



## Influence of supplementation of black pepper powder through feed in broiler chickens on their growth performance, blood profile, meat sensory qualities and duodenum morphology

JASWINDER SINGH<sup>1</sup>, MANJINDER SHARMA<sup>2</sup>, NITIN MEHTA<sup>3</sup>, N D SINGH<sup>4</sup>,  
PAVITER KAUR<sup>5</sup>, A P S SETHI<sup>6</sup> and S S SIKKA<sup>7</sup>

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab 14004 India

Received: 19 June 2017; Accepted: 17 August 2017

### ABSTRACT

A study was conducted to evaluate the black pepper powder (BP) as phytogetic alternative to antibiotic growth promoters in broilers. One-day old broiler chicks (225) were randomly distributed to five treatments with three replicates of each. The dietary treatments comprised basal diet as control (C), antibiotic group receiving 0.1 g/kg of oxytetracycline (AB), 0.5, 1.0, and 1.5% of BP added to basal diet to formulate BPL (low), BPM (medium) and BPH (high) groups. Body weight and feed consumed were recorded weekly and accordingly feed conversion ratio and protein efficiency ratio were calculated. At the end of 5<sup>th</sup> week, 2 birds per replicate were sacrificed to determine the carcass characteristics, meat sensory evaluation, blood parameters, duodenum morphology and faecal microbial load. The result revealed that inclusion of black pepper powder at 0.5% level improved the weight gain, feed conversion ratio and protein efficiency ratio as compared to other treatments. The dietary regimes failed to affect the carcass parameters studied except the heart weight. Black pepper powder supplementation at all the three level studied improved the appearance, colour and overall acceptability score of meat as compared to control. Blood parameters data revealed improvement in haemoglobin and reduction in triglycerides and cholesterol level in BP supplemented groups as compared to control. BP supplementation affected the fat digestibility and calcium retention. It can be concluded that black pepper has the potential to replace the prevalent antibiotic growth promoters used in broiler chickens.

**Key words:** Antibiotic, Black pepper, Broiler chickens, Growth performance, Meat sensory qualities

The alarming reports of presence of antibiotic residue in poultry products due to consistent and irrational use of sub-therapeutic dose of antibiotic in poultry feed as growth promoters has created a lot of concern among scientist fraternity for finding its alternative (Mansoub 2010). Herbs and spices have received substantial attention as a phytogetic / phytobiotic alternative to antibiotic growth promoters because of their antibacterial, antioxidant, anti-inflammatory potential, digestive stimulant, immunostimulants, hypocholestrolemic, growth promoting properties (Eevuri and Putturu 2013). Their use can ultimately minimize/exclude the serious threat of

development of bacterial resistance due to use of antibiotic growth promoters (Peric *et al.* 2009).

Black pepper (*Piper nigrum*) is a flowering vine, cultivated for its fruit, which when dried, used as spice and seasoning (Moorthy *et al.* 2009). Black pepper is a rich source of vitamin C (Mansoub 2011), Glutathione peroxidase and glucose-6 phosphate dehydrogenase (Alkassie *et al.* 2012). Piperine- the active ingredient of black pepper to increases absorption of Se, Vitamin B, beta carotene and other nutrients, favourably stimulating the digestive enzymes of pancreas, enhance the digestive capacity and significantly reduces the gastrointestinal food transit time (Srinivasan 2007).

So, the present study was executed to investigate the effect of graded level of black pepper on the growth performance, carcass characteristics, organoleptic parameters of meat, blood chemistry, duodenum morphology and faecal microbial load of the broiler chicken.

### MATERIALS AND METHODS

*Treatments and experimental design:* Day-old broilers chicks (225) were procured from University hatchery. Each bird was weighed on arrival and randomly assigned to 5

Present address: <sup>1</sup>Assistant Professor (jaswindervet@rediffmail.com), Department of Veterinary and Animal Husbandry Extension Education; <sup>2</sup>Assistant Professor (mannsharma77@gmail.com), Department of Veterinary Physiology; <sup>3</sup>Assistant Professor (nmvets220@gmail.com), Department of Livestock Product Technology; <sup>4</sup>Assistant Professor (drndsingh@gmail.com), Department of Veterinary Pathology; <sup>5</sup>Assistant Professor (paviterkaur@rediffmail.com), Department of Veterinary Microbiology; <sup>6</sup>Senior Nutritionist (apss\_pau\_ldh@yahoo.co.in), <sup>7</sup>Formerly Senior Nutritionist (sssikka04@rediffmail.com), Department of Animal Nutrition.

different dietary treatments using completely randomized design. Each dietary treatment of fourteen birds had three replicates. Equal sex ratio was maintained in all the replicates. The feeding was done in two phases i.e. starter (0–21 days) and finisher (22–35 days) phase. For each phase, five isocaloric and isonitrogenous diets were formulated (Table 1) as per BIS (2007). Basal diet served as control (C), basal diet supplemented with antibiotic growth promoter (oxytetracycline @ 0.1 g/kg) acted as Antibiotic group (AB). Black pepper berries were procured from local market and grounded to obtain the requisite black pepper powder (BP). Basal diet was supplemented with this @ 0.5, 1.0 and 1.5% level replacing maize in the ration respectively to obtain low (BPL), medium (BPM) and high (BPH) supplemented groups. All the experimental diets were analysed for proximate principles, phosphorus (AOAC 2000) and calcium (Talpatra *et al.* 1940) content. Ingredients and chemical composition of starter and finisher diets is presented in Table 1. Weighed amount of respective diet was offered daily to all groups to ensure *ad lib* feeding. Fresh and clean water was made available to the birds throughout the experimental period. The birds were reared on deep litter system maintaining standard managerial practices throughout the experimental period.

**Growth performance and carcass characteristics:** Body weight was recorded at weekly interval i.e. 7, 14, 21, 28 and 35 days of age to determine the weekly body weight and weight gain. Feed residue left of each replicate was also recorded at weekly interval to calculate feed intake and feed conversion ratio. Mortality if any was recorded daily. At the end of experiment i.e. on 35<sup>th</sup> day, two birds

(one male and one female of identical body weight) from each replicate were sacrificed. The birds were starved for 12 h but drinking water was provided *ad lib*. The birds were killed by serving the jugular vein and carotid artery on one side of the neck and allowed to bleed. Each bird was defeathered and eviscerated maintaining proper hygiene. The eviscerated weight and weight of liver, gizzard, heart, abdominal fat parameters were recorded and expressed in term of g/100 gm of body weight.

**Balance studies:** A metabolism trail was conducted at the age of five weeks. Two birds (one male and one female) from each replica with comparable body weights were selected and shifted in cage. The birds were housed in cages for a period of five days. During this period, weighed amount of feed was offered to the birds twice daily. After two days of adaptation, period the feed residue was removed. Weighed amount of fresh feed was offered to each group, for three consecutive days. Fresh water supply and 24 h light were assured during the trail. The feed residue was removed on the fourth day and weighed back to record the actual consumption of feed for each group. Dropping voided by each group were collected daily, weighed and dried separately at 80°C in hot air oven after the addition of 10 ml of dilute sulphuric acid. Three day dried droppings of each group were pooled and grounded for chemical analysis.

**Sensory evaluation of meat:** The dressed birds were also assessed for meat sensory evaluation. A seven member experienced panel of Department of Livestock Product Technology, GADVASU, evaluated the samples for appearance, colour, flavour, tenderness, juiciness and

Table 1. Composition of starter and finisher feed

Ingredient	Starter (S)					Finisher (F)				
	C	AB	BPL	BPM	BPH	C	AB	BPL	BPM	BPH
Maize	55.64	55.63	55.14	54.64	54.14	60.79	60.78	60.29	59.79	59.29
Soyabean meal	38.10	38.10	38.10	38.10	38.10	32.00	32.00	32.00	32.00	32.00
Oil	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0
DCP	1.7	1.7	1.7	1.7	1.7	1.5	1.5	1.5	1.5	1.5
LSP	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
Black pepper powder	-	-	0.5	1.0	1.5	-	-	0.5	1.0	1.5
Oxytetracyclin (g)	-	10	-	-	-	-	10	-	-	-
Additives*	+	+	+	+	+	+	+	+	+	+
<i>Analysed values (DM basis)</i>										
CP	21.42	21.24	20.89	20.71	21.06	19.14	19.14	18.60	18.25	18.60
Fat	3.03	3.17	2.61	2.79	2.41	5.7	5.4	5.91	5.66	5.88
Crude fibre	5.43	5.53	5.80	5.78	6.2	3.4	3.5	5.02	5.26	4.88
Ash	6.8	6.3	6.61	6.78	7.39	5.5	6.2	6.2	5.98	6.93
AIA	0.47	0.36	0.63	0.68	0.73	0.56	0.61	0.92	0.95	1.2
Calcium	1.16	1.07	1.01	1.11	1.09	1.18	1.20	1.05	1.05	1.10
Av. Phosphorus	0.49	0.48	0.56	0.51	0.52	0.48	0.49	0.56	0.56	0.55

\*Additives: Each 100 kg ration contained: vitamin A, 8,25,000 IU; vitamin D<sub>3</sub>, 1,20,000 IU; riboflavin, 500 mg; vitamin K, 100 mg; vitamin E, 800 mg; thiamin, 80 mg; pyridoxine, 160 mg; cyanocobalamin, 800 mg; niacin, 1200 mg; calcium pantothenate, 800 mg; manganese sulphate, 25 g; zinc sulphate, 25 g; ferrous sulphate, 10 g; copper sulphate, 500 mg; potassium iodide, 100 mg; lysine, 0.070 g (S) 0.010 g (F); methionine 0.170 g (S) 0.100 g (F); coccidiostat, 100 g, toxin binder; 100 g, Salt; 370 g.

overall acceptability using 8 point descriptive scale (Keeton 1983), where 8=extremely desirable and 1=extremely undesirable. The panelists were acquainted with the descriptive scale in two session before the start of experiments. Three sittings (n=21) were conducted for each replicate. The panelists were seated in a room free of noise and odours and suitably illuminated. The meat was cooked in salt and water for around 15 min till the internal temperature reached to 72°C. This full done meat sample was coded and served warm to the panelists. Water was provided in between samples to cleanse the mouth palate.

**Blood parameters:** Blood samples of three birds from each treatment on 35 days were collected from jugular vein in two EDTA and non-EDTA containing vial. The serum was prepared from the later. EDTA containing sample was used for determining haemoglobin (haemometer method) and packed cell volume while serum was used for other parameters like glucose, triglycerides, cholesterol, total protein and albumin. The measurements were taken using commercial Siemens autopack kits with RA 50.

**Duodenum morphology:** After thorough gross examination, small representative pieces (approximately 0.5 cm thickness) of duodenum were collected from each sacrificed bird and fixed in 10% neutral buffered formalin. After proper fixation for 3–4 days, tissues were cut into thinner sections (1–2 mm thick). The tissues were washed in running water for 7–8 h, dehydrated in ascending grades of ethyl alcohol, cleared in benzene and embedded in paraffin wax (melting point 58°C). The paraffin blocks were prepared and the sections were cut at 4–5 µ thickness with a hand operated microtome. The paraffin embedded sections were then passed through sequential steps of

deparaffinisation in xylene, rehydration through descending grades of ethyl alcohol to running water. Sections were stained by routine haematoxylin and eosin stain.

**Fecal microbial load:** Fresh faecal material was collected and same was sent to Department of Veterinary Microbiology, GADVASU. Viable bacterial cell counting was carried out using Miles-Misra technique. Serial tenfold dilution of the faecal samples containing bacteria were carried out as accurately as possible to minimize avoidable errors and an aseptic technique was used. Ranges of dilution were used and an inoculum of 0.02 ml, delivered as a drop was placed on the agar (Brain heart infusion agar for total bacterial load and Hichrome *E.coli* agar for *E. coli*). At least 4 drops per sample dilution were used. The inoculums were allowed to dry and the plates were incubated at 25–37°C for 24–48 h. Colony count obtained from the sample inoculums were then used to determine the number of bacteria/ml of original sample.

**Statistical analysis:** Growth performance, carcass characteristics and sensory evaluation data were subjected to analysis of variance using SPSS (version 16) and treatments mean were compared using Duncan's multiple range tests at 95% significant level.

## RESULTS AND DISCUSSION

**Growth performance:** Initial body weight (IBW), Final body weight (FBW), body weight gain (BWG), feed intake/bird/day (FI/B/D), feed conversion ratio (FCR) and protein efficiency ratio (PER) data for the starter (0–3 weeks), Finisher (4–5 weeks) phase and for overall growth (0–5 weeks) period are presented in the Table 2.

**Starter (0–3 weeks) phase:** The dietary regimes

Table 2. Effect of dietary BP powder for 5 weeks on growth performance in broiler chickens

Treatments parameter	C	AB	BPL	BPM	BPH	SEM	P value
<i>Starter phase</i>							
IBW	48.10	48.16	47.33	47.34	47.33	0.165	0.225
FBW	574.63 <sup>b</sup>	627.15 <sup>c</sup>	634.87 <sup>c</sup>	601.52 <sup>bc</sup>	490.49 <sup>a</sup>	14.74	0.001
BWG	526.53 <sup>b</sup>	578.98 <sup>c</sup>	587.53 <sup>c</sup>	554.85 <sup>bc</sup>	443.49 <sup>a</sup>	14.72	0.001
FI/B/D	41.70 <sup>bc</sup>	43.52 <sup>c</sup>	39.85 <sup>ab</sup>	42.82 <sup>bc</sup>	37.56 <sup>a</sup>	0.686	0.010
FCR	1.66 <sup>b</sup>	1.58 <sup>b</sup>	1.42 <sup>a</sup>	1.62 <sup>b</sup>	1.78 <sup>c</sup>	0.326	0.001
PER	2.76 <sup>ab</sup>	2.84 <sup>bc</sup>	3.37 <sup>d</sup>	2.98 <sup>c</sup>	2.67 <sup>a</sup>	0.0681	0.001
<i>Finisher phase</i>							
FBW	1287.40 <sup>b</sup>	1368.94 <sup>bc</sup>	1393.93 <sup>c</sup>	1315.41 <sup>bc</sup>	1111.9 <sup>a</sup>	28.30	0.001
BWG	712.77 <sup>b</sup>	741.79 <sup>b</sup>	759.11 <sup>b</sup>	713.96 <sup>b</sup>	621.46 <sup>a</sup>	14.17	0.002
FI/B/D	111.70 <sup>bc</sup>	116.89 <sup>c</sup>	113.87 <sup>bc</sup>	108.27 <sup>b</sup>	96.08 <sup>a</sup>	2.11	0.001
FCR	2.19	2.21	2.10	2.12	2.17	0.0197	0.425
PER	2.38 <sup>a</sup>	2.37 <sup>a</sup>	2.66 <sup>b</sup>	2.58 <sup>b</sup>	2.53 <sup>ab</sup>	0.036	0.009
<i>Overall period</i>							
IBW	48.10	48.16	47.33	47.34	47.33	0.165	0.225
FBW	1287.40 <sup>b</sup>	1368.94 <sup>bc</sup>	1393.93 <sup>c</sup>	1315.41 <sup>bc</sup>	1111.90 <sup>a</sup>	28.30	0.001
BWG	1239.30 <sup>b</sup>	1320.78 <sup>bc</sup>	1346.60 <sup>c</sup>	1268.07 <sup>bc</sup>	1064.60 <sup>a</sup>	28.26	0.001
FI/B/D	67.57 <sup>b</sup>	72.31 <sup>c</sup>	68.74 <sup>bc</sup>	69.00 <sup>bc</sup>	60.44 <sup>a</sup>	1.142	0.001
FCR	1.91 <sup>b</sup>	1.91 <sup>b</sup>	1.79 <sup>a</sup>	1.90 <sup>b</sup>	1.99 <sup>b</sup>	0.022	0.031
PER	2.53 <sup>a</sup>	2.56 <sup>a</sup>	2.93 <sup>c</sup>	2.74 <sup>b</sup>	2.59 <sup>a</sup>	0.043	0.001

a, b, c Means values with different superscripts are significantly different at P<0.05.

significantly ( $P < 0.05$ ) influenced the body weight and weight gain during this phase. The highest ( $P < 0.05$ ) body weight and weight gain was recorded in BPL group followed by AB group. Significant ( $P < 0.05$ ) influence was recorded on feed intake per bird per day (FI/B/D) during this phase (Table 2). Birds fed on antibiotic containing diet consumed highest ( $P < 0.05$ ) while birds kept on BPH consumed lowest feed/day. The best ( $P < 0.05$ ) FCR was observed in birds fed on diet having 0.5% BP (BPL) followed by AB group. The poorest FCR was observed in BPH group and was significantly ( $P < 0.05$ ) higher than FCR observed in all the treatment groups. The best ( $P < 0.05$ ) PER was found in BPL group followed by BPM group. PER was poorest ( $P < 0.05$ ) in BPH followed by C group.

**Finisher phase (4–5 weeks):** Birds fed on BPL diet attained highest ( $P < 0.05$ ) final body weight (1393.93 g) followed by antibiotic fed (AB) birds which was statistically comparable with the body weight of chicks fed 1.0% BP (BPM) diet. The lowest ( $P < 0.05$ ) body weight was found in 1.5% BP (BPH) containing group. Though the feed regime significantly ( $P < 0.05$ ) influenced the weight gain but gain in weight in C, AB, BPL and BPM failed to differ significantly ( $P < 0.05$ ). However the lowest gain in weight (621.46 g) was found in 1.5% BP containing diet (BPH). The highest ( $P < 0.05$ ) feed consumption per day was found in AB, followed by BPL and C which were statistically comparable. The lowest feed intake was observed in 1.5% BP supplemented group (BPH) followed by birds fed on BPM group. No significant effect of the treatments was observed on FCR though numerically lowest FCR was observed in 0.5% BP supplemented group (BPL). BP supplementation at all the level studied improved ( $P < 0.05$ ) the PER as compared to control (C) and antibiotic fed group (AB). The poorest ( $P < 0.05$ ) PER was observed in control (C) and antibiotic supplemented (AB) groups (Table 2).

**Overall performance (0–5 weeks):** During the overall growth performance period, body weight gain was significantly ( $P < 0.05$ ) higher in 0.5% BP fed group (BPL) than the rest of treatments studied. However, gain in weight in antibiotic fed group (AB) was statistically ( $P < 0.05$ ) comparable with the gain in weight observed in 1% BP supplemented group (BPM). The 1.5% inclusion level of BP (BPH) significantly ( $P < 0.05$ ) lowered the gain in weight as compared to control (C). The dietary regimes significantly ( $P < 0.05$ ) influenced the feed consumed, FCR and PER during the overall performance phase. The feed consumed/bird/day was higher ( $P < 0.05$ ) in AB group than the rest of treatment studied. FI/B/D in BPL and BPM did not differ significantly. The lowest feed consumption was found in birds fed on BPH diet. Best ( $P < 0.05$ ) FCR was found in group fed on 0.5% BP containing diet (BPL) and the rest of treatments did not differ significantly ( $P < 0.05$ ). The PER was best ( $P < 0.05$ ) when BP was supplemented at 0.5% level (BPL) in the diet followed by BPM. Phytogetic's antibacterial, antioxidant, antistress, gut microflora manipulation, immune enhancement properties are quoted as major mechanism behind the positive effects exerted by

them on the growth and health performance of animals (Hashemi and Davoodi 2010). The present study data perusal revealed that supplementation of BPP at 0.5% level (BPL) gives best result in terms of body weight gain and FCR. Myandoab and Mansoub (2011) also reported the significant ( $P < 0.05$ ) effect of 1.0, 1.5 and 2.0% black pepper inclusion on the growth performance, carcass traits and blood biochemical parameters of Japanese quails. The improved performance might be due to the black pepper or its active ingredient piperine favourably stimulate the digestive enzymes of pancreas, enhances digestive capacity, reduces the gastrointestinal food transit time (Srinivasan 2007), arousing digestive liquid in stomach and eradication of infectious bacteria (Safa *et al.* 2014) increases production of saliva and gastric secretion, thereby improved appetite (Meghwal and Goswami 2012). The present results were in line with Safa *et al.* (2014) who reported that 1% BP supplemented group attained the heaviest value for weight gain, feed intake, dressing, best feed conversion ratio and commercial cut percentage.

**Benefit cost ratio (BCR):** The feed cost (₹/kg) for broiler starter and finisher diets, feed cost /kg weight gain and benefit cost ratio are presented in Table 3. The highest ( $P < 0.05$ ) feed cost per kg weight gain (₹ 65.49) was observed in BPH group (1.5% BPP inclusion level), followed by BPM group. However, feed cost per kg weight gain in C, AB and BPL groups did not differ significantly ( $P < 0.05$ ) (Table 3).

Inclusion of BP powder at higher levels studied i.e. 1.0 and 1.5% deteriorated the BCR. However, the best ( $P < 0.05$ ) BCR of 1.33 was observed in the group fed on antibiotic containing diet (AB) and was statistically comparable with the BCR of control (C) and 0.5% BPP supplemented (BPL) groups. Safa *et al.* (2014) reported the highest profitability ratio in the 1.0% BP supplemented group followed by 0.75% and 0.5% BP supplemented group and control group recorded the lowest profitability ratio. Contrary to this, present study result showed that increasing the BPP supplementation reduces the benefit cost ratio. This might be due to high cost of black pepper in India. The higher dose of black pepper/piperine is toxic to liver and deteriorate the absorption surface of intestine (Cardoso *et al.* 2012). This

Table 3. Effect of different treatments on cost effectiveness of ration and benefit cost ratio

Treatment	Feed cost/kg (₹)		Feed cost/kg weight gain (₹)	BCR
	Starter	Finisher		
C	25.97	25.15	50.09 <sup>a</sup>	1.30 <sup>c</sup>
AB	26.00	25.18	49.18 <sup>a</sup>	1.33 <sup>c</sup>
BPL	28.37	27.55	50.27 <sup>a</sup>	1.31 <sup>c</sup>
BPM	30.77	29.94	57.59 <sup>b</sup>	1.16 <sup>b</sup>
BPH	33.16	32.34	65.49 <sup>c</sup>	1.01 <sup>a</sup>
SEM	-	-	1.708	0.0329
P value	-	-	0.001	0.001

<sup>a, b, c</sup>Means values with different superscripts are significantly different at  $P < 0.05$ .

might be the reason for poorest weight gain observed in 1.5% BPP supplemented group (BPH) in the present study.

**Carcass characteristics:** Different dietary treatments studied had no significant ( $P<0.05$ ) effect on carcass characteristics except heart weight. The highest ( $P<0.05$ ) heart weight was observed in BPH group then the other treatments. Heart weight in AB and BPM did not differ significantly ( $P<0.05$ ) and lowest heart weight was found in BPL (Table 4).

Al-Kassie *et al.* (2011) reported the nonsignificant effect of different level of black pepper on the edible giblet, but increasing the BP inclusion level from 0.25% to 1.0% significantly improved the dressing percentage. However, Myandoab and Mansoub (2011) reported the significant ( $P<0.05$ ) effect of black pepper on the liver, gizzard and breast. The presence of antioxidants and phenolic substances (Meghwal and Goswami 2012) in herbal plants may be the reason for improvement in various carcass traits.

**Sensory evaluation of meat:** Supplementation of BP at all the inclusion level studied significantly ( $P<0.05$ ) effected the appearance, colour and overall acceptability of meat (Table 5). BP supplemented treatment (BPL, BPM and BPH) had significantly ( $P<0.05$ ) better appearance and

colour than control group (C). The score of AB, BPL, BPM and BPH did not differ significantly and lowest ( $P<0.05$ ) was found in control (C). Dietary treatments fail to significantly ( $P<0.05$ ) effect the flavour, tenderness and juiciness of the meat. The overall acceptability score was highest ( $P<0.05$ ) in BPH group. The overall acceptability score of AB, BPL and BPM did not differ significantly ( $P<0.05$ ), however, the poorest ( $P<0.05$ ) overall acceptability score was found in Control (C) Table 5.

The improvement in meat quality due to BP supplementation observed in present study might be due presence of antioxidants like vitamin C, phenolic amides and flavonoids (Meghwal and Goswami 2012), antimicrobial properties and reducing lipid oxidation during storage (Velasco and Williams 2011).

**Blood biochemistry:** Dietary treatments significantly ( $P<0.05$ ) effected the haemoglobin (Hb), triglycerides and cholesterol (Table 6). Highest Hb level was observed in BPL and BPM groups. Hb level in BPH and AB did not differ significantly. The lowest ( $P<0.05$ ) Hb concentration was found in control (C) group. Feed regimes failed to ( $P<0.05$ ) effect the PCV, glucose, total protein and albumin. Numerically, supplementation of BP lower the glucose level

Table 4. Effect of dietary BP powder on carcass characteristics

Parameter	C	AB	BPL	BPM	BPH	SEM	P value
Dressing percentage	55.87	54.89	57.40	56.35	56.91	0.502	0.623
Liver*	3.16	2.89	2.82	3.11	2.76	0.102	0.726
Gizzard*	2.98	2.60	2.66	2.88	2.50	0.073	0.187
Heart*	0.544 <sup>ab</sup>	0.621 <sup>bc</sup>	0.522 <sup>a</sup>	0.636 <sup>bc</sup>	0.671 <sup>c</sup>	0.019	0.020
Abdominal fat*	2.35	1.90	1.83	2.39	2.18	0.135	0.646

a, b, cMeans values with different superscripts are significantly different at  $P<0.05$ . \*(g/100g).

Table 5. Influence of dietary BP powder on sensory score in chicken meat

Parameter	C	AB	BPL	BPM	BPH	SEM	P value
Appearance and colour	6.92 <sup>a</sup>	7.21 <sup>b</sup>	7.21 <sup>b</sup>	7.36 <sup>b</sup>	7.42 <sup>b</sup>	0.045	0.001
Flavour	6.96	7.04	7.17	7.25	7.29	0.332	0.390
Tenderness	6.75	6.99	7.11	7.12	7.25	0.385	0.225
Juiciness	6.88	7.13	7.08	7.02	7.23	0.065	0.544
Overall acceptability	6.67 <sup>a</sup>	6.96 <sup>ab</sup>	7.03 <sup>ab</sup>	7.08 <sup>ab</sup>	7.33 <sup>b</sup>	0.072	0.047

a, b, cMeans values with different superscripts are significantly different at  $P<0.05$ .

Table 6. Influence of in-feed BP inclusion on blood parameters

Parameter	C	AB	BPL	BPM	BPH	SEM	P value
Hb	8.93 <sup>a</sup>	9.54 <sup>ab</sup>	10.07 <sup>b</sup>	10.07 <sup>b</sup>	9.54 <sup>ab</sup>	0.142	0.029
PCV	28.33	29.50	30.83	30.00	29.50	0.551	0.764
Glucose	236.67	259.67	213.67	226.33	208.33	7.699	0.230
Triglycerides	106.02 <sup>c</sup>	99.08 <sup>bc</sup>	103.75 <sup>c</sup>	85.65 <sup>ab</sup>	82.69 <sup>a</sup>	3.057	0.012
Cholesterol	133.33 <sup>c</sup>	124.0 <sup>b</sup>	99.67 <sup>a</sup>	120.00 <sup>b</sup>	115.33 <sup>b</sup>	3.151	0.001
Total protein	3.93	3.90	4.13	3.67	3.54	0.085	0.183
Albumin	1.83	1.77	2.13	1.90	1.74	0.061	0.244

a, b, cMeans values with different superscripts are significantly different at  $P<0.05$ .

as compared to control and antibiotic fed groups. Supplementation of BP @ 1.0 (BPM) and 1.5% (BPH) significantly reduced the serum triglycerides level as compared to control (C). The lowest ( $P<0.05$ ) serum triglycerides level was observed in BPH group followed by BPM group. Triglycerides level in BPM and antibiotic fed group did not differ significantly ( $P<0.05$ ). Likewise BP supplementation significantly ( $P<0.05$ ) reduce the cholesterol level in BPL, BPM and BPH. The lowest cholesterol level was found in BPL and highest cholesterol level was observed in control group (C).

The improvement in Hb concentration in the BP supplemented groups was in line with Cardoso *et al.* (2012) who observed significant effect of 60 mg/kg piperine on Hb. The main reason behind the significant reduction in triglycerides and cholesterol level due to BP supplementation is presence of substances like carvacrol and thymol in the black pepper (Zargari 2001). The present results were in agreement with Al-Kassie *et al.* (2011) who also observed significant reduction in cholesterol level as the BP supplementation increases from 0.25% to 1.0%. Mahmoud and Mansoub (2011) also reported the non significant effect on black pepper on total protein and albumin as observed in the present study.

**Nutrient digestibility:** Dietary treatments failed to effect ( $P<0.05$ ) the dry matter, protein, fiber digestibility's and phosphorus retention; however, their effect on fat digestibility and calcium retention was significant ( $P<0.05$ ) (Table 7). The supplementation of BP at all the level studied improved the fat digestibility's as compared to control (C) and antibiotic fed (AB) groups. Lowest fat digestibility was

found in control group (C). The highest ( $P<0.05$ ) calcium retention was observed in BPH group which did not differ significantly from calcium retained by the birds fed on AB diet. Calcium retention in C, BPL and BPM did not differ significantly ( $P<0.05$ ).

The improved digestibility of fat and calcium retention can be justified that supplementation of black pepper reduces the microbial load in gut (Eevuri and Putturu 2013) and improved the absorption surface (Cardoso *et al.* 2012) thereby improving the absorption of nutrients.

**Duodenum morphology and faecal bacterial count:** The effect of dietary treatments on duodenum morphology and faecal bacterial count in broilers on 35<sup>th</sup> day of age are presented in Table 8. The highest ( $P<0.05$ ) villus was seen in 0.5% BP supplemented group (BPL) as compared to villus height in C, AB and BPH groups. The villus height in BPM group was statistically ( $P<0.05$ ) comparable with all other treatments. The deepest ( $P<0.05$ ) crypt was those of control group though it did not differ significantly from the crypt depth observed in AB, BPL and BPM groups. The smallest ( $P<0.05$ ) crypt depth was observed in 1.5% BP powder supplemented group (BPH). Villus height/crypt depth ratio was highest ( $P<0.05$ ) in 0.5% BP supplemented group (BPL) and was comparable with BPM and BPH groups, which indicated better intestine health. The lowest ratio was observed in control group (C). Total bacterial and *E.coli* count were highest in control group (C) when compared to rest of the treatments. Antibiotic and black pepper supplemented groups had statistically comparable ( $P<0.05$ ) total bacterial and *E. coli* count.

Higher villus height, low crypt depth and high villus

Table 7. Influence of dietary BP powder on nutrient digestibility's in chicken

Parameters	C	AB	BPL	BPM	BPH	SEM	P Value
DCP	70.22	71.92	70.71	70.68	72.89	0.813	0.877
DFAT	85.91 <sup>a</sup>	88.43 <sup>ab</sup>	91.71 <sup>b</sup>	91.93 <sup>b</sup>	89.97 <sup>b</sup>	0.753	0.029
DDM	78.02	79.06	77.27	78.02	80.76	0.588	0.415
DMDCF	22.38	22.02	25.12	28.93	29.72	1.353	0.232
DMDCa	43.17 <sup>a</sup>	52.12 <sup>b</sup>	42.99 <sup>a</sup>	43.04 <sup>a</sup>	53.46 <sup>b</sup>	1.584	0.022
DM DP	43.85	51.27	50.71	43.87	49.86	1.665	0.449

DCP, digestibility of crude protein; DFAT, digestibility of crude fat; DDM, dry matter digestibility; DMDCF, dry matter digestibility of crude fibre, dry matter digestibility of calcium, and dry matter digestibility of Phosphorus.

Table 8. Effect of BP supplementation on duodenum morphology and faecal bacterial count in broilers

Parameters	C	AB	BPL	BPM	BPH	SEM	P Value
Villus height( $\mu$ m)	1412.51 <sup>a</sup>	1419.80 <sup>a</sup>	2117.63 <sup>b</sup>	1936.86 <sup>ab</sup>	1470.40 <sup>a</sup>	102.811	0.043
Crypt depth( $\mu$ m)	95.15 <sup>b</sup>	87.24 <sup>b</sup>	77.70 <sup>b</sup>	79.33 <sup>b</sup>	54.64 <sup>a</sup>	4.375	0.013
Villus height: crypt depth	14.84 <sup>a</sup>	16.28 <sup>ab</sup>	27.25 <sup>c</sup>	24.42 <sup>bc</sup>	26.91 <sup>c</sup>	1.744	0.016
Total bacterial ( $10^{10}$ ) organisms / ml of sample	12.0 <sup>b</sup>	2.0 <sup>a*</sup>	1.8 <sup>a</sup>	1.0 <sup>a</sup>	1.4 <sup>a</sup>	1.432	0.002
<i>E. Coli</i> ( $10^8$ ) organism/ ml of sample	8.50 <sup>b</sup>	1.0 <sup>a</sup>	4.0 <sup>ab</sup>	1.3 <sup>a</sup>	1.4 <sup>a</sup>	1.0057	0.051

\*  $10^9$ : a, b, c, Means bearing different superscripts in a row differ significantly ( $P<0.05$ ).

height /crypt depth ratio are desirable parameters for better absorption of nutrients (Xu *et al.* 2003). Present study results were in agreement with Cardoso *et al.* (2012) who reported that supplementation of piperine at 60, 120 and 180 mg/kg improved the villi surface area (height and width) and reduces the crypt depth. The result of present study revealed that black pepper as phytobiotic growth promoter has the potential to replace the prevalent antibiotic growth promoters in broiler chickens along with added advantage of improved meat qualities.

#### ACKNOWLEDGEMENT

The authors express their sincere gratitude to Heads, Department of Animal Nutrition, Department of Veterinary Microbiology, Department of Veterinary Pathology, Department of Livestock Product Technology, Department of Veterinary Physiology and Biochemistry and Department of Veterinary Pathology for providing the research facilities for completion of this study.

#### REFERENCES

- Al-Kassie G A M, Mamdooh A M Al-Nasrawi and Saba J Ajeena. 2011. Use of black pepper (*Piper nigrum*) as feed additive in broilers diets. *Research Opinions in Animal and Veterinary Sciences* **1**: 169–73.
- AOAC. 2000. *Official Methods of Analysis*. 16<sup>th</sup> edn. Association of Official Analytical Chemist, Washigton, DC.
- BIS. 2007. *Requirement for Chicken Feed*. IS: 1374–1992, Manak Bhavan, 9 Bahadurshah Zafar Marg, New Delhi 110 001.
- Cardoso V da Silva, Cristina A R deLima, Marco E F deLima, Luis E G D and Maria das G M D. 2012. Piperine as a phytogenic additive in broiler diets. *Pesquisa Agropecuaria Brasileira* **47**: 489–96.
- Eevuri T R and Putturu R. 2013. Use of certain herbal preparation in broiler feeds- A review. *Veterinary World* **6**: 172–79.
- Hashemi S R and H Davoodi. 2010. Phyogenics as new class of feed additive in poultry industry. *Journal of Animal and Veterinary Advances* **9**: 2295–2304.
- Keeton J T. 1983. Effect of fat and sodium chloride phosphate levels on the chemical and sensory properties of pork patties. *Journal of Food Science* **36**: 261–76.
- Mansoub N H. 2011. Comparison of using different level of black pepper with probiotic on performance and serum composition of broiler chickens. *Journal of Basic and Applied Scientific Research* **1**: 2425–28.
- Meghwal M and Goswami T K. 2012. Chemical composition, nutritional and functional properties of black pepper: A review. *Open Access Scientific Reports* **1**: 1–5.
- Moorthy M, Saravanan S, Mehalala C, Ravi S, Ravi K M, Viswanathan K and Edwin S C. 2009. Performance of single white leghorn layer fed with aloe vera, *Curcuma longa* (turmeric) and probiotic. *International Journal of Poultry Science* **8**: 775–78.
- Myandoab M P and Mansoub N H. 2011. Black pepper improves performance, characteristics and effect on some blood parameters of Japanese quails. *Annals of Biological Research* **2**: 389–93.
- Peric L, Zikic D and Lukic M. 2009. Application of alternative growth promoters in broiler production. *Biotechnology of Animal Husbandry* **25**: 387–97.
- Safa M A El Tazi, Mukhtar M A, Mohamed K A and Tabidi M H. 2014. Effect of using black pepper as natural feed additives on performance and carcass quality of broiler chicks. *Global Advanced Research Journal of Agricultural Science* **3**: 113–18.
- Srinivasan K. 2007. Black pepper and its pungent principle- Piperine: A review of diverse physiological effects. *Critical Reviews in Food Science and Nutrition* **47**: 735–48.
- Talapatra S K, S C Roy and K C Sen. 1940. Estimation of phosphorus, chlorine, calcium, sodium and potassium in food stuffs. *Indian Journal of Veterinary Science and Animal Husbandry* **10**: 243–58.
- Velasco V and Williams P. 2011. Improving meat quality through natural antioxidants. *Chilean Journal of Agricultural Research* **71**: 313–22.
- Xu Z R, Hu C H, Xia M S, Zhan X A and Wang M Q. 2003. Effect of dietary fructooligosaccharide on digestive enzymes activities, intestinal microflora and morphology of male broilers. *Poultry Science* **82**: 648–54.
- Zargari. 2001. *Medicinal Plants*. 2<sup>nd</sup> edn, pp 25–36. Tehran University Press.