SHORT COMMUNICATION

Oleoresins from chili pepper and turmeric could substitute for salinomycin in broilers

Oleoresinas de pimiento y cúrcuma podrian reemplazar la salinomicina en pollos de engorde

Oleoresinas de pimenta chilli e cúrcuma podem substituir a salinomicina em frangos de corte

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Abstract

Background: Coccidiosis is the infectious disease with the greatest economic impact in poultry production. Additionally, chemotherapeutic growth promoters are being substituted for safer alternative strategies. **Objective:** To evaluate the effect of feeding oleoresins from chili pepper (*Capsicum annuum*) and turmeric (*Curcuma longa* L.) on the performance, survival rate, and the Productive Efficiency Index of broilers from 1 to 21d challenged by *Eimeria* sp. **Methods:** A total of 700 male 1-day-old chicks (Cobb 500) challenged with *Eimeria* sp, were assigned to a completely randomized design with four treatments: (1) negative control diet, without anticoccidial agent or growth promoters; (2) control diet+0.05% salinomycin; (3) negative control diet+100g/ton; and (4) negative control diet +140g/ton of test product (*Curcuma longa* L. plus *Capsicum annuum* oleoresins). **Results:** Body weight, weight gain, feed conversion and Productive Efficiency Index did not differ between broilers fed anticoccidial chemotherapeutics and oleoresins. In addition, there was no difference in feed intake and survival rate between dietary treatments. **Conclusion:** Broilers supplemented with chili pepper and turmeric oleoresins from 1 to 21d present similar body weight, weight gain, feed conversion, and Productive Efficiency Index compared to broilers supplemented with chemotherapeutic anticoccidials without affecting feed intake or survival rate.

Keywords: *antibiotic alternatives; antibiotics replacement; bacterial resistance; broiler; chili pepper; coccidiosis challenge; oleoresins; performance; phytogenic supplements; protozoa resistance; poultry production; turmeric.*

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Resumen

Antecedentes: El impacto económico generado por la coccidiosis en el sector avícola es el mayor en relación con otras enfermedades. Adicionalmente, los promotores de crecimiento quimioterapéuticos se han venido reemplazando por estrategias alternativas. **Objetivo:** Evaluar el efecto de oleorresinas de pimiento (*Capsicum annuum*) y cúrcuma (*Curcuma longa* L.) sobre el desempeño zootécnico, tasa de supervivencia y el Índice de Eficiencia Productiva en pollos de engorde de 1 a 21 dias desafiados con *Eimeria* sp. **Métodos:** Se utilizaron 700 pollos machos (Cobb500) de 1 día de edad, distribuidos en un diseño completamente al azar con cuatro tratamientos: (1) dieta control negativo sin agentes anticoccidianos ni promotores de crecimiento; (2) dieta control+0,05% de salinomicina; (3) dieta control negativa+100g/ton; y (4) dieta control negativa +140g/ton del producto a evaluar (oleorresina de *Curcuma longa* L. y *Capsicum annuum*). **Resultados:** Se obtuvieron resultados similares repecto a peso corporal, ganancia de peso, conversión alimenticia e Índice de Eficiencia Productiva en los tratamientos que contenían anticoccidiano quimioterapéutico y los que contenian oleorresinas. Además, no se observaron diferencias en el consumo de alimento ni en la tasa de supervivencia entre los tratamientos dietarios. **Conclusión:** Los pollos de engorde suplementados entre 1 y 21 d con oleorresinas de pimiento y cúrcuma presentan similar peso corporal, ganancia de peso, conversión alimenticia e Índice de Eficiencia Productiva en comparación con los suplementados con anticoccidianos quimioterapéuticos, sin afectar el consumo de alimento ni la viabilidad.

Palabras clave: *alternativas a los antibioticos; azafrán; desafío con coccidiosis; desempeño; pollos de engorde; oleorresinas; pimiento; producción de aves; reemplazo de antibióticos; resistencia bacteriana; resistência a protozoários; suplementos fitogénicos*.

Resumo

Antecedentes: O impacto econômico da coccidiose é o maior quando comparado a outras doenças na produção avícola. Além disso, promotores de crescimento quimioterápicos tem sido substituídos por estratégias alternativas. **Objetivo:** Avaliar o efeito das oleoresinas da pimenta Chilli (*Capsicum annuum*) e açafrão-da-terra (*Curcuma longa* L.) no desempenho zootécnico, taxa de sobrevivência e Índice de Eficiência Produtiva de frangos de corte de 1 a 21d desafiados por *Eimeria* sp. **Métodos:** Foram utilizados 700 pintos de 1d, machos (Cobb500) distribuídos em delineamento inteiramente casualizado, em quatro tratamentos: (1) dieta controle negativo, sem agente anticoccidiano ou promotores de crescimento; (2) dieta controle+0,05% de salinomicina; (3) dieta controle negativa+100g/ton; e (4)+140g/ton de produto teste (oleoresina de *Curcuma longa* L. mais *Capsicum annuum*) e desafiados por *Eimeria* sp. **Resultados:** Houve resultados similares para peso, ganho de peso, conversão alimentar e Índice de Eficiência Produtiva entre frangos alimentados com dietas contendo anticocidiano quimioterápico e dietas contendo oleoresinas. Além disso, não houve diferença para consumo de ração e a taxa de sobrevivência entre os tratamentos dietéticos. **Conclusão:** Frangos de corte alimentados com dietas suplementadas com oleorresinas de pimenta chili e açafrão-da-terra apresentaram resultados similares para peso, ganho de peso, conversão alimentar e Índice de Eficiência Produtiva que frangos de corte alimentados com dietas suplementadas com anticoccidianos quimioterápicos de 1 a 21d, sem afetar o consumo de ração e a taxa de sobrevivência dos animais.

Palavras-chave: *açafrão-da-terra; desafio com coccidiose; desempenho; frango; oleoresinas; pimenta chili; produção avícola; resistência bacteriana; resistência a protozoários; substituição de antibióticos; suplementos fitogênicos.*

Introduction

Coccidiosis is one of the most common and detrimental diseases in broiler production, mainly because of serious economic losses to the industry attributed to increased drug costs and low animal performance (Drăgan *et al.*, 2014; Tanweer *et al.*, 2014). In general, anticoccidial agents, such as ionophores, monensin, lasalocid, and salinomycin are used for strategic control and treatment, and have been used for several decades (Chapman, 1997; Jenkins *et al.*, 2010). However, unregulated use of these agents can cause a loss of efficiency due to protozoa resistance (Löhren *et al.*, 2009; Kheirabadi *et al.*, 2014). In addition, the use of chemical antimicrobials for growth promotion has been banned in many countries due to its linkage with antimicrobial resistance and meat residues (Bajpai *et al.*, 2012). Thus, there is an increased interest in finding alternative feed additives that can substitute chemical antimicrobials.

Plant extracts, such as chili pepper (*Capsicum annuum*) and turmeric (*Curcuma longa* L.) have gained popularity due to their antimicrobial effect similar to chemotherapeutics based on antioxidative status improvement, antibiotic and anti-inflammatory properties (Majolo *et al.*, 2014; Araújo *et al.*, 2015). Studies suggest that phytogenic supplements can improve antioxidative status by removing free radicals and improving the immune system. Phytogenic supplements protect infected tissue against oxidative stress damage, thus maintaining intestinal integrity during coccidial infection and reducing the negative impacts of coccidiosis (Allen and Fetterer 2002). Studies show positive effects on growth performance, intestinal lesions and pro-inflammatory cytokines of broilers challenged by *Eimeria* sp. and *Clostridium* sp. and fed capsaicin and thymol-supplemented diets (Lee *et al.*, 2013; Kim *et al.*, 2015).

Thus, the objective of this study was to evaluate the effect of oleoresins from chili pepper (*Capsicum annuum*) and turmeric (*Curcuma longa* L.) on the performance, survival rate, and Productive Efficiency Index of broilers from 1 to 21d challenged by *Eimeria* sp.

Materials and methods

Ethical considerations

All procedures and protocols were approved by the Ethical Committee for the Use of Animals of the School of Veterinary Medicine and Animal Science, Universidade de São Paulo, in accordance with the Arouca Law (No. 11,794 of October 8, 2008).

Housing and husbandry

A total of 700 1-day-old chicks (Cobb 500) obtained from a local commercial hatchery were used. The feed was provided by tubular feeders, and water was supplied in pendular drinking troughs arranged in the center of the pens. The pens measured 180x220 cm, were covered with pine wood shavings, and the density and ambient temperature were in accordance with the bird lineage manual (Cobb Vantress, 2012).

Experimental design

The 1-day-old chicks were distributed into four experimental treatments, a corn and soybean meal-based diet being formulated to meet the nutritional requirements of male chicks from 1-21 days (Rostagno *et al.*, 2011): (1) the negative control diet, free of anticoccidial agents and growth promoters (Table 1); (2) the positive control (PC) diet was supplemented with 0.05% salinomycin (Coxistac® 12%, Phibro Brazil Animal Health Corporation; Guarulhos, São Paulo, Brazil; (3) the negative control diet plus 100 g/ton of the test product (NC+10%); and (4) the negative control diet plus 140 g/ton of the test product (NC+14%), totalling four treatments with seven replicates of 25 animals each.

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Table 1. Ingredient composition and nutrients of the experimental diet.

	NC	PC	NC+10%	NC+14%
Corn	62.80	62.80	62.80	62.80
Soybean meal	32.75	32.75	32.75	32.75
Dicalcium phosphate	1.77	1.77	1.77	1.77
Soybean oil	0.76	0.76	0.76	0.76
Inert	0.06	0.01	0.01	0.01
Limestone	0.82	0.82	0.82	0.82
Salt	0.43	0.43	0.43	0.43
Methionine	0.22	0.22	0.22	0.22
Lysine	0.20	0.20	0.20	0.20
Threonine	0.04	0.04	0.04	0.04
Premix Vit/Min**	0.20	0.20	0.20	0.20
Test product	-	-	0.008	0.015
Salinomycin*	-	0.05	-	-
Calculated levels				
ME (kcal/kg)	2928.26	2928.26	2928.26	2928.26
CP (%)	19.8	19.8	19.8	19.8
Na (%)	0.19	0.19	0.19	0.19
aP (%)	0.44	0.44	0.44	0.44
Ca (%)	0.84	0.84	0.84	0.84
Lys (%)	1.12	1.12	1.12	1.12
Threo (%)	0.72	0.72	0.72	0.72
Met+Cys (%)	0.77	0.77	0.77	0.77

NC = negative control diet; PC = Positive control diet (0.05% of salinomycin); NC+10% = negative control diet plus 0.008% of test product; NC+14% = negative control diet plus 0.015% of test product; **Premix mineral vitamin without anticoccidial or growth promoters. Nutritional vitamin/mineral level per kg of diet from 1 to 21d of age: pantothenic acid: 12 mg; folic acid: 1.25 mg; biotin: 0.06 mg; niacin: 35 mg; thiamine: 1.5 mg; vit. A: 10000 IU; pyridoxine (B6): 3mg; riboflavin (B2): 6.5 mg; cobalamin (B12): 20 mg; vit. D3: 3000 IU; vit. E: 25 IU; vit. K^3: 2 mg; Cu: 9.5 mg; Fe: 40 mg; I: 1.1 mg; Mn: 70 mg; Se: 0.33 mg; Zn: 60 mg.

The product tested consisted of 4% oleoresin of chili pepper (*Capsicum annuum*) and 4% oleoresin of turmeric (*Curcuma longa* L.). At 7d, the chicks were infected by oral inoculation with an attenuated live commercial vaccine containing *E. tenella*, *E. acervulina*, *E. maxima* (5×10^6), and *E. necatrix* (1×10^6) (1ml/bird; Livacox® Q, Biopharm, Prague, Czech Republic).

Data collection

At 21d of age, the birds and the leftover feed were weighed in a mobile digital scale (*e*= 0.050) to assess weight gain (WG), feed intake (FI), feed conversion (FC), and the Productive Efficiency Index was obtained as follow:

$$PEI = \left(\frac{BWG * Sv}{FC}\right) * 100$$

PEI is the Productive Efficiency Index; *BWG* is body weight gain (kg); *Sv* is the survival rate (%); *FC* is the feed conversion (kg:kg).

Statistical analysis

The data were analyzed using the Statistical Analysis System (SAS Institute, 2009), version 9.2, by the GLM procedure. The data were submitted to analysis of variance, and the means were compared by the Tukey test at 5% significance level.

Results

Similar results were observed for FBW, WG, FC, and PEI of broilers fed the diet containing anticoccidial chemotherapeutics and diets containing oleoresins (Table 2; p<0.05). However, broilers not supplemented with any additive presented lower BW, FI, FC and PEI compared to the supplemented diets. In addition, there was no difference in feed intake and survival rate between dietary treatments.

Feed conversion was improved by the positive control treatments compared to the negative control. However, the supplemented treatments presented averages similar to the positive and negative control groups.

Table 2. Final body weight (FBW), weight gain (WG), feed intake (FI), feed conversion (FC), Productive Efficiency Index (PEI), and survival rate of broilers from 1 to 21d fed diets supplemented or not with essential oils.

	NC	PC	NC+10%	NC+14%	CV	p-value
Initial body weight (g)	51.71	51.57	51.43	51.43	1.14	0.777
FWB (g)	942.00^{b}	1016.02^{a}	1015.86^{a}	1004.3^{a}	3.82	0.004*
WG (g)	890.28^{b}	964.42^{a}	964.42^{a}	952.71^{a}	4.04	0.004*
FI (g)	1359.14	1373.87	1403.36	1363.63	4.72	0.612
FC (g:g)	1.53^{b}	1.42^{a}	1.45^{ab}	1.43^{ab}	4.84	0.039*
PEI	265.53^{b}	306.46^{a}	298.95^{ab}	299.42^{ab}	8.45	0.027*
Survival rate (%)	100	98.85	98.85	98.28	1.53	0.336

$^{a,\,b}$ p<0.05 (Tukey test); SEM= standard error of the mean; NC = negative control, free of anticoccidial agent and growth promoter; PC = positive control, diet with anticoccidial agent (salinomycin) and growth promoter; NC+10% = negative control+10% of test product (4% *Capsicum annuum* and 4% of *Curcuma longa* L. oleoresins); CN+14% = negative control+14% of test product. WG = weight gain; FI = Feed intake; FC = Feed conversion; PEI = Productive Efficiency Index; FWB = final body weight.

Discussion

Some studies suggest that growth performance and immunological response is improved in broilers fed diets supplemented with turmeric and *capsicum* under challenge conditions (Lee *et al.*, 2010a, b, 2013; Kim *et al.*, 2015). Our performance results corroborate those of Kim *et al.* (2015), who found similar weight gain for animals challenged with *Eimeria* sp./*Clostridium* sp. and supplemented with *Curcuma Longa* L. Furthermore, those researchers observed that diets supplemented with *Capsicum* sp. and *Curcuma longa* L. derivatives reduced the negative effects on body weight caused by intestinal lesions resulting from necrotic enteritis.

Previous studies suggest that mRNA from macrophages and spleen cell proliferation increased in birds submitted to *Curcuma longa* L. (Lee *et al.*, 2010a). In addition, a decrease in intestinal pro-inflammatory cytokines in birds fed a diet supplemented with *Capsicum* sp. oleoresins and challenged with necrotic enteritis, demonstrating increase weight gain, low *E. acervulina* fecundation rate, and reduction of the side effects of the disease (Lee *et al.*, 2010b). Thus, it is possible that the essential oil compounds have an immunomodular role in the immune profile of the birds, directly reflected in the performance of the animals.

Based on the performance results, it is possible to suggest that there was a synergistic effect between chili pepper oleoresin (which contains capsaicin as the main active compound) and turmeric oleoresin (which has thymol as the main active compound), promoting weight gain similar to the anticoccidial chemotherapeutic used, while not affecting feed intake or feed conversion. It is possible that supplementation of vegetable oil compounds in critical stages of development, demonstrated by coccidiosis exposure, minimizes the energy expenditure of the immune system, thus utilizing the absorbed nutrients for other functions, such as growth (Bento *et al.*, 2013). The literature regarding the effects of plant extracts or oleoresins on metabolizable energy and body weight gain is inconsistent. However, it has been reported that plant compounds can stabilize digestive functions (Pirgozliev *et al.*, 2018).

In conclusion, broilers fed diets supplemented with chili pepper and turmeric oleoresins presented similar results on body weight, weight gain, feed conversion, and Productive Efficiency Index similar to those fed a diet supplemented with chemotherapeutic anticoccidials from 1 to 21d. In addition, dietary inclusion of 4% oleoresins from chili pepper and turmeric could substitute for chemotherapeutic antimicrobials, such as salinomycin, as demonstrated in the present study.

Declaration

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Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

Author contribution

Maria Estela Gaglianone Moro, Cristiane Soares da Silva Araújo and Lúcio Francelino Araújo were responsible for the study design. Rafael Araújo Nacimento, Viviane Borba Ferrari, Luís Vinícius Sanfelice, Paulo Henrique Pelissari, Yasmin Gonçalves de Almeida Sartore, Mariana Llaqe Cuadros and Jose Antonio Rivera Ulloa were in charge of experiment conduction and data collection. Viviane Borba Ferrari and Rafael Araújo Nacimento carried out the statistical analysis. Rafael Araújo Nacimento and Lúcio Francelino Araújo drafted the manuscript. All authors read and approved the final manuscript.

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