a-day feed removal and litter material on litter anaerobic bacterial counts when broilers were reared to 47 days[1]

	Anaerobic bacterial counts (Log_{10})								
Main Effects	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 47	Day 56
Feeding treatment									
Ad libitum[2] (AL)	2.96	7.32	8.07	7.86	7.65	7.99	8.67	8.65	7.76
4 Days removal[3] (4R)	2.97	7.06	7.81	7.78	8.02	7.97	8.43	8.22	7.75
Litter Material									
Pine Shavings	2.80	7.31	8.39	8.16	8.15	8.22	8.85	8.50	7.94
Sand	3.14	7.07	7.48	7.47	7.52	7.74	8.26	8.38	7.57
SEM[4]	0.317	0.074	0.121	0.170	0.150	0.081	0.131	0.160	0.080
Effects	P Value								
Feeding	0.98	< 0.01	0.03	0.64	0.02	0.83	0.07	< 0.01	0.89
Litter	0.29	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.44	< 0.01
Feeding x litter	0.60	0.450	0.08	0.06	0.54	0.30	0.16	0.08	0.03

[1]Values are least squares means of 8 pens per main effect treatment with each contributing samples from 3 locations within each pen on each sampling day. [2]Feed provided ad libitum from 1 to 47 days. [3]Feed provided ad libitum, except for 24 hour removal periods beginning at 6, 8, 10 and 12 days of age. [4]Pooled SEM for main effects (n = 8).

also observed no difference in feed conversion (Bilgili *et al.*, 1999a, b).

Uniformity was not significantly affected by feeding treatment or litter type (Table 3). However, metabolic and total mortality were significantly reduced by the 4R Treatment (Table 3). In previous studies on SAD feed removal we did not observe reductions in mortality (Dozier *et al.*, 2002 and 2003). However, Arce *et al.* (1992) observed significant reductions in ascites induced mortality in broilers subjected to SAD feed removal during rearing at high altitude and Ballay *et al.* (1992) observed reduced mortality in broilers subjected to SAD feed removal for longer periods. It has been well documented that programs that reduce growth at an early age often reduce mortality, particularly due to metabolic diseases (Classen and Riddell, 1989; Classen *et al.*, 1991; Charles *et al.*, 1992). There was a nearly significant reduction (P=0.119) in non-metabolic mortality due to rearing on sand litter, although its cause was unclear. Previous reports on the use of sand litter have not noted reductions in mortality (Bilgili *et al.*, 1999a, b), although lower bacterial levels observed with sand than shaving litter in previous reports (Bilgili *et al*, 1999a; Macklin *et al.*, 2005) and later in this article could contribute to such an effect.

Processing performance: Unlike mean weights for all birds (Table 1), pre-slaughter live weights based on a sample from each pen did not differ significantly (P=0.191) between AL and 4R Treatments (Table 4). The decreased sample size increased the SEM 56% while decreasing the difference between treatments 15%. There were similar non-significant decreases in chilled carcass weight (P=0.113), carcass yield (P=0.194) and all parts weights (P values from 0.154 to 0.106) due to the 4R Treatment (Tables 4 and 5). It was expected that carcass and parts weights and yields would increase with body weight since they all generally have this tendency. However, abdominal fat and all parts yields showed no tendency to be influenced by feeding treatment. Dozier *et al.* (2002) observed no difference in carcass or fat pad yield due to 2 to 6 days of feed removal in SAD programs. Later they observed that parts weights decreased with body weights after 5 days of feed removal in a SAD program; however, parts yields were unaffected (Dozier *et al.*, 2003). As in the present study, this was likely due to body weight differences being so slight that parts yield differences were insignificant. In earlier studies, 3 days of feed removal in a SAD program had no effect on breast or abdominal fat percentages (Ballay *et al.*, 1992) and abdominal fat was decreased after 4 days of feed removal in a SAD program but no further effects on body composition were observed (Santoso *et al.*, 1995). Lighting programs that transiently reduce growth have been observed to decrease breast meat yield, sometimes with a concurrent increase in leg or wing yield (Renden *et al.*, 1993, Downs *et al.*, 2006; Lien *et al.*, 2007); however, it appears that early SAD feed removal may not have a similar effect.

As was the case for mean weights of all birds, litter type did not influence preslaughter live weights or any of the measures of processing performance (Tables 4 and 5). A previous report noted greater abdominal fat percentages but no differences in carcass yields with sand litter (Bilgili *et al.*, 1999a). However, in two later trials no differences were observed for carcass, fat pad, or various part yields (Bilgili *et al.*, 1999b).

Litter bacteria: The AL Treatment had lower litter aerobic bacterial counts than the 4R Treatment on days 42 and 47 (Table 6). Sand litter had lower aerobic bacteria counts than pine shavings on days 7, 42 and 47. The AL Treatment had lower litter enteric bacterial (fecal coliform) counts than the 4R Treatment on day 28 (Table 7). Sand litter had lower enteric bacteria counts than pine shavings on every sampling date except days

0 and 47, when the birds were placed and removed from the pens, respectively.

Differences in anaerobic bacterial counts due to the feeding treatments were more complicated (Table 8). On days 7 and 14 the counts were significantly lower in the 4R Treatment, which coincides with the days that the birds were without feed. However, on day 28 the 4R Treatment had higher anaerobic bacterial counts than the AL Treatment and on days 42 and 47 the 4R Treatment again had reduced anaerobe counts. Sand had lower anaerobic bacterial counts than shavings on every sampling date except for day 47.

The two feeding treatments produced divergent results concerning the anaerobic and aerobic counts collected on days 42 and 47. In general the AL Treatment had higher anaerobic bacterial counts and the 4R Treatment had higher aerobic bacterial counts. This observation may reflect the predominate microflora within the birds intestines, although without taking samples directly from the bird it is difficult to determine if this is indeed what is occurring.

Litter samples taken on day 47 seemed in disagreement with the previous sampling dates. Sampling on day 47 occurred after the birds were removed and perhaps during the final weighing, cooping and removal process the litter was mixed more than normal. Interestingly this situation did not occur with the aerobic samples, which may be due to the large number of aerobic bacteria that were already in both litter types. Overall the bacterial results observed with the pine shavings and sand litters are in agreement with what was reported previously by Macklin *et al.* (2005). In conclusion, feeding program had minor effects on bacterial populations in the litter; however litter samples taken from sand consistently produced lower bacterial numbers than did samples from pine shavings.

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