Influence of Two Plant Extracts on Broilers Performance, Digestibility, and Digestive Organ Size[1]

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ABSTRACT A 42-d trial was conducted to study the influence of 2 plant extracts on performance, digestibility, and digestive organ weights in broilers. The feeding program consisted of a starter diet until 21 d and a finisher diet until 42 d. There were 4 treatment groups: control; 10 ppm avilamycin (AB); 200 ppm essential oil extract (EOE) from oregano, cinnamon, and pepper; and 5,000 ppm Labiatae extract (LE) from sage, thyme, and rosemary. No differences in feed intake or feed conversion were observed. From 14 to 21 d of age, broilers fed the LE diet grew faster than the broilers fed the control or EOE feeds (68.8 vs. 63.9 and 61.6 g/d, respectively). Antibiotic and plant extract supplementation improved apparent whole-tract and ileal digestibility of the nutrients. For starter feed, LE supplementation improved apparent fecal digestibility of DM ($P < 0.01$), and all additives increased ether extract digestibility ($P < 0.001$). However, no effect was detected for CP digestibility ($P > 0.1$). At the ileal level, the AB, EOE, and LE supplementation of the starter feed increased DM and starch ($P < 0.01$) digestibility but not CP digestibility ($P > 0.1$). All additives improved apparent fecal digestibility of DM and CP of the finisher diet. No differences were observed for proventriculus, gizzard, liver, pancreas, or large or small intestine weight. In the present study, both plant extracts improved the digestibility of the feeds for broilers. The effect of different additives on digestibility improved the performance slightly, but this effect was not statistically significant.

(*Key words*: broiler, digestibility, growth promoter, plant extract)

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INTRODUCTION

The prophylactic use of antibiotics (as growth promoters) in animal feeds has made intensive farming possible and improved feed conversion in these animals. In the presence of low levels of antibiotic, resistant cells survive and grow, producing an antibiotic-resistant population. Consequently, the use of antibiotics for broilers has been limited in the European Union to only 4 antibiotics that are not associated with human treatment. They are avilamycin (AB) and flavophospholipol as growth promoter additives and salinomicin sodium and monensin sodium as coccidiostats (European Union, 1998). As a result, new commercial additives of plant origin, considered to be natural products that consumers would accept, have been proposed to livestock producers. Herbs, spices, and various plant extracts have received increased attention as possible antibiotic growth promoter replacements.

Useful antimicrobial phytochemicals can be divided into several categories: phenolics and polyphenols (simple phenols and phenolic acids, quinones, flavones, tannins, and coumarins), terpenoids and essential oils, alkaloids, and lectins and polypeptides (Cowan, 1999). In vitro antimicrobial activity of several plant extracts (essential oils, basically) has been demonstrated. Cinnamon extract inhibited *Helicobacter pylori* at the concentration range of common antibiotics. Its antimicrobial properties are mainly related to its cinnamaldehyde content followed by eugenol and carvacrol contents (Tabak et al., 1999). Cinnamon oil and its constituents (cinnamaldehyde and eugenol) have antibacterial activity against *Escherichia coli, Pseudomonas aeruginosa, Enterococcus faecalis, Staphylococcus aureus, Staphylococcus epidermis, Klebsiella pneumoniae, Salmonella* sp., and *Vibrio parahemolyticus* (Chang et al., 2001) and inhibitory properties against *Aspergillus flavus* (Montes-Belmont and Carvajal, 1998).

The phenolic compounds carvacrol and thymol present in the essential oil from oregano (as well as other lamiaceae species such as *Thymus vulgaris* L.) exhibit considerable antimicrobial and antifungicidal activity (Basilico and Basilico, 1999). In addition, thymol is currently used to inhibit oral bacteria (Twetman and Peterson, 1997).

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Abreviation Key: AB = avilamycin; EOE = essential oil extract; LE = Labiatae extract.

Sage has been credited with a long list of medicinal uses, including antiseptic and astringent. Tzakou et al. (2001) showed that the essential oils of salvia, and its pure monoterpenoids α-pinene and 1,8-cineole, exhibited antimicrobial profiles when they were tested against 6 gram (±) bacteria and 3 pathogenic fungi. However, to be effective on a practical scale, it is likely that these compounds need to be provided in a more concentrated form than they are found in their natural source and at higher levels than antibiotic growth promoters.

Plant extracts have demonstrated an antimicrobial effect in vitro, but their influence on growth performance of farm animal species has not been sufficiently documented. Thymol (from *Thymus* and *Origanum* plants) and *Salvia officialis* and *Equisetum arvease* extracts have been used in ruminants to control methanogenesis (Broudiscou et al., 2000; Evans and Martin, 2000). Botsoglou et al. (2002) indicated that dietary oregano oil exerted no growth promoting effect on broilers when administered at 50 or 100 mg/kg of feed. In several trials, the inclusion of peppermint, garlic, clove, cinnamon or *Echinacea* (alone or mixed) in weanling pig diets produced contradictory or inconsistent results (Turner et al., 2001).

In short, the positive effects observed in vitro justify further research in this area to determine the optimal dietary inclusion level and the mode of action of these plant products to achieve optimal growth performance and disease resistance in poultry production. The objective of this study was to evaluate the ability of various plant extracts to stimulate broiler performance when used as supplements in the diets of broilers. Two extracts were selected for their potential benefits to health, appetite, and digestion.

MATERIALS AND METHODS

Diet and Experimental Design

The feeding program consisted of a starter diet until 21 d of age and a finisher diet until 42 d of age. The composition of the experimental basal diets is shown in Table 1. All diets for each period were prepared with the same batch of ingredients, and all diets within a period had the same composition. Diets were formulated to meet or exceed requirements by the National Research Council (1994) for broilers of this age. The diet ingredients included 0.5% Celite [3] as an acid-insoluble ash digestibility marker (Scott and Boldaji, 1997). The finisher diet was steam pelleted using a 4-mm die, and the starter feed was offered in crumbles.

There were 4 treatment groups: control; 10 ppm AB; 200 ppm essential oil extract[4] (EOE) from oregano, cinnamon, and pepper; and 5,000 ppm Labiatae extract[5] (LE) from sage, thyme, and rosemary. These supplements were added to basal diets.

TABLE 1. Composition of experimental diets

	Basal diet (%)	
Ingredients	Starter	Finisher
Wheat	38.29	53.06
Corn	20.00	10.00
Soybean meal (47% CP)	28.71	25.41
Fish meal (60% CP)	8.04	3.00
Soy oil	2.52	4.89
Animal fat		0.29
Calcium carbonate	0.86	1.11
Calcium phosphate		0.50
Sodium bicarbonate	0.10	0.30
Sodium chloride	0.16	0.09
Celite	0.50	0.50
DL-Methionine	0.29	0.27
L-Lysine	0.18	0.26
L-Threonine	0.02	0.03
Choline chloride	0.09	0.07
Vitamin premix	0.05[3]	0.03[4]
Mineral premix	0.10[5]	0.10[6]
Natugrain (xylanases)[1]	0.03	0.03
Natuphos (phytase)[2]	0.01	0.01
Calculated composition[7]		
AME, kcal/kg	3,077	3,226
Lysine	1.47	1.22
Methionine + cystine	1.10	0.96
Threonine	0.93	0.79
Calcium	0.84	0.76
Phosphorus (total)	0.64	0.58
Linoleic acid	2.28	3.60
Analyzed composition (% DM)		
Ash	6.93	5.98
Crude protein	26.20	22.45
Ether extract	6.80	7.70
Fiber	2.70	3.01

[1]Natugrain product JEB8296569/1-54, BASF Group, Ludwigshafen, Germany.

[2]Natuphos product JEA8085632/1-29.

[3]Supplied per kilogram of diet: vitamin A (retinyl acetate), 15,000 IU; vitamin D_3, 5,000 IU; vitamin E (DL-α-tocopheryl acetate), 80 mg; vitamin K, 5 mg; thiamin, 3 mg; riboflavin, 10 mg; pyridoxine, 5 mg; vitamin B_{12}, 0.02 mg; niacin, 70 mg; folic acid, 2 mg; biotin, 0.4 mg; pantothenic acid, 20 mg.

[4]Supplied per kilogram of diet: vitamin A (retinyl acetate), 9,000 IU; vitamin D_3, 3,000 IU; vitamin E (DL-α-tocopheryl acetate), 48 mg; vitamin K, 3 mg; thiamin, 1.8 mg; riboflavin, 6 mg; pyridoxine, 3 mg; vitamin B_{12}, 0.012 mg; niacin, 42 mg; folic acid, 1.2 mg; biotin, 0.24 mg; pantothenic acid, 12 mg.

[5]Supplied per kilogram of diet: manganese, 120 mg; zinc 100 mg; iron, 80 mg; copper, 20 mg; iodine, 2 mg; selenium, 0.3 mg; cobalt ,0.5 mg.

[6]Supplied per kilogram of diet: manganese, 100 mg; zinc, 80 mg; iron, 30 mg; copper, 15 mg; iodine, 2 mg; selenium, 0.3 mg; cobalt, 0.2 mg.

[7]According to FEDNA (1999).

An experiment with Ross male broilers was conducted from 1 to 42 d of age. At 1 d of age, 120 chicks were placed in 4 electrically heated battery cages with a floor space of 0.3 m^2 /cage and wire floors. At 7 d of age, 10 chickens for each replicate (i.e., 3 replicates per treatment in a randomized complete block design) were placed in 70 × 60-cm pen with a 1 × 1-cm wire mesh bottom. Each pen was equipped with a feeding trough placed outside and water cups inside the pen and also an excreta collection tray.

The cages were situated in an insulated room with facilities to control temperature, light and humidity. The temperature was controlled and gradually reduced from 32 to 20°C on d 40. The lighting cycle was 24 h from 1 to 3 d of

[3]Food Chemicals Codex grade, Celite Corp., Lompar, CA.
[4]Xtract, Axiss, Archamps, France.
[5]Labiatae extract, Furfural Español, Murcia, Spain.

age, 18 h from 4 to 20 d of age, 21 h from 21 to 35 d of age, and 23 h from 35 to 42 d of age. Throughout the experiment, chickens were handled according to the principles of animals care in experimentation (NRC, 1985).

Fresh feed and water were provided daily at 0900 h and were available ad libitum. The chickens were weighed individually on d 1, 7, 14, 21, 28, 35, and 42. Feed intake per pen was measured throughout the experiment (remaining feed in the excreta collection tray was carefully removed and weighed, and that was considered as wastage feed), and the feed:gain ratio was calculated on a pen weight basis. Mortality and BW of dead birds were recorded daily.

During the last 5 d (16 to 21 d and 37 to 42 d) of each experimental diet, excreta from each cage were collected quantitatively and daily. Excreta were dried at 80°C until constant weight, homogenized, and sampled by cage. Diet and excreta were ground to pass through a 1-mm screen. At 21 and 42 d of age, individual birds were weighed, and 5 birds in each cage were randomly selected and killed by intravenous injection of sodium pentobarbital. The small intestine was immediately exposed, and the contents of the lower half of the ileum were collected by gently flushing with distilled water into plastic containers. The ileum was defined as that portion of small intestine extending from Meckel's diverticulum to a point 40 mm proximal to the ileocecal junction. Digesta were pooled within a pen, lyophilized, ground to pass through a 0.5-mm sieve, and stored at –18°C in airtight containers until laboratory analyses were conducted. The weights of the proventriculus, gizzard, small and large intestines without content, pancreas, and liver without gall bladder were measured individually.

Chemical Analysis

Diet, excreta, and ileal digesta were analyzed for nitrogen (Kjeldahl method; AOAC, 1990), CP (N × 6.25), dry matter (by drying in an oven at 103°C for 8 h), crude fiber (AOAC, 1990), and acid-insoluble ash (Vogtmann et al., 1975). In addition, diet and excreta were analyzed for lipid (6-h Soxhlet extraction), and diets and ileal digesta were analyzed for starch (AFNOR, 1997). All values are expressed on a dry matter basis.

Rosmarinic acid content in LE diets and carvacrol, capsaicin, and cinnamaldehyde contents in EOE diets were determined by HPLC. A Hewlett–Packard 1100 HPLC system was used, coupled with an ultraviolet diode array detector.[6] Separation was achieved by using a C18 LiChrospher 100 analytical column (250 mm long × 4 mm interior diameter) with a particle size of 5 μm; temperature was set at 30°C. The flow rate was 1 mL/min.

Two methods were used. For LE diet analysis, the mobile phase for chromatographic analysis as an isocratic system with 1% acetic acid in water:acetonitrile (83:17 vol/vol). Ultraviolet detection was fixed at 330 nm. For EOE diet analysis the mobile phase A consisted of 2.5% acetic acid in water, and mobile phase B was acetonitrile. The following program was run: 95% A: 5% B for 20 min; 75% A: 25% B for 20 min; 50% A: 50% B for 10 min; 20% A: 80% B for 10 min; and re-equilibration for 10 min (Benavente-García et al., 2000). Ultraviolet detection was fixed at 280 nm.

Sample preparations for HPLC analysis involved extraction of LE diet samples with dimethylsulfoxide (50 mg/mL) and EOE diet samples with methanol (100 mg/mL). The extraction was performed at room temperature for 60 min, and all solutions were filtered through a 0.45-μm nylon membrane.

[6]HP, Agilent Technologies S.L., Madrid, Spain.

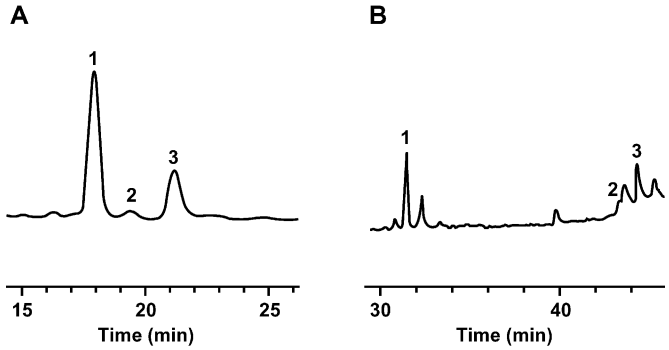

FIGURE 1. HPLC chromatograms of starter feeds with extracts: (A) Labiatae extract (hydro-alcoholic extract from sage, thyme and rosemary leaves) and (B) plant extract based on essential oils (blend of oregano, cinnamon, and pepper essential oils). Peaks were identified as follows: (A)1, rosmarinic acid; (A)2, apigenin-7-glucoside (flavone); (A)3, isocutellarein-7-glucoside (flavone); (B)1, cinnamaldehyde; (B)2, carvacrol; and (B)3, capsaicin.

Statistical Analysis

The effects of additives on performance, digestibility, and organ weights were analyzed statistically by ANOVA with SPSS (1997) software. The model used was

$$Y_{ij} = \mu + A_I + B_j + A\ B_{ij} + e_{ijk}$$

where μ = the common mean, A_I = the effects of the type of additive, B_j = the effect of the birds age, $A\ B_{ij}$ the effect of the ith A with the jth B, and e_{ijk} = the random error. When significant differences were found, the least significant difference test was calculated (Snedecor and Cochran, 1980). All statements of significance are based on a probability of less than 0.05.

RESULTS AND DISCUSSION

Plant Extracts in Feeds

The rosmarinic acid content of the starter (Figure 1A) and finisher LE feed were 370 and 285 ppm, respectively. The carvacrol, cinnamaldehyde, and capsaicin contents of the EOE starter feed (Figure 1B) were 19, 34, and 60 ppm and for EOE finisher feed were 50, 60, and 40 ppm, respectively. Consequently, in starter and finisher feeds active compounds of plant extracts have been identified.

TABLE 2. Effect of plant extracts on performance of broilers (1 to 42 d)[1]

Diet[2]	Period	Control	AB	EOE	LE	SEM	*P*-value
		(g)					
Body weight							
	21 d	920.2[ab]	969.2[a]	902.8[b]	939.2[ab]	16.0	0.08
	35 d	2,306.6[b]	2,466.3[a]	2,387.7[ab]	2,461.6[a]	42.5	0.07
	42 d	3,070.1	3,128.6	3,080.3	3,168.3	51.2	NS[3]
		(g/d)					
Weight gain							
	7 to 14 d	44.2	46.0	43.7	43.7	1.2	NS
	14 to 21 d	63.9[bc]	66.6[ab]	61.6[c]	68.8[a]	1.4	0.04
	21 to 28 d	101.3	102.4	105.4	109.2	2.1	0.08
	28 to 35 d	96.7[b]	111.3[a]	106.6[ab]	108.1[ab]	4.2	0.03
	35 to 42 d	109.0	94.6	98.9	100.9	4.8	NS
	7 to 42 d	83.0	84.6	83.2	85.7	1.4	NS
Feed intake							
	7 to 21 d	73.6	76.7	73,6	75.4	1.1	NS
	22 to 35 d	178.5	182.3	179.5	179.4	1.5	NS
	36 to 42 d	211.6	200.2	196.0	200.9	5.1	NS
	7 to 42 d	143.1	143.7	140.4	142.1	1.3	NS
		(g:g)					
Feed:gain							
	7 to 21 d	1.36	1.33	1.39	1.36	0.03	NS
	22 to 35 d	1.80	1.70	1.69	1.65	0.03	0.06
	36 to 42 d	1.95	2.11	1.98	2.11	0.09	NS
	7 to 42 d	1.72	1.69	1.68	1.65	0.02	NS

[a-c]Mean values within a row having different superscripts are significantly different by least significant difference test ($P < 0.05$).

[1]Means represent 3 pens.

[2]Ten parts per million avilamycin (AB); 200 ppm essential oil extract (EOE) from oregano, cinnamon, and pepper; 5,000 ppm Labiatae extract (LE) from sage, thyme, and rosemary.

[3]$P > 0.10$.

Growth Performance

In general, no differences in feed intake or feed:gain ratio were observed in male broilers fed with different diets (Table 2). From 14 to 21 d of age, broilers fed the LE diet grew faster than the broilers fed the control or EOE feeds (68.8 vs. 63.9 and 61.6 g/d, respectively). In addition, from 28 to 35 d of age broilers fed the AB diet grew faster than broilers fed the control diet. The last week of the trial, no differences in BW, feed intake, or feed:gain ratio were observed. Mortality was lower for birds fed the LE and EOE diets than for birds fed the AB and control diets for the entire growing periods (3.3 and 3.3 vs. 6.6 and 10%, respectively).

In our trial a little growth promoter effect of additives was observed ($P < 0.1$), but none of the treatments caused significant effects ($P < 0.05$). The trial was conducted at ideal conditions of experimentation, which could affect the degree of growth promotion.

Antibiotics, such as AB, at growth-promoting levels have been shown to improve the growth and feed efficiency and to reduce the amount of *Clostridium perfrigens* in the intestinal tract of chickens (Elwinger et al., 1993). Plant extracts fed to broilers gave live performance levels similar to those of the antibiotic growth promoter AB, results that agree with Jamroz and Kamel (2002) who observed improvements of 8.1% in daily gain and 7.7% in feed conversion ratios in 17-d-old poults fed a diet supplemented with a plant extract containing capsaicin, cinnamaldehyde, and carvacrol at 300 ppm. In contrast, Botsoglou et al. (2002) showed that oregano oil exerted no growth-promoting effect when administered at 50 or 100 mg/kg of feed.

Digestibility

In general, antibiotic and plant extract supplementation improved apparent whole-tract and ileal digestibility of the nutrients (Table 3). For starter feed, LE supplementation improved apparent fecal digestibility of DM ($P < 0.01$), and all additives increased ether extract digestibility ($P < 0.001$). However, no effect of supplementation was detected for CP digestibility ($P > 0.1$). The EOE and LE supplementation of the starter feed increased apparent ileal digestibility of DM and starch ($P < 0.01$), but no effect was noticed for CP digestibility ($P > 0.1$).

The AB, EOE, and LE supplementation improved apparent fecal digestibility of DM and CP ($P < 0.001$) of the finisher diet. Average apparent fecal and ileal digestibility of all nutrients in the diets were lower for the finisher feed than for the starter feed.

Phenolic compounds (rosmarinic acid, flavones, carvacrol, cinamaldehyde) of plant extracts did not affect the apparent CP digestibility of diets. Rawel et al. (2002) showed that in vitro peptic or pancreatic digestion of protein-phenol derivatives with flavones of soy proteins remained more or less unaffected. However, polyphenol compounds known to combine and form leather-like precipitates with proteins and consequently block the lysine, tryptophan, and cysteine residues. Protein bound in this form decreased the digestibility and biological value of

TABLE 3. Effect of plant extracts on apparent digestibility of the diets of broilers[1]

	Whole-tract[3] (%)						Ileum (%)					
	DM		CP		EE		DM		CP		Starch	
Diet[2]	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
Control	70.32^{b}	63.55^{d}	61.99	48.58^{c}	89.29^{c}	84.11	67.07^{c}	66.11^{c}	76.06	72.05	95.98^{b}	96.87
AB	70.77^{b}	75.24^{a}	63.34	62.12^{a}	92.99^{ab}	88.14	68.42^{bc}	71.65^{a}	78.03	76.76	96.41^{b}	97.17
EOE	71.40^{b}	72.20^{b}	63.03	57.08^{ab}	91.36^{b}	85.11	73.24^{ab}	70.71^{ab}	78.66	76.59	97.22^{a}	97.46
LE	74.49^{a}	69.36^{c}	66.97	53.56^{bc}	93.59^{a}	86.38	74.55^{a}	67.10^{bc}	79.68	74.34	97.37^{a}	96.86
P-value	0.01	0.001	NS[4]	0.001	0.001	NS	0.01	0.04	NS	NS	0.001	NS
SEM	0.80	0.83	1.36	1.99	0.56	1.08	1.80	1.17	1.56	2.41	0.23	0.31
Control	66.94^{b}		55.29^{b}		86.70^{c}		66.59^{b}		74.05		96.43^{b}	
AB	73.00^{a}		62.73^{a}		90.56^{a}		70.04^{a}		77.01		96.79^{ab}	
EOE	71.00^{a}		60.06^{a}		88.24^{b}		70.83^{a}		77.39		97.11^{a}	
LE	71.80^{a}		60.27^{a}		89.99^{ab}		71.97^{a}		77.62		97.34^{a}	
Source of variation												
Additive type	0.001		0.01		0.001		0.002		NS		0.03	
Period	0.005		0.001		0.001		0.06		0.05		0.06	
Diet × period	0.001		0.01		NS		0.03		NS		0.07	

[a-c]Mean values within a row having different superscripts are significantly different by least significant difference test ($P < 0.05$).

[1]Means represent 3 pens of 5 chicks per treatment.

[2]Avilamycin (AB) 10 ppm; 200 ppm essential oil extract (EOE) from oregano, cinnamon, and pepper; 5,000 ppm Labiatae extract (LE) from sage, thyme, and rosemary.

[3]As starch ileal digestibility was near 100%, starch in excreta was not analyzed. Ether extract was determined only in excreta because not enough ileal digesta was available.

[4]$P > 0.10$.

protein (Rawel et al., 2002). Zdunczyk et al. (2002) indicated that flavon extracts from skullcap depressed (approximately 2%) true digestibility of casein protein in rats.

Plant extract effects may be due to the greater efficiency in the utilization of feed, resulting in enhanced growth. There is evidence to suggest that herbs, spices, and various plant extracts have appetite- and digestion-stimulating properties and antimicrobial effects (Kamel, 2001). Plant extracts contain different molecules that have intrinsic bioactivities on animal physiology and metabolism. The EOE is a blend of capsaicin, cinnamaldehyde, and carvacrol. LE is a natural extract produced from the mediterranean sage, thyme, and rosemary plants. The main components are rosmarinic acid, flavones (as apigenin-7-glucoside), and flavanones as neoeriocitrin.

The mechanisms by which these products influence the gut microflora and growth performance of poultry are not known. As antibiotics, plant extracts could control and limit the growth and colonization of numerous pathogenic and nonpathogenic species of bacteria in the gut. The plant extracts clearly demonstrate antibacterial properties, although the mechanistic processes are poorly understood (Dorman and Deans, 2000). Thymol and carvacrol disrupt the membrane integrity, which further affects pH homeostasis and equilibrium of inorganic ions (Lambert et al., 2001).

Organ Weights

No differences were noticed for proventriculus, gizzard, liver, pancreas, or large or small intestine weight (Table 4). Visek (1978) indicated that dietary inclusion of antibiotics, given as growth promoters, reduced intestine weight by thinning the intestinal wall and shortening the gut, but in

TABLE 4. Effect of plant extracts on relative weight (% BW) of selected digestive organs of broilers

		Liver		Pancreas		Proventriculus		Gizzard		Small intestine		Large intestine	
Diet[1]	n	21 d	42 d	21 d	42 d	21 d	42 d	21 d	42 d	21 d	42 d	21 d	42 d
		(g/100 g BW)											
Control	15	3.07	2.25	0.23	0.15	0.71	0.31	1.35	0.7	2.85	2.30	0.63	0.46
AB	15	3.00	2.30	0.23	0.15	0.57	0.27	1.29	0.68	3.07	2.33	0.61	0.52
EOE	15	2.99	2.21	0.23	0.15	0.55	0.29	1.19	0.7	2.87	2.20	0.63	0.49
LE	15	3.21	2.16	0.26	0.15	0.51	0.34	1.41	0.71	3.07	2.23	0.64	0.50
P-value		NS[2]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEM		0.11	0.10	0.07	0.00	0.07	0.02	0.08	0.03	0.13	0.10	0.03	0.03
Source of variation													
Diet type		NS		NS		NS		NS		NS		NS	
Period		0.001		0.001		0.001		0.001		0.001		0.001	
Diet × period		NS		NS		NS		NS		NS		NS	

[1]Avilamycin (AB), 10 ppm; 200 ppm essential oil extract (EOE) from oregano, cinnamon, and pepper; and 5,000 ppm Labiatae extract (LE) from sage, thyme, and rosemary.

[2]$P > 0.10$.

our study this effect was not noticed for AB. Water-soluble extract from rosemary, containing rosmarinic acid, flavones, and monoterpenes, enhanced hepatic metabolism and increased relative liver weight in rats (Debersac et al., 2001). Relative weights of all the organs were higher at 21d of age than at 42 d ($P < 0.001$). Relative weights of all the organs studied decreased with age; these data are consistent with the findings of Iji et al. (2001).

We conclude that the LE and the blend of carvacrol, cinnamaldehyde, and capsaicin improved the digestibility of the feeds for broilers. The effect of different additives on digestibility improved the performance slightly, but this effect was statistically nonsignificant. No effects were noted on organ weights. Our results justify further research in this area to determine the optimal dietary inclusion level and the mode of action of these and other plant products to achieve optimal growth performance and digestion.

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