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Effect of dual herb combinations on the growth performance, benefit cost ratio, blood profile, meat sensory qualities of broiler chickens

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ABSTRACT

Herbs being natural and within farmers acquaintance, are one of the most tried antibiotic alternative supplement to enhance the growth of poultry birds. Based on results of our previous studies on single herb supplementation, the present study was conducted to evaluate the effect of two herb combinations on growth performance of broiler chicks. One day old IBL-80 broiler chicks (Average weight ~37 g) were randomly distributed to five treatments with three replicates of each. Dietary regimen consist of control (CO), antibiotic group receiving 0.1 g/kg of oxytetracycline (AN), control diet with 0.5% cinnamon powder + 0.5% black pepper powder (CB), with 0.5% cinnamon powder + 1% whole leaf aloe vera powder (CA) and with 1% whole leaf aloe vera powder + 0.5% black pepper powder (AB). Weekly body weight gain and feed consumed were recorded and accordingly feed conversion ratio and benefit cost ratio were calculated. At the end of 5th week, 2 birds per replicate were sacrificed to determine the carcass characteristics, meat sensory evaluation, blood parameters, duodenum morphology and faecal microbial load. Data revealed that these herbal combinations have significant effect on the growth performance, FCR, nitrogen and calcium retention, blood parameters and overall acceptability of meat. Herbal combinations supplementations were significantly more profitable when used in starter phase only. Study concluded that these herbal combinations can be safely used in poultry ration to improve growth and customer oriented parameters in broiler chicken meat.

Keywords: Broilers, Cost analysis, Growth performance, Herbal combinations

The prevalent practice of antibiotic use for prophylactic purpose and to improve growth and feed conversion ratio in poultry comes under lens after reports of emergence of resistance in microbes to the antibiotic used in human and animal treatment. This created an interest among scientific fraternity to find some safe alternative to these antibiotic growth promoters. Herbs being natural and farmer friendly come out as top alternative amongst many. Different scientists tried different herbs, in different form and at different doses and reported promising results. Our previous studies have revealed that black pepper (BP) at 0.5% (Singh *et al*. 2018), whole bulb garlic powder (WBGP) at 1.5% (Singh *et al.* 2015), cinnamon powder (CP) at 0.5% (Singh *et al.* 2014a), whole leaf aloe vera powder (WLAVP) at 1.0% (Singh *et al*. 2014b) and two herb combinations of garlic powder with black pepper, cinnamon and aloe vera (Singh *et al.* 2019) have the potential to enhance growth in poultry beside promoting consumer oriented parameters in chicken meat. Present study was conducted to evaluate other two herb combinations namely cinnamon + black pepper (CB), cinnamon and whole leaf aloe vera powder (CA) and whole leaf aloe vera powder + black pepper powder (AB) on growth performance, benefit cost ratio, meat sensory qualities, duodenum morphology and faecal microbial load.

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MATERIALS AND METHODS

Treatment and experimental design: The study was executed at Poultry farm, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab. Approval from University authority and animal ethic committee was taken. Day old broilers chicks of IBL-80 (n-225) strain were procured from university hatchery. Each chick was weighed on arrival and randomly assigned to five different dietary treatments using completely randomized design. Each dietary treatment comprised of three replicates with 14 birds (7 Male : 7 Female) in each. Phase feeding, i.e. starter (0–21 days) and finisher (22–35 days) was practiced and for each phase, five isocaloric and isonitrogenous diets were formulated (Table 1) as per BIS (1992). Basal diet served as control (CO), basal diet supplemented with antibiotic growth promoter (oxytetracycline @ 0.1 g/kg) acted as Antibiotic group (AN), with 0.5% cinnamon powder + 0.5% black pepper as CB, with 0.5% cinnamon powder + 1.0% whole-leaf aloe vera powder as CA and basal diet with 1.0% whole leaf aloe vera powder + 0.5% black pepper powder as AB (Table 1). Dose rate of these herbs were used based on the

Table 1. Ingredients composition of starter and finisher feed

Ingredient	Starter (S)					Finisher (F)				
(%)	CO	AN	CB	CA	AB	CO	AN	CB	CA	AB
Maize	56.5	56.49	55.50	55.00	53.64	60.60	60.59	59.60	59.10	59.10
Soybean meal	39.0	39.00	39.00	39.00	39.00	33.00	33.00	33.00	33.00	33.00
Oil	0.5	0.50	0.50	0.50	0.50	2.00	2.00	2.00	2.00	2.00
DCP	1.7	1.70	1.70	1.70	1.70	2.00	2.00	2.00	2.00	2.00
LSP	1.5	1.50	1.50	1.50	1.50	1.75	1.75	1.75	1.75	1.75
Herbal combination	–	–	1.00	1.50	1.50	–	–	1	1.50	1.50
Oxytetracyclin (g)	–	10.00	–	–	–	–	10	–	–	–
Additives*	+	+	+	+	+	+	+	+	+	+
Chemical composition in per cent										
CP	21.76	21.76	21.41	22.00	21.41	19.66	19.83	19.31	20.01	19.65
EE	1.92	2.00	2.29	1.84	2.08	4.48	4.21	4.11	4.50	4.21
CF	5.41	5.17	4.91	4.89	5.66	4.63	4.63	4.38	4.59	4.43
Ash	7.36	7.68	7.14	7.35	6.05	8.96	7.27	6.28	7.67	6.41
AIA	0.34	0.71	0.62	0.83	0.39	1.36	1.07	1.67	1.51	1.65
Ca	1.16	1.12	1.07	1.16	1.07	1.23	1.12	1.18	1.21	1.23
Av. P	0.63	0.61	0.64	0.62	0.67	0.64	0.62	0.61	0.60	0.62

*Additives: Per 100 kg ration: Vitamin A, 8,25,000 IU; Vitamin D_3, 1,20,000 IU; Riboflavin, 500 mg; Vitamin K, 100 mg; Vitamin E, 800 mg; Thiamin, 80 mg; Pyridoxine, 160 mg; Cynacobalamin, 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, 0.060 g (S); Methionine, 0.150 g (S) 0.100 g (F) Coccidiostat 60 g; Toxin binder, 50 g; Salt, 300 g.

result of previous studies on different level of individual herb (Singh *et al*. 2014a, Singh *et al*. 2014b, Singh *et al*. 2015 and Singh *et al*. 2018). 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. The birds were reared on deep litter system maintaining standard managemental practices throughout the experimental period with 24×7 availability of clean and fresh water.

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. On 35th day, two birds (one male and one female) of identical body weight from each replicate were sacrificed by severing the jugular vein and carotid artery on one side of the neck and allowed to bleed. The birds were starved for 12 hrs but drinking water was provided *ad lib*. Each bird was defeathered and eviscerated maintaining proper hygiene. The eviscerated weight and weight of liver, gizzard, heart, and 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 metabolic trial. The feed residue was removed on the fifth 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 1:4 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 overall acceptability using 8 point descriptive scale (Keeton 1983), where 8=extremely desirable and 1=extremely undesirable. The panellists were acquainted with the descriptive scale in two session before the start of experiments, three sittings (n=21) were conducted for each replicate. The panellists 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 panellists. 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. Serum was separated from the latter. 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.

Faecal microbial load: Fresh faecal material was collected in morning hours on last day of metabolic trial and same was sent to Department of Veterinary Microbiology, GADVASU. Viable bacterial cell counting was carried out using Miles-Misra technique (Quinn *et al.* 2000). 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 and other 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: Birds fed on herbal combinations containing diets CB, CA and AB grew faster (P<0.05) than CO and AN treatments and attained the highest (P<0.05) final body weight during starter phase (Table 2). Lowest (P<0.05) feed consumption/day was recorded in the control group (CO). Significantly (P<0.05) best FCR and PER was observed in herbal combination containing groups.

In finisher phase, birds fed on CB and AB diets attained the highest (P<0.05) body weight with highest (P<0.05) feed consumption/day during finisher phase. Best (P<0.05) FCR was observed in antibiotic fed group (AN) than the rest of treatments studied.

Overall birds fed on herbal combinations (CB, CA, AB) gained significantly (P<0.05) higher body weight as compared to birds fed on CO and AN diets due to higher weight gain and feed consumption. Best (P<0.05) feed

Table 2. Effect of herbal combinations on growth performance in broilers

Treatment Parameter	CO	AN	CB	CA	AB	SEM
Starter phase						
I BW (g)	36.67	37.67	37	37.33	37.00	0.153
FBW (g)	433.80^{a}	460.89^{a}	550.57^{b}	516.94^{b}	564.50^{b}	14.924
BWG (g)	397.13^{a}	423.23^{a}	513.57^{b}	479.61^{b}	527.50^{b}	14.873
FI/B/D (g)	37.66^{a}	39.96^{abc}	41.44^{bc}	39.03^{ab}	42.35^{c}	0.548
FCR	1.99^{b}	1.98^{b}	1.69^{a}	1.71^{a}	1.69^{a}	0.045
PER	2.32^{a}	2.32^{a}	2.71^{b}	2.73^{b}	2.81^{b}	0.0656
Finisher phase						
FBW (g)	1168.8^{a}	1222.1^{ab}	1323.6^{c}	1288.2^{bc}	1324.8^{c}	20.56
BWG (g)	735.05	761.28	773.09	771.32	760.33	8.199
FI/B/D (g)	111.49^{ab}	107.69^{a}	118.03^{b}	115.35^{ab}	117.37^{b}	1.408
FCR	2.13^{b}	1.98^{a}	2.14^{b}	2.09^{b}	2.16^{b}	0.02
PER	2.4	2.57	2.44	2.5	2.37	0.029
Overall period						
I BW (g)	36.67	37.67	37	37.33	37	0.153
FBW (g)	1168.8^{a}	1222.1^{ab}	1323.6^{c}	1288.2^{bc}	1324.8^{c}	20.56
BWG (g)	1132.1^{a}	1184.5^{ab}	1286.6^{c}	1250.9^{bc}	1287.8^{c}	19.956
FI/B/D (g)	66.08^{a}	67.05^{ab}	71.95^{b}	69.40^{ab}	72.36^{b}	0.835
FCR	2.04^{b}	1.98^{ab}	1.96^{a}	1.94^{a}	1.97^{ab}	0.013
PER	2.36^{a}	2.47^{b}	2.54^{b}	2.58^{b}	2.54^{b}	0.024

IBW, Initial body weight; FBW, Final body weight; BWG, Body weight gain; FI/B/D, Feed intake per bird per day; FCR, Feed conversion ratio; PER, Protein efficiency ratio; ^{a,b,c}Means bearing different superscripts in a row differ significantly (P<0.05).

Table 3. Effect of herbal combinations on benefit cost ratio

Treatment	Feed cost/kg (₹)		Feed cost/kg weight gain (₹)		BCR	
	Starter	Finisher	Starter	Overall	Starter	Overall
CO	24.88	24.39	49.63^{ab}	51.03^{ab}	0.919^{a}	1.25^{ab}
AN	24.90	24.41	49.41^{ab}	48.74^{a}	0.943^{a}	1.31^{b}
CB	28.17	27.68	47.04^{a}	52.00^{ab}	1.05^{b}	1.26^{ab}
CA	29.02	28.29	53.34^{b}	53.31^{bc}	0.947^{ab}	1.23^{ab}
AB	30.28	29.79	51.84^{b}	56.56^{c}	0.997^{ab}	1.18^{a}
SEM	0.587	0.578	0.759	0.83	0.017	0.016

^{a,b,c}Means bearing different superscripts in a column differ significantly (P<0.05).

Table 4. Effect of dietary treatments on per cent nutrients utilization

Parameter (%)	CO	AN	CB	CA	AB	SEM
DM	70.76	70.28	70.91	72.28	72.71	0.809
Nitrogen	67.53^{a}	67.96^{a}	71.62^{b}	68.77^{ab}	69.35^{ab}	0.535
EE	81.37	81.2	81.2	80.12	80.27	0.238
CF	21.48	23.35	20.18	21.99	21.7	0.711
Ca	46.73^{ab}	49.88^{ab}	48.19^{ab}	50.47^{b}	45.75^{a}	0.678
P	42.87^{a}	49.93^{ab}	42.57^{a}	53.93^{b}	50.00^{ab}	1.684

^{a,b,c}Means bearing different superscripts in a row differ significantly (P<0.05).

conversion was observed in CB and CA groups and was comparable with FCR observed in AN and AB groups. Protein efficiency ratio in antibiotic fed group and herbal combinations fed groups did not differ significantly but was better (P<0.05) than control group. Herbal combinations studied had the synergistic effect on the growth performance and can be used as a safe alternative to the antibiotic feed additives in broilers. Present results are in agreement with the previous studies on different dual herb combination (Al-Kassie *et al.* 2012, Abou-Elkhair *et al.* 2014, Singh *et al.* 2019). Improving gut microflora, increasing nutrient digestibility, and modification of digestive secretion morphology are the possible mechanisms of herb(s) or their combinations by which they improves the performances of birds (Hashemi and Davoodi 2010)

Cost effectiveness and Benefit cost ratio (*BCR*): Feed cost/kg, feed cost per kg weight gain and benefit cost ratio during starter and overall period were depicted in Table 3. During starter phase, highest (P<0.05) BCR was recorded in CB group and lowest (P<0.05) was in CO and AN groups. During overall period, highest (P<0.05) BCR was recorded in antibiotic fed group (AN) and lowest (P<0.05) was found in AB group. The lowest BCR in AB group is due to high cost of aloe vera and black pepper used in this group as reflected in feed cost and feed cost per kg weight gain. Mehla and Moorthy (2008 a and b)) reported the significantly (P<0.01) lower return over feed cost with Aloe vera alone or combination of Aloe vera and *Curcuma longa* at 0.1 and 0.2% each as compared to control. However, Moorthy *et al.* (2009) observed the non significant (P<0.01) difference in return over feed cost with the inclusion of 0.2% ginger + 0.2% curry leaf powder and 0.2% pepper and 0.2% curry leaf powder over the control. Tazi *et al.* (2014) reported the highest profitability ratio in the 1.0% BP supplemented group followed by 0.75% and 0.5% BP supplemented groups as compared to control. Perusal of the present data indicated that all the three herbal combination have the potential to act as growth promoters.

These herbs in the regions where these are locally produced and are available at cheaper cost could then be a better alternative to antibiotic growth promoters both in terms of growth as well as net profit.

Nutrient utilization: Herbal combinations supplementation was found to improve the nitrogen retention. Highest (P<0.05) per cent nitrogen retention was observed in CB group and lowest was recorded in CO and AN groups (Table 4). Highest (P<0.05) total calcium and phosphorus retention was found in CA group.

Substances having plant origin improves the gut microflora (Peric *et al.* 2008), modify the digestive secretion morphology (Jamroz *et al.* 2003) thereby enhance the nutrients digestibility and finally the performance (Kroismayr *et al.* 2008). Individually, garlic supplemetations were found to affect the fibre and calcium digestibility (Singh *et al*. 2017) and black pepper affect fat and calcium digestibility (Singh *et al*. 2018).

Carcass characteristics: Dietary regimes significantly (P<0.05) effected the carcass parameters studied except the abdominal fat (Table 5). Highest (P<0.05) dressing percentage was recorded in AB and AN groups.

Heaviest (P<0.05) liver was found in control CO, followed by CB and AN group in a sequential manner. The highest (P<0.05) gizzard weight was recorded in CO and AN groups and lowest was in AB group. Highest (P<0.05) heart weight occurred in birds fed on control diet (CO) as compared to other groups. Moorthy *et al.* (2009) did not observe any significant (P<0.01) effect of inclusion of combination of ginger and pepper, ginger and curry leaf powder and pepper and curry leaf powder @ 0.2% each on pre slaughtered weight, Newyork dressed weight and giblet

Table 5. Effect of dietary herbal combinations on carcass characteristics in broiler chickens

Parameter	CO	AN	CB	CA	AB	SEM
Dressing percentage	52.00^{a}	54.15^{b}	51.38^{a}	51.34^{a}	55.23^{b}	0.49
Liver*	3.85^{c}	3.44^{b}	3.48^{bc}	2.89^{a}	2.84^{a}	0.112
Gizzard*	3.32^{b}	3.18^{b}	2.87^{ab}	2.84^{ab}	2.65^{a}	0.087
Heart*	1.09^{b}	0.797^{a}	0.833^{a}	0.848^{a}	0.795^{a}	0.035
Abdominal fat*	2.39	2.01	2.03	1.87	1.79	0.144

^{a,b,c}Means bearing different superscripts in a row differ significantly (P<0.05); *(g/100 g).

Table 6. Effect of dietary herbal combination on sensory qualities of chicken meat

Parameter	CO	AN	CB	CA	AB	SEM
Appearance and colour	6.79	6.83	6.96	6.75	6.88	0.052
Flavour	6.83[a]	7.12[ab]	7.33[b]	7.17[ab]	7.16[ab]	0.057
Tenderness	6.79	7.10	6.99	7.13	7.25	0.070
Juiciness	6.92	7.13	7.08	7.00	7.13	0.062
Overall acceptability	6.71[a]	7.13[b]	7.04[ab]	7.17[b]	7.08[b]	0.057

[a,b,c]Means bearing different superscripts in a row differ significantly (P<0.05).

Table 7. Effects of herbal combinations on blood parameters of broilers

Parameter	CO	AN	CB	CA	AB	SEM
Hb (g %)	11.00[b]	10.15[ab]	10.90[b]	8.97[a]	8.90[a]	0.326
PCV (%)	37.33[b]	32.33[a]	36.00[ab]	34.33[ab]	32.00[a]	0.773
GLU (mg/dl)	316.67[b]	287.33[ab]	318.33[b]	304.33[ab]	261.00[a]	8.069
TG (mg/dl)	121.59[b]	108.65[b]	79.43[a]	80.69[a]	91.32[a]	4.699
CHOL (mg/dl)	139.67	129.33	127.33	106.67	103.67	6.066
TP (mg/dl)	4.60[b]	4.33[ab]	4.60[b]	4.40[ab]	4.13[a]	0.068
ALB (mg/dl)	1.7	1.73	1.97	1.77	1.6	0.055

[a,b,c]Means bearing different superscripts in a row differ significantly (P<0.05).

weight. Abou-Elkhair *et al.* (2014) also reported the non significant (P<0.05) impact of mixture of 0.5% black pepper + 0.5% turmeric and 0.5% black pepper + 2.0% coriander on the dressing percentage, gizzard, heart, spleen, thymus and bursa of fabricus at 35 day of age. Bone (1979) suggested that abnormalities in the weight of the internal organs like liver, kidney, and gizzard arise because of increased metabolic rate of the organs in attempt to reduce the toxic elements or anti-nutritional factors to non toxic metabolites. So, lower gizzard and heart weight in herbal combination treated groups (CB, CA, AB) reflected the better internal status or lesser toxic elements metabolites.

Sensory quality of meat: Dietary regimes failed to significantly (P<0.05) effect the appearance and colour, tenderness and juiciness traits of meat (Table 6). Meat of the birds fed on antibiotic and herbal mixture diet have higher (P<0.05) flavour score as comapred to meat of control group.

Overall acceptability score was higher (P<0.05) in AN, CA and AB groups compared to control. Puvaca *et al.* (2013) reported the beneficial effect of plant products on meat quality, which may be due to presence of antimicrobial and antioxidants properties in these compounds (Soltan *et al*. 2008.). Improvement in sensory evaluation in the present study are in agreement with Meghwal and Goswami (2012) and Sang -Oh *et al*. (2013) who revealed that amending the diet of broiler with black pepper and cinnamon powder can improve the quality of chicken meat including colour, flavour, texture and overall acceptability.

Blood parameters: Highest (P<0.05) Hb level was observed in CO and was statistically comparable with AN and CB groups (Table 7). Similarly, highest (P<0.05) PCV was recorded in CO groups and lowest (P<0.05) was in AB group. AB treatment significantly (P<0.05) reduced the serum glucose level.

All the three combinations of herbs studied significantly (P<0.05) lowered the serum TG level as compared to CO and AN groups. However, dietary treatment failed to significantly (P<0.05) effect the serum cholesterol and albumin level. Highest (P<0.05) total protein content was observed in CO and CB and lowest was recorded in AB group. Present results supported the findings of Abou-Elkhair *et al.* (2014) who observed that inclusion of 0.5% black pepper and 0.5% turmeric powder and 0.5% black pepper and 2% coriander seed combinations significantly (P<0.05) improved the total protein, and reduced the glucose and triglyceride level as compared to control group. Individually, aloe vera (Rajasekaran *et al.* 2006), cinnamon (Rahman *et al.* 2013) and black pepper (Meghwal and Goswami 2012) are reported to possess cholesterol lowering properties. The combinations of these herbs as tried in the present study were also showing the similar trends. Results of present study are in line with Shahverdi *et al.* (2013), who found that supplementation of 0.02% black pepper alone and in combination with red pepper (0.1% each) significantly (P<0.05) lowered the Hb and PCV value as compared to control group. Present results are in agreement with Kim *et al.* (2006) findings that supplementation of the diet of diabetic mice with 200 mg/kg of cinnamon powder decreased blood glucose, total cholesterol and TG level. Rahman *et al.* (2013) revealed cinnamon's lipid lowering properties as its inclusion in hypercholesterolemic rates significantly lower the total cholesterol, TG and LDL cholesterol.

Duodenal morphology and faecal bacterial count: Highest (P<0.05) villus height in duodenum was observed in CO group than the rest of treatments. Deepest (P<0.05) crypt depth was observed in control (CO) and least (P<0.05) was observed in AB group (Table 8). Highest (P<0.05) villus height/crypt depth ratio was observed in CA and lowest (P<0.05) was found in CO group. Higher villus height, low crypt depth and high villus height /crypts depth are desirable parameters for better absorption of nutrients (Xu *et al.* 2003).

Highest (P<0.05) total bacterial count and *E. coli* count per ml faecal sample were found in CA groups as compared to all other treatments. Lowest total bacterial count was found in CB group.

The present study results are in agreement with results of Darabighane *et al.* (2011) who revealed that supplementation of 1.5, 2.0 and 2.5% aloe vera gel significantly (P<0.05) improved the villus height, villus height :crypt depth ratio and lowered crypt depth as

Table 8. Effects of herbal combinations on duodenum morphology and faecal bacterial count in broilers

Parameter	CO	AN	CB	CA	AB	SEM
Villus height (μm)	2127.71[b]	1941.08[a]	1928.33[a]	1944.11[a]	1842.28[a]	29.699
Crypt depth (μ m)	139.83[d]	91.89[ab]	99.69[b]	113.32[c]	79.69[a]	5.732
Villus height: crypts depth ratio	15.22[a]	21.12[ab]	19.34[ab]	17.16[ab]	23.12[b]	0.974
Total bacterial (10^5) organisms /ml of faecal sample	5.50[b]	2.33[ab]	1.97[a]	11.80[c]	2.97[ab]	1.044
E. coli (10^5) organism /ml of faecal sample	3.83[b]	1.17[a]	1.60[a]	8.77[c]	1.15[a]	0.795

[a,b,c]Means bearing different superscripts in a row differ significantly (P<0.05).

compared to control group in broilers. Cardoso *et al.* (2012) reported that supplementation of piperine at 60, 120 and 180 mg/kg improved the villus surface area (height and width) and reduce the crypt depth. Present finding are in agreement with Awaad *et al.* (2014), who reported that supplementation of specific combination of carvacrol, cinnamaldehyde and *Capsicum oleoresin* significantly (P<0.05) increased the villus height and villus height/crypt depth ratio and decreased the crypt depth in ileum as compared to control.

The study concluded that the herbal combinations studied, viz cinnamon + black pepper, cinnamon + aloe vera and aloe vera + black pepper can be used as safe alternate to widely criticized antibiotic growth promoters in broiler chicken with added advantage of enhancement in consumers oriented parameters.

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