JAPR8110

The effect of a direct-fed microbial (Primalac) on turkey live performance[1]

S. M. Russell and J. L. Grimes[2]

Department of Poultry Science, North Carolina State University, Raleigh 27695-7608

Primary Audience: Nutritionists, Production Managers, Flock Supervisors, Producers

SUMMARY

Two pen trials and 2 field trials were conducted to determine whether a direct-fed microbial (DFM; Primalac) was effective in improving turkey productive performance. In the pen trials, typical turkey diets were formulated with and without Primalac. All feed was provided by a commercial feed mill. In trial 1, Large White male turkey poults were placed in 48 pens (18 birds/pen, 24 pens/treatment) on the day of hatch and were reared to 20 wk. In trial 2, Large White female turkey poults were placed in 48 pens (30 birds/pen, 24 pens/treatment) on the day of hatch and were reared to 18 wk. Cumulative FCR was significantly improved for birds fed DFM feed compared with birds fed control feed at 20 wk in trial 1 and at 8 wk in trial 2. Body weight was significantly greater for birds fed DFM feed compared with birds fed the control feed through 12 wk in both trials. In 2 field trials, 2 brooder houses and 4 grow-out houses were paired on each farm (4 brooder houses and 8 grow-out houses total). All birds received the same feed provided by the integrator. The DFM was provided in the water from placement to market in 1 brooder house and in the 2 matching grow-out houses. Breeder flocks were equally represented in both brooder houses within each trial. Approximately 12,000 male poults were placed in each brooder house and were transferred to 2 grow-out houses at 5 wk. Although no statistical analyses were computed for the field trials, there was a nominal improvement in performance associated with the DFM: mean livability was increased by 3.5%, mean BW was increased by 0.9 kg (2 lb), mean total weight removed from the farms was increased by 13,706 kg (30,153 lb), mean FCR was improved by 0.165, and cost of production was reduced by $0.0195/kg ($0.043/lb) of BW by the DFM. In conclusion, the DFM product (Primalac) used in these studies was effective in improving turkey live performance.

Key words: direct-fed microbial, Primalac, probiotic, turkey

TBC J. Appl. Poult. Res. TBC:1–8
doi:10.3382/japr.2008-00110

DESCRIPTION OF PROBLEM

Feed-borne antibiotic growth promoters (**AGP**) have been fed to livestock in the United States and in other countries for approximately 50 yr to improve growth performance [1]. Poultry have been fed AGP during the rearing period to protect them from pathogenic organisms, maintain health, improve growth efficiency, and improve meat quality and wholesomeness.

[1]The use of trade names in this publication does not imply endorsement by the North Carolina Research Service or the North Carolina Cooperative Extension Service of the products named or criticism of similar ones not mentioned.

[2]Corresponding author: Jesse_Grimes@ncsu.edu

However, antibiotics have come under increasing scrutiny by some scientists, consumers, activists, politicians, and bureaucrats because of the argued potential development of antibiotic-resistant bacteria (including pathogenic strains) after long use of AGP in livestock and poultry feed. Antibiotic resistance displayed by field *Escherichia coli* isolates from North Carolina commercial turkey farms has been reported, including resistance to Enrofloxacin, one of the most recently approved antibiotics for use in poultry [2]. However, most AGP have no specific claims to control disease [3]. Debate over resistance observed among bacteria such as *E. coli* and *Salmonella* has generated the strongest objection to antibiotic use [4–6]. Antibiotic resistance of indigenous *E. coli* of poultry has remained at a relatively high level since the 1950s [3]. In the United States, reports from the Institute of Medicine, the Council for Agricultural Science and Technology, and the Committee on Drug Use in Food Animals have recommended the reduction or elimination of AGP from livestock feeds, even though none of these reports provided data proving that AGP-resistant microorganisms were responsible for antibiotic-resistant infections in humans [1]. Although this debate continues, there is interest in developing alternatives to AGP, such as probiotics. The term probiotic has been used to refer to both live cultures and feed additives other than live cultures, such as nondigestible feed ingredients, that enhance host digestive tract microflora [6]. This would include many of the indigestible sugars such as oligosaccharides [7]. Therefore, for clarity, the Association of American Feed Control Officials [8] and the US Food and Drug Administration [9] have recommended that the term direct-fed microbials (**DFM**) be used to describe live-culture feed additives [10]. Other types of feed additives that are not live cultures but that promote microfloral development have been referred to as prebiotics [7]. Probiotics have been developed to counter the growth-depressing effects that certain strains of bacteria elicit in poultry. There are numerous reports of DFM, including *Lactobacillus* spp., being fed to poultry, including turkeys. Grimes et al. [11] reported the used of pelleted feed containing DFM fed to turkeys to 3 wk, resulting in improved live performance. The objective of this study was to evaluate the potential of DFM to improve the live performance of turkeys reared to market age.

MATERIALS AND METHODS

These studies were conducted under Animal Care and Use guidelines established by North Carolina State University's Animal Care and Use Committee. In trial 1, 18 Large White (**LW**) male turkey poults [12] were placed in each of 48 pens (24 pens/treatment; 6 m^2/pen) on the day of hatch. The pens were arranged into 4 rows (blocks) of 12. For pen trial 2, day-of-hatch LW female turkey poults [13] were reared in the same facility after a total clean-out with a separate set of 48 pens (30 birds/pen). The same treatments were applied in the same design as in trial 1. For trial 2, the area in each pen was restricted with a partition to approximately 3.7 m^2. This provided 0.1 m^2 per bird during brooding. At 6 wk, the partition was removed, providing 0.2 m^2 per bird.

All feed was provided by a commercial feed mill [14] and was formulated to meet or exceed NRC recommendations [15]. Typical commercial turkey diets (Table 1) were formulated with and without Primalac [16], which is a DFM product that contains *Lactobacillus acidophilus* and *Lactobacillus casei* as well as other genera (10^8 cfu/g). The DFM was added at inclusion rates of 0 or 1 kg/ton to 8 wk (females) or 9 wk (males) and then at 0 or 0.5 kg/ton to market age for each trial. The pelleted feed was crumbled through 6 wk, and feed was offered in pellet form thereafter. Birds were offered feed and water ad libitum. Feed samples (2/treatment per feed) were collected and sent, labeled but unidentified, to the sponsor laboratory for detection of lactic acid bacteria. Feed was provided by using one 22-kg-capacity tube feeder per pen. Lighting was provided 23 h/d for the first week. Beginning with the second week, lighting was by natural day length. Heat lamps provided heat for each pen, whereas gas-fired heaters provided background room heat.

Mortality and culled birds were recorded by pen. Feed consumption, by pen, and BW were measured at 3, 5, 6, 8, 10, 12, 15, and 20 wk in trial 1 and at 1, 3, 5, 6, 8, 10, 12, 14, 16, and 18 wk in trial 2. Period and cumulative feed consumption and FCR, adjusted for mortality plus

Table 1. Components of diets[1] fed to turkeys reared to 18 (females) or 20 (males) wk

	Diets						
Item	1	2	3	4	5	6	7
Ingredient (%)							
Corn	44.2	46.2	50.8	56.3	60.5	65.7	65.1
Wheat middlings	—	1.0	—	—	—	—	—
Soybean meal (48)	44.0	25.4	34.8	28.7	24.2	21.6	23.0
Meat meal	7.0	7.0	7.0	7.0	7.2	2.0	—
Fat	1.1	2.0	4.4	5.3	5.9	7.3	8.5
Lysine	0.13	0.09	0.12	0.13	—	—	—
DL-Methionine	0.18	0.17	0.13	0.13	0.08	0.06	0.03
Limestone	1.10	1.06	0.88	1.07	1.08	1.48	1.50
Phosphate	1.30	1.28	1.22	0.65	0.38	1.09	1.30
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Choline	0.10	0.10	—	—	—	—	—
Mineral mix[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin mix[3]	0.20	0.20	0.20	0.02	0.20	0.20	0.20
Selenium premix[4]	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Calculated nutrient content							
CP (%)	28.0	25.8	24.0	21.5	19.6	15.6	15.0
ME (kcal/kg)	2904	3036	3164	3278	3366	3432	3476
Fat (%)	3.9	6.1	7.3	8.3	9.1	10.1	11.0
Methionine (%)	0.64	0.60	0.54	0.51	0.43	0.36	0.32
TSAA (%)	1.09	1.02	0.94	0.87	0.77	0.65	0.61
Lysine (%)	1.80	1.66	1.53	1.37	1.15	0.90	0.86
Calcium (%)	1.35	1.30	1.20	1.15	1.10	1.00	0.90
Available phosphorus (%)	0.64	0.62	0.60	0.47	0.41	0.40	0.38
Age (wk)							
Males	0–3	3–6	6–9	9–12	12–15	15–18	18–20
Females	0–3	3–6	6–8	8–10	10–12	12–14	14–18

[1]Direct fed microbial (Primalac, Star Labs Inc., Clarksdale, MO) was added at 1 kg/ton through 9 wk (males) or 8 wk (females) and thereafter at 0.5 kg/ton.

[2]Mineral mix supplied the following per kilogram of diet: 60 mg of Zn as $ZnSO_4 \cdot H_2O$; 60 mg of Mn as $MnSO_4 \cdot H_2O$; 40 mg of Fe as $FeSO_4 \cdot H_2O$; 5 mg of Cu as $CuSO_4$; 1.25 mg of I as $Cu(IO_3)_2$; 0.5 mg of Co as $CoSO_4$.

[3]Vitamin mix supplied the following per kilogram of diet: vitamin A, 6,600 IU; vitamin D_3, 2000 ICU; vitamin E, 33 IU; vitamin B_{12}, 19.8 µg; riboflavin, 6.6 mg; niacin, 55 mg; D-pantothenate, 11 mg; menadione, 2 mg; folic acid, 1.1 mg; thiamine, 2 mg; pyridoxine, 4 mg; D-biotin, 126 µg; ethoxyquin, 50 mg.

[4]Selenium premix supplied 0.21 mg of Se, as Na_2SeO_3.

culls, were calculated. The data were subjected to the GLM procedure of SAS [17]. The pen served as the experimental unit. Variables having a significant *F*-test were compared by the LSMeans function of SAS [17] and were considered to be significant at $P \leq 0.05$.

Two field trials were conducted (1 trial on each of 2 farms). In each trial, 2 brooder houses and 4 grow-out houses were paired on a farm, for a total of 4 brooder houses and 8 grow-out houses across the 2 trials. All birds received the same feeds on the same schedule (lb/bird) provided by the integrator. The DFM was provided in the water at a rate of 2 oz/gal (vol/vol) of stock solution during brooding to 5 wk and then at 1 oz/gal of stock solution from grow-out to market. The stock solution was metered at 1 oz/gal. Water samples were taken from the end of the water line in each house to ascertain that the water in treated houses contained *Lactobacillus* organisms and the water in the control houses did not. Breeder flocks were equally represented in both brooder houses within each trial. Approximately 12,000 male poults were placed in each brooder house. They were transferred to 2 grow-out houses at 5 wk of age and reared to approximately 18 wk of age. No statistical analyses

Table 2. Body weight[1] and cumulative FCR of Large White turkey toms reared with or without a dietary direct-fed microbial (DFM[2])

	BW			FCR		
Age[3]	Control	DFM	SEM	Control	DFM	SEM
Placement	58.7	59.2	0.2			
3	686	703	4.2	1.557[a]	1.447[b]	0.14
6	2.35	2.37	0.02	1.583[a]	1.551[b]	0.01
8	4.07[b]	4.34[a]	0.03	1.678[a]	1.602[b]	0.01
10	6.64[b]	6.87[a]	0.04	2.03[a]	1.96[b]	0.02
12	9.20[b]	9.47[a]	0.07	1.99[a]	1.94[b]	0.02
15	13.5	13.6	0.1	2.15[a]	2.08[b]	0.02
20	21.0	21.1	0.1	2.59[a]	2.52[b]	0.02

[a,b]Means in a row with different superscript are significantly different ($P < 0.05$).

[1]BW is in grams for placement and 3 wk, and then kilograms for all other ages.

[2]The DFM was Primalac (Star Labs Inc., Clarksdale, MO) fed at 1 kg/ton through 8 wk, and then at 0.5 kg/ton until 20 wk

[3]Age: Placement is the day of delivery from the hatchery; all other ages are in weeks.

were conducted for the field trial data; therefore, observational comparisons are presented.

RESULTS

In trial 1, mean BW (Table 2) was significantly greater for DFM-fed compared with control-fed male turkeys at 12 wk (9.5 vs. 9.2 ± 0.1 kg). Cumulative FCR (Table 2) was significantly improved for birds fed DFM compared with birds fed the control feed at 20 wk (DFM = 2.52; control = 2.59 ± 0.02). In trial 2, mean BW (Table 3) of hen turkeys fed DFM was greater than birds fed the control feed through 8 wk and again at 12 wk (DFM = 6.36; control = 6.29 ± 0.02 kg). Mean cumulative FCR (Table 3) was improved for hens fed DFM through 8 wk (DFM = 1.39; control = 1.41 ± 0.01).

Although no statistical analyses were computed for the field trials, a nominal improvement in performance was associated with the DFM: mean livability was increased by 3.5% (actual), mean BW was increased by 0.9 kg, mean total weight removed from the farms was increased by 13,706 kg, mean FCR was improved by

Table 3. Body weight[1] and cumulative FCR of Large White turkey hens reared with or without a dietary direct fed microbial (DFM[2])

	BW			FCR		
Age[3]	Control	DFM	SEM	Control	DFM	SEM
Placement	53	52	1			
1	146[b]	156[a]	1	0.95[a]	0.84[b]	0.02
3	557[b]	586[a]	3	0.86[a]	0.76[b]	0.01
5	1.42[b]	1.47[a]	0.01	1.24[a]	1.20[b]	0.01
6	1.93[b]	2.00[a]	0.01	1.20[a]	1.16[b]	0.01
8	3.42[b]	3.50[a]	0.02	1.41[a]	1.39[b]	0.01
10	5.09	5.11	0.02	1.54	1.55	0.01
12	6.29[b]	6.36[a]	0.02	1.93	1.91	0.01
14	7.81	7.81	0.03	2.21	2.22	0.02
16	8.96	8.91	0.03	2.59	2.62	0.02
18	10.02	10.03	0.04	2.79	2.78	0.02

[a,b]Means in a row with different superscript are significantly different ($P < 0.05$)

[1]BW is in grams for placement, 1, and 3 wk, and then kilograms for all other ages.

[2]The DFM is Primalac (Star Labs Inc., Clarksdale, MO) fed at 1 kg/ton through 8 wk, and then at 0.5 kg/ton until 18 wk.

[3]Age: Placement is the day of delivery from the hatchery; all other ages are in weeks.

0.165, and cost of production was reduced by $0.0195/kg of BW by the DFM (Table 4).

DISCUSSION

Success of DFM fed to turkeys has varied. Carlson et al. [18] fed a microbial preparation to turkey hens and toms to 24 wk without any observed effect on BW or FCR. Potter et al. [19] reported that Medium White turkeys fed *L. acidophilus* were heavier than control birds at 8, 10, and 12 wk, but not at 16 wk. Feed efficiency was not affected. Francis et al. [20] fed a mixture of *L. acidophilus* and other lactobacillii alone or in combination with zinc bacitracin to Broad Breasted LW turkeys in battery cages to 3 wk. There were numerical, but not significant, improvements in BW and feed efficiency attributable to feed treatments. Damron et al. [21] fed a probiotic to LW turkey breeder hens in 2 experiments but did not observe any effect on reproductive performance.

However, other reports agree with the findings reported here. Grimes et al. [11] fed a pelleted and crumbled starter feed with or without the same DFM product reported herein to turkey poults to 3 wk and observed improved performance and reduced susceptibility to a *Salmonella* challenge. That this DFM product was effective after the feed-pelleting process was also reported by Angel et al. [22] with broiler chickens. England et al. [23] sprayed male LW turkey poults with *Lactobacillus reuteri* and included the *L. reuteri* in the feed with or without bacitracin methylene disalicylate to 126 d. The DFM-treated birds were significantly heavier at 126 d than control-fed birds (15.1 vs. 14.8 kg). There was no effect attributable to bacitracin methylene disalicylate. When adjusted to equal BW, birds fed *L. reuteri* were determined to have an improvement in FCR of 2.678 compared with the control birds, which had an FCR of 2.734. In addition to colonizing the intestinal tract, the use of *L. reuteri* resulted in shorter, lighter intestines and smaller relative intestinal weights in turkeys; similar results have been observed and reported in other studies with broilers [23].

Owings [24] fed diets containing 4 concentrations (100, 1,000, 10,000, or 100,000 cfu/g of feed) of a microbial preparation of selected and proprietary *Streptococcus* spp., plus an unsupplemented control (0 cfu/g), to male LW turkeys from 1 to 126 d. There was no effect of diet on 126-d BW. However, birds fed the 10,000 cfu/g treatment had improved FCR compared with control birds (3.12 vs. 3.23). The others were intermediate. Jiraphocakul et al. [25] conducted 2 experiments, 1 with LW hens and 1 with LW toms. In the first experiment, a control diet or the control diet plus 44 ppm of penicillin-streptomycin (1:3) or the control diet plus 44 ppm of zinc-bacitracin, all with or without a preparation of dried *Bacillus subtilis*, was fed to hens to 16 wk. In the second experiment, a control diet or

Table 4. Performance variables of Large White male turkeys in 2 field trials provided or not provided with a direct-fed microbial product (DFM[1]) in the water and reared to 18 wk

Variable	Treatment	Trial 1	Trial 2	Mean difference
Birds started	Control	11,200	12,097	
	DFM	11,195	12,098	
Total BW (kg)	Control	131,868	110,828	
	DFM	144,425	125,683	+13,706
Gain per day (kg)	Control	0.1000	0.0934	
	DFM	0.1092	0.0952	+0.0055
Mean BW (kg)	Control	14.3	11.3	
	DFM	15.5	11.9	+0.9
Cumulative FCR	Control	2.57	2.68	
	DFM	2.30	2.62	−0.165
Livability (%)	Control	82.2	81.0	
	DFM	83.2	87.0	+3.5
Cost difference	Control	0.0221	0.0169	+0.0195
$US/lb	DFM			

[1]The DFM (Primalac, Star Labs Inc., Clarksdale, MO) was provided at 2 oz/gal (brooder period) or 1 oz/gal (grow-out) stock solution. The stock solution was metered at 1 oz/gal.

the control diet plus 44 ppm of zinc-bacitracin or plus 2.2 ppm of bambermycin, all with or without a preparation of dried *B. subtilis*, was fed to toms to 20 wk. There was no effect of the microbial treatment on BW or FCR in the first experiment or on BW in the second experiment. However, in the second experiment, toms fed the microbial preparation had significantly improved FCR at 20 wk compared with birds fed the control diet (3.58 vs. 3.67). Blair et al. [26] fed Calsporin (30 g/ton), which contains *B. subtilis* in spore form (C-3102), bacitracin (50 g/ton), or an unmedicated control diet to LW turkey toms to 18 wk. Both the *B. subtilis* and the bacitracin treatment resulted in heavier turkeys compared with the control treatment (14.32 and 14.15 vs. 13.41 kg). There were no differences in FCR (2.41 ± 0.05) or in carcass yield or parts yield resulting from treatment. However, litter samples from the pens where the *B. subtilis* was fed had less ammonia volatilization than samples from pens where the control diet was fed (7.80 ± 4.87 vs. 25.2 ± 8.47 ppm).

All these studies had results very similar those reported here. Although toms fed DFM were not different in 20-wk BW, they did have improved FCR throughout the trial compared with birds fed the control feed. In addition, the work reported by Potter et al. [19] could be argued to be a positive study for DFM use, rather than a negative one, because of possible contamination of the control-fed birds by the live culture fed to the treated birds. For example, England et al. [23] reported observing, during a previous feeding study, contamination of control birds from across an isle by the *L. reuteri* being fed to treated birds. In a subsequent published work, England et al. [23] instituted measures to prevent contamination of the control birds. These observations and actions are supported by the observations and efforts made by others using chicks [27–30]. Even in the current study, measures were taken to contain the movement of the live cultures. For example, 18-in. partitions were placed around every pen to prevent litter contact from pen to pen. In addition, all work was conducted first with the control birds. All work conducted with the treated birds was conducted with disposable boots worn by animal caretakers, and after all work was accomplished, the hallways were washed. However, even with these efforts, it is possible that the hens in trial 2 experienced the spread of live culture into the control pens, as evidenced by the fact that the control birds caught up with the treatment birds with respect to BW and FCR. However, we observed no direct evidence of this occurring or not occurring.

There are few reports of field trials describing the effects of DFM under commercial conditions. The 2 field trials reported here resulted in advantages for the birds provided the DFM in the water. This work is supported by the results of Fritts et al. [27] describing field trials conducted by the Calpis Corporation (Kanagawa, Japan). In those trials, both BW and FCR were improved by feeding *B. subtilis* to broiler chickens. In addition, Casas et al. [31] reported the results of 16 paired-house field trials involving 280,000 commercial turkeys. *Lactbacillus retuteri* [32] was applied to the poults by spray post-hatch and then metered into the feed in the feed hopper during the brooding period. They reported that the *L. reuteri*-treated birds had 2.8% less mortality in 13 trials, a 2.1% increase in BW in 12 trials, a 3.5% improvement in FCR in 13 trials, and a 9% increase in the number of grade A carcasses, all statistically significant at $P < 0.05$. In 1 flock, BW was measured at transfer from the brooder house to the grow-out house. The treated toms weighed 1.9 kg compared with the control toms, which weighed 1.7 kg at 42 d. Torres-Rodriguez et al. [33] administered a *Lactobacillus*-based product through the water to commercial hen turkeys under field conditions for 3 d at placement and at transfer to grow-out facilities. The treated hens had improved market BW (190 g) and improved daily gain (1.63 g). The cost of production was also reduced by 1.53 cents/kg of live turkey.

Not every trial with DFM has resulted in improved turkey performance. For example, Casas et al. [31] reported that *L. reuteri* administration to unstressed turkey poults had no effect. However, in poults stressed by cold temperature and hatchery services, such as beak and toe conditioning, *L. reuteri*-treated poults experienced increased BW gain. The implication is that there may be many opportunities for producers to test DFM products in their production systems.

Although the explanation of the mode of action of DFM is not within the scope of this paper,

proposed mechanisms of pathogen reduction or inhibition include competition for nutrients, production of toxic conditions and compounds, competition for binding sites on the intestinal epithelium, stimulation of the immune system, and enhancement of the mucous layer that covers the intestinal surface [6, 7, 34–36]. The use of DFM supplements in poultry diets changes and stabilizes the microflora environment of the avian digestive tract [7, 36–38]. There are numerous reports describing competitive exclusion, including the significant reduction of intestinal levels of *Salmonella* spp., in turkeys or other livestock by the use of DFM [11, 31, 39–41]. Higgins et al. [42] reported that a young commercial flock of turkeys with Enteritis associated with a *Salmonella seftenburg* infection experienced improved BW gain when treated with antibiotics, followed by a *Lactobacillus* probiotic culture.

CONCLUSIONS AND APPLICATIONS

1. In 2 pen trials, the use of a dietary DFM product (Primalac) improved the performance of male and female LW turkeys reared to market age compared with birds fed the control feed.
2. In 2 field trials, the use of the water-delivered DFM improved the nominal performance of commercial male turkeys reared to 18 wk.
3. Further research is needed to better understand the compatibility of DFM with other feed additives, including commonly used antibiotic growth promotants.

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