Influences of Supplemental Dietary Poultry Fat and F-Strain *Mycoplasma gallisepticum* Infection on the Early Performance of Commercial Egg Laying Hens[1,2]

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ABSTRACT F-strain *Mycoplasma gallisepticum* (FMG) may alter reproductive performance in layers through its effects on lipid metabolism. Therefore, the influences of 1.5% supplemental dietary poultry fat (PF) and FMG infection on the early performance of commercial egg-laying hens were determined. Birds were either sham- or FMG-inoculated at 12 wk, and experimental diets were initiated at 20 wk of age. Body weight at 12, 20, and 24 wk, total daily egg mass, feed consumption and feed conversion at 20 and 24 wk, weekly egg weight between 19 and 26 wk, weekly egg production (EP) between 18 and 26 wk, and weekly mortality between 12 and 26 wk of age were determined. Inoculation with FMG reduced EP at 18 and 19 wk of age. Between 20 and 26 wk, FMG reduced EP in birds fed control diets, conversely, PF eliminated differences in EP between sham- and FMG-inoculated birds. Furthermore, at wk 20 and 24, birds consumed less feed when fed PF-supplemented diets than when fed control diets if they were sham-inoculated, but the difference in feed consumption between diets was ameliorated if birds were previously inoculated with FMG. These data demonstrate that the effects of a 12-wk inoculation of FMG on EP and feed consumption through 26 wk of age in commercial egg-laying chickens can be modified by 1.5% supplemental dietary PF. More specifically, PF may alleviate reductions in early EP due to FMG.

(*Key words*: commercial layer, egg production, F-strain *Mycoplasma gallisepticum*, performance, poultry fat)

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INTRODUCTION

Mycoplasma gallisepticum (MG) is a pathogenic organism that primarily causes problems within the respiratory tract of laying hens (Ley and Yoder, 1978; Branton et al., 1984). However, it has been suggested that infection can also spread from the hen's respiratory tract to the oviduct via the blood, causing reduced egg production (EP) and poor egg quality (Yoder and Hofstad, 1964; Domermuth et al., 1967). Feed consumption, BW, and EP have been reported by Mohammed et al. (1987) to be reduced in MG-infected birds.

During the past several years, vaccination of commercial layers with a live MG vaccine produced from an F-strain (FMG) of low to moderate virulence has become available to protect flocks against natural MG infections (Branton et al., 1997). The vaccine strain displaces natural field strain infections, and FMG has a relatively poor transmissibility (Levisohn and Kleven, 1981; Kleven et al., 1990). Once vaccinated, the birds remain permanent carriers of FMG (Brown et al., 1995). Live vaccines are effective in minimizing EP losses if administered to commercial layers before exposure to more virulent field strains of MG (Luginbuhl et al., 1976). Inoculations with FMG between 8 and 18 wk of age allows a pullet to receive a mild infection and recover before coming into EP (Yoder et al., 1984).

Layers vaccinated with FMG will produce more eggs than unvaccinated hens naturally infected with MG, while MG-clean flocks have been reported to lay more eggs than either FMG-vaccinated or field strain MG-infected hens (Carpenter et al., 1981; Mohammed et al., 1987; Branton et al., 1997, 1999). Commercial layers housed in biological isolation units have been reported to experience a 1 wk delay in onset of lay and a decrease in total EP, after

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Abbreviation Key: EP = egg production; FA = fluorescent antibody; FMG = F-strain of *Mycoplasma gallisepticum*; HI = hemagglutination-inhibition; MG = *Mycoplasma gallisepticum*; MS = *Mycoplasma synoviae*; PF = poultry fat; SPA = serum plate agglutination.

being inoculated with FMG at 12 wk of age (Burnham et al., 2002a). Furthermore, Branton et al. (1999) found that hens inoculated with FMG at 10 wk of age laid 7.97% fewer large eggs than did FMG-clean hens over a 44-wk laying cycle.

The inclusion of supplemental fats in the diets of laying hens frequently results in an increase in egg weights. This effect may occur even without any change in the ME of the diet (Sell et al., 1987). Other studies have also shown that increases in egg weight caused by the supplementation of diets with fat were most pronounced during early EP (Shutze et al., 1962; Marion and Edwards, 1964). Grobas et al. (1999) reported that 4% supplemental fat in layer diets having AME_n contents of either 2,680 or 2,810 kcal/kg increased EP, egg weight, and daily egg mass output during a complete laying cycle. The current study was, therefore, designed to determine if decreases in the early performance of layers as a result of FMG infection may be alleviated by 1.5% supplemental poultry fat (PF).

MATERIALS AND METHODS

Pretreatment Pullet Management

One thousand Hy-Line W-36 pullets were obtained at 1 d of age from a commercial source that was monitored and certified free of MG and *M. synoviae* (MS) (National Poultry Improvement Plan and Auxiliary Provisions, 1995). Chickens were vaccinated at 10 d of age for infectious bursal disease via the drinking water. At 12 d and again at 4 wk of age, chickens were vaccinated for Newcastle disease and infectious bronchitis by the some route. At 5 wk of age, 10 randomly selected pullets were bled from the left *cutanea ulnea* wing vein and tested for antibodies to both MG and MS using both the serum plate agglutination (SPA) and the hemagglutination-inhibition (HI) tests (Yoder, 1975). At the same time, birds were also swabbed from the choanal cleft (Branton et al., 1984), and samples were placed into sterile tubes containing Frey's broth medium (Frey et al., 1968) supplemented with an additional 0.15 mg thallium acetate and 10^6 IU penicillin-G/mL. Tubes were incubated at 37°C for 30 d or until a phenol red indicator reaction occurred in the media. A sample from those that changed color was then inoculated onto Frey's-based (Papageorgiou medium) agar and incubated at 37°C. Colonies with morphology suggestive of *Mycoplasma* species were examined by an agar plate fluorescent antibody (FA) method (Baas and Jasper, 1972) that used direct labeling of colonies stained with anti-FMG polyclonal antibodies produced in rabbits and labeled with fluorescein isothiocyanate (Kleven, 1981). Initially, fluorescein isothiocyanate conjugated antiserum was run against several *Mycoplasma* species to validate the specificity of binding. Simultaneously, this procedure confirmed that binding does not occur with other common *Mycoplasma* species.

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One thousand pullets were initially placed on clean dry litter in a 5.5-m × 6.1-m section of a conventional house resulting in a flock density of 0.034 m^2/bird. A daily artificial lighting schedule followed a 13 h L:11 h D cycle. One 75-W incandescent light bulb was used to illuminate each 8.4 m^2 of floor space, providing an intensity at bird level of 35.5 lx. Light intensity was measured in footcandles by light meter and was then converted to lux. Feed and water were provided for ad libitum consumption. Ingredient percentages and calculated analyses of the basal starter and grower diets used are provided in Table 1. These diets were formulated to meet or exceed NRC (1994) specifications. No medications were administered during the trial.

Pullet Housing in Caged Layer Facility

At 12 wk of age, 120 birds were randomly placed in individual cages in a caged layer facility. Birds were equally divided into two isolated ends of the facility and were watered, fed, and ventilated separately. One end housed uninoculated or control birds (n = 60), and the other end housed FMG-inoculated birds (n = 60). In each end, there were three replicate groups of birds per dietary treatment (initiated at 20 wk), with each replicate containing 10 individually caged birds. Artificial lighting schedules were increased 15 min/d beginning at 18 wk of age until a 16 h 15 min L:7 h 45 min D cycle was achieved. Chickens were maintained on that schedule through the remainder of the experiment. Feed and water were provided for ad libitum consumption. Ingredient percentages and calculated analyses of the basal developer and prelay diets used are provided in Table 1. These diets were formulated to meet or exceed NRC (1994) specifications.

FMG Inoculation

At 12 wk of age, pullets treated with FMG were inoculated via eye drop in the right eye with 0.04 mL of a 24-hr broth culture of high-passage FMG (99th passage above the unknown passage level) provided by S. H. Kleven.[4] Inoculum titer was 2.0×10^6 cfu/mL. Titer was determined by incubating the inoculum on plated agar containing Frey's broth medium for a minimum of 4 d and a maximum of 28 d. Similarly, pullets designated as controls were sham inoculated via eye drop in the right eye with 0.04 mL of sterile Frey's broth media.

Mycoplasma Identification

At 20 wk, one randomly selected hen from each replicate group in each treatment was bled, swabbed, and tested for the presence of *Mycoplasma* species as previously described for pullets at 5 wk of age.

Experimental Diets

Experimental layer diets were made available beginning at 20 wk of age and were continued through wk 26.

TABLE 1. Ingredient percentages and calculated analyses of pullet diets

Age (wk)	Starter (0–6)	Grower (6–12)	Developer (12–18)	Prelay (18–20)
	(%)			
Corn (8.6% CP)	64.51	73.64	72.22	61.35
Soybean meal (48% CP)	30.97	22.09	17.17	19.13
Dicalcium phosphate[1]	2.08	1.99	1.92	1.68
Limestone[2]	1.06	0.95	0.98	4.82
Salt (NaCl)[3]	0.48	0.47	0.47	0.47
Vitamin premix[4,5]	0.25	0.25	0.25	0.25
DL-Methionine[6]	0.15	0.11	0.10	0.13
Poultry fat	0.50	0.50	0.50	0.50
Wheat middlings	0.00	0.00	6.39	11.67
Calculated analysis				
CP	20.50	17.00	15.50	16.34
Calcium	0.88	0.82	0.82	2.25
Available phosphorus	0.43	0.42	0.42	0.38
ME, kcal/kg	3,000	3,101	3,051	2,819
Lysine	1.10	0.85	0.73	0.80
Methionine + cystine	0.81	0.68	0.61	0.65
Sodium	0.20	0.20	0.20	0.20
Potassium	0.81	0.66	0.55	0.56
Crude fat	3.22	3.52	3.68	3.48
Methionine	0.50	0.42	0.38	0.41
Tryptophan	0.28	0.23	0.20	0.22
Xanthophyll	6.45	7.36	7.22	6.14
Crude fiber	2.29	2.24	2.55	2.76

[1]Manufactured by IMC-Agrico Feed Ingredients, Bannockburn, IL.

[2]Manufactured by Franklin Industrial Minerals, Nashville, TN.

[3]Manufactured by Cargill Incorporated, Minneapolis, MN.

[4]Vitamin premix provided per kilogram of diet: vitamin A, 7,710 IU; cholecalciferol, 2,202 IU; vitamin E, 10 IU; menadione, 0.88 mg; vitamin B_{12}, 0.01 mg; choline, 380 mg; riboflavin, 5 mg; niacin, 33 mg; pantothenic acid, 9 mg; thiamine, 1 mg; folic acid, 0.6 mg; biotin, 0.06 mg; pyridoxine, 0.9 mg; ethoxyquin, 0.03 g.

[5]Trace minerals provided in vitamin premix: manganese, 2.2%; zinc, 2.0%; iron, 1.1%; copper, 1,400 ppm; iodine, 200 ppm; and selenium, 40 ppm.

[6]Manufactured by Degussa Corp., Ridgeland Park, NJ.

Both diets were isocaloric and isonitrogenous; however, one diet served as a basal control diet, and the other was the basal diet supplemented with 1.5% PF. Ingredient percentages and calculated analyses of the layer diets at wk 20 and 24 are provided in Table 2. Available protein and lysine percentages in the layer diets were adjusted according to the amount of feed consumed per bird when new feed batches were mixed every 28 d (wk 20 and 24). The diets are formulated to meet or exceed NRC (1994) specifications. Determined analyses of the CP, crude fat, crude fiber, ash, and moisture contents of both diets at wk 20 are also included. Determined percentages of total fatty acids in both diets at wk 20 are provided in Table 3. Four equal samples were randomly taken per batch of mixed feed and were blended prior to analysis. All dietary analyses were performed according to the methods of the Association of Official Analytical Chemists (1980).

Data Collection

Individual BW of hens in each cage were determined at 12, 20, and 24 wk of age. Bird mortalities were recorded daily between 12 and 26 wk. Eggs were collected daily for determination of weekly percentage hen-day EP between 18 and 26 wk. Individual eggs were weighed weekly between 19 and 26 wk of age. Total egg mass produced per hen per day, total feed consumed per hen per day, and feed conversion (g feed/g egg) were determined at 20 and 24 wk of age.

Statistical Analysis

A completely randomized experimental design was utilized. All data were subjected to a repeated measures analysis where effects of inoculation treatment and experimental diet were observed over multiple ages. Individual sample data within each replicate unit were averaged prior to analysis. Least squares means were compared in the event of significant global effects (Steel and Torrie, 1980). All data were analyzed using the mixed procedure of SAS software (1996). Statements of significance for global effects and least squares means comparisons were based on $P \leq 0.05$ unless otherwise stated.

RESULTS

All initial mycoplasmal cultures as well as SPA and HI test results obtained from 5-wk-old pullets were negative for MG and MS. Control serum samples obtained at 20 wk of age were SPA and HI negative for MG, while the same tests were positive for MG in the 12-wk FMG-inoculated hens. Hens were considered FMG-free when they exhibited no detectable HI titers. All FMG-inoculated hens had HI titers ≥ 1:80. Similarly, FA culture results

TABLE 2. Ingredient percentages and calculated analyses of experimental layer diets at wk 20 and 24

	Experimental diets[1]			
	Week 20		Week 24	
Ingredient	1	2	1	2
	(%)			
Corn (8.6% CP)	64.35	58.61	63.00	57.23
Soybean meal (48% CP)	23.29	22.65	24.76	24.16
Dicalcium phosphate[2]	1.81	1.74	1.81	1.74
Limestone[3]	8.58	8.60	8.45	8.47
Salt (NaCl)[4]	0.53	0.53	0.53	0.53
Vitamin premix[5,6]	0.25	0.25	0.25	0.25
Choline (CL-70%)	0.06	0.06	0.06	0.06
DL-Methionine[7]	0.17	0.18	0.17	0.19
Poultry fat	0.50	2.00	0.50	2.00
Wheat middlings (15%)	0.46	5.38	0.47	5.37
Dietary analysis				
CP, calculated	16.50	16.50	17.10	17.11
CP, determined	16.90	16.40	—	—
Calcium, calculated	3.70	3.70	3.65	3.65
Available phosphorus, calculated	0.34	0.34	0.34	0.34
ME, kcal/kg, calculated	2,819	2,819	2,808	2,808
Lysine,[8] calculated	0.85	0.85	0.89	0.89
Methionine + cystine, calculated	0.71	0.71	0.73	0.73
Sodium, calculated	0.21	0.21	0.21	0.21
Potassium, calculated	0.65	0.62	0.68	0.65
Crude fat, calculated	3.12	4.56	3.08	4.52
Crude fat, determined	3.20	5.20	—	—
Methionine, calculated	0.46	0.47	0.47	0.48
Tryptophan, calculated	0.22	0.22	0.23	0.23
Xanthophyll, calculated	6.44	5.86	6.30	5.72
Crude fiber, calculated	2.23	2.44	2.24	2.45
Crude fiber, determined	2.90	3.40	—	—
Ash, determined	14.70	13.40	—	—
Moisture determined	10.20	10.50	—	—

[1]Diets 1 and 2, respectively contained: 1) no supplemental fat; 2) 1.5% supplemental poultry fat.

[2]Manufacturd by IMC-Agrico Feed Ingredients, Bannockburn, IL.

[3]Manufactured by Franklin Industrial Minerals, Nashville, TN.

[4]Manufactured by Cargill Incorporated, Minneapolis, MN.

[5]Vitamin premix provided per kilogram of diet: vitamin A, 7,710 IU; cholecalciferol, 2,202 IU; vitamin E, 10 IU; menadione, 0.88 mg; vitamin B_{12}, 0.01 mg; choline, 380 mg; riboflavin, 5 mg; niacin, 33 mg; pantothenic acid, 9 mg; thiamine, 1 mg; folic acid, 0.6 mg; biotin, 0.06 mg; pyridoxine, 0.9 mg; ethoxyquin, 0.03 g.

[6]Trace minerals provided in vitamin premix: manganese, 2.2%; zinc, 2.0%; iron, 1.1%; copper, 1,400 ppm; iodine, 200 ppm; and selenium, 40 ppm.

[7]Manufactured by Degussa Corp., Ridgeland, Park, NJ.

[8]Dietary lysine was adjusted by the feed consumed per bird at each 28-d interval.

for swabs obtained at 20 wk of age were negative for *Mycoplasma* species growth for 12 out of 12 FMG-free hens tested, while growth was evident for 12 out 12 FMG-inoculated hens tested.

The FMG inoculation at 12 wk had no effect on BW at 12, 20, or 24 wk. Nevertheless, there was a significant ($P \leq 0.05$) age by diet interaction for BW over wk 20 and 24. No differences were observed between diets at wk 20 and 24; however, as expected within each individual diet (control and PF), birds at 24 wk were heavier than those at 20 wk. Mean BW in birds fed the control diet were 1,467 and 1,550 g at 20 and 24 wk, respectively, and in birds fed the PF diet, BW were 1,487 and 1,531 g at 20 and 24 wk, respectively (SEM = 15.4). There was no mortality in any replicate group between wk 12 and 26.

Egg production at 18 and 19 wk of age was affected by age ($P \leq 0.02$) and FMG treatment ($P \leq 0.03$). At 18 and 19 wk, EP was 1.7 and 9.5%, respectively (SEM = 1.89). Infection with FMG reduced EP in this period by approximately 7.0%. In sham- and FMG-inoculated birds, mean EP was 8.9 and 2.2%, respectively (SEM = 1.89). There was a treatment by diet interaction ($P \leq 0.04$) for EP between 20 and 26 wk of age (Table 4). When birds were fed control diets, FMG reduced ($P \leq 0.01$) EP between 20 and 26 wk; however, FMG did not reduce ($P = 0.87$) EP when birds were provided 1.5% added PF in their diets. Adding 1.5% PF to layer diets between 20 and 26 wk caused EP in both sham- and FMG-inoculated birds to be similar but intermediate to that of birds in those same inoculation treatments when fed unsupplemented diets.

At 19 wk of age, there was no effect due to FMG on egg weight. Also, between 20 and 26 wk, there were no effects due to FMG or diet on egg weight. There was an age main effect ($P \leq 0.0001$) in that egg weight increased with hen age. Egg weight at 20, 21, 22, 23, 24, 25, and

TABLE 3. Determined percentages of total fatty acids of laying hen diets at wk 20

Fatty acid type	Diet[1] 1	2
	(%)	
Myristic	0.2	0.4
Palmitic	16.2	19.5
Palmitoleic	2.0	3.8
Stearic	3.3	4.1
Oleic	30.7	32.9
Linoleic	45.2	37.5
Linolenic	1.7	1.5
Others	0.7	0.3
Saturated fatty acids	20.1	24.3
Unsaturated fatty acids	79.9	75.7

[1]Diets 1 and 2, respectively, contained 1) no supplemental fat and 2) 1.5% supplemental poultry fat.

26 wk were 43.2, 45.5, 47.3, 49.4, 51.2, 52.0, and 53.0 g, respectively (SEM = 0.44). Significant increases occurred between all ages except between 24 and 25 and 25 and 26 wk. Total daily egg mass produced (g/hen per day) at 20 and 24 wk was also only affected ($P \leq 0.0001$) by hen age. Total daily egg mass at 20 and 24 wk was 44.2 and 52.4 g, respectively (SEM = 0.83).

There was a treatment by diet interaction ($P \leq 0.05$) for feed consumption (g/hen per day) over 20 and 24 wk (Table 5). In sham-inoculated birds, less ($P \leq 0.02$) feed was consumed when birds were fed PF-supplemented diets rather than control diets. Also, in FMG-treated birds, there was no difference ($P = 0.73$) in the amount of feed consumed when birds were fed either control of PF diets. There were no effects due to bird age, inoculation treatment, or diet on feed conversion at 20 and 24 wk of age.

DISCUSSION

In previous research, supplemental fat at the 4% level in layer diets containing either 2,680 or 2,810 kcal/kg AME_n between 22 and 65 wk resulted in an increase in EP between 38 and 61 wk and an increase in egg weight between 22 and 57 wk. Changing the linolenic acid content of the diets approximately 1.15% did not have any additional influence (Grobas et al., 1999). Sell et al. (1979), on the other hand, found no effect of 2, 3, 4, or 6% added levels of fat (yellow grease) provided in layer diets between 37 and 65 wk on EP or egg weight during that same period, despite an improvement in feed efficiency. Scragg et al. (1987) also noted that increases in the intake of readily absorbable oil without increases in linoleic acid concentration did not affect EP, egg weight, feed consumption, or feed efficiency in Babcock B380 layers between 22 and 69 wk of age.

TABLE 4. Egg production between 20 and 26 wk in sham- and F-strain *Mycoplasma gallisepticum* (FMG)-inoculated hens fed control and 1.5% poultry fat (PF)-supplemented diets[1]

Diet			
Control		PF	
Sham	FMG	Sham	FMG
(% hen-day)			
84.7[a]	70.1[b]	77.0[ab]	76.4[ab]

[a,b]Means among diets and inoculation treatments with no common superscript differ significantly ($P \leq 0.05$).

[1]SEM based on pooled estimate of variance = 2.45.

In the current study, 1.5% added PF between 20 and 26 wk also had no significant effects on egg weight, daily egg mass output, or feed conversion. The diet with added 1.5% PF did not vary in energy content but contained 0.02 and 0.5% higher levels of linolenic and linoleic acids, respectively, compared to the control diet. Nevertheless, linoleic acid levels in the control and 1.5% PF diets were 1.45 and 1.95%, respectively. Kivimae et al. (1970) reported that there was little difference in the egg weights of birds fed diets containing between 1.13 and 1.58% linoleic acid during a 52-wk experimental period. Balnave and Weatherup (1974) further suggested that apart from a possible beneficial effect during the first few weeks of EP, which may be associated with ovarian development, increasing linoleic acid in diets that already contain sufficient levels to satisfy the bird's requirements, as does the control diet in this study, produces negligible effects on egg weight.

Pullets are generally vaccinated with FMG between 8 and 18 wk of age (Yoder et al., 1984) and remain infected for life (Brown et al., 1995). At 20 wk, the SPA tests from swabs and sera, the HI sera tests, and the FA tests verified systemic infections in FMG-inoculated birds. Conversely, sham-inoculated birds remained FMG-free, which indicates that there was no cross-contamination between FMG-inoculated and FMG-clean birds. The results of this study, showing the depressing effect of an FMG inoculation at 12 wk of age on EP in layers between 18 and 26 wk, confirm earlier results by Burnham et al. (2002a). Burnham et al. (2002a) reported that inoculation of pullets in isolation units at 12 wk of age delayed onset of lay approximately 1 wk. Upon completion of the entire laying period in that trial, the FMG-inoculated hens also laid significantly fewer total eggs.

Through early vaccination of pullets, FMG can eliminate, through displacement, later infections from other more virulent field strains of MG (Levisohn and Kleven, 1981; Kleven et al., 1990). It has been reported (Carpenter et al., 1981; Mohammed et al., 1987; Branton et al., 1997, 1999) that although layers vaccinated with FMG will produce more eggs than unvaccinated hens naturally infected with MG, FMG-vaccinated hens lay fewer eggs than MG-clean flocks. It would, therefore, be advantageous to alleviate reductions in EP, as a result of FMG vaccination, while benefiting from the exclusion of the field strains of MG.

Commercial layers vaccinated with FMG at 12 wk of age have exhibited decreased percentage total yolk lipid and yolk cholesterol contents in their eggs at wk 22 and 28, respectively (Burnham et al., 2003). In an independent report of birds from those same trials, Burnham et al. (2002b) also reported that FMG-inoculation at 12 wk re-

TABLE 5. Feed consumption over 20 and 24 wk in sham- and F-strain *Mycoplasma gallisepticum* (FMG)-inoculated hens fed control and 1.5% poultry fat (PF)-supplemented diets[1]

Treatment			
Sham		FMG	
Control	PF	Control	PF
(g/hen per day)			
90.3[a]	83.4[b]	84.9[ab]	85.7[ab]

[a,b]Means among inoculation treatments and diets with no common superscript differ significantly ($P \leq 0.05$).

[1]SEM based on pooled estimate of variance = 1.81.

sulted in higher incidences of fatty liver hemorrhagic syndrome and ovarian follicular regression. F-strain MG may, therefore, alter the reproductive performance of layers through its effects on lipid metabolism in the liver and the subsequent deposition of lipids in the ovary. It would be probable that birds, having been compromised metabolically through FMG infection, may benefit from supplemental fat. Although the 1.5% added PF did not improve EP in uninfected birds, as noted in other studies, it did alleviate depressions in EP that would have occurred in infected birds not provided additional PF. The added PF may have reversed some of the effects that FMG has been previously observed to have on the liver and ovary.

The diet by inoculation treatment interaction observed for feed consumption in this study also implicates an involvement of the digestive system in the influence that 1.5% PF had on EP in FMG-vaccinated birds. Although Burnham et al. (2002b) found no changes in the weights, lengths, or gross histologies of intestinal segments in birds vaccinated with FMG at 12 wk of age, MG has previously been isolated from the choanal cleft or palatine fissure (Branton et al., 1984) and cloaca (Amin and Jordan, 1979; MacOwan et al., 1983) of infected birds. The addition of 1.5% PF significantly reduced feed consumption in sham-inoculated birds, but when birds were previously inoculated with FMG, added PF did not reduce feed consumption. These results suggest that FMG infection may have inhibited utilization of the added dietary PF by reducing its absorption in the gut. However, although both EP and feed consumption were highest in sham-inoculated birds fed unsupplemented diets, there were no consistent associations between the effects of added dietary PF and FMG inoculation on EP and feed consumption. This further suggests that the means by which supplemental PF and FMG interact to influence EP is not solely attributable to changes in feed consumption. In conclusion, 1.5% added PF in the diets of young commercial layers may help to alleviate the depressing effects that a 12-wk inoculation of FMG has on EP. The effects that FMG exerts on the feed consumption of these birds is also modified by 1.5% added dietary PF, but because modifications on EP and feed consumption by PF and FMG had no consistent association, the effects observed on EP cannot be entirely ascribed to changes in feed consumption.

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