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Effects of *Moringa* Leaf and Fruit Powders and a Commercial Herbal Preparation on the Organ Size, Ileal Digestibility and Intestinal Microflora of Broiler Chickens

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Abstract: A floor pen experiment was carried out to investigate the effects of *Moringa oleifera* and a commercial herbal preparation Zigbir® on the organ size, ileal digestibility and intestinal microflora of broiler chicken. Total of 308, day-old, male broiler chicks of Indian River strain were randomly allotted to seven experimental diets namely negative control, 0.0125% flavomycin as positive control, 0.1% *Moringa* leaf powder, 0.05% *Moringa* leaf powder, 0.035% Zigbir® (commercial herbal product), 0.1% *Moringa* fruit powder and 0.05% *Moringa* fruit powder, in a complete randomized design. Each treatment contained 44 birds with four replicates of 11 birds each. The results revealed that the *Moringa* feed additives and Zigbir® increased the relative gut weight and duodenum length in the chickens on day 21 and the antibiotics significantly reduced the relative liver weight in the broiler chickens on day 42. During early stage of growth in floor pens, antibiotic and Zigbir® increase both ileal and caecal lactic acid bacteria counts in broiler chickens while antibiotics, Zigbir® and *Moringa* feed additives reduce the ileal and caecal coliform counts. During starter diet period, the herbal dietary supplements significantly improved the apparent ileal dry matter digestibility in the broiler chickens.
Keywords: Broiler chicken, Digestibility, Feed additives, Microflora, Moringa, Organ

INTRODUCTION

Antibiotic growth promoters have been used to enhance the performance and gut health of poultry more than last 50 years. However, the use of antibiotics in therapeutic or sub-therapeutic doses in poultry feed has been severely limited or eliminated in many countries due the development of resistant strains of microorganisms. This reality has led to the search for antibiotic growth promoter replacements. Ultimately, the herbal and plant extracts have given attention as alternatives to antibiotic growth promoters. Plant extracts have been shown to improve the apparent ileal dry matter digestibility of nutrients in broiler chickens [1]. In addition, many herbs and their bioactive constituents possess a broad antimicrobial activity [2, 3].

Moringa oleifera is the most widely cultivated plant species in the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan and every part of *Moringa* tree, from the roots to the leaves has beneficial properties. *M. oleifera* is considered as a multipurpose tree. The uses of *Moringa* include, alley cropping (biomass production), animal forage, biogas, domestic cleaning agent, blue dye, fencing, fertilizer, foliar nutrient, green manure, gum, honey and sugar cane juice clarifier, honey, medicine, ornamental plantings, biopesticide, pulp, rope, tannin for tanning hides and water purification [4]. *M. oleifera* tree leaves contain high amount of vitamins and minerals. In addition, *M. oleifera* contains very high antioxidants and anti-inflammatory compounds [5]. Furthermore, *M. oleifera* leaves are potential plant material to enhance immune responses and improve intestinal health of broilers. A compound pterygospermin found in *Moringa* plant, has been shown to have antibiotic and fungicidal properties [6]. *Moringa* seeds are known to have inhibitory effect on several types of bacteria [7]. A reduced *E.coli* counts was reported when feeding dehydrated leaves of *Moringa* to the broiler chickens [5]. Moreover, studies have shown that *Moringa* leaf juice can be particularly effective against the *Pseudononas aeruginosa* bacterium, which can cause diseases in both animals and humans. Hence, *Moringa* could be used as a nutrient supplement and feed additive in broiler chicken diet to improve nutrition and strengthen immune functions.

Zigbir® is a commercially available herbal feed additive which is a synergistic blend of phytochemical actives with performance enhancing characteristics. The four herbal plant parts *Andrographis paniculata* (King of Bitters), *Solanum nigrum* (European Black Nightshade), *Phylanthus niruni* (Tonebreaker, Seed-Under-Leaf) *and Boerhavia diffusa* (Hog Weed) are used in the preparation of Zigbir®. It has been shown

that these herbs have beneficial effect on liver health and productivity of livestock [8]. In this regard, an experiment was designed to study the beneficial effect of *Moringa* and Zigbir® on the performance of broiler chicken. It was hypothesized in this study that the selected herbal feed additives would improve the growth performance of broiler chicken without any negative consequence for broiler chicken's health and performance.

MATERIALS AND METHODS

Experimental Design and Animals

Three hundred and eight, day-old male broiler chicks of Indian River strain were purchased from the Ceylon Grain Elevators PLC (Prima Group) and assigned into seven dietary treatments in a complete randomized design. After three weeks of brooding period in the electrically heated battery brooder, each group was divided into four equal replicates of eleven chicks per replicate. The chicks were housed in floor pens (0.09 m^2/bird). The average temperature in experimental house was maintained at 32°C during the first week by providing artificial illumination and gradually decreased in the second and third weeks, and finally fixed at 26°C thereafter. The average relative humidity during the experimental period was 70%.

Experimental Diet and Dietary Treatments

Corn-soya based broiler starter and finisher basal diets were formulated according to the ingredient composition [9] given in Table 1.

Table 1: Ingredient composition and estimated nutrient composition of broiler starter and finisher basal diets

Ingredient	Broiler Starter %	Broiler Finisher %
Maize	49.00	40.00
Rice polish	08.00	21.00
Fish meal	04.80	0.00
Soybean meal	27.70	21.00
Coconut poonac	5.00	10.00
Shell grit powder	2.08	2.70
Di Calcium Phosphate	0.50	0.40
L-Lysine	0.10	0.50
DL-Methionine	0.20	0.40
Coconut oil	2.00	3.40
Salt	0.30	0.30
Coccidiostat	0.02	0.00
Vitamin and mineral Premix	0.30	0.30
Calculated nutrient composition		
Metabolizable energy (kcal/kg)	3100	3100
Crude protein (%)	22.22	18.30
Calcium (%)	1.50	1.50
Phosphorus (%)	0.78	0.70
Lysine (%)	1.16	0.96
Methionine (%)	0.53	0.52
Methionine + Cystine (%)	0.93	0.89
Estimated composition, % of dry matter		
Ether extract	7.13	10.43
Crude fibre	4.85	5.68
Ash	8.87	9.25
Nitrogen free extract	50.25	52.07

Seven dietary treatments namely 0.05% and 0.1% *Moringa* fruit powders, 0.05% and 0.1% *Moringa* leaf powders, 0.035% commercial herbal preparation Zigbir®, 0.0125% flavomycin as positive control as well as the negative control diet without any additives were prepared. Starter diets and finisher diets were offered *ad libitum* from day 1 to 21 and from day 22 to 42, respectively. Clean water was provided all the time. The birds were vaccinated twice against Gumboro disease (Infectious Bursal Disease) on day 12 and 21.

Organ size

On 21st and 42nd day one bird from each replicate was sacrificed for the measurement of organ weights and gut length. Birds were individually weighed before sacrificing for the organ weights and gut length measurement. The abdominal cavity of the bird was opened and the digestive tract was taken out. Weights of duodenum, jejunum, ileum, proventriculus, gizzard, pancreas, spleen, and bursa of fabricus, caeca, heart and liver and the lengths of duodenum, jejunum and ileum were measured. Relative organ weights and

gut lengths were ecpressed as g/100 g body weight and cm/100 g body weight, respectively.

Intestinal microflora

On 14th day and 38th day the digesta samples of ileum and caeca were collected from one bird per replicate. Nearly one gram of digesta samples of the ileum and caecae were collected into pre autoclaved, labeled and weighed sample bottles containing 10 mL peptone water. Standard microbial enumeration methods were used for enumeration of lactic acid bacteria, total coliforms and total anaerobic bacteria. All the equipment such as, culture media, glassware and micro pipette tips were autoclaved at 121 °C for 20 minutes. Screw cap tubes were filled with 9ml peptone water and autoclaved at 121 °C for 20 minutes. According to the manufacturer's recommendations, MacConkey agar (Oxoid CM0007, UK), MRS agar (Oxoid CM0361, UK) and Wilkins-Chalgren anaerobe agar (Oxoid CM0619, UK) plates were prepared day before the sample collection and kept in the refrigerator (5 °C). The digesta samples were brought to the microbiology laboratory as soon as possible and weighed. Sample bottles were mixed thoroughly using vortex mixture. Dilution series of samples were prepared (1 mL of sample into 9 mL of peptone water) up to required dilutions. Lactic acid bacteria were enumerated on MRS agar (Oxoid CM0361, UK) and total viable anaerobic bacteria were enumerated on Wilkins-Chalgren anaerobe agar according to the pour plate method. Coliforms were enumerated on MacCkonkey agar according to the spread plate technique. Prepared Wilkins-Chalgren anaerobe agar culture plates were placed inside the polycarbonate anaerobic jars along with AnaeroGen sachet (Oxoid AN0025A, UK), to maintain the anaerobic conditions (<1% oxygen and 9-13% carbon dioxide) and incubated at 37 °C. MacConkey and MRS culture plates were kept in incubator at 37° C under aerobic conditions. Presumptive colonies on the MacConkey, MRS and Wilkins-chalgren anaerobe agar culture plates were started after 24, 48 and 72 hours of incubation, respectively. The lactic acid bacteria, coliforms and total anaerobic colonies were identified by pale colour colonies in the MRS medium, pink color, non-mucoid colonies in MacConkey medium and straw colour colonies in Wilkins-Chalgren anaerobe agar, respectively. The microbial data were expressed as log CFU/g.

Apparent ileal dry matter digestibility

Apparent ileal dry matter digestibility was determined by means of measuring the acid insoluble ash (AIA) as an internal marker. The ileal digesta samples were collected during the starter (21st day) and finisher (42nd day) periods for the digestibility test. The digesta collected by gently squeezing out from the ileum were freeze dried and ground to pass through a 0.5 mm sieve for the digestibility test.

RESULTS AND DISCUSSION

Organ size

Effects of dietary treatments on relative organ weights and gut length of broiler chickens on day 21 and 42 are presented in Table 2 and 3, respectively. The positive control diet did not result any effect on the organ size of birds on day 21. Furthermore, no gut thinning and shortening effects of antibiotics were observed on day 21. Dietary supplementation of 0.05% *Moringa* fruit powder significantly increased the relative weights of duodenum, jejunum and ileum as compared to the negative control on day 21. The relative jejunum weight of broiler chicken was significantly increased by all herbal feed supplements compared to the negative control on day 21 among which Zigbir® recorded significantly higher relative jejunum weight as compared to the positive control. Furthermore, 0.1% *Moringa* fruit powder significantly increased the relative weight of large intestine of broiler chicken on day 21.

The results related to the gut length on day 21 revealed that all *Moringa* feed additives significantly increased the length of duodenum in broiler chickens as compared to the negative control. On day 42, no treatment effects (P>0.05) were observed on the relative organ size of broiler chickens. The positive control diet significantly reduced the relative liver weight of broiler chickens as compared to the negative control diet on day 42.

The relative weights of duodenum, jejunum and ileum and the relative length of duodenum in broiler chickens were increased by either one or all herbal feed additives compared to those fed with the negative control on day 21. This could be due to increased (P<0.05) apparent dry matter digestibility recorded in the broiler chickens fed with all herbal feed additives compared to those fed with the negative control diet and positive control diet which intern would increase the development of the gut. A significant increase in the relative weight of duodenum in the chickens fed with the diet containing 0.05% *Moringa* fruit powder could be due to the increase (P<0.05) in relative length of duodenum in the chickens fed with the same diet. A significant increase in the weight of the large intestine of broiler chickens fed with the diet containing 0.1% *Moringa* fruit powder could be due to an increase in the feed intake of broiler chicken. A research indicated that feed intake stimulates the development of the gastrointestinal tract of broiler chickens [10]. A significant reduction in the relative liver weight of broiler chickens as compared to the negative control diet on day 42 could be due to the inefficient nutrient absorption and digestibility in the birds due to the absence of significant gut thinning effect which could reduce the liver weight in broiler chickens. Even though the gut thinning and shortening effects of antibiotics were not reported in broiler chickens on day 42, a numerical reduction in the

relative weight and length of duodenum, jejunum and ileum were observed in the birds fed with the positive control. A research indicated that dietary inclusion of antibiotics given as growth promoting agent reduced intestinal weight by thinning the intestinal wall and shortening the gut [11]. Absence of treatment effects observed in the weights of proventriculus, gizzard, pancreas, spleen, bursa, caeca, heart, crop and in the length of ileum on day 21 and 42 agreed with the findings [12-14] which indicated no difference among the control treatment and those containing antibiotic or mixtures of plant extracts for organ weight of broiler chickens.

Table 2: Effect of dietary treatments on the relative organ weights (g/100 g body weight) and gut length (cm/100 g body weight) of broiler chickens on day 21 (Mean±SE)

Parameters	Treatment[1]						
	NC	PC	MLP 0.05%	MLP 0.1%	Zigbir®	MFP 0.05%	MFP 0.1%
Organ weight							
Duodenum	1.36 ± 0.25^{b}	1.57 ± 0.77^{b}	1.62 ± 0.69^{b}	1.95 ± 0.43^{ab}	1.76 ± 0.35^{ab}	2.46 ± 0.45^{a}	2.04 ± 0.74^{ab}
Jejunum	2.26 ± 0.51^{c}	2.55 ± 0.52^{bc}	3.08 ± 0.75^{ab}	3.25 ± 0.43^{ab}	3.44 ± 0.55^{a}	3.19 ± 0.57^{ab}	2.99 ± 0.75^{ab}
Illeum	1.81 ± 0.61^{b}	1.96 ± 0.37^{ab}	2.40 ± 0.19^{ab}	2.78 ± 0.55^{ab}	2.62 ± 0.57^{ab}	2.86 ± 0.47^{a}	2.69 ± 0.58^{ab}
Proventriculus	0.79 ± 0.23	0.64 ± 0.42	0.76 ± 0.19	0.79 ± 0.43	0.78 ± 0.19	0.72 ± 0.20	0.74 + 0.37
Gizzard	2.83 ± 0.24^{ab}	3.25 ± 0.33^{ab}	4.27 ± 1.07^{a}	3.75 ± 0.55^{ab}	2.09 ± 1.34^{b}	3.62 ± 0.84^{ab}	3.73 ± 0.84^{ab}
Pancreas	0.57 ± 0.32	0.54 ± 0.46	0.75 ± 0.21	0.57 ± 0.36	0.66 ± 0.43	0.67 ± 0.44	0.65 ± 0.30
Spleen	0.16 ± 0.23	0.11 ± 0.22	0.15 ± 0.09	0.11 ± 0.08	0.15 ± 0.20	0.12 ± 0.24	0.16 ± 0.18
Bursa	0.19 ± 0.24	0.17 ± 0.30	0.17 ± 0.20	0.10 ± 0.19	0.18 ± 0.30	0.13 ± 0.10	0.12 ± 0.14
Caeca	0.61 ± 0.63	0.56 ± 0.46	0.67 ± 0.59	0.79 ± 0.42	0.87 ± 0.37	0.81 ± 0.46	0.69 ± 0.51
Heart	0.64 ± 0.43	0.58 ± 0.47	0.88 ± 0.66	0.91 ± 0.39	0.97 ± 0.32	1.17 ± 0.74	0.91 ± 0.54
Liver	3.67 ± 0.64	3.86 ± 1.13	4.75 ± 1.19	4.82 ± 0.89	4.80 ± 0.97	4.71 ± 0.84	5.46 ± 1.17
Crop	0.49 ± 0.28	0.56 ± 0.73	0.69 ± 0.51	0.76 ± 0.43	0.63 ± 0.40	0.69 ± 0.45	0.69 ± 0.38
Large Intestine	0.26 ± 0.30^{b}	0.36 ± 0.16^{ab}	0.27 ± 0.19^{b}	0.33 ± 0.19^{ab}	0.21 ± 0.21^{b}	0.34 ± 0.34^{ab}	0.47 ± 0.36^{a}
Gut length							
Duodenum	6.36 ± 1.22^{c}	9.20± 1.07^{abc}	10.12± 0.98^{ab}	9.86 ± 1.10^{ab}	7.90 ± 0.72^{bc}	11.60 ± 1.49^{a}	10.34±1.80^{ab}
Jejunum	16.05 ± 1.72	18.15 ± 1.88	24.27 ± 0.85	23.69 ± 1.91	18.19 ± 1.62	22.58 ± 3.20	21.93 ± 1.40
Illeum	15.39 ± 1.83	17.82 ± 1.54	23.33 ± 1.81	20.71 ± 1.29	15.68 ± 1.89	20.68 ± 3.01	19.59 ± 0.97

a, b, c: Means having different letters within the same row are significantly different (P<0.05).
SE: Standard error of the mean (n=4)
1: Treatments: Negative control (NC), 0.01% of flavomycine as positive control (PC), 0.1% of *Moringa* leaf powder (MLP 0.1%), 0.05% of *Moringa* leaf powder (MLP 0.05%), 0.035% Zigbir®, 0.1% of *Moringa* fruit powder (MFP 0.1%) and 0.05% of *Moringa* fruit powder (MFP 0.05%).

Table 3: Effect of dietary treatments on the relative organ weights (g/100 g body weight) and gut length (cm/100 g body weight) of broiler chickens on day 42 (Mean±SE)

Parameters	Treatment[1]						
	NC	PC	MLP 0.05%	MLP 0.1%	Zigbir®	MFP 0.05%	MFP 0.1%
Organ weight							
Duodenum	1.22 ± 0.46	0.98 ± 0.37	1.14 ± 0.44	1.16 ± 0.47	1.10 ± 0.51	1.07 ± 0.32	1.01 ± 0.26
Jejunum	1.96 ± 0.55^{ab}	1.52 ± 0.36^{b}	1.81 ± 0.48^{ab}	2.12 ± 0.77^{a}	1.72 ± 0.64^{ab}	1.82 ± 0.19^{ab}	1.76 ± 0.42^{ab}
Illeum	1.39 ± 0.39	1.15 ± 0.34	1.46 ± 0.42	1.41 ± 0.54	1.28 ± 0.47	1.22 ± 0.33	1.38 ± 0.41
Proventriculus	0.55 ± 0.26	0.51 ± 0.25	0.51 ± 0.24	0.54 ± 0.15	0.53 ± 0.16	0.57 ± 0.31	0.57 ± 0.25
Gizzard	2.22 ± 0.37^{ab}	2.22 ± 0.51^{ab}	2.08 ± 0.32^{ab}	2.13± 0.44^{ab}	2.03 ± 0.43^{ab}	2.01 ± 0.58^{b}	2.36 ± 0.33^{a}
Pancreas	0.46 ± 0.29	0.39 ± 0.16	0.42 ± 0.20	0.44 ± 0.31	0.44 ± 0.24	0.43 ± 0.25	0.39 ± 0.23
Spleen	0.18 ± 0.21	0.12 ± 0.17	0.12 ± 0.23	0.13 ± 0.20	0.16 ± 0.23	0.12 ± 0.16	0.19 ± 0.26
Bursa	0.16 ± 0.29	0.17 ± 0.16	0.10 ± 0.09	0.12 ± 0.24	0.15 ± 0.24	0.12 ± 0.28	0.12 ± 0.25
Caeca	0.58 ± 0.34	0.50 ± 0.29	0.55 ± 0.15	0.61 ± 0.31	0.57 ± 0.33	0.55 ± 0.30	0.61± 0.27
Heart	0.62 ± 0.30	0.58 ± 0.24	0.45 ± 0.56	0.63 ± 0.31	0.57 ± 0.31	0.59 ± 0.22	0.61 ± 0.26
Liver	3.46 ± 0.46^{a}	2.76 ± 0.42^{b}	3.19 ± 0.47^{ab}	3.55 ± 0.43^{a}	3.34 ± 0.70^{a}	3.23 ± 0.62^{a}	3.14 ± 0.48^{ab}
Crop	0.33 ± 0.24	0.34 ± 0.22	0.41 ± 0.36	0.34 ± 0.27	0.32 ± 0.21	0.39 ± 0.17	0.34 ± 0.23
Large Intestine	0.21 ± 0.32	0.20 ± 0.24	0.17 ± 0.28	0.20 ± 0.17	0.20 ± 0.32	0.19 ± 0.21	0.21 ± 0.29
Gut length							
Duodenum	2.85 ± 0.44	2.57 ± 0.50	2.77 ± 0.52	3.16 ± 0.65	2.88 ± 0.54	2.66 ± 0.77	3.00 ± 0.59
Jejunum	7.18 ± 0.82^{ab}	5.96 ± 0.82^{b}	6.36 ±1.03^{ab}	7.03± 1.20^{ab}	7.21 ± 1.15^{ab}	6.64 ± 0.71^{ab}	7.66 ± 0.85^{a}
Illeum	6.79 ± 0.77	5.95 ± 0.31	6.14 ±1.32	7.08 ± 1.03	6.85 ± 1.00	6.56 ± 0.86	7.17 ± 0.81

a, b: Means having different letters within the same row are significantly different (P<0.05).
SE: Standard error of the mean (n=4)
1: Treatments: Negative control (NC), 0.01% of flavomycine as positive control (PC), 0.1% of *Moringa* leaf powder (MLP 0.1%), 0.05% of *Moringa* leaf powder (MLP 0.05%), 0.035% Zigbir®, 0.1% of *Moringa* fruit powder (MFP 0.1%) and 0.05% of *Moringa* fruit powder (MFP 0.05%).

Intestinal microflora

Effects of dietary treatments on ileal and caecal microflora of broiler chickens on day 14 and 38 are presented in Table 4. The positive control diet significantly increased both ileal and caecal lactic acid bacteria in broiler chickens on day 14 as compared to the negative control. The treatment effects on lactic acid bacteria revealed that the herbal dietary treatments Zigbir® and 0.05% *Moringa* fruit powder significantly increased the ileal lactic acid bacteria counts as compared to the negative control on day 14. The dietary treatments Zigbir®, 0.05% *Moringa* fruit powder and the positive control resulted significantly similar ileal lactic acid bacteria counts on day 14. However, no treatment effects were reported for the lactic acid bacteria on day 38.

The ileal coliform count was significantly reduced in broiler chickens fed with the *Moringa* leaf powder (0.05% and 0.1%) and 0.1% *Moringa* fruit powder as compared to those fed with the negative control on day 14. The dietary treatments *Moringa* leaf powder, 0.1% *Moringa* fruit powder and the positive control resulted significantly similar coliform counts. In addition, the caecal coliform count of broiler chickens was significantly reduced by the dietary supplement *Moringa* fruit powder (0.05% and 0.1%) as compared to the negative control on day 14. Furthermore, 0.1% *Moringa* fruit powder treated birds had significantly lower caecal coliform counts than those fed on the positive control. In contrast, none of the dietary treatments had significant effects on the coliform counts of broiler chickens on day 38. However, the positive control and all herbal dietary treatments numerically reduced the caecal coliform counts compared to the negative control on day 14 and 38.

The results of total viable anaerobic bacteria counts revealed that there were no significant treatment effects on both ileal and caecal total viable anaerobic bacterial counts on day 14 and 38. However, the herbal dietary treatments numerically reduced the caecal total viable anaerobic bacterial counts as compared to the negative control on both day 14 and 38.

The results on gut microflora of the current study revealed that the treatment effect on both lactic acid bacteria and coliform were apparent on the early stage (day 14) of the chickens than the later stage (day 38). Lactic acid bacteria in the intestine of poultry showed beneficial effects on resistance to infectious agents such as *E. coli* [15], *Salmonella* [16], *Campylobacter* [17] and *Eimeria acervulina* [18]. Scientific evidences revealed that herbs and plant extracts stimulate the growth of beneficial bacteria and minimize pathogenic bacterial activity in the gastrointestinal tract of poultry [19, 20]. In the current experiment, an increase ($P<0.05$) of lactic acid bacteria in the ileum and caecum of broiler chickens fed with the positive control, Zigbir®, 0.05% *Moringa* fruit powder on day 14 was observed as indicated by another research [21] which indicated a significant increase in lactic acid bacteria in the ileum and caecum of broiler chicken fed with herbal additives and antibiotic compared to the negative control. The results related to the coliform counts revealed that the coliform counts in the gut of broiler chickens were significantly reduced by the dietary treatment containing *Moringa* feed additives compared to others. *Moringa* leaves are potential plant material to improve intestinal health of broilers [5]. Studies have shown that *Moringa* leaf juice can be particularly effective against the *Pseudononas aeruginosa* bacterium, which can cause diseases in both animals and humans. A compound called pterygospermin from *Moringa* plant has the antibacterial effect against a variety of microbes [6]. Pterygospermin, once consumed, breakdown into two separate benzyl isothiocyanate, a substance with known antimicrobial properties. However, a clear effect of flavomycine on the coliform counts was not reported in the current study. The *Moringa* feed additives used in the current study were the crude products rather than the purified compounds and this might be the reason for the absence of significant effect on the gut microflora. Therefore, further research is warranted with purified compounds of these feed additives.

Table 4: Effect of dietary treatments on ileal and caecal microflora of broiler chickens on days 14 and 38 (Mean±SE)

Microflora	Treatment[1]						
	NC	PC	MLP 0.05%	MLP 0.1%	Zigbir®	MFP 0.05%	MFP 0.1%
Lactic acid bacteria (log cfu/g)							
Ileum							
Day 14	5.49 ± 0.34^{c}	5.96 ± 0.56^{ab}	5.72 ± 0.43^{bc}	5.49 ± 0.40^{c}	6.11 ± 0.51^{a}	5.93 ± 0.37^{ab}	5.67 ± 0.23^{bc}
Day 38	6.56 ± 0.57	6.48 ± 0.68	6.41 ± 0.64	6.28 ± 0.91	6.58 ± 0.22	6.54 ± 0.39	6.44 ± 0.77
Caeca							
Day 14	7.28 ± 0.45^{bcd}	8.34 ± 0.74^{a}	7.63 ± 0.62^{b}	6.77 ± 0.72^{d}	7.45 ± 0.43^{bc}	6.91 ± 0.12^{d}	7.19 ± 0.19^{bcd}
Day 38	7.04 ± 0.85	6.56 ± 0.29	7.04 ± 0.63	7.01 ± 1.08	6.63 ± 0.72	6.46 ± 0.73	6.83 ± 0.49
Coliform (log cfu/g)							
Ileum							
Day 14	6.76 ± 0.65^{a}	5.78 ± 0.64^{abc}	5.56 ± 0.79^{bc}	4.83 ± 0.09^{c}	6.10 ± 0.80^{ab}	6.16 ± 0.81^{ab}	5.53 ± 0.87^{bc}
Day 38	5.82 ± 0.31^{ab}	5.97 ± 0.50^{ab}	4.93 ± 0.64^{b}	5.55 ± 0.77^{ab}	5.59 ± 0.97^{ab}	6.04 ± 0.33^{a}	5.73 ± 0.91^{ab}
Caeca							
Day 14	6.73 ± 0.14^{a}	6.50 ± 0.76^{ab}	6.17 ± 0.88^{abc}	6.31 ± 0.22^{abc}	6.47 ± 0.09^{ab}	5.73 ± 0.53^{bc}	5.51 ± 0.85^{c}
Day 38	6.26 ± 0.80	5.85 ± 0.39	5.80 ± 0.43	6.08 ± 0.20	5.83 ± 0.63	5.02 ± 1.87	5.89 ± 0.51
Anaerobic bacteria (log cfu/g)							
Ileum							
Day 14	5.92 ± 0.18^{ab}	6.82 ± 0.67^{a}	6.25 ± 0.56^{ab}	5.83 ± 0.09^{b}	6.15 ± 0.54^{ab}	6.75 ± 1.00^{a}	6.20 ± 0.65^{ab}
Day 38	6.37 ± 0.73	6.52 ± 0.35	5.97 ± 0.95	6.27 ± 0.64	6.60 ± 0.33	6.16 ± 0.46	6.53 ± 0.84
Caeca							
Day 14	6.59 ± 0.72^{ab}	6.75 ± 0.66^{a}	6.13 ± 0.19^{ab}	6.24 ± 0.69^{ab}	5.91 ± 0.10^{b}	6.28 ± 0.37^{ab}	6.27 ± 0.72^{ab}
Day 38	7.28 ± 0.67	6.90 ± 0.38	7.13 ± 0.86	6.93 ± 0.88	6.57 ± 0.99	6.18 ± 1.00	6.67 ± 0.64

a, b, c, d: Means having different letters within the same column are significantly different ($P<0.05$).
SE: Standard error of the mean (n=4)
1: Treatments: Negative control (NC), 0.01% of flavomycine as positive control (PC), 0.1% of *Moringa* leaf powder (MLP 0.1%), 0.05% of *Moringa* leaf powder (MLP 0.05%), 0.035% Zigbir®, 0.1% of *Moringa* fruit powder (MFP 0.1%) and 0.05% of *Moringa* fruit powder (MFP 0.05%).

Apparent ileal dry matter digestibility

Effects of dietary treatments on the apparent ileal dry matter digestibility of broiler chickens on day 21 and 42 are presented in Table 5. On day 21, all herbal dietary supplements significantly increased the apparent ileal dry matter digestibility of broiler chickens as compared to the negative control and the positive control diets. Both positive control and

negative control diets resulted significantly similar ileal dry matter digestibility on day 21. Among the herbal feed additives, 0.1% *Moringa* leaf powder exerted the highest apparent ileal dry matter digestibility followed by 0.1% *Moringa* fruit powder on day 21. None of the dietary treatments significantly improved the apparent ileal dry matter digestibility on day 42. The results related to the apparent ileal dry matter digestibility of broiler chickens on day 21 agreed with another finding [12] that indicated an improvement in the apparent ileal dry matter digestibility of broiler chickens fed with antibiotic and plant extracts. Significant increase in the apparent ileal dry matter digestibility in the chickens fed with herbal dietary treatments on day 21 could be due to an increase in the gut length on day 21 which would have facilitated an efficient nutrient absorption in birds. Another study reported that, 200 ppm of plant extract based on a blend of oregano, cinnamon, and pepper essential oils have significantly improved the apparent ileal dry matter digestibility of nutrients [1].

Table 5: Effect of dietary treatments on apparent ileal dry matter digestibility of broiler chickens on days 21 and 42 (Mean ± SE)

Treatment[1]	Apparent ileal dry matter digestibility	
	Day 21	Day 42
NC	48.80 ± 1.86^{d}	88.02 ± 1.55^{ab}
PC	54.28 ± 0.10^{d}	90.26 ± 1.48^{a}
MLP 0.05%	65.16 ± 0.95^{c}	90.07 ± 2.01^{a}
MLP 0.1%	75.61 ± 1.97^{a}	85.39 ± 0.89^{b}
Zigbir®	66.78 ±0.10^{c}	86.48 ± 1.24^{ab}
MFP 0.05%	63.99 ± 0.10^{c}	88.92 ± 1.24^{ab}
MFP 0.1%	70.48 ± 0.10^{b}	88.46 ± 1.26^{ab}

a, b, c, d: Means having different letters within the same column are significantly different (P<0.05).
SE: Standard error of the mean (n=4).
1: Treatments: Negative control (NC), 0.01% of flavomycine as positive control (PC), 0.1% of *Moringa* leaf powder (MLP 0.1%), 0.05% of *Moringa* leaf powder (MLP 0.05%), 0.035% Zigbir®, 0.1% of *Moringa* fruit powder (MFP 0.1%) and 0.05% of *Moringa* fruit powder (MFP 0.05%).

CONCLUSION

The study concludes that the *Moringa* feed additives and Zigbir® increase the relative gut weight and duodenum length in the chickens in floor pens on day 21 and the antibiotics significantly reduces the relative liver weight in the broiler chickens in floor pens on day 42.

During early stage of growth in floor pens, antibiotic and Zigbir® increase both ileal and caecal lactic acid bacteria counts in broiler chickens while antibiotics, Zigbir® and *Moringa* feed additives reduce the ileal and caecal coliform counts. Thus, it could be concluded that the herbal feed additives, especially *Moringa* based feed additives have the potential to improve gut health of broiler chickens by increasing the beneficial microflora and by reducing the pathogenic bacteria.

During starter diet period, the herbal dietary supplements significantly improve the apparent ileal dry matter digestibility in the chickens reared in floor pens.

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