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Effect of *Anacardium occidentale, Ricinus communis* and *Spirulina* sp. on the diets of broiler chickens

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The use of antibiotics as a growth promoter was banned because of residues that are left in animal products. Alternatives to antibiotics that promote animal growth and health without leaving residues in food are being sought. An experiment was conducted to evaluate the effects of a commercial mixture of functional oils and algae (FOA) on growth and gut morphology in broiler chickens. A total of 224 one day-old Cobb male broilers were randomly divided into 2 dietary treatment groups, with 8 replicate pens per treatment group (14 birds each). The dietary treatments consisted of a control basal diet without FOA, or control diet plus 1.50 kg/ton of FOA. The FOA was a commercial mixture of castor oil plant *(Ricinus communis* L.), Cashew nut oil (*Anacardium occidentale* L.) and spirulin (*Spirulina* sp.). Body weight and viability were not significantly influenced by treatments (P>0.05). Feed intake and feed conversion rate improved significantly upon the use of FOA (P<0.05). Villus height, villus width, crypt depth, or crypt diameter were not influenced by treatments. This therefore suggest that the use of FOA improves performance parameters in broiler chickens and is economically viable.

Key words: *Anacardium occidentale*, body weight gain, feed conversion rate, villus height, *Ricinus communis.*

INTRODUCTION

Feed additives have been used in the poultry industry for several decades. A number of additives, including antibiotics, have been used to manipulate gut function and microbial habitat with the objective of improving growth performance and feed conversion rate. However, growing concerns that antibiotic use could leave residues in animal products and increase resistance of disease-causing microorganisms in humans led to decisions on their being banned as a feed additive. This also accelerated research on feed additive alternatives in animal production. In addition, consumers are demanding animal products that are free of residues and have minimal impact on the environment.

In the search of alternatives to antibiotics, several

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natural alternatives such as probiotics, prebiotics, organic acids, enzymes, essential oils, and functional oils have been developed. As one of the alternatives, functional oils are used to improve only growth and reduction of pathogenic bacteria. Unlike essential oils which are obtained from plants oils (herbs) or spices, functional oils are obtained from seeds that have some added benefits and further energy value. (Bess et al., 2012). Their mode of action is similar to that of ionophores, inhibit resistant bacterial and provide antimicrobial, antioxidant, and anti-inflammatory properties.

Castor oil bean (*Ricinus communis*) and Cashew oil (*Anacardium occidentale*) are a by-product of the castor and cashew oil extraction industry, respectively. Castor oil is a Euphorbiaceae used primarily in the cosmetic industry. The world's largest castor oil producers are India, China and Brazil. Castor oil is rich in ricinoleic acid, and chemical reactions involving this acid yield numerous compounds (Oliveira, 2012). The cashew is a tropical plant from north and from northeast Brazil belonging to the Anacardiaceae family. Cashew is rich in vitamin C, calcium, and iron, and is used primarily in some cuisines. Cashew oil (*Anacardium occidentale*) extracted from cashew fruit is composed of anacardiol acids, cardol and cardanol, which give an antioxidant effect to the oils extracted (Oliveira, 2012)

Recent studies have shown that adding castor and ricinus oils to poultry diet increased the growth performance and related antimicrobial and anti-inflammatory effects (Bess et al., 2012). In addition, castor oils in broiler diets reduce *Escherichia coli* present in the gut (López et al., 2012). Castor and ricinus oils added to broiler diets improves growth performance, metabolizable energy, and gut morphometry (Murakami et al., 2011). In addition, ricinus meals and oil do not negatively influence the growth performance, nutrient digestibility, or gut morphology of broiler chickens (Sobayo et al., 2012). In broiler chickens affected with coccidiosis, the functional oils improve energy utilization and survival rate and decrease lesions caused by coccidiosis in supplemented birds (Murakami et al., 2014).

Other substances, such as algae, may also contribute to an improvement in the health and performance of animals. Algae have antioxidant properties, and can stimulate the immune system. Also, algae can be utilized as an alternative ingredient to other protein sources because they are rich in amino acids (Becker, 2007), and in some instances, they can work as source of calcium (Souza, 2012), thus reducing feed cost when used as an alternative to other protein sources. The high demand for substitutes to antibiotics in poultry has triggered extensive research in this field. The current study aim to evaluate the effect of commercial mixtures made of functional oils and algae on the growth performance and the commercial mixture's cost and benefit when applied to rearing of broiler chickens.

MATERIALS AND METHODS

This experiment was approved by the Ethics Committee on Animal Use at Federal Technologic University of Parana, UTFPR, Dois Vizinhos, Paraná, Brazil, Protocol number: 2014-006. A total of 224 one day-old male Cobb broiler chickens were obtained from a commercial hatchery - Pluma Agro Avícola, Dois Vizinhos, PR, Brazil. The birds were weighed at a day-old and sorted by body weight into litter-floor pens of identical size (1 m^2). The initial average Body Weight (BW) for all pens was 44.8 g. The dietary treatments consisted of control diet, plus a commercial mixture of functional oils with algae (FOA) (1.5 kg/ton), with 8 replicates of 14 birds each. The test product was a mixture of castor oil plant *(R. communis* L.), Cashew nut oil (*A. occidentale* L.) and spirulin (*Spirulina* sp.) from Natupremix LDTA. The feeding program consisted of a pre-starter diet, which was fed until 7 days of age; a starter diet which was fed from day 8 to 21; grower diet, which was fed from day 22 until 39; and finisher diet, which was fed from day 40 until 42 (Table 1). The diets were formulated to meet the requirements recommended by Rostagno et al. (2011) for broiler chickens.

The water and feed were *ad libitum*, and all diets were fed as mash. The feeder space for 50 old birds was provided as recommended by manufacturer. The light regimen was as follows: day 1 to 7, 23L:1D; day 8 to 21, 20L:4D; day 22 to 28, 14L:10D; day 29 to 35, 18L:6D; and day 36 to 42, 23L:1D (Moraes et al., 2008). The light intensity (lx) was reduced from 20lx from day 1 to 7 to 10-5lx from day 8 to 42 in accordance with standard management practice of Cobb manual. The temperature was reduced gradually from 32°C at beginning of the study to approximately 20°C at the end of the experiment and in accordance with standard management practice of Cobb manual.

Data on body weight (BW) and feed consumption were measured on weekly basis and used to calculate the weight gain, feed intake, and feed conversion ratio. Mortality was recorded as it occurred. The economic viability was calculated according to Sogunle et al. (2014). At the end of the feeding trial (day 42), 1 bird per pen (8 birds/diet) was euthanized by cervical dislocation. Intestinal segment samples (approximately 3 cm in length) of duodenum, jejunum, and ileum were excised and flushed with 0.9% saline to remove the contents. For histology, gut segments were fixed in solution containing 85 ml of 80% ethanol, 15 ml of formaldehyde (37-40%), and 5 ml of glacial acetic acid for 16 hours. The segments of intestine collected were first section of the duodenum, a midpoint between the bile duct entry and Meckel's diverticulum (jejunum), and midway between Meckel's diverticulum and the ileocecal junction (ileum). Samples were dehydrated, cleared, and paraffin-embedded. Intestinal segments from 8 birds per dietary treatment were sectioned at a 5-µm thickness, placed on glass slides, and processed in Leica's trichrome stain, the histological sections were stained with hematoxylin and eosin (HE) as described by Gava (2012).

The morphometric indices evaluated were villus height, villus width, crypt depth, and crypt diameter, according to Gava (2012). Morphometric investigations were performed on 5 intact villi and 5 crypts from each intestinal segment of broiler chickens per treatment. All parameters were analyzed with an ANOVA, as a completely randomized design using the Statistix® software at $P<0.05$.

RESULTS AND DISCUSSION

The growth performance parameters are listed in Table 2. No treatment differences ($P>0.05$) were observed on body weight gain (BWG) and viability overall. However,

Table 1. Composition of experimental diets.

Ingredient (%)	Pre-starter d 1-7	Starter d 8-21	Grower d 22-39	Finisher d 40-42
Maize	57.5	64.3	67.1	69.4
Soybean meal (48% CP[1])	31.8	25.3	22.7	20.5
Soybean oil	0.7	1.1	1.6	2.2
Meat and bone meal (45% CP SPF[2])	7.6	6.9	6.2	5.5
Vitamin and mineral premix[3]	2.4	2.4	2.4	2.4
Calculated chemical composition				
AMEn[4] (kcal/kg)	2926.25	3028.72	3090.93	3143.72
CP (%)	23.05	20.38	19.10	17.76
Fiber (%)	3.35	3.15	3.06	2.98
Lysine (%)	1.47	1.27	1.17	0.99
Methionine (%)	0.64	0.61	0.58	0.46
Threonine (%)	1.47	1.27	1.17	0.99
Calcium (%)	1.16	1.06	0.998	0.931
Phosphorus (%)	0.524	0.478	0.474	0.471
Sodium (%)	0.233	0.228	0.216	0.204
Linoleic acid (%)	1.78	2.06	2.35	2.69

[1]CP: crude protein. [2]SPF: Specific Pathogen Free. [3]Supplied per kilogram of diet, initial: vitamin A, 562.5 KUI; vitamin D3, 156.25 KUI; vitamin E, 1.25 g/kg; vitamin K3, 0.16 g/kg; vitamin B1, 0.13 g/kg; vitamin B2, 0.38 g/kg; vitamin B6, 0.19 g/kg; pantothenic acid,0.75g/kg; folicacid, 0.09% g/kg; vitamin B12, 0.94 mg/kg; iodine, 0.00147%; selenium, 0,00156%; copper, 0.04; manganese, 0.24%; zinc, 0.27%; iron, 0.24%; cupper, 0.04 mg; manganese, 0.24 %.Supplied per kilogramof diet, grower: vitamin A, 431.25 KUI; vitamin D3, 119.79 KUI; vitamin E, 0.96 g/kg; vitamin K3, 0.12 g/kg; vitamin B1, 0.10 g/kg; vitamin B2, 0.29 g/kg; vitamin B6, 0.14 g/kg; pantothenicacid, 0.58 g/kg; folicacid, 0.07 g/kg; vitamin B12, 0.72 mg/kg; iodine, 0.00417 %; selenium, 0.00120 %; copper, 0.04 %; manganese, 0.35 %; zinc, 0.27 %; iron, 0.00417 %.cupper, 0.04 mg; manganese, 0.24 %. Supplied per kilogram of diet, finisher: vitamin A, 300; vitamin D3, 83.33; vitamin E, 0.67; vitamin K3, 0.08; vitamin B1, 0.07; vitamin B2, 0.20; vitamin B6, 0.10; pantothenic acid, 0.40; folic acid, 0.05; vitamin B12, 0.50; iodine, 0.00417 %; selenium, 0.00083 %; copper, 0.04 %; manganese, 0.46 %; zinc, 0.27 %; iron, 0.00417 %; cupper, 0.27 %; manganese, 0.46%. [4]AMEn: Apparent Metabolizable Energy corrected for nitrogen.

Table 2. Effect of functional oil and algae on growth performance of broiler chickens.

Variable	Control	FOA	P value
Feed consumption, g			
1-7d	177.7	167.6	ns
7-14d	370.7	328.4	ns
14-21d	671.8[a]	608.5[b]	0.0396
21-28d	1077.0[a]	941.2[b]	0.0002
28-35d	1356.5[a]	1247.7[b]	0.0073
35-42d	695.7	668.2	ns
1-42d	4349.2[a]	3961.5[b]	0.0019
Body weight gain, g			
1-7d	132.1	132.0	ns
7-14d	266.9[b]	291.2[a]	0.0006
14-21d	404.7[a]	292.8[b]	0.0002
21-28d	694.0	667.6	ns
28-35d	771.5	792.6	ns
35-42d	676.8[b]	816.4[a]	<0.0001
1-42d	2946.0	2992.7	ns
Feed conversion, g:g			
1-7d	1.34	1.27	ns
7-14d	1.39[a]	1.13[b]	0.0092
14-21d	1.67[b]	2.11[a]	0.0028

Table 2. Contd.

21-28d	1.55^{a}	1.41^{b}	0.0157
28-35d	1.75^{a}	1.58^{b}	0.0491
35-42d	1.02^{a}	0.82^{b}	0.0003
1-42d	1.47^{a}	1.32^{b}	0.0003
Viability, %			
1-42d	98.2	93.8	ns
Cost benefit to FOA			
Cost of feed intake per bird per day, R$	1.18	1.06	-
Cost of feed intake per weight gain, R$	0.40	0.35	-

a-bValues in the same row with different superscript are significantly different (P<0.05); NS: P>0.05.

Table 3. Villus height, villus width, crypt depth, crypt diameter in duodenum, jejunum and ileum in chickens fed with or without FOA.

Treatments	Control	FOA	P value
Duodenum			
Villus height, µm	990.45	985.17	ns
Villus width, µm	187.85	182.07	ns
Crypt depth, µm	251.14	207.53	ns
Crypt diameter, µm	47.36^{a}	38.32^{b}	0.0179
Jejunum			
Villus height, µm	846.7	861.35	ns
Villus width, µm	156.08	167.35	ns
Crypt depth, µm	191.13	227.51	ns
Crypt diameter, µm	39.87	43.08	ns
Ileum			
Villus height, µm	693.09	728.9	ns
Villus width, µm	161.58	161.71	ns
Crypt depth, µm	181.39	185.05	ns
Crypt diameter, µm	45.64	42.8	ns

a –b Values in the same row with different superscript are significantly different (P<0.05); NS: P>0.05.

low body weight gain in birds fed with FOA compared to control diets from 14 to 21 days of age was observed. Therefore, part of this reduction in BWG in birds supplemented with FOA could be attributed to dietary energy levels, since the product was added on top and this could reduce feed intake resulting in lower BWG. In addition, spirulin resulted to a reduced feed intake in rats Mitchell et al. (1990) and broilers Kharde et al. (2012), and could negatively affect the BWG results in this study. These results on growth performance are not in agreement with the results obtained by Bess et al. (2012), where birds supplemented with castor oils–CNSL mixture showed improved BWG. The viability results are not in agreement with those of Murakami et al. (2014) who observed that birds challenged with coccidiosis, when supplemented with functional oils improved in viability.

Feed intake and feed conversion rate (FCR) were significantly affected by the dietary treatments (P<0.05). Birds fed with FOA had lower feed intake and feed conversion ratio compared to control diet (Table 2). This result is in consonance with the findings of Bess et al. (2012) who observed an improvement in feed conversion ratio in birds supplemented with castor oils–CNSL mixture, which showed an improvement in FCR. The reduction of feed consumption was visible on feeders during the experiment and affected the BWG within the 14-21day old chicks. The economic feasibility result (Table 2) showed that it is feasible to use FOA poultry diets, since the cost of feed intake per body weight gain was 0.05 cents lower and the cost of feed intake per bird per day was 0.12 cents lower when birds were fed supplementary FOA compared to control diet.

No differences (P>0.05) were observed in villus height, villus width, crypt depth, or crypt diameter between treatments (Table 3). An exception was a crypt diameter in the duodenum (P<0.05), which was lower when birds were fed supplementary FOA than when they were fed the control diet (Table 3). These results are not in agreement with those reported by Murakami et al. (2014) that observed higher villus height in jejunum for birds supplemented with functional oils on 14 days. Since functional oils have antimicrobial properties, these could decrease microbial effects and improve performance parameters. Thus, functional oils may act as growth promoters by eliminating some pathogenic bacteria from the gastrointestinal tract.

Conclusion

The present study suggests that FOA is a useful feed additive for broiler chickens and it could be included in broiler diets to improve growth performance. The addition of FOA in the diets of broiler chickens till 42 days of age is economically feasible because it reduced the cost of feed intake of 0.12 cents of a bird per day. Further investigations are needed to evaluate better dose of FOA from 14 to 35 days of age, to reduce the negative effect on weight gain and feed intake.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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