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Use of essential oils in the diet of slow-growing broilers and their effects on performance

Uso de óleos essenciais em dietas de frangos de corte de crescimento lento e seus efeitos sobre o desempenho

DIOGO, Ingrid Andressa Jesus[1*]
https://orcid.org/0000-0002-7067-9157

PINEDO, Lerner Arévalo[2]
https://orcid.org/0000-0001-8119-8626

FREITAS, Henrique Jorge de[1]
https://orcid.org/0000-0003-3967-3483

SOUZA, Edcarlos Miranda de[1]
https://orcid.org/0000-0001-8701-9545

GOMES, Fábio Augusto[1]
https://orcid.org/0000-0003-2369-8838

[1] Universidade Federal do Acre, Programa de Pós-graduação em Sanidade e Produção Animal na Amazônia Ocidental, Rio Branco, Acre, Brasil.
[2] Universidade Federal Rural do Semi-Árido, Programa de Pós-Graduação em Produção Animal, Mossoró, Rio Grande do Norte, Brasil.
*Mail for correspondence: ingrid.diogo@ufac.br

ABSTRACT

This study proposes to examine the effect of supplementing the diet of slow-growing broilers with essential oils. A total of 270 one-day-old female chicks of the Pesadão Vermelho line, reared in an intensive system, were allocated to one of three treatments (1: Control, without addition of essential oils; 2: Feed supplemented with cinnamon essential oil; and 3: Feed supplemented with lemongrass essential oil) in a completely randomized design with nine replicates of 10 birds each. Growth performance variables were evaluated at 14, 28, 42, 56, and 70 days, whereas carcass yield, primal cuts, and internal organs were analyzed at 71 days of age. Data were subjected to analysis of variance and differences between means were compared using the Scott-Knott test at 5% probability. Supplementation with lemongrass essential oil improved the live weight of birds at 14, 28, and 42 days, as well as feed conversion and feed efficiency at 42 and 56 days of rearing ($P<0.05$). The treatments with cinnamon and lemongrass essential oils provided the highest thigh yields ($P<0.05$). The other evaluated variables did not show statistically significant differences ($P>0.05$) between treatments.
Keywords: Additives. Animal nutrition. Cinnamon. Lemongrass. Poultry farming.

RESUMO

O experimento teve como objetivo, avaliar o efeito da suplementação de óleos essenciais nas dietas de frangos de corte de crescimento lento. Foram utilizados 270 pintos de um dia, fêmeas da linhagem Pesadão Vermelho, criados em sistema intensivo. O

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delineamento experimental foi o inteiramente casualizado (DIC) com três tratamentos (Tratamento 1: Controle, sem adição de óleo essencial; Tratamento 2: Ração suplementada com óleo essencial de canela e Tratamento 3: ração suplementada com óleo essencial de capim-cidreira) e nove repetições de 10 aves cada. Aos 14, 28, 42, 56 e 70 dias foram avaliadas as variáveis de desempenho zootécnico e aos 71 dias o rendimento de carcaça, cortes nobres e órgãos internos. Os dados foram submetidos à análise de variância e as diferenças entre as médias foram comparadas pelo teste de Scott-Knott a 5% de probabilidade. A suplementação com óleo essencial de capim-cidreira melhorou o peso vivo das aves aos 14, 28 e 42 dias e a conversão e eficiência alimentar aos 42 e 56 dias de criação ($P<0,05$). Os tratamentos com óleo essencial de canela e de capim-cidreira proporcionaram maior rendimento de sobrecoxa ($P<0,05$). Em relação as demais variáveis avaliadas, não foram verificadas diferenças estatísticas significativas ($P>0,05$) para os tratamentos testados.
Palavras-chave: Aditivos. Avicultura. Canela. Capim-Cidreira. Nutrição Animal.

INTRODUCTION

Nutrition accounts for up to 70% of production costs in poultry farming. For this reason, studies in this field have focused on discovering new strategies to improve the utilization of feed ingredients, thereby increasing productivity rates and the feed efficiency of broilers (Praes et al., 2016).

Plant essential oils can be an interesting option to improve feed efficiency and, consequently, animal performance, due to their functional and digestive properties that enhance nutrient utilization, allowing the animals to express their maximum genetic potential for meat production (Hafeez et al., 2015).

Essential oils inhibit the growth of pathogenic microorganisms, increase mucus production and antioxidant properties, and reduce ammonia production (Hashemi and Davoodi, 2011). Several studies using essential oils have shown interesting results, demonstrating their effectiveness in the diet of broilers by improving feed conversion and increasing weight gain (Rizzo et al., 2010; Teixeira et al., 2014; Cho et al., 2014; Koiyama et al., 2014; Fascina et al., 2017).

Because of their recognized beneficial properties, various plant species have the potential to be used in poultry feeding, including cinnamon (*Cinnamomum* spp.) and lemongrass (*Cymbopogon citratus* Stapf).

Cinnamon is an aromatic plant known for over 2500 B.C. and one of the first spices used by humanity. It is native to Sri Lanka and belongs to the family Lauraceae. Its properties include antioxidant, sedative, antiseptic, anti-inflammatory, appetite-stimulating, and digestive effects (Freire et al., 2011).

Lemongrass is originally from India and was introduced in Brazil in the colonial period. It is also popularly known as citronella grass, barbed wire grass, and fever grass. Like cinnamon, lemongrass is also widely used in folk medicine due to its restorative, digestive, analgesic, antipyretic, anti-inflammatory, and calming properties (Costa et al., 2011).

These properties make essential oils extracted from these plants a viable option to be used in poultry feed, as they are innovative, natural products that do not leave residues (Silva et al, 2011). Despite all these benefits, there are few studies evaluating feed

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supplementation for slow-growing broilers, and most of this limited research was carried out with industrial broilers.
Therefore, the present study was undertaken to examine the effects of essential oils on the growth performance and carcass yield of slow-growing broilers reared from 1 to 70 days of age.

MATERIALS AND METHODS

The experiment was conducted from March to May 2018 in the Poultry Section of the Federal University of Acre (UFAC). All procedures were approved by the Ethics Committee on Animal Use (CEUA) of UFAC, Brazil (approval no. 50/2017), and carried out in accordance with guidelines for the use of research animals.

Air temperature data were obtained from the Meteorological Station of UFAC, located in the municipality of Rio Branco - AC, Brazil (9°57'14.3" S and 67°51'44.7" W).
Table 1 shows the minimum, maximum, and average temperatures collected during the experiment developed from March 15 to May 25, 2018.

Table 1. Minimum, maximum, and average air temperatures during the rearing periods.

Period (days)	**Temperature (°C)**		
	Minimum	**Maximum**	**Average**
1 to 7	23.3	32.0	26.2
8 to 14	21.9	30.7	25.2
15 to 21	22.3	31.5	25.9
22 to 28	22.8	31.6	25.7
29 to 70	22.1	30.9	25.2

Source: Duarte (2018).

The study involved 270 one-day-old female chicks of the Vermelho Pesado line vaccinated against infectious bursal disease, Marek’s disease, and fowl pox. All birds were housed in an experimental chick-chicken shed measuring 16 m × 5 m, with 32 partitions of 2 m^2 each, with a usable area consisting of 27 boxes. The floor was covered by a shavings bed with a height of 10 cm and the sides of the shed were protected by curtains. Each partition was equipped with a 100-W incandescent lamp for heating the birds in the initial period of rearing, a pendulum drinker, and a tray-type feeder that was replaced with another semi-automatic type after 15 days of experiment.

The birds were reared in an intensive system in which they received fresh water and feed *ad libitum*. The experiment was laid out in a completely randomized design with three treatments and nine replicates, totaling 27 experimental plots, with 10 animals each.
Treatments consisted of a diet without essential oil (control) and diets with the addition of cinnamon essential oil (37.5 ppm) and lemongrass essential oil (37.5 ppm) (Koiyama et al., 2014).
The diets were isonutritive and isoenergetic, maize- and soybean meal-based, and prepared according to the nutritional levels recommended by Rostagno et al. (2011) (Table 2).

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Table 2. Guaranteed levels of chemical components in the experimental diets.

Component (%)	Age (days) Idades (dias)	
	1 to 30	31 to 70
Moisture (max.)	12	12
Crude protein (min.)	19	17
Ether extract (min.)	30	30
Crude fiber (max.)	50	50
Ash (max.)	110	110
Calcium (min.)	0.7	7
Calcium (max.)	1.5	15
Phosphorus (min.)	0.6	0.6
Sodium (min.)	0.014	0.014
Folic acid (min.)	0.00006	0.00005
Pantothenic acid (min.)	0.0008	0.0008
Biotin (min.)	0.000006	3E-06
Copper (min.)	0.00063	0.0006
Choline (min.)	0.000035	0.025
Iron (min.)	0.00525	0.005
Iodine (min.)	0.000126	0.00012
Manganese (min.)	0.007	0.006
Methionine (min.)	0.000216	0.00017
Niacin (min.)	0.0032	0.0024
Selenium (min.)	0.00003	0.00003
Zinc (min.)	0.0063	0.006

The essential oils were first incorporated into a portion of the diet and, after their complete homogenization, the rest of the feed to be supplied to the animals was mixed. To minimize the effects of volatilization of essential oils, this procedure was performed daily.

At 14, 28, 42, 56, and 70 days, birds and orts were weighed to measure the following performance parameters: feed intake (kg), live weight (kg), feed conversion (kg/kg), and feed efficiency (kg/kg). Animals that died during the experiment were weighed to determine production viability (Viability (%) = 100 – % mortality).

To evaluate carcass yield, one bird with average weight representative of the experimental unit was separated per replicate, for each treatment. The birds

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were fasted for 12 h and on the following day (71 days) they were stunned and slaughtered by jugular vein section, followed by scalding, plucking, and evisceration. The yields of carcass, abdominal fat, primal cuts (breast, drumsticks, thighs, and wings), and internal organs (liver, gizzard, heart, bursa of Fabricius, spleen, and intestines) were also evaluated.

Carcass yield was calculated as the ratio between clean carcass weight (without feet and head) and fasted live weight. The yields of breast, drumsticks, thighs, and wings were calculated as the ratio between the weight of these parts and clean carcass weight. The proportion of abdominal fat and internal organs (liver, gizzard, heart, bursa of Fabricius, spleen, and intestines) was obtained as the ratio between the weight of these parts and organs relative to fasted weight.

Growth performance and yield data were subjected to analysis of variance (ANOVA). When significant differences were found between treatments, the Scott-Knott mean comparison test was performed at the 5% significance level.

RESULTS AND DISCUSSION

Table 3 shows the live weight, feed intake, feed conversion, and production viability results.

There were no significant differences for feed intake between treatments (P>0.05), in any of the rearing periods. A major concern is that the addition of essential oils could cause a reduction in feed intake by birds, as observed by Alçiçek et al. (2003), who described a reduction in the intake of birds that received a diet with a mixture of essential oils of oregano, bay leaf, sage, fennel, and citrus. As in this study, Azevedo et al. (2017) did not find significant differences in an experiment evaluating the feed intake of broilers (Cobb) that received diets supplemented with 120 mg of lemongrass essential oil. Qotbi (2016), in turn, observed that in the period from 1 to 21 days, Ross 308 birds exhibited a higher feed intake when treated with 200 ppm of cinnamon extract.

Table 3. Live weight, feed intake, feed conversion, and viability.

	Period (days)				
	1-14	1-28	1-42	1-56	1-70
			Live weight (kg)		
Treatment					
Control	0.183 b	0.499 b	1.022 b	1.607 a	2.201 a
Cinnamon	0.182 b	0.505 b	1.018 b	1.601 a	2.192 a
Lemongrass	0.190 a	0.533 a	1.086 a	1.672 a	2.233 a
CV (%)[1]	3.76	5.03	4.84	4.50	4.20
SEM[2]	±0.185	±0.008	±0.016	±0.024	±0.030
			Feed intake (kg)		
Treatment					
Control	0.291 a	0.969 a	2.142 a	3.641 a	5.489 a
Cinnamon	0.290 a	0.956 a	2.090 a	3.551 a	5.352 a
Lemongrass	0.298 a	0.977 a	2.106 a	3.611 a	5.450 a

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CV (%)[1]	2.82	5.81	5.33	4.15	4.32
SEM[2]	±0.003	±0.019	±0.037	±0.049	±0.078
			Feed conversion (kg/kg)		
Treatment					
Control	1.587 a	1.940 a	2.094 b	2.266 b	2.495 a
Cinnamon	1.598 a	1.896 a	2.054 b	2.218 b	2.440 a
Lemongrass	1.568 a	1.836 a	1.941 a	2.161 a	2.442 a
CV (%)[1]	3.00	5.21	4.26	3.26	3.17
SEM[2]	±0.158	±0.032	±0.028	±0.024	±0.025
			Production viability (%)		
Treatment					
Control	97.78 a	97.78 a	96.67 a	96.67 a	96.667 a
Cinnamon	100 a	98.89 a	98.89 a	98.89 a	98.89 a
Lemongrass	100 a	100 a	100 a	100 a	100 a
CV (%)[1]	2.56	3.23	3.52	3.52	3.52
SEM[2]	±0.848	±1.063	±1.156	±1.156	±1.156

*Means followed by the same letter in the column do not differ by the Scott-Knott test (P>0.05).
*Means followed by different letters in the column differ by the Scott-Knott test (P<0.05).
[1] Coefficient of variation; [2] Standard error of the mean.

At 14, 28, and 42 days of age, live weight differed significantly ($p < 0.05$), with higher results occurring in the group fed lemongrass essential oil than in those which received cinnamon essential oil. However, at 56 and 70 days, the treatment with lemongrass essential oil did not maintain this result. Koiyama et al. (2014) also observed good performance with the use of phytogenic additives in the initial and intermediate stages of rearing and, similarly to the present study, they reported a decrease in the effectiveness of the compounds in the final period. According to these authors, the beneficial action of phytogenic additives on broiler performance is age-dependent. Thus, the absence of a significant effect of lemongrass essential oil on live weight in the final stages of rearing may be related to the decrease in the nutritional requirements of birds with age and the development of their organs and digestive system. In addition, the response seen in the experiment suggests that there was a compensatory gain in the other treatments in the final production stages.

As in this study, Mukhtar et al. (2012) also observed that the inclusion of different levels of *Cymbopogon citratus* essential oil in the diet resulted in higher body weight in Ross (308) broilers when compared with the treatment without additives. On the other hand, the body weight of birds supplemented with cinnamon essential oil was similar to that of birds fed the control diet throughout the rearing period. The results of this study were similar to those observed by Barreto et al. (2008), who did not find statistically significant differences in the live weight of Cobb broilers fed diets supplemented with 1000 ppm cinnamon essential oil. According to Thayalini et al. (2011), the differences in performance between the cinnamon and lemongrass essential oil groups in this

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experiment can be explained by variations in the quality of the plants present in the essential oils and the rates used.

Birds that received diets containing lemongrass essential oil showed better feed conversion (P<0.05) from 1 to 42 and 1 to 56 days of age (Table 3). Considering that this parameter is dependent on body weight and feed intake, this improvement was possibly due to the lower feed intake and higher body weight of the birds in the treatment with lemongrass essential oil, which resulted in an improved feed conversion during these stages of rearing. For Brenes and Roura (2010), the inclusion of phytogenic additives in poultry feed leads to a reduction in feed intake with practically unchanged final body weight, resulting in a better feed conversion rate, which may be a consequence of better utilization of the diet nutrients. Toghyani et al. (2011) compared the effect of diets containing antibiotics (flavophospholipol) or essential oils of cinnamon and garlic extract and observed that in the period from 14 to 29 days, birds of the Ross line that received the treatment with the essential oil showed better feed conversion than the control group. In the study by Azevedo et al. (2017), however, there were no significant differences in the feed conversion of Cobb broilers fed diets containing microencapsulated essential oils of *Cymbopogon flexuosus* and *Lipia rotundifolia* alone or combined.

The inclusion of essential oils did not influence the birds' production viability, which was high (98 to 100%). This is likely due to the good sanitary conditions in which the animals were raised, which also explains the absence of significant results between treatments. According to Fernandes et al. (2015), the action of performance-enhancing additives, including phytogenic additives such as essential oils, is more effective when birds are subjected to sanitary challenge conditions, such as high population density, high risk of contamination, poor hygiene, or exposure to diseases. As in this study, Noleto et al. (2018) also found no significant differences in the production viability of broilers fed diets containing diesel tree (*Copaifera langsdorffii*) or sucupira (*Pterodon emarginatus*) essential oils in all rearing periods. The authors highlighted the lack of a sanitary challenge as a reason for the results. Hajati et al. (2011), in turn, found that pumpkin (*Cucurbita pepo*) oil reduced broiler mortality, without having any adverse effect on bird performance.

Table 4 describes the effect of supplementation with essential oil on the yields of carcass, primal cuts (breast, thighs, drumsticks, and wings), and abdominal fat of the broilers.

Table 4. Yields of carcass, breast, drumsticks, thighs, wings, and abdominal fat of slow-growing broilers fed a diet containing cinnamon essential oils or lemongrass at 71 days.

Treatment*	Carcass	Breast	Drumsticks	Thighs	Wings	AF
Control	72.460 a	26.513 a	14.714 a	12.758 b	12.524 a	2.555 a
Cinnamon	71.925 a	26.479 a	15.005 a	14.120 a	12.413 a	2.734 a
Lemongrass	72.546 a	26.425 a	15.042 a	14.654 a	12.074 a	2.992 a
CV (%)[1]	2.91	6.06	7.35	9.83	7.14	26.59
SEM[2]	±0.701	±0.534	±0.365	±0.453	±0.293	±0.244

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*Means followed by the same letter in the column do not differ by the Scott-Knott test (P>0.05).
[1]Coefficient of variation.
[2]Standard error of the mean.

Among the analyzed variables, only thigh yield was affected by the inclusion of cinnamon and lemongrass essential oils in the diet (P<0.05). A similar fact was described by Koiyama et al. (2014), who did not observe differences in carcass yield; however, the drumstick + thigh yield was significantly higher in the treatment with a mixture of essential oils of rosemary, clove, ginger, oregano, cinnamon, sage, white thyme, and copaíba oil-resin. Najafi and Torki (2010) found that treatment with cinnamon essential oil provided the best drumstick yield. Khattak et al. (2014), in turn, observed higher carcass and breast yields in animals treated with a commercial combination of essential oils of basil, cumin, bay leaf, lemon, oregano, sage, tea, and thyme, compared with the feed without additives. According to Teixeira et al. (2013), the better performance for some carcass traits with the use of essential oils (cinnamon and lemongrass) described in this study may have been due to the action of these additives as a reducer of immune stress, which improves the integrity of the intestinal mucosa and provides better use of dietary nutrients for muscle growth.

Table 5 shows the yields of internal organs, which did not differ between treatments (P>0.05). Kırkpınar et al. (2010) worked with a control diet and diets with essential oils of oregano, garlic, or a mixture of both and did not find differences in the relative weight of organs. Gomathi et al. (2018) made similar observations regarding the yields of liver, gizzard, and heart when cinnamon essential oil was added to the broilers' diet.

Table 5. Yields of gizzard, liver, heart, intestines, bursa of Fabricius, and spleen of slow-growing broilers fed a diet containing essential oils of cinnamon or lemongrass at 71 days of age.

Treatment*	Gizzard	Liver	Heart	Intestines	Bursa	Spleen
Control	1.672 a	1.487 a	0.498 a	3.406 a	0.325 a	0.141 a
Cinnamon	1.723 a	1.522 a	0.443 a	3.443 a	0.298 a	0.146 a
Lemongrass	1.804 a	1.540 a	0.457 a	3.400 a	0.338 a	0.146 a
CV (%)[1]	16.06	11.49	16.69	11.8	31.85	41.21
SEM[2]	±0.092	±0.058	±0.466	±0.134	±0.034	±0.144

* Means followed by different letters in the column differ by the Scott-Knott test (P<0.05).
[1]Coefficient of variation.
[2]Standard error of the mean.

CONCLUSIONS

Diet supplementation with lemongrass essential oil at a concentration of 37.5 ppm improves performance rates in the starter and grower phases. The inclusion of cinnamon or lemongrass essential oils improves thigh yield.

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