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Pawpaw, Black Cumin, and Mustard Seed Meals Dietary Supplementation in Broiler Chickens: Effect on Performance, Gut Microflora, and Gut Morphology

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ABSTRACT

This study evaluated the effect of pawpaw, black cumin, and mustard seed meals (PSM, BSM, and MSM, respectively) supplementation on broiler chickens' performance, gut microflora, and gut morphology. Two basal diets were formulated for the starter and grower phases and divided into five portions. Portion one (Diet 1), the negative control, contained no supplementation, portion two (Diet 2), was supplemented with 0.11 g kg^{-1} oxytetracycline. The third (Diet 3), the forth (Diet 4) and the fifth portions (Diet 5) were supplemented with 15 g kg^{-1} PSM, MSM and BSM, respectively. Three-hundred 1-day old Arbor Acres broiler chicks were randomly distributed into five treatments (10 chicks/replicate; 60 chicks/treatment) in a completely randomized design. The performance characteristics of the birds were determined on 7 days interval. On day 42, three birds per replicate were sacrificed for the determination of the carcass traits and relative internal organs weights. At the grower phase and overall, the Body Weight Gain (BWG) of broiler chickens fed Diet 3 was similar (P> 0.05) to those fed Diet 4, but significantly (P< 0.05) higher than the broiler chickens fed the rest of the diets. The liver, pancreas and gizzard relative weights were affected (P< 0.05) by the treatment. On day 42, higher (P< 0.05) Lactic Acid-producing Bacteria (LAB) count was recorded in birds fed Diet 2. In the jejunum, the villi heights and crypt depths were higher (P<0.05) in bird fed Diets 1, 2, and 3. Supplementation of the broiler diets with 15 g kg^{-1} of PSM, BSM and MSM enhanced the body weight of broiler chicken.

Keywords: Arbor Acres broiler, Oxytetracycline, Phytogenic feed, Phytogenic feed supplements.

INTRODUCTION

The farm animals' performance and wellbeing are affected by both internal and external factors that include nutrition (Karaskova *et al.*, 2015). In the past, the use of antibiotic growth promoters was used to enhance the performance and health status of farm animals (Bednarczyk *et al.*, 2016). At present, the existing ban on the use of the antibiotic growth promoters in farm animal production has steered up the search for alternative feed supplements such as exogenous enzymes (Oloruntola *et al.*2018a; Oloruntola, *et al.*

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2018b), prebiotics (Bednarczyk *et al.*, 2016), fermented stuff (Alshelmani *et al.*, 2017) and phytogenic feed additives (Ipcak and Alcicek 2018; Oloruntola *et al.*, 2018c).

Phytogenic feed additives or supplements relevance in animal nutrition is on the increase (Karaskova *et al.*, 2015; Adegbeye *et al.*, 2018) because they exert positive effects on the sensory properties of animal products, exert immunomodulatory effects, stimulate the digestion processes and secretion of substance that enhance the growth and performance, and improve the antioxidative status of the animals (Karaskova *et al.*, 2015; Oloruntola *et al.*, 2018d; Oloruntola *et al.*, 2018e). Reports have shown that botanicals improve productivity by maintaining the gut microflora balance, exert antimicrobial effects on pathogenic microorganisms, improve the stimulation of enzyme production in the gut and improve the health status of farm animals (Seidavi and Simoes, 2015). Generally, herbs contain flavonoids, alkaloids, and polyphenol among other phytochemicals of benefits in animal production (Adegbeye *et al.*, 2018; Falmideh *et al.*, 2019). Recently, the antimicrobial and antihelminthic impacts of black cumin, pawpaw, and mustard seeds were reported by (Adegbeye *et al*., 2018). Improved body weight gain, triglyceride, and cholesterol-lowering effects were reported in broiler chickens fed diets supplemented with phytogenic feed supplements (Oloruntola *et al*., 2018c).

Black cumin (*Nigella sativa*) seed meal, pawpaw (*Carica papaya*) seed meal and mustard (*Brassica juncea*) seed meal could be promising phytogenic growth health-enhancing feed supplement in broiler production. Therefore, this study aimed to evaluate the effect of black cumin, paw-paw, and mustard seed meals on performance, carcass characteristics, gut microflora, and gut morphology of broiler chickens.

MATERIALS AND METHODS

Ethical Approval, Seeds Collection, Processing, and Analysis

Seeds of pawpaw were obtained from pawpaw fruits being obtained from the western part of Nigeria, while the brown mustard and black cumin seeds were obtained from local markets in northern Nigeria. These seeds were milled separately into the size of about 100 µm to produce Pawpaw Seed Meal (PSM), Black cumin Seed Meal (BSM) and Mustard Seed Meal (MSM), respectively. Thereafter, the seed meals were analyzed in triplicate (Table 1) for proximate composition (AOAC.1995), alkaloid (Harborne, 1973), saponin and tannin (Aina *et al.*, 2012), phenol (Xu and Diosady, 1997), flavonoid (Bohm and Kocipai-Abyazan, 1994), benzyl isothiocyanate (Marton and Lavric, 2013), allyl isothiocyanate (Mukhopadhyay, and Bhattacharyya, 1983), and thymoquinone (Taleuzzaman, *et al.*, 2017).

Experimental Diets

Two basal diets (Table 1) were formulated for the starter phase (1-21 days of age) and grower phase (22-42 days of age) in accordance with NRC (1994) requirement. Thereafter, the basal diets were divided into five dietary treatments. Diet 1 contained no supplementation, Diet 2, was supplemented with 0.11 g kg^{-1} OxyTetracycline (OT). Diets 3, 4, and 5 were supplemented with 15 g kg^{-1} of PSM, MSM, and BSM, respectively. The five diets were analyzed (AOAC.1995).

Birds and Experimental Design

Three-hundred 1-day old Arbor Acres broiler chicks were randomly distributed into five dietary treatments (10 chicks/replicate; 60 chicks/treatment) in a

Table1. Composition of the experimental diets and seed meals of mustard, pawpaw, and black cumin.

Experimental diets			Phytogenics			
Ingredients [a] (%)	Starter diet (1-21 Days)	Grower diet (22-42 Days)	Parameters	Mustard seed meal	Pawpaw seed meal	Black cumin seed meal
Maize	42.66	48.56	Crude Protein	18.68	15.78	16.68
Soybean meal	38.69	34.79	Ether extract	13.88	3.68	2.87
Wheat offal	12.10	10.10	Crude Fibre	5.69	11.86	6.36
Vegetable oil	2.20	2.30	Ash Content	4.25	5.29	5.09
Limestone	1.40	1.40	NFE	49.61	51.99	60.96
DCP	1.80	1.70	Alkaloid	526.33	407.67	495.33
Methionine	0.30	0.30	Tannin	43.33	28.00	37.00
Premix [b]	0.30	0.30	Phenol	187.00	206.00	176.33
Lysine	0.25	0.25	Saponin	116.33	310.67	126.67
Salt	0.30	0.30	Flavonoid	7.10	8.33	5.50
Chemical analysis (%)			TQ (mmol kg^{-1})	-	-	25.29
Crude protein	22.13	20.78	BIC (mmol kg^{-1})	-	37.32	-
Crude fiber	4.55	43.89	AIC(mmol kg^{-1})	14.57	-	-
Calculated analysis (%)						
ME (kcal kg^{-1})	2,955.88	3,000.24				
Available P	0.60	0.55				
Ca	1.02	0.93				
Methionine	0.63	0.38				
Lysine	1.15	1.03				

[a] DCP: DiCalcium Phosphate; ME: Metabolizable Energy; NFE: Nitrogen Free Extract; TQ: ThymoQuinone; BIC: Benzyl IsothioCyanate, AIC: Allyl IsothioCyanate. [b] Composition of vitamin premix: Vitamin A (10,000 iu), D (2,000,000 iu), E (35, 000 iu), K (1,900 mg), B12 (19 mg), Riboflavin (7,000 mg); Nicotinic acid (45,000 mg)' Folic acid (1,400 mg); Pyridoxine (3,800 mg); Thiamine (2,200 mg); Pantothenic acid (11,000 mg); Biotin (113 mg) and trace element such as Cu (8,000 mg), Mn (64,000 mg); Zn (40,000 mg), Fe (32,000 mg), Se (160 mg), I(800 mg); and other items as Ca (400 mg); Chlorine (475,000 mg) Methionine (50, 000 mg); BHT (5,000 mg) and Spiramycin (5,000 mg) in 2.5 kg of premix.

completely randomized design. During the first 7 days of brooding, the temperature of the house was maintained within 31±2°C. The temperature was reduced by 2°C after each consecutive 7 days until the house temperature was 26±2°C. The light was provided 22 hours/day while the feed and water were provided *ad libitum*.

Chicken Growth Performance, Slaughtering Procedure, Carcass Trait, and Internal Organ Evaluation

The Body Weight (BW) and Feed Intake (FI) of the birds were determined on 7 days interval. Thereafter, the average Body Weight Gain (BWG) and Feed Conversion Ratio (FCR) were estimated. On day 42, three birds per replicate were randomly selected, tagged, weighed, sacrificed, de-feathered, eviscerated, dressed and weighed to determine the dressed weigh and dressed percentage. The heart, lung, pancreas, spleen, liver, proventriculus, and gizzard were excised out, weighed and expressed as percentage slaughtered weight.

Microbial Sampling and Cultivation and Gut Morphology

At the end of the trial (day 42), three chickens per replicate was slaughtered. The cecum and ileum content of the slaughtered chickens were extracted and used for subsequent analysis of the bacterial population by serial dilution. One gram of feces was diluted serially (1:10) to 10-6 with a 0.85 NaCl solution. Thereafter, 0.1 mL of each dilution was plated onto nutrient agar and Mac-Conkey agar to culture the total aerobic bacterial and *Escherichia coli* counts, respectively. MRS agar was used to culture the lactic acid-producing bacteria (Seidavi and Simoes, 2015; Dibaji, *et al.*, 2014; Esmailzadeh, *et al.* 2016).

The gastrointestinal tract of slaughtered birds was removed and separated into the duodenum (taken distally from the gizzard to the end of the pancreatic loop), the jejunum (taken distally from the pancreatic loop to Meckel's diverticulum), ileum (taken from the Meckel's diverticulum to the ileocaecal junction. A length of 0.5 cm was taken from the middle portion of each of the three intestinal segments, placed into separate bottles containing 10% formalin and processed for histological studies (Adeleye, *et al.*, 2018; Alshelmani, *et al.* 2016). The intestinal villi with their crypts were separated individually under a dissecting microscope (Goodlad, *et al.* 1991). The length and width of the villi were also measured (Adeleye, *et al.*, 2018).

Statistical Analysis

All data were subjected to statistical analysis using one-way ANOVA for a completely randomized design. Means were separated by Duncan's Multiple Range Test for significance at 0.05 level.

RESULTS

Composition of Phytogenics and Their Effects on Broiler Chicken Performance

The proximate composition of the experimental diets and phytogenic Supplements (PSM, MSM, and BSM) are presented in Table 1. Alkaloid, tannin, phenol, saponin, and flavonoid were detected in PSM, MSM, and BSM, while thymoquinone, benzyl isothiocyanate, and allylisothiocyanate were only present in BSM, PSM, and MSM, respectively. Table 2 shows the effect of phytogenic supplementation on the performance, dressing percentage, and relative internal organ weights of the broiler chickens. At the starter phase, BWG, FI and FCR were not (P> 0.05) affected by the dietary treatment. At the grower phase and overall (1-42 days), the BWG of broiler chickens fed the 15 g kg^{-1} of PSM, MSM and BSM supplemented diets were higher (P< 0.05) than the control.

Table 2. Effect of seed meals supplementation on the performance of the broiler chickens.[a]

Parameters	Diet 1 (Control)	Diet 2 (0.11 g kg^{-1} OT)	Diet 3 (15 g kg^{-1} PSM)	Diet 4 (15 g kg^{-1} MSM)	Diet 5 (15 g kg^{-1} BSM)	SEM	P-value
Starter phase (1-21 Days)							
Initial body weight (g bird^{-1})	36.45	36.66	36.49	36.44	36.52	0.29	0.99
Body weight gain (g bird^{-1})	613.62	634.26	653.57	664.95	653.68	9.01	0.43
Feed intake (g bird^{-1})	1201.75	1272.00	1325.64	1317.23	1239.06	20.31	0.26
Feed conversion ratio	1.96	2.01	2.03	1.98	1.89	0.04	0.88
Grower phase (22-42 Days)							
Body weight gain (g bird^{-1})	1221.38^{c}	1312.13^{bc}	1486.04^{a}	1423.09^{ab}	1279.98^{bc}	29.86	0.01
Feed intake (g bird^{-1})	2212.34	2319.53	2363.24	2419.20	2334.31	25.07	0.10
Feed conversion ratio	1.82	1.78	1.58	1.71	1.82	0.04	0.18
Overall (1-42 Days)							
Body weight gain (g bird^{-1})	1835.00^{c}	1946.39^{bc}	2139.61^{a}	2088.04^{bc}	1933.67^{bc}	34.61	0.02
Feed intake (g bird^{-1})	3414.09	3591.53	3688.88	3736.44	3573.37	41.98	0.12
Feed conversion ratio	1.86	1.85	1.72	1.79	1.84	0.03	0.53
Carcass traits and internal organ (Day 42)							
Dressing percentage	73.13	73.41	75.21	73.54	76.30	0.47	0.14
Liver	2.72^{a}	2.26^{bc}	2.33^{bc}	2.38^{b}	2.05^{c}	0.05	0.01
Lung	0.51	0.47	0.56	0.58	0.53	0.02	0.48
Heart	0.41	0.43	0.44	0.43	0.41	0.02	0.96
Pancreas	0.28^{b}	0.28^{b}	0.34^{ab}	0.43^{a}	0.27^{b}	0.02	0.01
Gizzard	3.09^{a}	2.57^{b}	2.51^{b}	2.99^{a}	2.51^{b}	0.07	0.01
Proventriculus	0.51	0.52	0.53	0.49	0.53	0.01	0.96
Spleen	0.11	0.07	0.09	0.10	0.10	0.01	0.34

[a] Means within a row with different superscripts are significantly different ($p < 0.05$).

Generally, higher (P< 0.05) BWG was recorded in birds that were fed PSM supplemented-diet during the grower and overall periods.

The relative liver weight of the birds fed the control diet was higher (P< 0.05) than those fed the supplemented diets. The relative pancreas weight of broiler chickens fed MSM and PSM supplemented diet were similar (P> 0.05) but higher (P< 0.05) than those fed the control and the rest diets. The gizzard relative weights of birds fed the control and MSM supplemented-diet were similar (P> 0.05) but higher than those fed the rest diets.

Effects of Phytogenic Supplementation on the Ileum and Cecum Microflora and Gut Morphology

The effects of the phytogenic supplementation on the ileum and cecum microflora of broiler chicken are shown in Table 3. The ileum and cecum Total Aerobic Bacteria (TAB), *E. coli* and Lactic Acid-producing Bacteria (LAB) count in the experimental birds were not affected (P> 0.05) by the treatments on day 22. On day 42, the ileum TAB, *E. coli* and LAB count was stable (P> 0.05) across the treatments. However, on day 42, the Cecum *Escherichia coli* and LAB count of the birds fed the control diet, PSM, MSM, and BSM supplemented diets were similar (P> 0.05), while the higher count (P< 0.05) was recorded in birds fed the OT supplemented-diet. Table 4 shows the effect of phytogenic supplementation on the gut morphology of broiler chicken at days 42. In the jejunum, the villi heights and crypt depths were higher (P< 0.05) in birds fed the control diet, OT, and PSM supplemented diets compared to those fed the rest of the diets. In the duodenum, the crypt depth recorded across the various dietary treatments were comparable (P> 0.05), except in those birds fed BSM supplemented diet that had lower (P< 0.05) crypt depth compared to the OT supplemented diet.

DISCUSSION

The variation in the compositions of PSM, MSM, and BSM being recorded in this study suggests the diversification of their effects or activities when used as dietary supplements in animal feeds. The nutrient composition and effects supplied by phytogenics was reported to be a function of the plant source (Oloruntola *et al.*, 2018c). For instance, the thymoquinone being detected in BSM was reported to have hepato-protective properties (Khader, and Eckl, 2014), while benzyl isothiocyanate in PSM plays suppresses allergic inflammation and combats carcinogens (Tang, *et al.* 2014), the ally isothiocyanate that was found in MSM possesses anti-microbial and anti-cancer activities (Zhang, 2010). The weight gain determination is useful in assessing the nutritional and health status of broiler chickens (Adeyeye, *et al.* 2019). Similar performance characteristics of birds at the starter phase in this study suggest that the feed supplements used in this study had a similar influence on the nutritional status of the birds (Adeyeye, *et al.* 2019). The improved BWG recorded in birds fed the PSM and BSM supplemented diets when compared to the control and OT supplemented diet at the grower phase (22-42 days) support the earlier reports (Oloruntola *et al.*, 2018c; Valenzuela-Grijalva, *et al.* 2017). Improved BWG due to the influence of phytogenic supplementation was linked to their antibacterial, digestive fluid secretion and intestinal pH reducing activities, which may result in reduced enteric disorder, improved health, and better nutrients utilization (Oloruntola, *et al.*, 2018b; Valenzuela-Grijalva, *et al.* 2017). The depressed body weight gain recorded in birds fed the MSM supplemented diet when compared to others fed the diets supplemented with PSM and BSM may be due to the variations in the phyto-constituents of the phytogens and the tolerability of the experimental birds to the various phytochemicals and their

Table 3. Effect of seed meals supplementation on the microflora of the broiler chickens.[a]

Parameters	Diet 1 (Control)	Diet 2 (0.11 g kg^{-1} OT)	Diet 3 (15 g kg^{-1} PSM)	Diet 4 (15 g kg^{-1} MSM)	Diet 5 (15 g kg^{-1} BSM)	SEM	P-value
Ileum microbial count (log 10 CFU g^{-1}) on day 21							
Total aerobic bacteria	4.39	4.87	4.79	4.32	4.95	0.13	0.73
Escherichia coli	4.16	4.68	4.74	4.87	4.06	0.12	0.12
Lactic acid producing bacteria	4.46	4.99	5.08	4.72	4.72	0.10	0.34
Cecum microbial count (log 10 CFU g^{-1}) on day 21							
Total aerobic bacteria	4.56	5.10	4.81	5.06	5.37	0.14	0.50
Escherichia coli	4.76	4.91	4.34	3.71	4.14	0.17	0.16
Lactic acid producing bacteria	5.00	5.38	4.96	4.96	4.67	0.12	0.47
Ileum microbial count (log 10 CFU g^{-1}) on day 42							
Total aerobic bacteria	5.65	6.13	5.84	5.99	5.53	0.12	0.58
Escherichia coli	5.46	5.53	5.25	5.86	4.90	0.14	0.30
Lactic acid producing bacteria	5.55	5.79	5.29	5.63	4.04	0.30	0.38
Cecum microbial count (log 10 CFU g^{-1}) on day 42							
Total aerobic bacteria	6.12	6.18	5.63	5.99	6.20	0.09	0.28
Escherichia coli	5.92^{b}	7.11^{a}	5.46^{b}	5.80^{b}	6.17^{ab}	0.18	0.02
Lactic acid producing bacteria	5.75^{ab}	5.94^{a}	5.48^{b}	5.47^{b}	5.69^{ab}	0.07	0.14

[a] Means within a row with different superscripts are significantly different ($p < 0.05$). OT: OxyTetracycline; PSM: Pawpaw Seed Meal; MSM: Mustard Seed Meal, BSM: Black cumin Seed Meal.

Table 4. Effect of seed meals supplementation on the gut morphology of the broiler chickens at 42 days.

Parameters	Diet 1 (Control)	Diet 2 (0.11 g kg^{-1} OT)	Diet 3 (15 g kg^{-1} PSM)	Diet 4 (15 g kg^{-1} MSM)	Diet 5 (15 g kg^{-1} BSM)	SEM	P-value
Duodenum							
Villi height (µm)	1176.14	1073.84	1032.45	1321.44	980.20	57.29	0.37
Apical width (µm)	73.83	62.37	70.11	75.43	67.63	2.14	0.33
Crypt depth (µm)	150.17^{ab}	161.22^{a}	134.38^{ab}	133.69^{ab}	94.36^{b}	9.21	0.190
Jejunum							
Villi height	1178.75^{a}	1216.74^{a}	1305.10^{a}	866.59^{b}	915.45^{b}	44.82	0.01
Apical width (µm)	85.77	80.28	88.28	81.23	76.89	4.02	0.92
Crypt depth (µm)	189.90^{a}	196.87^{a}	219.32^{a}	120.74^{b}	115.45^{b}	11.88	0.01
Illeum							
Villi height (µm)	898.00	785.25	857.47	780.62	875.73	59.88	0.96
Apical width (µm)	51.51	63.89	73.03	73.71	63.82	4.12	0.46
Crypt depth (µm)	89.64	96.74	117.81	112.38	97.24	8.43	0.84

[a] Means within a row with different superscripts are significantly different ($p < 0.05$). OT: OxyTetracycline; PSM: Pawpaw Seed Meal; MSM: Mustard Seed Meal, BSM: Black cumin Seed Meal.

concentrations in the phytogenic feed supplements used in this feeding trial. Phytogenic feed additives have a vast group of compounds with great diversity in chemical structure and bioavailability (Surai, 2014). In addition, the superior overall BWG of the birds fed PSM supplemented diet over the other groups may indicate the better growth-promoting effects of the phyto-constituents of pawpaw seed meal when compared to the other phytogenic supplements used in this study. Pawpaw parts including seeds are a good source of an endolytic plant cysteine protease enzyme, which is useful for exerting various health beneficial effects or processes such as antioxidative, protein digestion, antimicrobial, immune-modulatory, and cancer-fighting activities (Kumar, and Devi, 2016). The general protective and growth-enhancing effects of phytogenic compounds were reported to associate with anti-oxidative properties (Valenzuela-Grijalva, *et al.* 2017; Kumar, and Devi, 2016). The relative internal organs weight is one of the indices for determining the effect of feed on the animals' health status (Oloruntola, 2018f). The relatively lower liver weights recorded in birds fed the supplemented diets compared to the control diet agreed with the report of (Oloruntola *et al.*, 2018c) and may indicate the anti-inflammatory properties possessed by the feed supplements (Kumar, and Devi, 2016). The higher pancreas weights of the birds fed PSM and MSM supplemented diets may be due to increased activities and secretion of the digestive juice in the birds (Steiner, and Syed, 2015). This may also be related to improved BWG observed in the experimental birds. The level of activities has a positive correlation with the weight of the gizzard. The low relative weight of the gizzard recorded in birds fed OT, PSM, and BSM in this study compared to those fed other experimental diets shows that feed supplements have variable effects on gizzard weight. The observed stability of the total aerobic bacteria, *E. coli* and LAB count in the birds' ileum and cecum on day 21 and their stability in the ileum on day 42 are in tandem with earlier report of (Seidavi and Simoes, 2015) and suggest that the feed supplements support the maintenance of the normal microflora in the ileum and cecum. This is commendable as the stability or the increase of non-pathogenic intestinal microbes is a contributory factor to inhibition of the pathogenic intestinal microbes' growth, morbidity, and mortality in animals (Guo, *et al.* 2004). In addition, the gastrointestinal imbalance due to dietary alterations could cause damages to the growth, feed utilization, and normal physiological status of the animals; while the stabilized and ideal microbiota supports optimum growth performance (Steiner, and Syed, 2015). The observed stability of *E. coli* count and LAB on day 42 in the cecum of the broiler chicken fed the control diet and the phytogenic supplements is another pointer to the possibility of these phytogenic feed supplements in maintaining the intestinal microbes at the nonpathogenic level. Although the pathogenic *E. coli* causes diverse infections in animals, many *E.coli* strains are harmless commensals (Stromberg *et al*., 2017). In this study, the *E. coli* isolate was not classified as either pathogenic or non-pathogenic; however, the apparently healthy status maintained by the experimental birds throughout the feeding trial (42 days) may suggest that the isolated bacteria were harmless. The metabolic activities of Lactobacilli acidified the digestive milieu and inhibited the proliferation of unwanted bacteria. Therefore, higher LAB recorded in birds fed the OT supplemented diets in this study are supposed to be beneficial to the birds, but did not translate to improved performance when compared to those birds fed the control and the phytogenic feed supplemented diets. This result disagreed with (Brzoska *et al.*, 2007) who recorded 10.3% higher final body weight in birds having higher ileum lactic acid bacterial population (birds fed LAB supplemented diet) compared to those having a relatively lower lactic acid bacterial population (the birds fed the control diet). The influence of phytogenic feed supplements on the intestinal morphology of the birds was reviewed by (Steiner, and Syed, 2015). The villi, a repetitive formation protruding into the intestinal lumen is considered a specialized structure for increasing the absorptive surface area (Sen, *et al.* 2012). The relatively higher jejunum villi height and jejunum crypt depth recorded in birds fed the PSM supplementary diets may have a contribution to their superior BWG because higher villi height and crypt depth has an influence on the absorption of nutrients that are needed for performance (Sen, *et al.* 2012).

CONCLUSIONS

Phytogenic feed supplementation with 15 g kg^{-1} of PSM, MSM, and BSM enhance the BWG and supports the normal ileum and cecum microflora of broiler chicken.

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اثر مکمل های غذایی بذری پاپایا، زیره سیاه، و خردل روی عملکرد، میکروفلورا و مورفولوژی معده و روده جوجه های کبابی

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چکیده

در این پژوهش،اثر مکمل های غذایی بذری پاپایا، زیره سیاه، و خردل (به ترتیب PSM، BSM، و MSM) روی عملکرد ، میکروفلورا و مورفولوژی معده و روده جوجه های کبابی ارزیابی شد. دو جیره پایه فرموله شد برای فازهای آغازین و دوره رشد و به ۵ قسمت تقسیم شد. قسمت ۱(Diet 1) یا شاهد منفی بدون مکمل غذایی بود و قسمت ۲ (Diet 2) مکملی شامل ۰/۱۱ گرم بر کیلو گرم(g/kg) ماده اکسی تتراسیکلین (oxytetracycline) داشت. قسمت ۳(**Diet 3**)، ۴(Diet ۴)، و قسمت ۵ (Diet ۵) به ترتیب دارایg/kg ۱۵ مکمل های PSM،MSM وBSM بود. ۳۰۰ جوجه کبابی یک روزه Arbor Acres به طور تصادفی در این ۵ جیره (۱۰ جوجه در هر تکرار، و ۶۰ جوجه در هر تیمار) در طرح آماری کاملا تصادفی تقسیم شد. ویژگی های عملکرد جوجه ها در دوره های ۷ روزه تعیین شد. در روز ۴۲، از هر تکرار سه جوجه سر بریده شد تا وزن لاشه، و وزن نسبی اندام داخلی آنها تعیین شود. در دوره رشد و به طور کلی، افزایش وزن بدن (BWG) جوجه های کبابی که جیره 3 Diet را داشتند شبیه Diet ۴ بودند (P>0.05) ولی به طور معناداری از جوجه های کبابی با جیره تیمارهای دیگر بیشتر بودند. وزن نسبی جگر، لوزالمعده، و سنگدان به طور معناداری (**P<0.05**) تحت تاثیر تیمارها قرار گرفت. در روز ۴۲، در جوجه های تیمار Diet 2 شمارش باکتریهای تولید کننده اسید لاکتیک مقادیر بیشتری داشت (P<0.05). در ژژنوم (jejunum)، بلندی villi و عمق crypt در تیمارهای دارای جیره ۱ Diet، Diet 2، و **۳** Dietبیشتر بود (P<0.05). بنا بر این، افزودن **g/kg** ۱۵ مکمل PSM، BSM، **و**MSM به جیره جوجه های کبابی باعث افزایش وزن بدن این جوجه ها شد.