Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v35i2.15376

Effect of copaiba essential oil on broiler chickens' performance

Cesar Augusto Lopez Aguilar[1*], Kedson Raul de Souza Lima[2], Maria Cristina Manno[2], Fernando Barbosa Tavares[2], Vanessa Pereira de Souza[3] and Dario Lisboa Fernandes Neto[2]

*[1]Universidade Federal Rural da Amazônia, Av. Presidente Tancredo Neves, 2501, 66077-901, Belém, Pará, Brazil. [2]Instituto de Saúde e Produção Animal, Universidade Federal Rural da Amazônia, Belém, Pará, Brazil. [3]Programa de Pós-graduação em Ciência Animal, Universidade Federal do Pará, Belém, Pará. Brazil. *Author for correspondence. E-mail: cesaruel@gmail.com*

ABSTRACT. The effects of copaiba essential oil on growth performance and yield of slaughtered broilers were evaluated. Four hundred and fifty broiler chicks were distributed in a completely randomized design, with five treatments, and six replicates of 15 broiler chicks. Treatments comprised Control (commercial promoter) and four levels of copaiba essential oil, or rather, 0.15 (0.15EO); 0.30 (0.30EO); 0.45 (0.45EO) and 0.60 mL (0.60EO) kg^{-1} feed. The 21-day-old broilers fed on growth promoter had a greater body weight than that of birds fed on treatments with inclusion 0.30, 0.45 and 0.60 mL of essential oil ($p < 0.05$). Aged 40 days, only the broilers fed on treatment with high level of inclusion of essential oil showed lower body weight when compared with those fed on treatment with growth promoter ($p < 0.05$). Feed intake, feed conversion, viability of broilers, carcass yield, commercial cuts and weight of the internal organs were not affected by treatments ($p > 0.05$). The efficiency of productive index decreases in proportion to the increase of copaiba essential oil inclusion level. Copaiba essential oil may be included in the diet up to 0.15 mL kg^{-1} level without affecting the performance of broiler chickens.

Keywords: feeding, feed conversion, nutrition, vegetable extract.

Efeito do óleo essencial de copaíba sobre o desempenho de frangos de corte

RESUMO. Um estudo foi conduzido para avaliar os efeitos do óleo essencial de copaíba sobre o desempenho e rendimento de abate de frangos de corte. Foram utilizados 450 pintos, distribuídos num delineamento inteiramente casualizado com 5 tratamentos e 6 repetições de 15 aves. Os tratamentos consistiram em Controle (promotor comercial) e quatro níveis de óleo essencial de copaíba sendo estes 0,15 (0,15EO); 0,30 (0,30EO); 0,45 (0,45EO) e 0,60 mL (0,60EO) kg^{-1} de ração. Aos 21 dias de idade, as aves do tratamento com promotor apresentaram peso corporal superior ao das aves que receberam os tratamentos com 0,30; 0,45 e 0,60 mL de inclusão de óleo essencial ($p < 0,05$). Aos 40 dias de idade apenas as aves que receberam o tratamento com maior nível de inclusão de óleo essencial apresentaram menor peso corporal em relação ao tratamento com promotor de crescimento. O consumo de ração, a conversão alimentar e a viabilidade das aves, assim como o rendimento de carcaça, cortes comerciais e peso dos órgãos internos não foram afetados pelos tratamentos ($p > 0.05$). Conclui-se que o óleo essencial de copaíba pode ser usado na ração até o nível de 0,15 mL kg^{-1} sem afetar o desempenho das aves.

Palavras-chave: alimentação, conversão alimentar, nutrição, extrato vegetal.

Introduction

The prophylactic use of antibiotics as growth promoters in diets for broilers has triggered intensive poultry production and improved feed conversion in the animals. Resistant microorganisms survive and grow at low antibiotics level and produce an antibiotic-resistant population. As a result, new commercial additives of plant origin, considered as natural products acceptable by consumers, have been offered to poultry producers. Herbs, spices and various plant extracts have received rising attention as replacements of possible antibiotic growth promoters.

Although several experimental studies demonstrate the antimicrobial effects of different plants that grow in the Amazon, they have been performed in *in vitro* studies. This research seeks to evaluate the essential oil extracted from copaiba (*Copaifera Reticulata*).

The copaiba oil resin accumulates in cavities of tree trunk from where it is extracted through holes and collected by tubes only once a year (VEIGA JUNIOR; PINTO, 2002). After filtering, the oil is a consistent fluid, featuring a yellow-brown to pale-green color, an aromatic odor and a characteristically bitter taste. Essential oil is partly formed by volatile sesquiterpenes compounds, mainly β-caryophyllene

(50-52%), with smaller amounts of eight other sesquiterpenes. In fixed resin fractions, some diterpenes, especially copalic acid, predominate (SIMÕES et al., 2001).

In antimicrobial activity tests the copaiba essential oil proved to be effective against *Staphylococcus aureus*, *Bacillus subtilis* and *Escherichia coli*. Several of its components have scientifically proven pharmacological activity, among which may be mentioned β-caryophyllene with its anti-inflammatory action and protection against gastric mucous (TAMBE et al., 1996).

In short, the positive effects observed in *in vitro* tests justify further research in the area to determine the ideal dietary inclusion level and the mode of action of this vegetal extract so that optimal growth performance and disease resistance in poultry production may be achieved. Current study evaluated the capacity of copaiba essential oil used as supplement in broiler chickens' diets to stimulate broiler performance and yield.

Material and methods

The experiment was conducted in the Poultry Sector of the Animal Science Department at the Federal Rural University of Amazonia. For this trial, 450 one-day old Ross-308 male chicks, vaccinated against Marek disease, average weight 39.7 ± 1.7 g, were distributed in a completely randomized design, with five treatments and six replications, each replication with fifteen broilers. Treatments comprised control (Control - growth promoter virginiamycin, without Copaiba essential oil); the other treatments consisted of four inclusion levels, or rather, 0.15 (0.15EO), 0.30 (0.30EO), 0.45 (0.45EO) and 0.60 mL (0.60EO) of copaiba essential oil kg^{-1} of diet.

The birds were reared in 30 pens of 1.5 m^2 each, with water troughs and hanging feeders, 250W infrared heating lamps, with water and feed *ad libitum*. Shavings bed was used at a height of 5 cm. The birds were vaccinated against Newcastle and Gumboro diseases when seven days old and a continuous light system was used in this experiment. The feeding program consisted of a starter diet (until 21 days of age), a growing diet (from 22 to 35 days of age) and a finisher diet (from 36 to 40 days of age). Table 1 shows the composition of the experimental basal diets. All diets for each period were prepared with the same batch of ingredients and all diets within the same period had the same composition. Diets were formulated to meet requirements proposed by the Brazilian Tables for Poultry and Swine - Feed Composition and Nutritional Requirements (ROSTAGNO et al., 2005) for broilers of this age. The antibiotic growth promoter virginiamycin was included in the diet at a concentration of 10 ppm. Different levels of copaiba essential oil were included in basal diet to replace the growth promoter virginiamycin. Anticoccidial ionophores, salinomycin and senduramycin were included in the starter and growing rations, respectively. Anticcocidial agents, growth promoters and copaiba essential oil were not included in the diet of the finishing phase. Copaiba oil resin was collected by drilling the tree trunk with an auger of about 2 meters in diameter in two holes. The first hole was made 1 meter above the base of the plant and the second hole one meter above the other. The drill was then inserted in a PVC tube with ¾-inch holes for the drainage of the oil. The latter was stored in amber glass bottles. When the resin oil was extracted, the holes were covered with plastic lids. Copaiba essential oil was extracted from the oleoresin at the Laboratory of the Emilio Goeldi Museum by the hydro distillation method using a Clevenger-type apparatus. Two gas chromatographs coupled to mass spectrometers (GC-MS, Finnegan Mat model Incos-XL and Thermo model DSQ II) were used for the analysis of essential oils (SIMÕES et al., 2001).

Table 1. Composition of experimental diets.

Ingredients	Basal diet (%)		
	Starter	Growing	Finisher
Corn (8% CP)	57.279	65.206	66.518
Soybean meal (45% CP)	33.80	26.00	23.90
Meat and bone meal (45% CP)	5.50	5.20	4.80
Limestone (37% Ca)	0.44	0.43	0.45
Soybean oil	2.00	2.20	3.50
Sodium chloride	0.36	0.28	0.31
Sodium bicarbonate	0.09	0.150	0.09
DL-Methionine	0.208	0.170	0.159
L-Lysine	0.071	0.107	0.123
Vitamin-mineral premix[1]	0.20	0.20	0.15
Senduramicin sodium	0.05	-	-
Salinomicin	-	0.055	-
Virginiamycin	0.002	0.002	-
Calculated composition			
Metabolizable Energy (kcal/kg)	3,000	3,100	3,200
Crude Protein (%)	22.45	19.45	18.42
Total lysine (%)	1.30	1.12	1.06
Total methionine + cystine (%)	0.92	0.80	0.76
Total threonine (%)	0.88	0.76	0.72
Total tryptophan (%)	0.27	0.23	0.21
Total arginine (%)	1.50	1.27	1.19
Calcium (%)	1.00	0.94	0.88
Available phosphorus (%)	0.48	0.45	0.42
Sodium (%)	0.22	0.20	0.19
Potassium (%)	0.91	0.78	0.73
Chloride (%)	0.30	0.35	0.27
Ether Extract (%)	5.03	5.46	6.66
Fiber (%)	3.59	3.25	3.13
Electrolytic Balance (mEq kg^{-1})	243	215	195

[1]The vitamin and trace mineral mix provided the following rates per kilogram of diet: retinyl palmitate, 6,000 IU; cholecalciferol, 1,000 ICU; DL-α-tocopherol acetate, 10 IU; menadione sodium bisulfite, 1 mg; thiamin, 1.8 mg; riboflavin, 3.6 mg; niacin, 25.0 mg; pantothenic acid, 10.0 mg; pyridoxine, 3.5 mg; folacin, 0.5 mg; biotin, 0.15 mg; choline, 500 mg; 50 mg; copper, 8 mg; iron, 80 mg; manganese, 60 mg; selenium, 0.1 mg; and zinc, 40 mg.

Body weight, feed intake, feed conversion and viability were evaluated at 21 and 40 days of age, during the experimental period. Efficiency productive index (EPI) was determined at 40 days of age, according to the following formula: EPI = (P40 x VC) / (IA x CA) x 100; where P40 - body weight at 40 days of age (kg); VC - viability of poultry (%); IA - age at slaughter (days) and CA - feed conversion (g g^{-1}). When 40 days old, two poultry per replicate were selected (12 birds per treatment) and after a fast of six hours they were slaughtered to determine carcass yield and commercial cuts (breast, thigh and drumstick, back, wings, feet, head and neck), which were expressed as percentage of body weight before slaughter. In addition, proventriculus, gizzard, intestines (small and large), pancreas, spleen, heart and liver were removed to determine the relative weight of internal organs (% body weight). Broiler chickens were killed at the same time to avoid the influence of the period of feed withdrawal on the weight of birds.

The study consisted of a complete randomized design with five treatments. The number of replicates varied according to data assessed, including six for performance data and 12 for the slaughter yield and relative weight of internal organs. All data were analyzed by GLM procedure of SAS Institute (SAS, 1997). Means of each treatment containing essential oil were compared with the control group (standard commercial) by Dunnett test at 5%. The regression analysis used to determine linear and quadratic responses was set at 5%. This evaluation only assessed the treatments supplemented with copaiba essential oil (0.15EO, 0.30EO, 0.45EO and 0.60EO).

Results and discussion

The Table 2 shows the main components of copaiba essential oil. Chromatographic analysis of the composition of copaiba essential oil (*Copaifera reticulata*) demonstrated that main components were β-bisabolene (40.92%), trans-α-bergamotene (28.14%) and β-caryophyllene (14.84%).

Table 2. Principal components of copaiba essential oil (*Copaifera Reticulata*).

Component	(%)
β-bisabolene	40.92
Trans-α-bergamotene	28.14
β-caryophyllene	14.84
α-humulene	3.86
(Z)-α-bisabolene	2.78
β-sesquifelandreno	1.78
β-selinene	0.93
α-selinene	0.47
Ciperene	0.35
Others	5.95

Detailed compositional analysis of volatile compounds was performed by gas chromatography and mass spectrometry of the essential oils (DELAQUIS et al., 2002). Since the essential oils from the chemical point of view are quite complex mixtures constituted by dozens of components, frequently such complexity makes it difficult to explain their activities (MORONE-FORTUNATO; AVATO, 2008). They are composed of variable mixtures, mainly terpenoids, and a variety of low molecular weight aliphatic hydrocarbons. Main constituents were characterized by two or three components at fairly high concentrations (up to 85%) when compared to other constituents present in trace amounts (BAUER et al., 2001). Generally, the main constituents represented the biophysical and biological features of the essential oils from which they were isolated. The phenolic components were primarily responsible for the antibacterial properties of essential oils (WINDISCH et al., 2008).

The chromatographic analysis of copaiba essential oil showed that the vegetable product contained three main chemical constituents, totaling approximately 84% of the oil. However, Maia and Andrade (2009) found that its main constituents were β-caryophyllene (40.3%), β-bisabolene (10.6%), α-humulene (6.8%). According to Carvalho Filho et al. (2006), significant percentage changes occurred in the main constituents of the essential oil of different plants, depending on season, region, soil, vegetative stage of plant, time of collection, etc. In addition, the oil composition alters during the harvesting and post-harvesting processes, due to spontaneous conversions occurring continuously which change the essential oil composition.

Essential oils have been developed as an alternative to antibiotics in the animal industry, partly due to their biological properties, such as antimicrobial and antiseptic activities. However, only limited studies are available to assess the possible application of these oils as alternatives to antibiotics in broiler chicken production. The efficacy of essential oils on growth performance in poultry is not consistent, as it was supplemented to the diets at levels 20-200 mg EO kg^{-1} diet. Although positive results have been reported from several field studies (LANGHOUT, 2000), non-significant results have also been registered (BOTSOGLOU et al., 2002).

Table 3 shows the performance results of 21-day-old poultry. There was significant difference in body weight between treatments ($p > 0.05$). The birds fed on diets containing the growth promoter virginiamycin had a higher body weight ($p < 0.05$)

than that in birds on diets containing 0.30, 0.45 and 0.60 mL kg^{-1} copaiba essential oil. The birds fed on a diet containing 10 ppm of virginiamycin and 0.15 mL kg^{-1} copaiba essential oil had similar body weight ($p > 0.05$).

Regression analysis for performance variables, EPI, carcass yield, commercial cuts and relative weight of internal organs revealed that regression curve coefficients were not significant ($p > 0.05$). This fact limited the discussion to the test of means by Dunnett test. However, EPI (at 40 days of age) showed a linear effect ($p < 0.05$) when assessing only the different levels of inclusion of copaiba essential oil in the diet (Table 4).

Table 3. Effects of copaiba essential oil on performance of broilers (1 to 21days of age).

Diet	Variables			
	Body weight (g)	Feed Intake (g)	Feed: gain (g g^{-1})	Viability (%)
Control	1.125	1.449	1.336	98.9
0.15EO	1.096^{ns}	1.461^{ns}	1.384^{ns}	100.0^{ns}
0.30EO	1.087*	1.436^{ns}	1.373^{ns}	100.0^{ns}
0.45EO	1.086*	1.446^{ns}	1.383^{ns}	98.9^{ns}
0.60EO	1.088*	1.406^{ns}	1.343^{ns}	98.9^{ns}
C.V.(%)	2.02	2.86	2.93	2.13

*Means in the same column differ ($p < 0.05$) from control by Dunnett test. ^{ns}Means in the same column did not differ ($p > 0.05$) from control by Dunnett test.

At 40 days of age, there was a significant difference ($p < 0.05$) between the treatment with the growth promoter and the treatment with the highest inclusion level of Copaiba essential oil (0.60 mL kg^{-1}) on body weight of birds (Table 4).

Table 4. Effects of copaiba essential oil on performance of broilers (1 to 40 days of age).

Diet	Variables				
	Body weight (g)	Feed Intake (g)	Feed: gain (g g^{-1})	Viability (%)	IPE^{l}
Control	2884	4824	1.697	92.2	386
0.15EO	2863^{ns}	4881^{ns}	1.729^{ns}	97.8^{ns}	399^{ns}
0.30EO	2817^{ns}	4838^{ns}	1.743^{ns}	98.9^{ns}	394^{ns}
0.45EO	2821^{ns}	4833^{ns}	1.738^{ns}	97.8^{ns}	391^{ns}
0.60EO	2795*	4821^{ns}	1.750^{ns}	97.8^{ns}	385^{ns}
C.V.(%)	2.06	2.20	2.53	4.71	4.61

*Means in the same column differ ($p < 0.05$) from control by Dunnett test. ^{ns}Means in the same column did not differ ($p > 0.05$) from control by Dunnett test. ^{l}Linear effect: $Y = 403.5 - 30X$ ($R^2 = 0.98$).

Increase in inclusion level of copaiba essential oil in the diet decreased the index of productive efficiency at 40 days of age.

In current study, at 21 days of age, only the treatment with the lower inclusion level of copaiba essential oil had a similar performance to that in poultry fed on virginiamycin. However, at the end of the experiment, only the treatment with the high level of inclusion of copaiba essential oil showed lower body weight when compared to that with growth promoter treatment.

When poultry age is taken into account, these different responses suggest that the younger birds are more susceptible to a higher consumption of copaiba essential oil when compared with that by older birds. Further, this response suggested that there was a compensatory growth of other treatments, except the one with the highest inclusion level of essential oil, with similar body weight at the end of the experiment. This response seemed to indicate that high consumption of copaiba essential oil might be toxic to young birds. Perhaps, in terms of consumption by the bird, this inclusion level became toxic and impaired the birds' growth. According to Simões et al. (2001), the degree of toxicity depended on the dose of essential oil. In some cases, a low dose might lead to poisoning due to individual sensitivity, allergies and photosensitivity reactions or to more serious problems, especially when it was orally administered.

Since the presence of β-caryophyllene and α-humulene caused hemolysis in different types of erythrocytes, including chickens', these terpenoids should be cautiously used. Human and bovine erythrocytes were the most sensitive to these terpenoids and thus indicated that, in the case of the therapeutic use of the essential oil with these chemical components, the quantity of oil that reached the bloodstream should be observed (SILVA et al., 2008). The above may partially explain the negative effect on body weight of birds fed on the highest inclusion level of copaiba essential oil. However, studies on the serum biochemical profile are necessary to be able to confirm the toxic effect of the chemical components of copaiba essential oil.

Reported responses to various essential oils have been varied and may depend on the type of basal diet used, real or artificial disease challenge, and other factors related to stress imposed on the birds. Vogt (1990) fed caged broilers on a mixture of essential oils or 20 mg/kg virginiamycin. The addition of virginiamycin resulted in improved growth and feed conversion but no significant response to the mixture of essential oils was noted. In a further study, Vogt (1991) conducted three experiments with caged broilers fed on mixtures of various essential oils. The addition of the essential oil mixtures had no significant effect on body weight or feed efficiency. Employing a wheat-soybean meal basal diet, Botsoglou et al. (2002) observed no effect of oregano essential oil on improvement on growth rate or feed conversion of broiler chickens grown to 38 days of age in litter floor pens.

García et al. (2007) found that although feed additions did not improve body weight gain, they improved feed conversion when compared to that of the negative control group, when evaluating diets containing avilamycin and a blend of essential oils in relation to a control diet. The beneficial effect of growth promoter substances, such as antibiotics, on performance was related to a more efficient use of nutrients, which, in turn, resulted in an improved feed conversion.

There were no significant differences for the variables feed conversion, feed intake and viability of birds. Responses were similar to those found by Hernandez et al. (2004) on feed intake and feed conversion, but the authors observed lower mortality rates in birds fed on plant extracts containing essential oils of salvia thyme and rosemary.

In contrast, when Jang et al. (1997) assessed different inclusion levels of essential oil in the diet, they did not find any difference between the lowest and highest inclusion level in the diet. However, Barreto et al. (2008) found that the essential oils of cinnamon, clove, oregano and red pepper, individually added to broiler feed at 200 mg kg^{-1}, failed to influence broiler performance. The same occurred with the supplementation of 10 mg of the antibiotic avilamycin per kg of feed. The authors explained such an absence in significant treatment effects, including the treatment with the antibiotic growth promoter, as caused by a lack of microbiological challenges or inactivity of the added substances or perhaps due to the dose of the tested active principles. Growth promoter virginiamycin showed similar EPI with regard to the different inclusions of copaiba essential oil in the diet. This result was different from that by Langeroudi et al. (2008) who observed higher EPI in chickens fed on virginiamycin when compared to that in birds fed on the extracts of Zataria multiflora and Ziziphora clinopodioides. EPI reduction with increasing inclusion levels of the essential oil content in the diet probably resulted from a combination of lighter body weight, worse feed conversion and a higher mortality rate, in which differences as individual variables were not evident.

Table 5 shows the effect of dietary copaiba essential oil on yields of carcass, breast, whole leg, back, wings, feet, head and neck. There were no significant effects of any experimental treatment on the yield of carcass and commercial cuts ($p > 0.05$).

Table 5. Yield of commercial cuts of broilers (% of body weight) fed on copaiba essential oil in the diet.

Diet	Variables (%)							
	Carcass	Breast	Thighs	Back	Wings	Feet	Head	Neck
Control	81.7	25.3	21.3	18.3	7.9	3.49	2.05	3.34^{ns}
0.15EO	81.1^{ns}	24.4^{ns}	20.7^{ns}	18.7^{ns}	7.6^{ns}	3.54^{ns}	2.19^{ns}	3.41^{ns}
0.30EO	81.5^{ns}	24.9^{ns}	21.6^{ns}	18.1^{ns}	7.6^{ns}	3.49^{ns}	2.12^{ns}	3.67^{ns}
0.45EO	81.9^{ns}	24.4^{ns}	21.2^{ns}	19.1^{ns}	8.2^{ns}	3.54^{ns}	2.02^{ns}	3.29^{ns}
0.60EO	81.7^{ns}	26.0^{ns}	22.0^{ns}	17.4^{ns}	7.4^{ns}	3.52^{ns}	2.11^{ns}	3.35^{ns}
C.V. (%)	1.61	6.85	6.65	8.99	8.46	7.82	10.2	17.1

^{ns}Means in the same column did not differ ($p > 0.05$) from those of control by Dunnett test.

Despite differences in body weight at the end of the experiment, no differences occurred in the yield of carcass and commercial cuts. Reports in the literature showed divergent effects on carcass yield. For instance, García et al. (2007) observed no effect on carcass weight in broilers fed on diets containing avilamycin or on 200 ppm of a blend of oregano, cinnamon, and pepper essential oils. On the other hand, Alçiçek et al. (2003) reported that carcass yield was higher in treatments containing feed additives in the diet and among the treatments; or rather, which contained the highest essential oil yield observed in the group with the intermediate inclusion level. García et al. (2007) found that the inclusion of the different essential oils and growth promoter did not affect broiler chickens' carcass, breast and thigh yield.

Essential oils fed to broilers may cause morphological changes in the gastrointestinal tract (JAMROZ et al., 2006) and stimulate the production of certain digestive and pancreatic enzymes (JANG et al., 2007), since the thymus, for example, has stimulatory effects on pancreatic enzyme secretion in broiler chickens (LEE et al., 2003). According to Mellor (2000), plant extracts in the diet may increase the secretion of pancreatic enzymes by causing an increase in gastric acid and pepsin production and providing pH reduction in the stomach and small intestine. Another explanation for the high enzymatic activity and pancreatic secretion in pigs might have resulted from the pancreas relative weight gain that these oils could have caused.

Table 6 shows the relative weight of internal organs (percentage of body weight) of broilers at 40 days of age. It seems that treatments influenced the relative weights of the pancreas, heart and liver ($p < 0.05$). Other variables were not affected by treatments ($p > 0.05$).

Table 6. Relative weight of internal organs (%) of broiler chickens with copaiba essential oil in diet.

Diet	Variables (%)						
	Proventriculus	Gizzard	Intestines	Pancreas	Spleen	Heart	Liver
Control	0.33	1.26	3.47	0.15	0.09	0.48	1.65
0.15EO	0.38^{ns}	1.32^{ns}	3.60^{ns}	0.19^{ns}	0.11^{ns}	0.39*	1.75^{ns}
0.30EO	0.38^{ns}	1.18^{ns}	3.50^{ns}	0.22*	0.11^{ns}	0.41*	1.80^{ns}
0.45EO	0.36^{ns}	1.24^{ns}	3.46^{ns}	0.20*	0.09^{ns}	0.40*	1.99*
0.60EO	0.34^{ns}	1.28^{ns}	3.44^{ns}	0.18^{ns}	0.09^{ns}	0.42^{ns}	1.82^{ns}
C.V. (%)	22.9	13.3	12.5	25.2	41.0	15.7	15.0

*Means in the same column differ ($p < 0.05$) from those of control by Dunnett test. ^{ns}Means in the same column did not differ ($p > 0.05$) from those of control by Dunnett test.

With regard to the weight of the pancreas, broilers fed on levels of 0.15 and 0.30 mL kg^{-1} of copaiba essential oil had a greater weight of this organ when compared to that of control containing the growth promoter virginiamycin. The relative weight of heart was lower in treatments with the addition of copaiba essential oil of 0.15, 0.30, and 0.45 mL kg^{-1} when compared to that of control with the growth promoter ($p < 0.05$). However, liver weight was higher in birds fed on a 0.45 mL kg^{-1} dietary level of copaiba essential oil when compared to that of control with virginiamycin ($p < 0.05$).

The relative weight of the pancreas increased up to the level of 0.30 ml kg^{-1}, undergoing a gradual reduction to 0.60 ml kg^{-1}. The above may explain the pancreas's hypertrophy in treatment with 0.30 and 0.45 mL inclusions of essential oil in the diet. The same may be said on the liver in treatment containing 0.45 mL kg^{-1} of essential oil in the diet. Furthermore, this may be related to the fact that the active ingredients of extracts of spices increased the liver's metabolism and caused an increase in weight of this organ (DEBERSAC et al., 2001). With regard to the lighter weight on the heart by increasing the level of inclusion of plant extract, Barcelos et al. (2010) observed a reduction of cardiac hypertrophy in spontaneously hypertensive rats caused by treatment with essential oil of *Alpinia zerumbet* (Pers.).

Moreover, Traesel et al. (2011) has proved that essential oils from oregano, sage, rosemary and aqueous extract of pepper may cause kidney damage at concentrations of 50, 100 and 150 ppm (mg kg^{-1}) and liver damage at doses of 100 and 150 ppm. However, these changes were not observed in the control group with no feed additions. The results were compared with the group receiving the product routinely employed (growth promoters in feed-based antibiotics). In fact, only the dose 150 ppm of essential oil caused kidney and liver damage, suggesting hepatotoxicity and nephrotoxicity of essential oils when administered at this dose.

Conclusion

Copaiba essential oil is an additive with a potential to improve performance when included at low concentrations in the diet.

The copaiba essential oil may be included in the diet at the level of 0.15 mL kg^{-1} during different growth phases without impairing the performance of birds, EPI, slaughter yield and internal organs.

References

ALÇIÇEK, A.; BOZKUR, M.; ÇABUK, M. The effect of an essential oil combination derived from selected herbs growing wild in Turkey on broiler performance. **South African Journal of Animal Science**, v. 33, n. 2, p. 89-94, 2003.

BARCELOS, F. F.; OLIVEIRA, M. L.; GIOVANINNI, N. P. B.; LINS, T. P.; FILOMENO, C. A.; SCHNEIDER, S. Z.; PINTO, V. D.; ENDRINGER, D. C.; ANDRADE, T. U. Estudo químico e da atividade biológica cardiovascular do óleo essencial de folhas de *Alpinia zerumbet* (Pers.) B. L. Burtt & R. M. Sm. em ratos. **Revista Brasileira de Plantas Medicinais**, v. 12, n. 1, p. 48-56, 2010.

BARRETO, M. S. R.; MENTEN, J. F. M.; RACANICCI, A. M. C.; PEREIRA, P. W. Z.; RIZZO, P. V. Plant extracts used as growth promoters in broilers. **Brazilian Journal of Poultry Science**, v. 10, n. 2, p. 109-115, 2008.

BAUER. K.; GARBE, D.; SURBURG, H. **Common fragrance and flavor materials**: preparation, properties and uses. 2nd ed. Weinheim: Wiley-VCH, 2001.

BOTSOGLOU, N. A.; FLOROU-PANERI, P.; CHRISTAKI, E.; FLETOURIS, D. J.; SPAIS, A. B. Effects of dietary oregano essential oil on performance of chickens and on iron-induced lipid oxidation of breast, thigh and abdominal fat tissues. **British Poultry Science**, v. 43, n. 2, p. 223-230, 2002.

CARVALHO FILHO, J. L. S.; BLANK, A. F.; ALVES, P. B.; EHLERTI, P. A. D.; MELO, A. S.; CAVALCANTI, S. C. H.; ARRIGONI-BLANKI, M. F.; SILVA-MANN, R. S. Influence of the harvesting time, temperature and drying period on basil (*Ocimum basilicum* L.) essential oil. **Revista Brasileira de Farmacognosia**, v. 16, n. 1, p. 24-30, 2006.

DEBERSAC, P.; VERNEVAUT, M. F.; AMIOT, M. J.; SUSCHETET, M.; SIESS, M. H. Effects of a water-soluble extract of rosemary and its purified component rosmarinic acid on xenobiotic metabolizing enzymes in rat liver. **Food and Chemical Toxicology**, v. 39, n. 2, p. 109-117, 2001.

DELAQUIS, P. J.;. STANICH, K.; GIRARD, B.; MAZZA, G. Antimicrobial activity of individual and mixed fractions of dill, cilantro, coriander and eucalyptus essential oils. **International Journal of Food Microbiology**, v. 74, n. 1-2, p. 101-109, 2002.

GARCÍA, V.; CATALÁ-GREGORI, P.; HERNÁNDEZ, F. M.; MEGIAS, M. D.; MADRID, J. Effect of formic acid and plant extracts on growth, nutrient digestibility, intestine mucosa morphology, and meat yield of broilers. **Journal of Applied Poultry Research**, v. 16, n. 4, p. 555-562, 2007.

HERNANDEZ, F.; MADRID, J.; GARCIA, V.; ORENGO, J.; MEGIAS, M. D. Influence of two plants extracts on broiler performance, digestibility and digestive organ size. **Poultry Science**, v. 83, n. 2, p. 169-174, 2004.

JAMROZ, D.; WERTELECKI, T.; HOUSZKA, M.; KAMEL, C. Influence of diet type on the inclusion of plant origin active substances on morphological and histochemical characteristics of the stomach and jejunum walls in chicken. **Journal of Animal Physiology and Animal Nutrition**, v. 90, n. 5-6, p. 255-268, 2006.

JANG, I. S.; KO, Y. H.; KANG, S. Y.; LEE, C. Y. Effect of a commercial essential oil on growth performance, digestive enzyme activity and intestinal microflora population in broiler chickens. **Animal Feed Science and Technology**, v. 134, n. 3-4, p. 304-315, 2007.

LANGEROUDI, G. A.; KIAEI, S. M. M.; MODIRSANEI, M.; MANSOURI, B.; ESTABRAGH, A. S. Comparison of chemical and biological growth promoter with two herbal natural feed additives on broiler chicks performance. **Journal of Animal Veterinary Advances**, v. 7, n. 5, p. 570-574, 2008.

LANGHOUT, P. New additives for broiler chickens. **World Poultry**, v. 16, n. 3, p. 22-27, 2000.

LEE, K. W.; EVERTS, H.; KAPPERT, H. J. M.; FREHNERB, M.; LOSAB, R.; BEYNENA, A. C. Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens. **British Poultry Science**, v. 44, n. 3, p. 450-457, 2003.

MAIA, J. G. S.; ANDRADE, E. H. A. Database of the Amazon aromatic plants and their essential oils. **Quimica Nova**, v. 32, n. 3, p. 595-622, 2009.

MELLOR, S. Herbs and spices promote health and growth. **Pig Progress**, v. 16, n. 4, p. 18-21, 2000.

MORONE-FORTUNATO, I.; AVATO, P. Plant development and synthesis of essential oils in micropropagated and mycorrhiza inoculated plants of *Origanum vulgare* L. ssp. *hirtum* (Link) Ietswaart. **Plant Cell, Tissue and Organ Culture**, v. 93, n. 2, p. 139-149, 2008.

ROSTAGNO, H. S.; ALBINO, L. F. T.; DONZELE, J. L.; GOMES, P. C.; OLIVEIRA, R. F., LOPES, D. C.; FERREIRA, A. S.; BARRETO, S. L. T. **Tabelas Brasileiras para Aves e Suínos**. Viçosa: UFV, 2005. p. 186.

SAS-Statistical Analysis System. **User's guide**. Version 6. SAS Institute Inc. 4th ed. North Caroline: SAS Institute, 1997.

SILVA, S. L.; CHAAR, J. D.; FIGUEIREDO, P. M. S.; JANO, T. Cytotoxic evaluation of essential oil from *Casearia sylvestris Sw* on human cancer cells and erythrocytes. **Acta Amazonica**, v. 38, n. 1, p. 107-112, 2008.

SIMÕES, C. M. O.; SCHENKEL, E. P.; GOSMAN, G.; MELLO, J. C. P.; MENTZ, L. A.; PETRVICK, P. R. **Farmacognosia – da planta ao medicamento**. Porto Alegre/Florianópolis: UFRGS/UFSC, 2001.

TAMBE, Y.; TSUJIUCHI, H.; HONDA, G.; IKESHIRO, Y.; TANAKA, S. Gastric cytoprotection of the non-steroidal anti-inflammatory sesquiterpene, β-caryophyllene. **Planta Medica**, v. 62, n. 5, p. 469-470, 1996.

TRAESEL, C. K.; LOPES, S. T. A.; WOLKMER, P.; SCHIMIDT, C.; SANTURIO, J. M.; ALVES, S. H. Óleos essenciais como substituintes de antibióticos promotores de crescimento em frangos de corte: perfil de soroproteínas e peroxidação lipídica. **Ciência Rural**, v. 41, n. 2, p. 278-284, 2011.

VEIGA JUNIOR, F.; PINTO, A. C. O. Gênero copaifera L. **Química Nova**, v. 25, n. 2, p. 273-286, 2002.

VOGT, H. The effect of a mixture of essential oils in broiler diets. **Landbauforshung Volkenrode**, v. 40, n. 2, p. 157-159, 1990.

VOGT, H. Essential oils in broiler diets. **Landbauforshung Volkenrode**, v. 41, n. 2, p. 94-97, 1991.

WINDISCH, W.; SCHEDLE, K.; PLITZNER, C.; KROISMAYR, A. Use of phytogenic products as feed additives for swine and poultry. **Journal of Animal Science**, v. 86, n. 4 (suppl.), p. 140-148, 2008.

Received on December 19, 2011.
Accepted on April 24, 2012.