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Research Article
The Influence of a Quillaja and Yucca Combination on Growth Performance and Lesion Scores of Broilers Administered Chemical Anticoccidials or a Live Coccidiosis Vaccine

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Abstract

Background and Objective: In the USA, consumer demand has led to the reduction in use of all antibiotics, including ionophores. The broiler industry, in turn, has relied upon coccidiosis vaccines and chemicals as the means of reducing the effects of coccidial infection. Because these products are limited by incomplete anticoccidial activity and/or inconsistent performance results, they are frequently supported by phytochemical products to improve their efficacy. The objective of the current study was to determine the effects of a quillaja and yucca saponin combination (QY) on lesion scores, performance and mortality when broilers were fed 3 chemical programs or a coccidiosis vaccine in a disease challenged, floor pen environment. **Materials and Methods:** Using randomized complete block designs, 2 identical trials were conducted involving a total of 9,900 Ross 708 broilers. A non-medicated control, 3 commonly-used chemical programs (nicarbazin, nicarbazin: decoquinate and zoalene) and a coccidiosis vaccine were evaluated; these treatments were fed in the absence and presence of QY. Growth performance, coccidial lesion scores and total mortality were primary variables evaluated. Treatments were replicated 10 times in each test and all data were combined prior to statistical analysis. **Results:** During the first 28 days of testing, addition of QY improved growth performance, lesion scores and mortality of each anticoccidial program. In addition, pooled results across all treatments demonstrated that QY significantly improved final growth measurements and mortality. **Conclusion:** In the face of an intestinal disease challenge, QY improved coccidial lesion scores and mortality of 3 chemical programs and a coccidiosis vaccine. This reduction in coccidial exposure contributed to improved growth responses compared to all non-QY treatments.

Key words: Quillaja and yucca combination, coccidiosis, *Eimeria*, lesion scores, zootechnical performance

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Coccidiosis remains one of the most significant diseases affecting poultry production globally. It is well-recognized that infection with *Eimeria* parasites occurs in every location where chickens are raised and these infections influence growth, feed efficiency, mortality and the susceptibility to other diseases. As a result, the economic impact of coccidiosis is likely greater than any other disease affecting poultry production, with a recent global estimate of costs in the range of 15 billion USD annually[1]. This fact underscores the requirement for effective methods of coccidiosis control in order to minimize these adverse effects.

In the United States, poultry veterinarians consider coccidiosis the disease of greatest importance in broiler and layer production and often express concerns related to the lack of products needed to control the disease[2]. This scenario has been worsened in recent years by marketing programs that restrict the use of antibiotic-based health programs. Thus, in order to comply with consumer demands for antibiotic-free poultry products, use of the polyether ionophorous antibiotics and their combinations with nicarbazin has ceased in antibiotic-free production. Recent reports[2,3] indicate that the reductions in ionophore usage brought about by these marketing initiatives have elevated the levels of coccidial infection normally observed and have led to a greater incidence of bacterial complications such as necrotic enteritis.

In the absence of ionophore-based prevention programs, the American industry has relied upon older, chemically synthesized anticoccidials (referred to as "chemicals") and live coccidiosis vaccines as the means of controlling *Eimeria* infections[1,2]. Inherent in these changes, however, are concerns related to product efficacy, zootechnical performance and consistency of the anticoccidial response. To assuage these concerns, broiler producers have turned to phytonutritional (eubiotic) feed additives which may provide benefits in the control of *Eimeria*, reduce bacterial sequalae or exert undefined effects in the intestinal milieu.

Saponins are plant-derived compounds known to exert numerous biological activities[4]. Investigation of these biological effects in animals has shown that saponins can reduce pathogen loads, influence nutrient uptake, reduce ammonia production and affect the growth process[4,5]. Although the original proposal for evaluating the effects of saponins on coccidial infections was made more than 20 years ago[5], recent research has shown that combinations of saponins derived from *Quillaja saponaria* (the Chilean soapbark tree) and *Yucca schidigera* (a desert plant of the American southwest) diminished the adverse effects of *Eimeria* infections in broilers[6]. Because this saponin combination has become a frequently used feed supplement that assists in the maintenance of intestinal health in commercial broilers, evaluating its effects in typical American antibiotic-free anticoccidial programs was needed. Thus, the objectives of the current work were to evaluate the effects of the quillaja and yucca saponin combination (QY) when fed concurrently with 3 chemical anticoccidial programs that are often used in American production. In addition, the combined effects of QY with a live, partially attenuated coccidiosis vaccine were also tested.

MATERIALS AND METHODS

The experiments carried out in this trial series were conducted at AHPharma, Inc., Hebron, Maryland, USA. All birds used in these tests were reared under the animal welfare guidelines specified by the Animal Care and Use Committee of AHPharma, Inc. Birds were humanely euthanized by cervical dislocation using procedures approved by the committee noted above.

The quillaja and yucca-based product tested in this series of trials was sourced from *Quillaja saponaria* trees and *Yucca schidigera* plants. This combination is a commercially prepared product (Magni-Phi®, Phibro Animal Health Corp., Teaneck, New Jersey, USA) that consists of 100% ground plant material that is formulated in a proprietary ratio where quillaja is the major component. No excipients, carriers or extracted materials are used in the product. Thus, unaltered quillaja saponins supplemented with the saponins naturally contained in yucca comprise the active ingredients of the product. Additional product information has been presented previously[6].

The anticoccidial products and the coccidiosis vaccine evaluated in these tests are commonly-used methods for the control of coccidiosis in the USA. The products nicarbazin, (Phibro Animal Health Corporation, Teaneck, NJ, USA), decoquinate and zoalene (Zoetis Animal Health, Durham, NC, USA) were acquired commercially and administered at approved dosage levels in feed. In the case of the live coccidiosis vaccine (VAC), Coccivac B52 (Merck Animal Health, Madison, NJ, USA) was applied by spray at the hatchery according to the instructions outlined by the manufacturer. Following vaccine application, adequate time was allowed for the consumption of vaccinal oocysts to ensure optimal results.

Two floor pen trials of identical design were conducted. In addition to a non-medicated control, 4 additional anticoccidial programs were tested: nicarbazin (NIC:NIC, 125 ppm in starter feed, 100 ppm in grower feed); nicarbazin:

decoquinate (NIC:DEC, 125 ppm NIC in starter, 30 ppm DEC in grower); zoalene (ZOL, 125 ppm in starter and grower feeds) and a live coccidiosis vaccine (VAC, Coccivac B52). In addition, each of these 4 programs was evaluated in the presence of QY (250 ppm), administered in feed from placement until trial termination. In both tests, completely randomized block designs were employed utilizing 10 blocks in each trial. Fifty-five Ross 708 broilers were assigned to each pen at day-of-hatch and grown until day 42. Together, the trials involved 9,900 broilers.

Diets used in the tests were standard corn-soy based commercial rations formulated to meet or exceed the nutrient requirements of growing broilers[7]. Specific dietary ingredients and proximate analyses of these feeds have been reported previously[8]. Consistent with many feeding regimes used in the USA, a feeding plan involving starter, grower and finisher feeds was employed in which starter was fed to day 14, grower until day 28 and finisher rations from day 29-42. Since many commercial programs in the USA limit the use of anticoccidial products to starter and grower feeds, a similar approach was used in the current study. That is, finisher feeds used in these tests did not contain anticoccidial products. However, the experimental design shown above illustrates that QY (250 ppm) was fed for the duration of the tests. No antibiotics of any type were administered during these tests and management procedures used in both trials were consistent with methods used in commercial US broiler production.

As is typical in US commercial production, all birds in these trials were reared on used, built-up litter. Since the litter conditions used in each trial were designed to induce an enteric disease challenge, each pen was also supplemented with litter that was collected from commercial broiler farms in the Delmarva region of the United States. The farms were known to have had consistent production difficulties with coccidiosis; further analysis of this litter indicated that the spores of *Clostridium perfringens* were present as well. Prior to the start of each trial, 5 kg of this litter were mixed into the existing litter in each pen in the test facility. In addition, the sporulated oocysts of *E. acervulina* and *E. maxima* (1×10^5 and 3.5×10^4 per bird, respectively) were added to the litter contained in each pen. The pathogenic nature of this challenge was confirmed through scoring of coccidial and clostridial lesions at several points in each trial. As an indicator of the severity of the intestinal challenge, the mean mortality of the control treatment was approximately 2 times greater than American industry standards.

Body weight gain and feed conversion values were determined at both 28 and 42 days of testing, such that the timing of the interim measurements was coincident with changes from anticoccidial medication (at day 28). As a result, final results are presented in terms of the anticoccidial method applied in starter and grower (each chemical program or vaccine) and whether QY was administered as part of the feeding program. Bird mortality was evaluated daily but is expressed as percent mortality from all causes recorded from day 0-28 and percent total mortality recorded throughout the entire test period (day 0-42). Coccidial lesion scores were evaluated in 4 birds per pen on days 21 and 28 using the procedures described by Johnson and Reid[9]. Lesions produced by *E. tenella* were recorded at both time points in these trials, however, the scores recorded were quite mild. Since all scores were 0.5 or less and showed no differences between treatments, *E. tenella* lesion scores were not included.

Statistics: The statistical analyses were conducted on data from 2 trials collected during the winter of 2020. Since experimental treatments, animals, pens, facilities, rations and study methods in both tests were the same, trial results were combined. Consequently, each treatment mean presented represents results of 20 replicates (10 replications per treatment per trial). In addition, a combined analysis comparing the means of control pens to those receiving QY and those fed in the absence of QY is presented in Table 4. In this evaluation, the means of 20 control pens were compared to the means of 80 replications utilized in both QY-fed and non-fed treatments. Differences in group means of combined QY-fed and non-fed treatments were tested with one-way ANOVA; statistical differences between individual treatments were determined by Tukey's HSD to account for multiple testing. In all cases, the threshold of $p<0.05$ was used to determine whether outcomes were statistically different. All statistical analyses were conducted using the R statistical software[10].

RESULTS

The lesion scores recorded for non-medicated controls at 21 and 28 days indicate that a meaningful intestinal coccidiosis challenge was produced in these tests (Table 1). In addition, the majority of the mortality occurred during the first 28 days (Table 2 and 3), indicating that the pathogenic effects of the challenge were greatest in younger birds. Compared to controls, all chemical anticoccidials and the VAC reduced duodenal and ileal lesion scores at day 21 and day 28 (Table 1). At these same intervals, the lesion scores of the VAC program were significantly greater than those of the chemical anticoccidials. At day 21, *E. acervulina* lesions for the NIC:NIC

Table 1: Duodenal (*Eimeria acervulina*) and ileal (*E. maxima*) lesion scores recorded at days 21and 28 for anticoccidial programs fed in the absence and presence of quillaja and yucca (QY)

	Duodenal lesion scores		Ileal lesion scores	
Treatments[1,2]	Day 21	Day 28	Day 21	Day 28
Non medicated controls	2.65^{a}	2.31^{a}	2.66^{a}	2.34^{a}
NIC:NIC	1.04^{de}	1.09^{cd}	1.10^{cde}	1.12^{c}
NIC:DEC	1.23^{cd}	1.29^{c}	1.20^{cd}	1.26^{c}
ZOL	1.39^{c}	1.38^{c}	1.38^{c}	1.34^{c}
VAC	1.80^{b}	1.76^{b}	1.85^{b}	1.96^{b}
NIC:NIC+QY	0.59^{f}	0.59^{e}	0.74^{f}	0.62^{d}
NIC:DEC+QY	0.60^{f}	0.60^{e}	0.60^{f}	0.60^{d}
ZOL+QY	0.73^{ef}	0.76^{de}	0.76^{ef}	0.64^{d}
VAC+QY	1.00^{de}	0.59^{e}	0.94^{def}	0.64^{d}
PSEM[3]	0.053	0.048	0.052	0.050

[1]Data are the means of 2 trials in which each treatment was replicated 10 times per trial. [2]Anticoccidial treatments were administered in starter and grower feeds only. Programs differing in product or dosage from starter to grower are separated by a colon. NIC: Nicarbazin, DEC: Decoquinate, ZOL: zoalene, VAC: Live coccidiosis vaccine, QY: Quillaja and yucca. Doses used were; Nicarbazin starter: 125 ppm, Grower: 100 ppm, Decoquinate: 30 ppm, Zoalene: 125 ppm, QY: 250 ppm. See Materials and Methods for details. [3]Pooled standard error of the mean. [a-f]Means were separated by Tukey's HSD where significance was determined at p<0.05. Within columns, means not sharing a common letter are statistically different

Table 2: Twenty-eight day growth performance and total mortality of anticoccidial programs fed in the absence and presence of quillaja and yucca (QY).

Treatments[1,2]	Weight gain (g)	FCR (g:g)	Percent mortality
Non medicated controls	1291^{c}	1.462^{a}	5.19^{a}
NIC:NIC	1387^{b}	1.396^{bcd}	2.12^{cd}
NIC:DEC	1370^{b}	1.410^{bc}	1.73^{cd}
ZOL	1368^{b}	1.423^{ab}	2.79^{bc}
VAC	1320^{c}	1.433^{ab}	3.75^{ab}
NIC:NIC+QY	1431^{a}	1.355^{e}	0.77^{d}
NIC:DEC+QY	1427^{a}	1.355^{e}	0.96^{d}
ZOL+QY	1400^{ab}	1.366^{de}	1.35^{cd}
VAC+QY	1389^{b}	1.375^{ab}	1.15^{d}
PSEM[3]	4.072	0.004	0.152

[1]Data are the means of 2 trials in which each treatment was replicated 10 times per trial. [2]Anticoccidial treatments were administered in starter and grower feeds only. Programs differing in product or dosage from starter to grower are separated by a colon. NIC: nicarbazin, DEC: Decoquinate, ZOL: Zoalene, VAC: Live coccidiosis vaccine, QY: Quillaja and yucca. Doses used were; Nicarbazin starter: 125 ppm, Grower: 100 ppm, Decoquinate: 30 ppm, Zoalene: 125 ppm, QY: 250 ppm. See Materials and Methods for details. [3]Pooled standard error of the mean. [a-e]Means were separated by Tukey's HSD where significance was determined at p<0.05. Within columns, means not sharing a common letter are statistically different.

program were significantly lower than those for ZOL. Other significant differences among the 3 chemical programs in duodenal or ileal lesions were not observed (p>0.05). When QY was added to each of the programs described above, significant reductions in duodenal and ileal lesion scores occurred at each time point. Across all treatments at each time point, QY reduced both *E. acervulina* and *E. maxima* lesion scores by approximately 50%.

Table 3: Growth performance and total mortality (day 42) of anticoccidial programs fed in the absence and presence of quillaja and yucca (QY)

Treatment[1,2]	Weight gain (g)	FCR (g:g)	Percent mortality
Non medicated controls	2398^{c}	1.852^{a}	5.96^{a}
NIC:NIC	2546^{ab}	1.768^{cd}	2.31^{cd}
NIC:DEC	2519^{abc}	1.784^{bcd}	2.31^{cd}
ZOL	2505^{abc}	1.794^{bc}	3.37^{bc}
VAC	2443^{bc}	1.825^{ab}	4.52^{ab}
NIC:NIC+QY	2626^{a}	1.730^{d}	0.77^{d}
NIC:DEC+QY	2623^{a}	1.746^{cd}	1.35^{d}
ZOL+QY	2564^{ab}	1.756^{cd}	1.44^{d}
VAC+QY	2563^{ab}	1.775^{bcd}	1.54^{cd}
PSEM[3]	6.746	0.005	0.179

[1]Data are the means of 2 trials in which each treatment was replicated 10 times per trial. [2]Anticoccidial treatments were administered in starter and grower feeds only. Programs differing in product or dosage from starter to grower are separated by a colon. NIC: Nicarbazin, DEC: Decoquinate, ZOL: Zoalene, VAC: Live coccidiosis vaccine, QY: Quillaja and yucca. Doses used were; Nicarbazin starter: 125 ppm, Grower: 100 ppm, Decoquinate: 30 ppm, Zoalene: 125 ppm, QY: 250 ppm. See Materials and Methods for details. [3]Pooled standard error of the mean. [a-d]Means were separated by Tukey's HSD where significance was determined at p<0.05. Within columns, means not sharing a common letter are statistically different.

Twenty-eight-day weight gain, feed conversion and mortality data are presented in Table 2. Although chemical programs significantly improved weight gains compared to the non-medicated control, body weight improvements by the VAC were not different from the controls (p>0.05). Likewise, the weight gain response produced by each chemical program was significantly greater than the response produced by the VAC. Significant differences among the chemical programs were not evident in weight gain at 28 day. Compared to the non-medicated control, NIC-based programs significantly improved FCR values at day 28. Differences of this nature were not observed for the ZOL and VAC programs.

Additions of QY significantly improved the 28 day weight gain responses of the coccidial vaccinates and both NIC-based programs (Table 2). While QY improved body weights of ZOL, this effect was not significantly different from ZOL alone. When compared to their non QY-fed counterparts, QY also improved the FCR values for all chemical programs. However, a similar effect was not observed with VAC.

Mortality was significantly reduced by all medicated programs; however, differences of this nature were not observed with vaccination. Differences among the chemical programs were not significant but all were statistically different from the VAC, which showed no differences compared to control. All QY treatments demonstrated reduced mortality at 28 day versus controls but significant QY effects were observed only for birds vaccinated for coccidiosis.

Since medicated feeds were administered up to day 28 in these tests, differences in 42 day growth performance (Table 3) are largely dependent upon the anticoccidial effects

Table 4: Comparative final weight gain, feed conversion and total mortality of control and anticoccidial treatments when arranged and analyzed by QY administration

Treatments[1]	Weight gain (g)	FCR (g:g)	Total mortality (%)
Non medicated controls	2398[a]	1.854[a]	5.96[a]
Non QY treatments	2503[b]	1.793[b]	3.13[b]
QY treatments	2594[c]	1.751[c]	1.28[c]
Mean difference: QY vs. non QY	91*	-0.042*	-1.85*
Standard error of the difference	9.049	0.008	0.293

[1]Data represent the means of two identical trials averaged across the anticoccidial programs administered and arranged according to QY feeding: controls, all treatments without QY and all treatments containing QY. Data presented are the means of 20, 80 and 80 replications, respectively. [a-c]Means were separated using Tukey's HSD where significance was established at $p<0.05$. Within columns, means not sharing a common letter are statistically different. *Mean differences between combined QY and non QY treatments were significant ($p = 0.01$)

produced by the starter: grower programs and whether QY was included in the feeding program. Thus, of the starter and grower anticoccidial programs fed in the absence of QY, only the NIC:NIC program showed significant improvements versus controls in weight gain at trial termination. Final FCR values were improved by all chemical programs applied in starter and grower but birds vaccinated for coccidiosis showed no differences from non-medicated controls. All QY-fed treatments displayed significantly improved final weight gain and FCR compared to controls but comparisons between each program based on QY feeding showed only numerical improvements in final weight and FCR values ($p>0.05$). The responses produced in 42 day mortality were similar to the trends shown at day 28. That is, mortality was significantly reduced by all medicated treatments but not by vaccination; QY further reduced mortality of all treatments, with significantly lower mortality occurring when QY was combined with VAC ($p<0.05$).

Table 4 presents weight gain, feed conversion and mortality data for all treatments when results were pooled according to QY feeding. These data demonstrate that compared to controls, zootechnical results and mortality improved for all anticoccidial programs fed in the absence of QY. Further significant improvements in theses variables were shown for the treatments administered QY ($p<0.05$). Likewise, the differences between the means of QY-fed versus non-fed treatments were significant ($p = 0.01$).

DISCUSSION

In the United States, changes in antibiotic usage have occurred primarily at the demand of the consumer, a fact which is different from the bans of antibiotics that have occurred in other parts of the world. However, in the USA, limitations of antibiotic usage also include the polyether ionophorous antibiotics and likewise, their combinations with nicarbazin, products that have served as the backbone of coccidiosis control wherever broiler chickens are produced. The industry in turn, has had to rely upon the use of chemical anticoccidials and live coccidiosis vaccines as the means of controlling *Eimeria* infections. As discussed by Cervantes[11], the shortcomings associated with these products are evident, because their use may lead to erratic control of intestinal pathogens and increase the incidence of both coccidiosis and necrotic enteritis. As unintended consequences of these changes, bird welfare is often compromised and sustainability is questioned[3,11].

The studies presented herein were conducted to investigate the overall responses of common methods of coccidiosis control used in American antibiotic-free production (often called "no antibiotics ever") and to determine the effects of QY use in these programs. The challenge levels used in these trials represent typical growing conditions in the US in which litter is rarely changed. As a result, intestinal disease challenge occurs early in the growth cycle and influences growth and feed conversion from placement onward. The lesion scores recorded in this environment were moderately severe and are typical for many locations where US production occurs. As an indicator of the severity of this challenge, mortality exceeded American industry averages.

In this environment, NIC:NIC showed the greatest reduction in intestinal lesions and as feeding of NIC decreased from starter and grower (NIC:NIC) to starter only(NIC:DEC) to none (ZOL), there was a tendency for intestinal lesions to increase. This fact correlates well with growth performance, which followed similar trends at day 28 and 42. Nicarbazin responses of this nature have been reported previously and coupled with its low potential for resistance development[12], remains an extremely valuable product, especially in the absence of ionophore medication. While ZOL has been used successfully in many programs in recent years, resistance development among field coccidia remains a threat to long-term usage[13]. Data contained here indicate that when effective, performance responses of ZOL are competitive but still deficient to those of NIC.

It is well-recognized that the coccidial cycling induced by live coccidial vaccination impairs intestinal integrity resulting in diminished nutrient uptake and compromised growth performance[14-16]. Data presented here reflect these responses and suggest the elevated challenge levels used in these tests further affected these results. While lesion scores of coccidial vaccinates were reduced compared to controls, they were

significantly greater than each of the chemical programs. Moreover, 28 day weight gain of vaccinated broilers did not improve compared to controls and differed significantly from each of the chemical programs.

QY was shown in these trials to reduce intestinal lesion scores for all chemical programs and the coccidiosis vaccine and in each instance reductions of approximately 50% were recorded. These data are in accord with previously published studies[6] describing the anticoccidial effects of this saponin combination. In addition to lower lesion scores, previous work has shown significant reductions in faecal oocyst counts when the product was fed either in combination with ionophores[6] or when used concurrently with live coccidiosis vaccines[6,17]. The results presented here expand these observations to include the chemical products utilized in these tests and indicate that the effectiveness of QY on *Eimeria* is likely independent of the anticoccidial method with which it is combined.

Saponins have been shown to affect the viability of several protozoan parasites[4] and it is likely that this activity is associated with destabilization and perforation of the parasitic cell membrane[18]. As an example, studies on *Trichomonas vaginalis* showed that pore formation occurred prior to membrane rupture and death of the parasite[19]. It is thought that other protozoan parasites respond similarly[4]. Assuming responses of this type occur with *Eimeria*, this activity may occur concurrently with enhancements of the immune response. Since quillaja saponins are widely used as adjuvants and are known to facilitate antigenic recognition[20] and yucca saponins are known to modify cytokine production[21], QY is likely involved in several aspects of the immune response. These stimulatory effects are correlated with reductions in oocyst production and in the maintenance of intestinal integrity that is typically lost during coccidiosis. Thus, QY may affect *Eimeria* directly and simultaneously influence the development of the protective immune response to *Eimeria*. Further research on these topics is already underway.

The final zootechnical results produced in these trials demonstrated that improvements of 2-5% occurred with feeding of QY. While similar improvements were recorded during periods of highest challenge (starter and grower feeds, Table 2), direct comparisons of each program with and without QY feeding show that final weight gain (day 42) was improved by 80, 104, 59 and 120 g in the respective anticoccidial programs. Likewise, final feed conversions were improved by at least 0.03 points in each program. These results are comparable to those presented in a meta-analysis of performance responses produced when QY was fed in combination with different coccidial vaccines[17]. They are further illustrated by the combined performance analysis presented in Table 4.

While the effects of QY on *Eimeria* are evident in these trials, previous studies have shown that the saponins contained in QY produce additional effects in the intestinal tract. Among these are improvements in villus height and a reduction in crypt depth[22], measurements that have been associated with improved villus function and better intestinal health[23]. Moreover, in unchallenged, disease-free broilers, nutrient digestibility was enhanced by QY feeding[22]. These reports indicate that proteins, fats and minerals were more readily digested in broilers fed QY and explain, in part, the improvements in growth and feed conversion normally reported during QY usage. They also indicate that the effects of QY on nutrient digestibility are not dependent upon the reduction of *Eimeria* or other pathogens in the intestine. While the specifics of these observations are currently being examined in greater detail, it is clear that QY exerts multiple effects in the digestive tract that are beneficial to growing broiler chickens. In a world where reliance on antibiotic medication is decreasing, these findings should be of significance to all broiler producers.

CONCLUSION

A disease challenged floor pen model was used to evaluate the effects of typical anticoccidial programs used in American antibiotic-free (no antibiotics ever) production. Use of chemically synthesized anticoccidials reduced coccidial lesions scores and improved zootechnical performance compared to controls. However, a partially attenuated live coccidiosis vaccine was not as effective in reducing lesions or improving growth performance as these chemicals. Additions of a QY saponin combination significantly reduced coccidial lesion scores and provided improvements in body weight, feed conversion and mortality for each program tested. These responses illustrate the importance of QY in antibiotic-free production systems.

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