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Essential Oil Blend Containing Capsaicin, Carvacrol and Cinnamaldehyde in Broiler Production Performance and Intestinal Morphometrics

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Abstract**—**The aim of this study is to evaluate the effect of supplementing broiler starter diet with different levels of an essential oil blend (EOB) containing capsaicin, carvacrol and cinnamaldehyde on the performance of broilers. A total of 300 day-old straight-run Cobb broiler chicks were randomly assigned to three treatments after 7-day group brooding following a completely randomized design (CRD). Birds assigned in treatment 1 were given starter basal diet while those in treatments 2 and 3 were given starter basal diet with 400 mg/kg antibiotic growth promoter (AGP) and 150 mg/kg EOB, respectively, until the 28th day. Basal finisher feed were given for all the treatments until harvest. Following 37 d feeding, body weight gain, feed consumption, feed efficiency, dressing percentage, livability and jejunal villi height were determined. Results showed no significant differences (P>0.05) in growth performance. However, villi height and crypt depth was significantly lower for birds fed EOB.

Keywords**—**Broiler, capsaicin, carvacrol, cinnamaldehyde, essential oil.

I. Introduction

CONTROVERSIES on the presence of antibiotic residues and microbial resistance to antibiotics arose and prompted the emergence of non-antibiotic growth promoters (NAGPs) in the market. In fact, most European countries shifted to NAGPs or so-called "greener" alternatives and banned on antibiotic use as growth promoters. Limitations in antibiotic use in Sweden started in 1986 and in Denmark in 2000 [5], [12]. Both countries have been successful in removing its dependence on AGPs that is from over hundreds of metric tons to nil. This led to the evolution of a number of alternatives to AGPs including essential oils (EOs). These are secondary plant metabolites known to exhibit inhibitory effect against bacteria, fungi, and viruses and serve as defense mechanism for the plant. These compounds are volatile in nature responsible for the characteristic odor in many plants [1]. The primary functions of essential oils in animal feeding include stimulation of digestive juices [26], improvement of gut integrity [4], inhibition of bacterial growth [23], and enhance immune response [14], [16]. Furthermore, recent studies have also demonstrated the use of capsaicin, carvacrol and cinnamaldehyde as alternative to AGPs. Studies reveal that any one or a combination of the said essential oils led to improvement in growth and feed efficiency of broilers and fattening pigs and feed intake [13], [18], [23], [24], [30], [32]. Although numerous studies show the benefits of using essential oils in broiler production, different blends or mixes are available for farm users and studies in tropical systems such as in the Philippines are limited.

The aim of the present study is to assess the effect of an essential oil blend containing capsaicin, carvacrol and cinnamaldehyde on the production performance of broilers.

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II. Materials and Methods

A. Animals and Housing

Three hundred day-old straight-run Cobb broilers were used in the study. The study was conducted in a conventional open sided broiler house with elevated pens at the Animal and Dairy Sciences Cluster Farm in Los Banos, Laguna, Philippines. The study was conducted from February to April 2014.

Birds were group-brooded for 7 days and were distributed randomly to 30 pens with 10 birds per pen. Three dietary treatments were randomly assigned to each pen following CRD. Each treatment was replicated 10 times.

B. Diet

The dietary treatments were: 1) basal diet, 2) basal diet + 400 mg kg^{-1} AGP, and 3) basal diet + 150 mg kg^{-1} EOB. The essential oil blend used was a commercially available product composed of capsaicin from 2% capsicum, 5% carvacrol and 10% cinnamaldehyde. The ingredient and nutrient composition of the basal diet are presented in Table I. Feed was offered in mash form. Feed and water were offered *ad libitum*.

C. Data Collection

Body weight, feed intake and F:G were measured at day 28 and 37 days. Livability was recorded daily and was adjusted to the total number of birds to determine the total feed intake per bird. Dressing percentage was determined at 37 days of age using 10 birds per treatment. Jejunal villi height was also determined with 2 birds per treatment at 28 and 37 days.

D. Statistical Analysis

All data were subjected to analysis of variance in the mixed model (one-factor analysis of variance procedure) using the statistical software SAS 9.1.3 (SAS, 2009: SAS Institute Inc.,

Cary, NC, USA). Posthoc analyses were carried out to determine differences between treatments using Least Significant Difference with alpha = 0.05.

TABLE I
INGREDIENT COMPOSITION AND CALCULATED NUTRIENT CONTENT OF BASAL BROILER DIETS SUPPLEMENTED WITH AGP/EOB[1]

INGREDIENTS	AMOUNT (%)		
	Booster	Starter	Finisher
Corn, Yellow	53.85	59.48	64.44
Soybean oil meal, US	39.00	33.74	28.78
Coconut Oil	3.00	3.00	3.00
Limestone	1.30	1.70	1.60
Mono-dicalcium Phosphate	1.90	1.15	1.25
DL-methionine	0.35	0.32	0.30
Vitamin Premix[2]	0.13	0.13	0.13
Mineral Premix[3]	0.12	0.12	0.12
Salt	0.25	0.25	0.25
L-Lysine	0.10	0.11	0.13
Total	100	100	100
Guaranteed Analysis (as fed)			
Metabolizable Energy, kcal/kg	3039	3151	3103
% Crude Protein	22.31	21.82	18.00
% Crude Fiber	5.20	5.39	5.51
% Crude Fat	2.79	2.80	3.51
% Methionine + Cysteine	1.00	1.00	0.93
% Methionine	0.71	0.66	0.60
% Lysine	1.44	1.25	1.14
% Calcium	1.00	0.91	0.89
% Available Phosphorus	0.49	0.44	0.45
% Total Phosphorus	0.79	0.62	0.62

[1] Starter diets were supplemented with Antibiotic Growth Promoter (400 mg kg^{-1}) and Essential Oil Blend (150 mg kg^{-1}).

2 per kg premix contains : Vitamin A (50,000,000 IU); Vit D3 (90,000,000 IU); Vit E (200,000 mg); Vit K (9,000 mg); Vit B2 (22,000 mg); Vit B6 (14,000 mg); Vit B12 (100 mg); Niacin (150,000 mg); Pantothenic acid (70,000 mg); Biotin (1,000 mg); Folic acid (10,000 mg).

3 per kg premix contains : Iron (125 g); Copper (7.5 g); Manganese (25 g); Zinc (125 g); Cobalt (0.5 g); Iodine (0.175 g); Selenium (0.3 g); Anticake (10 g); Carrier (1 g).

III. RESULTS AND DISCUSSION

The performance of broilers fed diet supplemented with AGP/EOB is summarized in Table II. No significant difference (P>0.05) were observed in BW gain, feed intake and feed efficiency and dressing percentage of broilers.

Although not significant, body weight and gain of birds fed diets with AGP or EOB at 28 days of age was better than those fed BD. These could be due to the reported ability of plant extracts to stimulate enzymatic action and improve the use of the nutrients from the diet of birds and pigs [2], [8], [19], [21], [31]. However, the effect of EOB at 37 days was reduced. The withdrawal of EOB at day 29 had no carry over effect on the succeeding days.

No statistical differences (P>0.05) were detected with feed consumption of birds fed supplemented treatments. These suggest that the AGP and EOB have no effect on feed consumption of broilers. However, studies of essential oils primarily from cinnamaldehyde and capsaicin were reportedly able to stimulate digestive secretions such as saliva, pancreatic secretions and bile with consequent improvement in feed consumption [25], [26], which was not observed in this study.

Feed efficiency is a function of feed intake and liveweight gain, however, no difference was observed in the said parameters. References [17] and [22] observed the same results. On the other hand, improvements on feed efficiency were reported as in [2], [3], [8], [9], [20]. The observed significant effect of essential oils in feed efficiency in related studies was due to increased feed intake and consequent increase in nutrient intake that can be used for metabolic functions and weight gain. However, this was not observed in the study.

TABLE II
PRODUCTION PERFORMANCE OF BROILERS FED STARTER DIETS SUPPLEMENTED WITH AGP/EOB[1]

PARAMETER	TREATMENT			P-value
	BD	BD + AGP	BD + EOB	
Body Weight, kg				
7 days	0.12	0.12	0.12	0.5052
28 days	1.00	1.03	1.02	0.7694
37 days	1.86	1.78	1.72	0.6544
Feed Consumption, g				
8-28 days	1788	1767	1740	0.9013
28-37 days	1383	1298	1268	0.5316
8-37 days	3508	3249	3177	0.4853
Gain, g				
8-28 days	858	894	885	0.7022
28-37 days	738	693	641	0.6039
8-37 days	1596	1587	1526	0.8071
F:G				
8-28 days	2.08	1.99	1.97	0.4589
28-37 days	1.98	1.92	2.06	0.7156
8-37 days	2.19	2.05	2.10	0.4083
Mortality, %	0.08	0.04	.04	0.3811
Dressing, %	65.41	65.50	66.88	0.6167

[1] Starter diets were supplemented with Antibiotic Growth Promoter (400 mg kg^{-1}) and Essential Oil Blend (150 mg kg^{-1}).

Mortality was not significantly different among treatments. References [3] and [7] also noted similar results. This suggests that the AGP and EOB have comparable effects on livability of broilers. It is also important to note that no microbial challenge was introduced in the flock.

Statistical analysis revealed no significant difference (P>0.05) on dressing percentage among treatments. These findings agree with the results of [3], [15] who found no differences in dressing percentage of broilers fed essential oil supplements. Reference [3] also reported that organ weights were not affected by supplementation of essential oils. In contrast, significant difference was reported as in [2] on broilers dressing percentage with diets supplemented with essential oils at 48 mg/kg.

The results suggest that the supplementation of diet with EOB did not affect the dressing percentage of broilers. However, the numerical differences observed could be partly due to the reported effect of phenols such as carvacrol that could increase turnover rate of intestinal epithelial cells to

twice of normal thereby reducing intestinal weight and thinning of the intestinal wall [11], [16].

The effect of AGP/EOB supplementation of broiler starter diets on the jejunum villi height is shown in Table III. No significant difference was observed in villi height and crypt depth of birds; however, the villi:crypt ratio was significantly lower for birds fed diets with EOB at 28 days.

TABLE III
INTESTINAL MORPHOMETRY OF BROILERS FED STARTER DIETS SUPPLEMENTED WITH AGP/EOB[1]

PARAMETER	TREATMENT			
	BD	BD + AGP	BD + EOB	P-value
Villi height, mm				
28 days	0.91	0.82	0.72	0.1884
37 days	0.83	0.68	0.58	0.1678
Crypt depth, mm				
28 days	0.14	0.12	0.14	0.2599
37 days	0.18[a]	0.22[a]	0.13[b]	0.0145
Villi height: Crypt depth				
28 days	6.50[ab]	6.86[a]	5.14[b]	0.0815
37 days	4.72	3.24	5.11	0.3443

The villi height indicates the absorption capacity of the intestine, wherein an increase in the villi height subsequently increases the absorption area, thus improving the use of the nutrients [28]. Shorter villi and deeper crpyts have been associated with the presence of toxins and decreased nutrient absorption [10]. Reference [29] noted that dietary essential oil supplementation at the different levels might have reduced the number of the total harmful bacteria and its adhesion to epithelium in the intestinal wall, hence reducing production of toxic compounds and damage to intestinal epithelial cells of broiler chicks.

Although not statistically significant, broilers fed EOB-supplemented diets consistently had the shortest villi among the treatments (Table III). This could be due to the presence of phenols such as carvacrol that could increase turnover rate of intestinal epithelial cells to twice of normal thereby posing a shorter time for villi to elongate resulting to shorter villi and reduction of pathogen attachment to enterocytes and subsequently improving nutrient absorption capacity [11], [16].

Reference [27] also had similar results with the duodenum villi height of broilers at 21 days of age fed oregano extract. In addition, crypt depth and the villi height/crypt depth ratio were not affected by the different treatments in the said study. Reference [29] also observed significant increase ($P<0.05$) in JVH, as well as duodenum villi height, of broiler chicks fed immediately with an oregano essential oil at 250 and 500mg/kg.

Inconsistent results gathered from the use of essential oil blends could be attributed to differences in the form of individual essential oils, proportion of individual essential oils in a blend, nutrient density of diet, microbial load of the animal or flock, type and strain of animal used and inclusion of essential oils at varying levels. Reference [6] reported beneficial effect of using a blend of essential oil 48 mg kg^{-1} on broiler breeders from day-old to 45 weeks but not at 24 mg kg^{-1}. In addition, studies conducted in avian species challenged by a disease agent showed positive results with essential oil supplementation.

IV. CONCLUSION

With the conditions under which this study was done, production performance of broilers fed essential oil blend containing capsaicin, carvacrol and cinnamaldehyde tend to have no difference than those fed basal diet or from those fed AGP. Given that the EOB tend to have similar performance with AGP, use of EOB can be further explored as an alternative growth promoter in broiler diets.

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